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HYDROELECTRIC POWER SYSTEMS OF CALIFORNIA
AND
THEIR EXTENSIONS INTO OREGON AND NEVADA

BY

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HYDROELECTRIC POWER SYSTEMS OF CALIFORNIA AND THEIR EXTENSIONS INTO OREGON AND NEVADA.

By Frederick Hall Fowler.[1]

Chapter I.—INTRODUCTION.

PURPOSE OF REPORT.

Since the earliest days of electric-power transmission California has ranked among the leading States in the utilization of hydroelectric energy, only two plants in other States—one in Oregon and one in Colorado—antedating the first two California long-distance alternating-current hydroelectric transmission stations. The plant in Oregon, at Oregon City, transmitting energy 13 miles to Portland, was put into commission in the summer of 1890. The line was operated on the monophase system at the generator potential of 4,000 volts, with step-down transformers only at the terminus, and the current was used exclusively for lighting. The plant in Colorado, near Telluride, which began regular operation in June, 1892, transmitted power somewhat more than 3 miles to a mine, where it was used for driving motors as well as for lighting. The transmission was made at a generator potential of 3,000 volts without step-down transformers at the terminus and was also of the monophase type.

The so-called "Pomona plant" of the San Antonio Light & Power Co., which is about 14 miles from Pomona, was the first alternating-current station to be put into operation in California. Though it was of the monophase type, like the two plants already mentioned, it differed from them in one very important respect—the generator potential (1,000 volts) was stepped up to a higher line voltage (10,000 volts) at the plant, and the line voltage was stepped down at the receiving stations. It is the application of this principle which has made possible the wonderful transmission systems that now extend throughout the State. The Pomona plant was put into operation on December 31, 1892. On September 7, 1893, the Redlands Electric Light & Power Co. began operation of Mill Creek plant No. 1 (now operated by the Southern California Edison Co.), the first polyphase transmission plant in the State. Power was at first transmitted from this

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[1] District engineer, U. S. Forest Service.

plant at the generator voltage of 2,200, but in 1896 the line potential was raised to 10,000 volts.

In the 30 years that have elapsed since these first two stations in California went into commission the installation of hydroelectric plants and the extension of long-distance transmission systems in the State have kept well abreast of the best current practice in electrical engineering. Physical and economic conditions have so greatly encouraged the extension of the earlier systems and the building of new systems that the State is now exceeded only by New York in amount of developed water power. As would be expected, the most important phases of this extensive development have been described in articles appearing in the technical journals, in the transactions of the national engineering societies, and in technical works dealing with power development and transmission in general. No single work, however, gives a complete description of all the systems serving the State, and those who are interested in the subject must search an extensive and widely scattered literature. The need for data on existing developments was keenly felt by the officers of the United States Forest Service in 1910, when the engineering force was reorganized and new and broader water-power regulations were adopted. Up to that time administrative action by the Service had been based solely on such general information as its officers were able to obtain through private sources and from the articles that appeared in the technical press.

The newly appointed engineers in district 5, which comprises all of California and parts of western Nevada, found themselves called upon to give technical advice concerning applications for power rights of way in national forests that included wholly or partly most of the best power sites in the State. The areas of these forests are shown in Table 1.

TABLE 1.—*Areas, in acres, of national forests in Forest Service district 5, July 1, 1919.*

Forest.	Gross area.	Alienations.[a]	Net area.
Angeles	1,058,532	241,091	817,441
California	1,062,622	255,214	807,408
Cleveland	813,616	265,765	547,851
Eldorado	836,200	286,740	549,460
Inyo	1,308,059	60,459	1,247,600
Klamath	1,743,558	240,333	1,503,225
Lassen	1,321,343	384,386	936,957
Modoc	1,582,859	396,586	1,186,273
Mono	1,358,380	108,363	1,250,017
Monterey	360,494	40,213	320,281
Plumas	1,432,860	288,442	1,144,418
Santa Barbara	1,928,294	239,043	1,689,251
Sequoia	2,021,609	145,709	1,875,900
Shasta	1,586,880	777,866	809,014
Sierra	1,662,560	173,905	1,488,655
Stanislaus	1,104,412	293,610	810,802
Tahoe	1,222,382	677,319	545,063
Trinity	1,746,147	317,759	1,428,388

[a] Other lands within national-forest boundaries.

Since July 1, 1919, the Monterey has been consolidated with the Santa Barbara Forest and there have been relatively minor changes in the various areas given in Table 1. It serves, however, to show the wide extent of national forests in the area covered by this report.

In August, 1911, in order to obtain comprehensive data, the writer was detailed to make the study that has resulted in this volume. The report has been considerably enlarged in scope since the work was first undertaken, and it now comprises the available information on the history, markets, electric systems, finances, and rates of each of the operating hydroelectric companies in the State and shows in outline the general conditions under which they have attained their present stage of development. The work therefore represents an economic as well as an engineering study.

SCOPE OF FIELD AND OFFICE WORK.

A preliminary outline of the data to be collected was drawn up when the work was begun, and an itinerary was planned which included examinations of all the principal generating stations in California. In the course of these examinations the writer or his assistants have visited all the plants mentioned in this report except certain specified plants of minor importance. The field work has extended from Oregon southward through California to the plants in Imperial Valley and has included also the plants on the east side of the Sierra in California and Nevada. In addition to the power stations, most of the conduit lines and headworks were inspected, and a number of trips have been made into and across the drainage basins that supply water to the systems.

Routine inspections of power systems operating under Federal permits during the 10 years that have elapsed since the work was started have also afforded additional opportunities to procure first-hand information utilized in the report.

In intervals between field trips the writer, since October, 1911, has given as much of his time as routine work would permit to writing up the notes taken in the field and obtained from the officials of the power companies. In connection with this work he has examined nearly all the publications listed in the bibliographies and has attempted to reconcile all differences found between the notes taken and the printed descriptions.

PLAN OF PUBLICATION.

TEXT.

For clearness of arrangement, as well as to enable the reader to refer with equal ease either to the general facts concerning the subject as a whole or to detailed information pertaining to the individual company, this report presents first a description of the natural conditions that affect water-power development in the State and next outlines the economic factors that have influenced development, those factors including public control, franchises, and water rights.

The systems in operation September 1, 1921, are grouped into markets, or fields of distribution (see fig. 1), and the general features of the territory covered by each market, as well as the population, status of operating companies, and growth of load, are described.

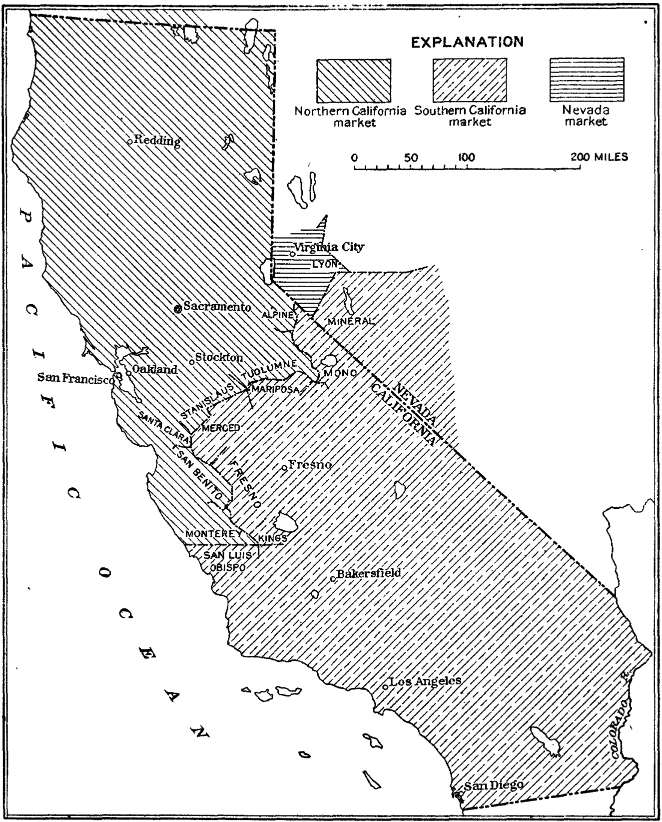

FIGURE 1.—Key map of markets.

The information concerning the history, markets, and electric system of each company is given in full so far as it is obtainable. Data on rates and finances are presented in appendixes A and B. Physial and operating data for systems of minor importance not covered in the body of the report are given in Appendix C.

MAPS AND ILLUSTRATIONS.

The drainage basins of the streams now utilized in developing hydroelectric power, including the land lines (if available), the topography to 1,000-foot contours, and the mean seasonal rainfall at observation stations within their boundaries, are shown on the accompanying maps. Most of these areas are covered also by the topographic maps of the Geological Survey (see p. 12), which show topography and culture in much greater detail than the maps accompanying this volume.

The pictorial illustrations have been selected from a large number of photographs, most of which were obtained by the writer but some of which have been kindly furnished by officers of the power companies or by engineers.

BIBLIOGRAPHIES.

In compiling the bibliographies liberal use has been made of the "Engineering index," of the "Monthly list of recent engineering articles of interest" appearing in the proceedings of the American Society of Civil Engineers, and of the annual and consolidated indexes of technical journals. Several titles which would otherwise have escaped notice have been added from an extensive bibliography collected for Prof. Charles Gilman Hyde by Mr. E. M. Chandler and several from a bibliography made by Mr. A. S. Kalenborn.

The list of titles collected from these sources is long, but it does not include all notes and references that are of passing interest only. It is believed that the bibliography is more complete than any yet published. The notes are given in the general form devised by the late Prof. J. B. Johnson and followed in the "Engineering index," but the form has been amplified to include the numbers of the photographs, maps, plans, and sections.

The fact that a paper or article is listed in the bibliography should not be taken as a guaranty of its accuracy, for many of the papers listed are valuable only because they contain some special details or illustrations.

Except where noted specifically the data given in this report are not based on published information. All articles listed in the bibliography have, however, been carefully read, any disagreements with notes taken by the writer or furnished by the companies have been investigated, any additional points of interest brought out by the articles have been noted, and many inquiries have been suggested by them. Moot points have been taken up with the companies and the information concerning them has been either verified, disproved, or revised to bring it up to date.

COMPLEMENTARY REPORTS.

When the writer began to collect data for this volume a preliminary survey of a large part of the natural resources of California was in progress. This survey has since been completed and its results are given in published reports. The first of these reports completed contained all available records of stream flow made in California up to June 30, 1912. The work was done and the report was prepared by Messrs. H. D. McGlashan and F. F. Henshaw, of the United States Geological Survey, in cooperation with the State Water Commission and with the Conservation Commission of the State of California, and the report has been published by the Geological Survey in three parts, under the general title "Water resources of California." The title and the serial numbers of the parts are as follows: "Part I, Stream measurements in Sacramento River basin" (Water-Supply Paper 298, 1913); "Part II, Stream measurements in San Joaquin River basin" (Water-Supply Paper 299); "Part III, Stream measurements in the Great Basin and Pacific coast river basins" (Water-Supply Paper 300). Most of the records contained in these three volumes had been published previously in water-supply papers, but a number of extremely important measurements were there made available for the first time.

Three introductory gazetteers prepared by Mrs. B. D. Wood, of the United States Geological Survey, containing summary descriptions of the surface waters in the three divisions of the State covered by the main report, were also published by the Survey under the general title "Gazetteer of Surface Waters of California." The titles and numbers of these gazetteers are as follows: "Part I, Sacramento River basin" (Water-Supply Paper 295); "Part II, San Joaquin River basin" (Water-Supply Paper 296); "Part III, Pacific Coast and Great Basin streams" (Water-Supply Paper 297).

The results of stream measurements in the drainage basins of the Pacific slope of southern California up to September 30, 1918, have been published by the Geological Survey as Water-Supply Paper 447.

The State Water Commission published, in connection with its First Annual Report, entitled "Report of the State Water Commission of California, 1912," a report containing a set of river profiles made by the United States Geological Survey under a cooperative agreement. These profiles cover Pit, Feather, American, Tuolumne, and San Joaquin rivers. The text of that report deals chiefly with the power sites on Pit River and possibilities of storage in the basin of Sacramento River.

The State Conservation Commission, in the text of its first annual report, entitled "Report of the Conservation Commission of the State of California, 1912," confined itself almost entirely to a consideration of waters available for irrigation. In the large maps issued with the report, however, it has given graphic data on the ownership of forest reserve lands, the extent of timber lands, the location of State school lands, and the extent of irrigated and irrigable areas. The report contains also a vast amount of tabulated data and gives the results of two special studies of ground-water supplies.

While it was preparing its own report the Conservation Commission also arranged for a cooperative report, entitled "Irrigation resources of California and their utilization," by Frank Adams, irrigation manager in charge of work in California. This volume, which was issued by the Office of Experiment Stations of the United States Department of Agriculture as Bulletin 254, is a summary of the irrigation reports published in the main report of the Conservation Commission and of some supplementary work not included in that volume.

The present report on the developed water power in the State was not undertaken as a part of a general investigation of developed and latent natural resources, nor was the work done under cooperative agreement, but its results are of the same general character as those given in some of the reports cited above.

Fuel oil from the fields of central and southern California is the only source of energy employed in active competition with hydroelectric power. Much valuable information concerning the supply of this oil will be found in "Petroleum industry of California," Bulletin 69 of California State Mining Bureau, prepared by R. P. McLaughlin, assisted by G. A. Waring, and published with a map folio in 1914. More recent information is contained in the "Report of the Committee on Petroleum," California State Council of Defense, published July 7, 1917.

ACKNOWLEDGMENTS.

The preparation of this report was first undertaken by permission of Mr. O. C. Merrill, formerly chief engineer, United States Forest Service, and now executive secretary of the Federal Power Commission; to him the writer's thanks are due for so arranging other engineering work as to permit its completion.

A great debt is due the operating companies for their very generous cooperation in furnishing and checking information. The preparation of such material has entailed a large amount of labor upon their engineers and administrative officers, and it is hoped that consolidating in a single volume information that has hitherto been widely scattered may in a measure recompense them for their labor.

Thanks for similar courtesies are due the officials in charge of the municipal power systems of the cities of San Francisco and Los Angeles.

The officials of the California Railroad Commission have extended many courtesies to the writer, who has availed himself fully of the opportunity to examine data in the official reports filed with that body and to transcribe them for incorporation in this report.

Thanks are due also to the California State Water Commission, particularly to Mr. A. E. Chandler, former executive member of the commission, for comments on the status of California water legislation.

Mr. D. M. Folsom, Federal petroleum director for the Pacific coast during the war, has rendered great aid and has made valuable suggestions on many questions concerning the oil situation.

Mr. R. P. McLaughlin, former State oil and gas supervisor, and Mr. R. E. Collom, his successor, have furnished statistics concerning the California oil supply.

Mr. W. L. Huber, civil engineer, formerly district engineer, United States Forest Service, has supplied notes on important engineering structures.

Thanks are due Dr. Cyrus G. Baldwin and Messrs. E. B. Bumsted, John S. Eastwood, H. L. Haehl, H. Hawgood, A. S. Kalenborn, H. A. Kluegel, C. E. Paris, and J. E. Woodbridge for historical and engineering information.

The task of editing the report and preparing it for the printers was assigned to the late Mrs. B. D. Wood, who, through the kind cooperation of Mr. N. C. Grover, chief hydraulic engineer, United States Geological Survey, was detailed to San Francisco from July to November, 1919. Her ability in her chosen work was of the highest order, and she rendered capable and kindly assistance in many things not strictly included in her official duties. It was with a sense of great personal sorrow that the writer received the news of her death soon after her return to Washington.

Messrs. J. L. Mathias, R. R. Randell, Stanley Sharp, F. D. Bowlus, and J. C. Dort, of the Office of Engineering, United States Forest Service, have rendered valuable aid in collecting engineering data.

The illustrations have been prepared under the supervision of Messrs. R. E. L. Borgfeldt and H. A. Sedelmeyer, chief draftsmen, United States Forest Service. Most of the maps were completed by Messrs. J. G. Shumate and A. I. Bell. Several of the compilations were made by D. M. Hoffman and U. Graff.

The final revision of load curves and other line illustrations was made chiefly by J. H. Lawrence, R. E. Skinner, and Miss D. E. Walker, and the final revision of text and tabular material by Mrs. M. B. Fulham (chief clerk), Mrs. C. I. Decker, and Mrs. E. P. Ward, of the Office of Engineering, United States Forest Service, San Francisco. To all these members of the organization the writer desires to express his thanks for their painstaking and effective work.

CHAPTER II.—CONDITIONS AFFECTING THE DEVELOPMENT OF HYDROELECTRIC POWER IN CALIFORNIA.

NATURAL CONDITIONS.

GEOGRAPHY.

GENERAL RELATIONS.

The area covered by this report includes a strip, 200 miles in average width, extending down the western coast of the United States from the southern part of Oregon to the Mexican line. Nearly all the hydroelectric systems within this area are entirely in California, but a part of one system extends into southern Oregon and parts of two others extend into western Nevada. The total area covered in the report comprises 155,651 square miles in California, 10,430 in southern Oregon, and 39,676[1] in western Nevada, a total in round numbers of 205,800 square miles.

The geographic form and position of California may seem to be so well known as to demand no mention, but there are certain facts concerning them that should be kept in mind and certain errors in the popular conception that should be corrected. Most of these errors arise from the fact that the great bend in the coast line at Cape Mendocino is not clearly recognized unless attention is specifically drawn to it. The usual idea of California is that it is an extremely long State extending due north and south along the Pacific coast; the fact that the coast line really runs northwest and southeast is overlooked. On account of this fact, although it is only 200 miles wide, the meridian passing through its westernmost point, Cape Blanco, 124° 34′ west of Greenwich, is about 585 miles west of that passing through its easternmost point, near Parker, on Colorado River, in longitude 114° 7′ W.; and although the parallel forming its northern boundary, 42° N., is 650 miles due north of that at National City, the most southerly point in the State, in latitude 32° 32′ N., its maximum length from the point where the California-Oregon boundary strikes the coast to the point where the California-Mexican boundary strikes Colorado River, is fully 820 miles.

A short study of a general map shows that the northernmost part of California is in the same latitude as the southern boundary of Idaho, southern Wyoming, central Nebraska and Iowa, northern

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[1] Combined areas of counties entered by transmission systems.

Illinois, Indiana, Ohio, and Pennsylvania, and southern New York, and that the southern boundary is in the same latitude as southern Arizona and New Mexico, central Texas, northern Louisiana, and southern Mississippi, Alabama and Georgia.

The westernmost point in the State is almost as far west as Cape Flattery in Washington, the extreme western point of the United States. Because of the bend in the coast, the easternmost point, at Parker, on Colorado River, is due south of the eastern boundary of Nevada, of central Idaho, and of western Montana.

HARBORS.

Owing to the proximity of the Coast Range to the Pacific there are remarkably few harbors along the 800 miles or more of the coast of California. On account of its natural advantages the port of San Francisco leads all others, but an artificial harbor has been created at San Pedro (Los Angeles), and there is a fine natural harbor at San Diego. There is an exposed anchorage and landing at Monterey, 125 miles south of San Francisco, and landings are also made at a number of points between Port Harford, San Luis Obispo County, and San Pedro, and at several small ports north of San Francisco. The harbor at Eureka, the only good harbor north of San Francisco, is being improved, but the Humboldt bar there is still notoriously rough.

This comparative scarcity of harbor facilities and the mountainous character of much of the coast has concentrated a large part of the agricultural and municipal growth in the interior of the State. The only coast towns and cities large enough to warrant an extension of hydroelectric transmission systems are Eureka, San Francisco, Santa Cruz, Monterey, Santa Barbara, Ventura, the beach cities near Los Angeles, and San Diego. All these except San Francisco, Los Angeles, San Diego, and Eureka are served by comparatively short extensions from main systems. San Diego and Santa Barbara, though important load centers, were until recently supplied only with power from steam-electric systems because of their distance from centers of hydroelectric power.

TOPOGRAPHY.

MOUNTAIN RANGES.

The salient features of the topography are the two nearly parallel mountain systems, the Coast Range and the Sierra Nevada, which are separated by the Great Valley of California.

The Sierra system forms a part of the great cordillera that runs along the west coast of both Americas. In the northern part of California, at Feather River gap, there is a break in this system, but though the ranges to the south are known as the Sierra Nevada and those to the north are termed the Cascades both are really merely different parts of the same great system.

Northwest of the Pit River region and west of Mount Shasta there is a broken, mountainous country in which the Coast Range and the main cordillera merge; at the extreme south end of the Great Valley there is another similar junction, southeast of which there is a series of broken ranges that gradually merge into the northern part of the Sierra Madre.

From Klamath River near the Oregon boundary southward to the vicinity of Santa Barbara the Coast Range is unbroken except in the vicinity of San Francisco Bay, where the combined drainage of the two great river systems of California reaches the ocean.

DRAINAGE SYSTEMS.

A large part of California is drained by Sacramento and San Joaquin rivers. These two streams unite near the head of San Francisco Bay, into which the Sacramento carries the drainage from the part of the valley to the north and the San Joaquin the drainage from the part to the south. Most of the larger tributaries of the Sacramento and all the larger tributaries of the San Joaquin flow down from the Sierra and drain the country west of the crest of the main range. The eastern slope of the Coast Range is, in general, more arid than the western slope of the Sierra, the streams on it shorter, and the elevations of the range are below those at which snowfall is heavy. Approximately the southern third of the San Joaquin Valley is cut off from the main drainage system by the delta of Kings River. The basin south of that delta, though it forms part of the main valley, discharges its run-off not into the San Joaquin drainage system but into Tulare Lake, a shallow body of fresh water, and into a similar lake—Buena Vista reservoir—in a subbasin formed by the delta of Kern River in the extreme lower end of the valley. When Kings River is in flood it discharges part of its water into the San Joaquin and part into Tulare Lake.

The country along the northern boundery of the State, west and northwest of Mount Shasta, is drained by Klamath River, which in California flows nearly due west into the ocean. South of the Klamath are its tributary Trinity River, which also drains the west side of the Coast Range, and Eel and Russian rivers, which lie between Trinity River and San Francisco Bay. Both Eel and Russian rivers flow through long, narrow valleys within and parallel to the general course of the Coast Range. South of San Francisco Bay is Salinas River, which, like the two streams just mentioned, flows through a long, narrow valley in the Coast Range and discharges into Monterey Bay; and south of the Salinas is the Santa Maria, a similar stream. Most of the streams down the coast beyond the Santa Maria are short and relatively small, except Santa Ana River and its tributaries, which drain the long valley west of Mount San Bernardino, and the southern scarp of the San Bernardino Range.

The drainage from the east slope of the Sierra as far south as Mohave Desert passes into the numerous alkaline lakes and so-called "sinks" of western Nevada and southeastern California. This eastern slope, though it is drier than the western slope, has at many places extremely heavy stream gradients, which give to its small streams a value for power that they would not otherwise possess. The small quantity of water that flows from the desert east of the broken ranges in San Bernardino, Riverside, and Imperial counties is lost by percolation and evaporation or finds its way into the lower course of the great Colorado River.

TOPOGRAPHIC DATA AVAILABLE.

Topographic maps of a large part of California have been published by the United States Geological Survey.[2] Most of these maps are on the scale of 1 to 125,000, or very nearly one-half inch to the mile, and bear contours representing intervals of height of 100 feet, but many are on the scale of 1 to 62,500, or very nearly 1 inch to the mile, and are contoured at 50-foot intervals, and certain sheets covering part of the Sacramento Valley, and therefore not of great interest hydroelectrically, are on a scale of 1 to 31,680, or about 2 inches to the mile. Some of the early maps were reconnaissance sheets published on the scale of 1 to 250,000, or about one-fourth inch to the mile, with contour intervals of 200 feet.

Several relief maps of California and the neighboring territory have been made. A large model, which gives a good idea of the general features of the region, is now in the exhibit of the California Development Board in the Ferry Building, San Francisco. The best detailed relief map of California is one made by Mr. N. F. Drake and now in the museum of the department of geology at Stanford University. It is from this map that Plate I of this report was prepared. Certain extensions have been made in railway lines since the map was constructed, but these changes do not, of course, affect the value of the map for topographic study; it is to-day the most accurate and thorough map of its kind.

GEOLOGY.

ROCKS OF THE SIERRA.

The geologic structure of the region has given rise to a topography that has confined all the largest water-power developments to the

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[2] An index map showing areas covered may be obtained by applying to the Director, U. S. Geological Survey, Washington, D. C.

east and west sides of the Cascade Range and the Sierra Nevada and its southward extension. These are the only ranges in which the river systems are long enough to afford any considerable area for drainage basins and in which the elevations are sufficiently high to insure the heavy snowfall that hitherto, with inadequate artificial storage, has been depended upon to maintain stream flow during the dry season. In the Coast Ranges, although the rainfall is at many places very heavy, the drainage basins are in general small or are at low altitudes. Up to the present time only three comparatively unimportant hydroelectric systems have been developed in these ranges. It is therefore only the geology of the Sierra Nevada that is of immediate concern in the discussion of hydroelectric development.

By far the greater part of the Sierra region is made up of igneous rocks. Only in the lower drainage basins, from the central part of the State southward, and in one or two unutilized basins in the north are there any considerable areas of sedimentary rocks. Much of the region from the Oregon boundary southward to the Feather River basin is covered with lava and basalt. In areas farther south the rocks of the upper slopes are nearly all granitic, but they include here and there isolated dikes or patches of lava. On the lower slopes of the range large areas of andesites are interspersed with smaller areas of shales and slates. Many of the streams used by power plants drain areas composed almost wholly of granitic rocks, though the conduits of the plants lie largely in andesites and shales, for the rivers have cut more rapidly through these than through the harder materials. The rocks of probably fully two-thirds of the total drainage area of the streams above the intakes for the power plants are granitic and those of the other third are divided between andesites and slates, the andesites predominating. It should be understood, however, that this is only a rough estimate, for the studies of the areal geology of the region do not yet afford a basis for more accurate determinations.

RELATION OF GEOLOGY TO RUN-OFF.

The effect of geologic structure on both the quantity and the rate of stream run-off is very marked and is due directly to the permeability or lack of permeability of the geologic formations—that is, it depends largely upon the character of the formations, which are granitic, volcanic, and sedimentary. Indirectly, it is due to the manner in which different formations have determined the present topographic form of the region, both the gradients of the streams and the general slopes of the drainage basins.

The most marked differences appear between the flow of streams that drain granitic and those that drain volcanic formations. In the region north of the Feather River country, that is, in the Cascade Range, where most of the rocks are basalts and other lavas, stream discharge has a regularity that is entirely lacking in the areas of granitic rocks to the south. Few of the scattered areas of lava found for some distance south of the Feather River basin are large enough to have a marked regulative effect on stream flow. Many of the northern streams receive above a certain level almost no return water from springs during the dry season, even where the formation is entirely of lava, though springs may be numerous below this level. This condition is due to the fact that the waters about the volcanic summits follow the lava-covered rock surface that controlled the distribution of the lava flows and do not appear as springs until they reach the lower end of the flows unless they are brought to the surface by faults that cut the lavas. It can not therefore be stated as a universal fact that all the stretches of a river in a volcanic country are equally benefited by such features.

A large part of the areas at the head of the streams from Feather River southward consists of nearly bare granitic rocks, from which the rate of run-off is extremely high. In the spring the flow begins almost with the first melting of the snow, and in the summer any rain falling on the surface passes immediately into the stream beds to flow away toward the lower stretches. Only a very small proportion of the rainfall sinks into the ground. The stream flow is especially "flashy" in some of the secondary and tertiary tributaries of the rivers in the southern part of the Sierra Nevada, where the proportion of bare rock is even greater than usual and where the stream gradients are much steeper than in the main river channels. These small drainage basins, though they give a large total annual run-off, are almost wholly useless for power development without storage.

Stream gradients are thus largely determined by geology. For the purpose of comparison the gradients of the streams largely utilized for power, as well as those of the principal streams remaining unutilized, are given in Table 2.

TABLE 2.—*Rate of fall of typical streams in California in feet per mile between 500-foot contours.*

Stream.	Rate of fall between contours.														
	1,000 to 1,500	1,500 to 2,000	2,000 to 2,500	2,500 to 3,000	3,000 to 3,500	3,500 to 4,000	4,000 to 4,500	4,500 to 5,000	5,000 to 5,500	5,500 to 6,000	6,000 to 6,500	6,500 to 7,000	7,000 to 7,500	7,500 to 8,000	8,000 to 8,500
Pit River [a]	27	78	39	24	19	72									
North Fork of Feather River [b]	57	46	53	96	179	62									
Middle Fork of Feather River [a] [b] [c]	114	63	74	73	83	94	22								
North Fork of Yuba River [b]	74	46	50	68	86	178	132								
Middle Fork of Yuba River [b]	74	88	96	89	139	139	250	357	208	104					
South Fork of Yuba River [b]	100	89	51	85	208	625	250	116	208	100	104	109			
North Fork of American River [b]	45	74	38	78	98	192	333	385	250	200					
Middle Fork of American River [a] [b] [d]	83	111	178	208	227	218	208	227	88	119					
South Fork of American River [a] [b] [e]	81	55	119	125	77	128	218	294	156	147					
Mokelumne River [b]	114	167	96	68	78	96	132	147	208	218	192	139	156	125	
North Fork of Stanislaus River [b]	96	250	333	357	208	132	139	104	125	357	227				
Middle Fork of Stanislaus River [b]		94	147	143	81	162	147	227	111	104	125	835	1,670	96	
Tuolumne River [a] [b] [c]	43	119	104	98	56	50	109	185	166						
Main San Joaquin River [a] [b] [f]	39	200	102	88	48	161	250	238	178	156	88				
North Fork of San Joaquin River [b]		250	172	106	74										
Big Creek of San Joaquin River [b]				417	333	500	500	715	2,500	835	835	86	417		
Kings River and Middle Fork [b]		147	132	227	500	357	192	200	357	122	125	835	625	357	178
South Fork of Kings River [b]				227	192	278	172	74	156	625	551	186	178	333	500
Kaweah River and Middle Fork [b]	122	250	250	333	313	333	385	357	313						
East Fork of Kaweah River [b]		333	294	294	313	313	313	500	557	357	625	625	625		
Tule River [b]	162	333	200	625	455	238	278								
Kern River [b]				38	67	58	51	119	88	91	71	70	156	167	294
Santa Ana River [b]			208	208	313	357	250	227	227	218	178	218			
Bishop Creek [b]								192	385	500	385	278	417	500	208
Truckee River [b] [g]								36	42	32	[g] 56				

[a] Data taken from river profiles found in reports of State Water Commission, 1912 and 1914.
[b] Data obtained by scaling distances on topographic sheets.
[c] Data taken from river profile up to 3,500-foot contour.
[d] Data taken from river profile up to 5,000-foot contour.
[e] Data taken from river profile up to 2,000-foot contour.
[f] Data taken from river profile up to 5,500-foot contour.
[g] 6,000 to Lake Tahoe at 6,225.

GEOLOGIC DATA AVAILABLE.

The United States Geological Survey is gradually extending its study of the areal and structural geology along the Sierra, but this work has not proceeded so rapidly as its topographic mapping.[3] The Survey has also published a general stratigraphic map of North America,[4] which shows approximately the stratigraphy of California.

A map showing the areal geology of California, on the scale of 12 miles to the inch, was published by the State Mining Bureau in 1916. The geology on this map was worked out by Prof. James Perrin Smith, whose comprehensive knowledge, gained by many years of field work in California, makes the map especially valuable. A similar map has been published as Plate II of Water-Supply Paper 338, "Springs of California," by Gerald A. Waring.

CLIMATE.

CAUSES OF CLIMATIC CONDITIONS.

The controlling factors on the climate of California are summed up as follows[5] by Prof. A. G. McAdie, who was for many years in charge of the work of the Weather Bureau in San Francisco:

> 1. The movements of the great continental and oceanic pressure areas, the so-called permanent "highs" and "lows." Under this head we include also the most active factor in climatic development, namely, the movements of individual pressure areas, since there is now good ground for believing that the paths of these individual disturbances—large-sized whirls and counter whirls—are largely determined by the general relations of the permanent pressure areas.
> 2. The prevailing drift of the atmosphere in temperate latitudes from west to east.
> 3. The proximity of the Pacific Ocean, with a mean annual temperature near the coast line of about 13° C. (55° F.), a great natural conservator of heat, to which is chiefly due the moderate range of temperature along the coast from San Diego even to Tatoosh Island.
> 4. The exceedingly diversified topography of the country for a distance of 200 miles from the coast inland.

Of these four factors, the first is most intimately connected with the rainfall, as Prof. McAdie points out later in his article, where he states:

> Over the North Pacific Ocean in winter there exists an area of low barometer covering the region between the latitudes of 40° and 60° north and 130° west to 140° east longitude. An area of high pressure overlies the greater part of North America with a southwest extension to the Tropics and west to the one hundred and sixtieth meridian. We shall find that typical wet winters on the California coast occur when this

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[3] The areas for which detailed geology is published are shown on an index map of California, copies of which may be obtained by applying to the Director, U. S. Geological Survey, Washington, D. C. See also List of publications, U. S. Geol. Survey, finding list by States.

[4] Willis, Bailey, Index to the stratigraphy of North America, accompanied by a geologic map of North America, compiled by the United States Geological Survey in cooperation with the Geological Survey of Canada and the Instituto Geologico de Mexico, under the supervision of Bailey Willis and G. W. Stose: U. S. Geol. Survey Prof. Paper 71, Plate I, 1912.

[5] Climatology of California: U. S. Dept. Agr. Weather Bureau Bull. L, p. 7, 1903.

great North Pacific low extends well eastward, overlying the continent west of a line drawn from San Francisco to Calgary. At the same time the great continental high area apparently recedes to the southeast. On the other hand, the pressure distribution characteristic of a dry winter on the California coast is marked by the prevalence of the continental high over the entire country west of the Rocky Mountains.

To the second and third factors the State owes its very moderate climate, and to the fourth are traceable some of the local peculiarities in climate that can be explained in no other way.

TEMPERATURE.

The climate of the coast is in general equable and moderate, and from the vicinity of Santa Barbara southward to the Mexican line may be classed as very mild.

The Coast Range as a whole is not high enough to get very cold weather except at its northern extremity, east of Eureka, and even there very low temperatures are unusual and much of the precipitation is in the form of rain instead of snow. At Weaverville, a typical station for the region, the temperature ranges from 7° to 100° (F.); at Eureka it ranges from 20° to 85°.

Although the Great Valley is large, there is little variation in maximum, minimum, and mean temperatures at stations on the valley floor. In summer the temperatures in the entire valley are very high, running up to 118°; in winter temperatures as low as 13° have been recorded.

The west slope of the Sierra, except at altitudes well above the highest hydroelectric plants, is not as a whole subject to very low temperatures. A minimum below −10° is probably reached at but few stations in the belt east of the Great Valley reaching up to 7,000 feet. The summer temperatures on this slope range from the extreme heat of the valley and foothills to more moderate temperatures near the crest, and in the highest country the nights are frosty.

The east side of the range is subject to greater variations in temperature than the west. The summers in the desert valleys at the foot of the range are often extremely hot and the winters are cold, temperatures as low as −30° being frequently recorded in the vicinity of Bodie and Bridgeport. Strange to say, thermometers exposed at the crest of Mount Lyell through two winters have not registered lower than −17.6°.

The variations in temperature throughout the State are greatly affected by differences in the local topography as well as by differences in altitude. Table 3 gives comparative maxima, minima, and mean temperatures at stations throughout the State selected with especial reference to the topographic divisions of the region. The red lines on Plate II show the location of isotherms as calculated by the United States Weather Bureau from long-term records.

TABLE 3.—*Temperature at selected stations in California.*

[The stations whose names are printed in small capitals appear on Plates III-XII.]

Station.	County.	Elevation.	Total length of record.	Length of record from which maximum and minimum have been taken.[a]	Temperature.		
					Maximum.	Minimum.	Mean.[b]
		Feet.	*Years.*	*Years.*	°*F.*	°*F.*	°*F.*
Alturas	Modoc	4,400	12	10	105	−30	....
Arrowhead Springs	San Bernardino	2,000	7	7	107	31	....
Auburn	Placer	1,360	45	39	110	12	60.5
BAKERSFIELD	Kern	404	27	19	118	13	65.1
BARSTOW	San Bernardino	2,105	13	13	114	12	64.2
Bishop Creek	Inyo	8,500	5	5	82	−13	....
Blocksburg	Humboldt	1,700	10	10	107	16	....
Blue Canon	Placer	4,695	17	17	98	7	50.2
Branscomb	Mendocino	2,000	16	13	104	18	53.1
Burney	Shasta	3,300	6	6	99	−15	....
Caliente	Kern	1,290	40	19	114	19	65.0
Camptonville (near)	Yuba	3,500	9	8	112	10	....
CEDARVILLE	Modoc	4,675	21	19	107	−15	48.2
Claremont	Los Angeles	1,200	24	19	112	19	61.2
COLFAX	Placer	2,421	44	19	110	8	58.8
CUYAMACA	San Diego	4,677	17	17	96	− 1	49.9
Deer Creek	Nevada	3,700	9	9	107	2	....
Delta	Shasta	1,138	30	18	114	15	59.4
De Sabla	Butte	2,500	12	10	106	9	....
Dobbins (near)	Yuba	1,650	12	12	113	9	....
Downieville	Sierra	3,150	5	5	104	1	....
Dudleys	Mariposa	3,000	7	7	97	0	....
Dunsmuir	Siskiyou	2,285	27	19	111	12	53.5
EUREKA	Humboldt	64	30	29	85	20	51.3
Fordyce dam	Nevada	6,500	21	9	92	−12	....
Gilta	Siskiyou	3,300	5	5	109	13	....
Glennville	Kern	3,300	6	6	98	9	....
Gold Run	Placer	3,222	17	11	106	14	57.5
Grass Valley	Nevada	2,690	7	7	102	11	....
Greenville	Plumas	3,600	20	17	105	−14	48.8
Groveland	Tuolumne	2,828	6	6	102	9	....
Hearst	Mendocino	1,800	4	4	104	20	....
Hetch Hetchy	Tuolume	3,665	6	5	103	− 3	....
Hot Springs	Tulare	3,300	9	9	103	12	....
Hullville	Lake	2,250	9	9	109	5	....
INDEPENDENCE	Inyo	3,907	20	18	105	3	58.5
Inskip	Butte	4,975	9	9	96	6	....
Jamestown	Tuolumne	1,471	12	12	113	12	58.3
Lake Eleanor	Tuolumne	4,700	6	6	97	− 3	....
La Porte	Plumas	5,000	22	19	95	0	46.2
Lick Observatory	Santa Clara	4,209	27	27	94	11	52.1
Lone Pine	Inyo	3,728	11	11	105	2	....
LOS ANGELES	Los Angeles	293	39	39	108	28	60.3
McCloud	Siskiyou	3,410	6	5	99	0	....
Macdoel	Siskiyou	4,258	7	7	102	−15	....
Magalia	Butte	2,321	12	10	107	10	....
MAMMOTH TANK	Imperial	257	38	38	130	21	76.0
MERCED	Merced	173	42	19	116	16	63.2
Mill Creek	Amador	2,500	9	9	106	10	....
MOJAVE	Kern	2,751	37	17	115	10	63.6
Mokelumne Hill	Calaveras	1,550	23	17	106	18	58.0
Mono Ranch	Ventura	3,210	9	9	103	1	....
Montague	Siskiyou	2,450	28	16	108	−10	54.7
MONTEREY	Monterey	15	51	19	98	24	56.6
Mount Tamalpais	Marin	2,375	17	18	100	20	55.4
Nevada City	Nevada	2,580	24	19	104	4	53.6
North Bloomfield	Nevada	3,214	19	18	109	8	54.4
PASO ROBLES	San Luis Obispo	800	29	19	113	0	58.3
Placerville	Eldorado	1,875	27	19	114	10	55.2
QUINCY	Plumas	3,400	21	19	98	−14	48.8
RED BLUFF	Tehama	307	39	38	115	18	62.5
REDLANDS	San Bernardino	1,352	23	19	113	24	63.3
RENO	Washoe	4,532	27	4	98	−11	49.1
Rialto (near)	San Bernardino	2,250	10	....	110	22	....
SACRAMENTO	Sacramento	71	39	19	110	24	59.6
San Bernardino	San Bernardino	1,054	24	....	112	18	62.5
SAN DIEGO	San Diego	93	45	44	110	25	60.6

[a] Reckoned back from 1915, except for a few stations.

[b] Except those for a few stations, the means in the last column are figured by decades, beginning with first year of term given in the fourth column. No records for years subsequent to 1912 have been used in computing the means.

TABLE 3.—*Temperature at selected stations in California*—Continued.

Station.	County.	Elevation.	Total length of record.	Length of record from which maximum and minimum have been taken.	Temperature.		
					Maximum.	Minimum.	Mean.
		Feet.	*Years.*	*Years.*	*° F.*	*° F.*	*° F.*
SAN FRANCISCO	San Francisco	207	45	....	101	29	54.9
San Jacinto	Riverside	1,550	23	19	112	7	61.9
SANTA BARBARA	Santa Barbara	130	32	19	108	27	60.0
Seven Oaks	San Bernardino	5,000	6	5	90	7	....
Sierra Madre	Los Angeles	1,400	19	19	106	28	62.2
Sierraville	Sierra	5,000	6	6	97	−30	....
SISSON	Siskiyou	3,555	27	19	108	− 9	49.9
Sonora	Tuolumne	1,825	7	7	108	14	....
Springville	Tulare	4,000	9	9	104	7	....
Squirrel Inn	San Bernardino	5,280	6	6	92	5	....
Stanwood	Butte	2,140	12	12	114	10	....
Stirling City	Butte	3,525	12	10	103	5	....
Sulphur Banks	Lake	1,350	4	....	106	18	....
SUMMIT	Placer	7,017	43	19	90	− 8	42.1
Tamarack	Alpine	8,000	9	9	87	−29	....
Tejon Rancho[a]	Kern	1,500	12	12	106	22	62.4
Towle	Placer	3,704	30	14	102	5	53.8
Upper Lake	Lake	1,350	30	18	111	13	57.6
Warner Springs	San Diego	3,165	8	7	103	13	....
Weaverville	Trinity	2,162	4	4	105	7	....
Weitchpec	Humboldt	1,700	6	4	102	17	....
Yosemite	Mariposa	3,945	12	11	110	− 2	....

[a] Broken record.

WINDS.

The prevailing winds are so much affected by local conditions that they can be described only in a general way. The prevailing directions of the winds at certain points in the State are shown in Plate II by arrows. The general direction of the wind throughout the State is decidedly toward the east, or from the ocean toward the Sierra, but it naturally varies with the drift of storms, with the local topography, and with the season of the year. At certain times there are very cold and dry north winds, especially in the Great Valley and on the east side of the Sierra, but these have small effect on the development of water power, whose users are interested chiefly in the moisture-laden winds that drift in from the Pacific from October to the middle of April and, most frequently, during the height of the rainy season, from January 1 to March 15.

RAINFALL.

Though the rainfall on the west coast usually accompanies storms that drive in from the Pacific during the winter, not all parts of the State are equally favored. In the vicinity of Upper Mattole, in the northwestern part of the State, the mean seasonal rainfall for the 29 seasons from 1887–88 to 1916–17 was 82.25 inches; at Mammoth, in the desert region in the southeastern part of the State, the mean annual rainfall for 31 seasons from 1887–88 to 1918–19 amounted to only 2.18 inches. Even in certain small areas the rainfall is greatly affected by topographic peculiarities and by the general slope, the exposure, and the elevation. July, August, and September and in many years June and October are almost rainless.

As there are very few low-head developments, the power operators are concerned chiefly with the rainfall and snowfall in the Sierra and only indirectly with the rainfall in other parts of the State. A number of very interesting studies of the distribution of rainfall and of its variation with altitude have shown that during the winter the moisture-laden winds that drift in from the Pacific deposit a large part of their content of water on the west slope of the Coast Range, a smaller part in the Great Valley, and almost all of what remains on the west slope of the Sierra. In the Sierra there is, in general, a marked increase in rainfall with elevation up to a certain level, which varies with the slope of the country and with the latitude. Records from the few high-altitude rainfall stations seem to show that above this level rainfall decreases gradually up to the crest of the range and then very rapidly from the crest eastward. The decrease east of the crest is probably due to the abruptness of the east slope of the mountains; if that slope were as gradual as the west, the decrease in rainfall beyond the crest would probably also be more gradual.[6]

In order to represent the conditions clearly the writer, though he has not undertaken to deduce any general laws, selected several groups of rainfall stations along what may be called "rainfall cross-section lines," crossing the State in the prevailing direction of the storms. These stations are arranged in eight groups, as follows: (1) Eureka, Sisson, Cedarville; (2) Upper Mattole, Red Bluff, Quincy; (3) San Francisco, Sacramento, Westpoint, Colfax, Emigrant Gap, Summit, Truckee, Reno; (4) Monterey, Merced, Summerdale, Bodie, Bishop; (5) Paso Robles, Bakersfield, Milo, Kernville, Independence; (6) Santa Barbara, Mohave, Barstow; (7) Los Angeles, Redlands, Palm Springs; (8) San Diego, Campo, Cuyamaca, Mammoth Tank. The records for corresponding seasons for the stations in each group are arranged one under another in Plates III to XII. In these plates the station nearest the coast is placed at the top and the station farthest inland at the bottom. The charts show whether the station is in the Coast Range, in the interior valley, on the west slope or east slope of the Sierra, or in the desert region east and south of the Sierra. An idea of the cross section cut by each group of stations may be obtained from Plate II, which shows the location of the stations.

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[6] For a discussion of this subject see Lee, C. H., An intensive study of the water resources of a part of Owens Valley, Calif.: U. S. Geol. Survey Water-Supply Paper 294, pp. 27-30, 1912. See also Water-Supply Paper 446, pp. 87-90.

RELIEF MAP OF CALIFORNIA

SHOWING ISOTHERMS AND ISOHYETES

Scale

100 0 100 miles

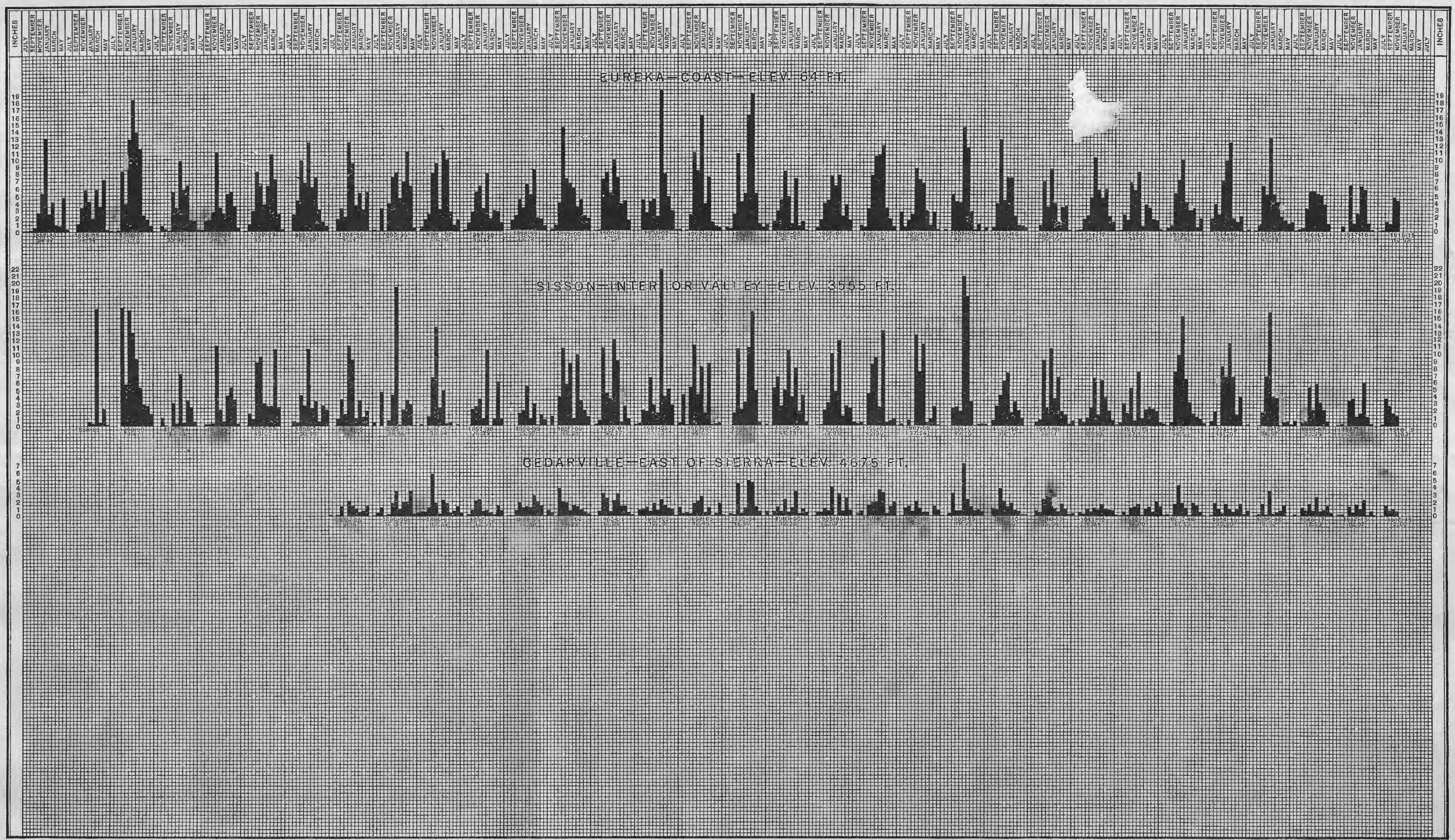


DIAGRAM SHOWING COMPARATIVE SEASONAL RAINFALL AT EUREKA, SISSON, AND CEDARVILLE.

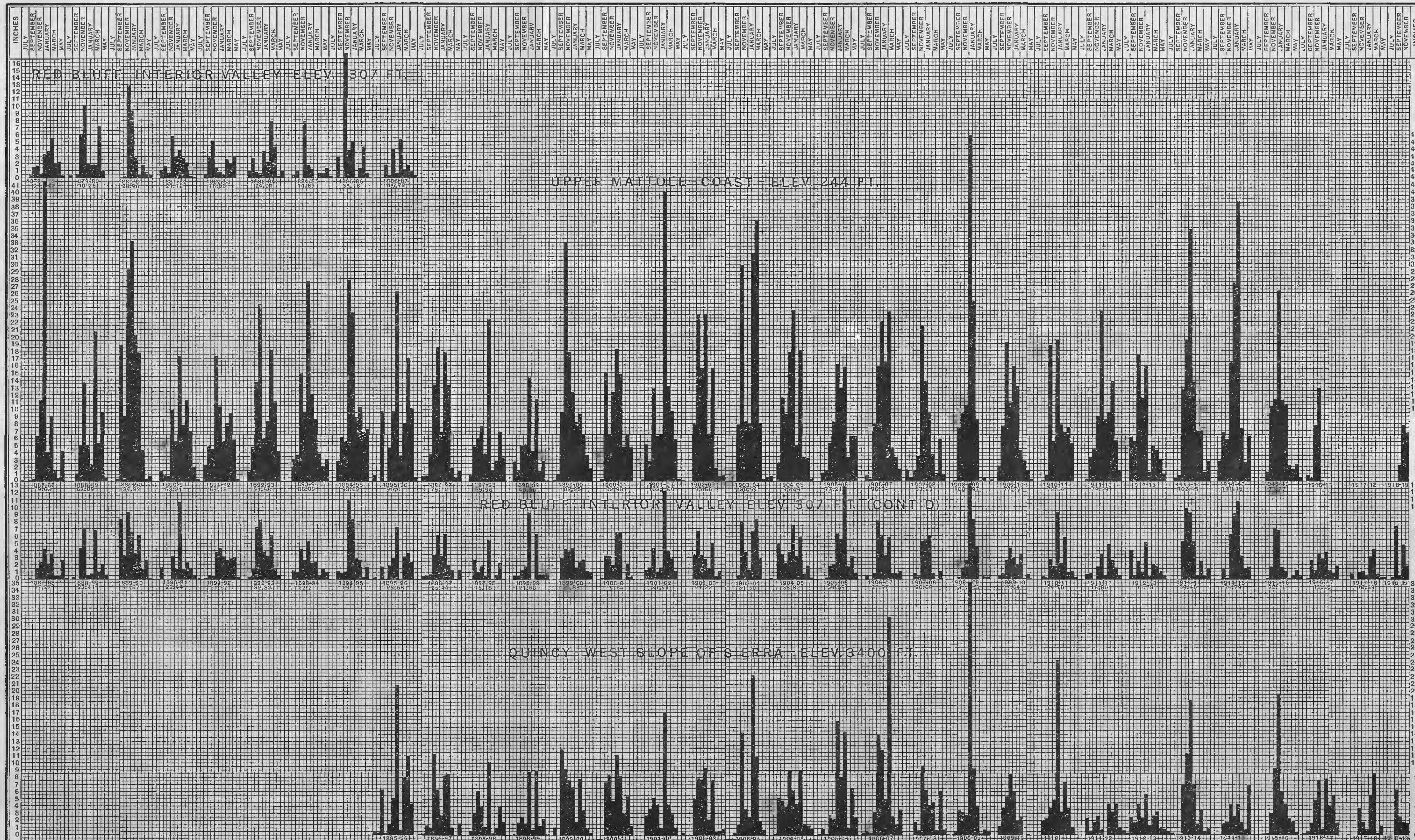
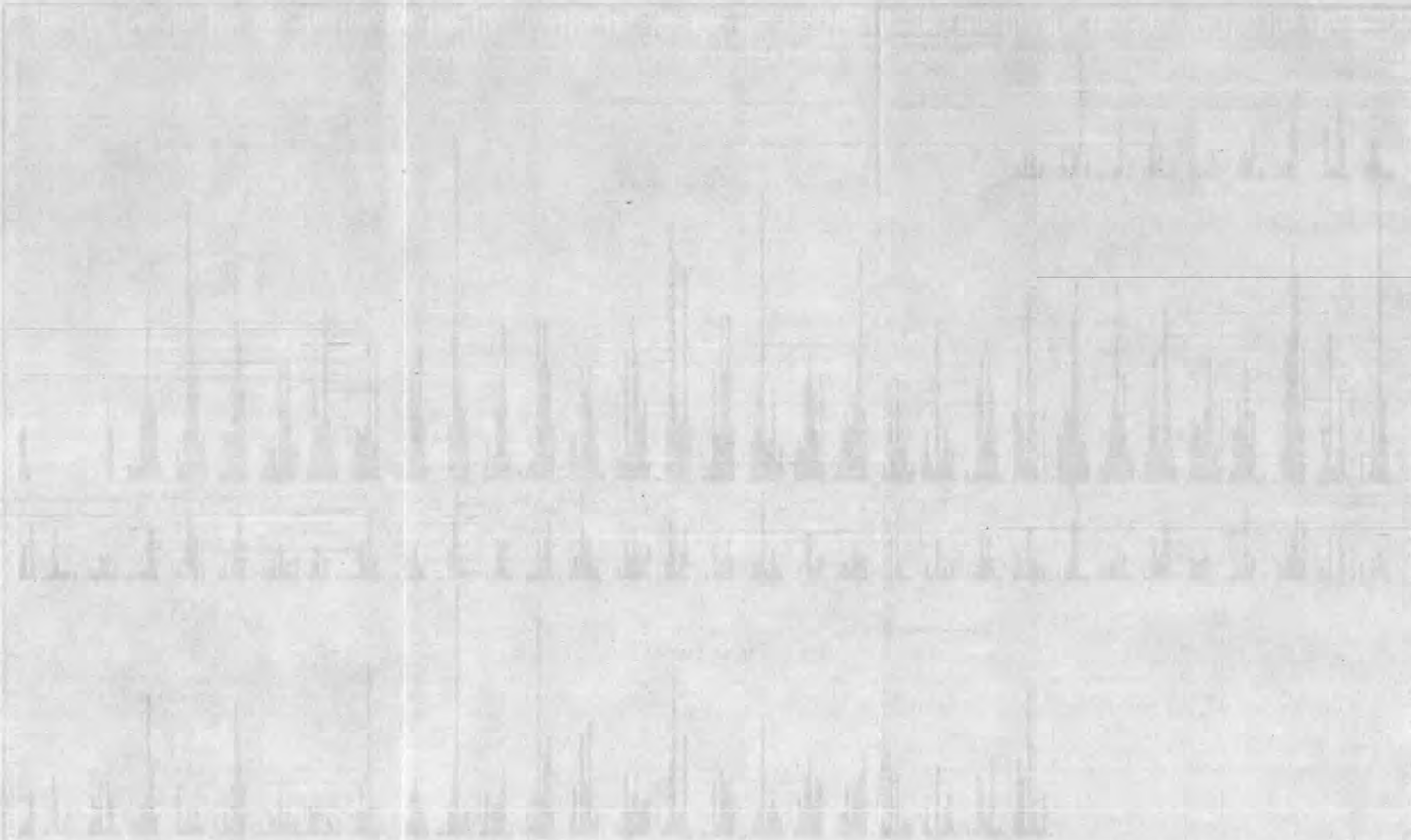


DIAGRAM SHOWING COMPARATIVE SEASONAL RAINFALL AT RED BLUFF, UPPER MATTOLE, AND QUINCY.



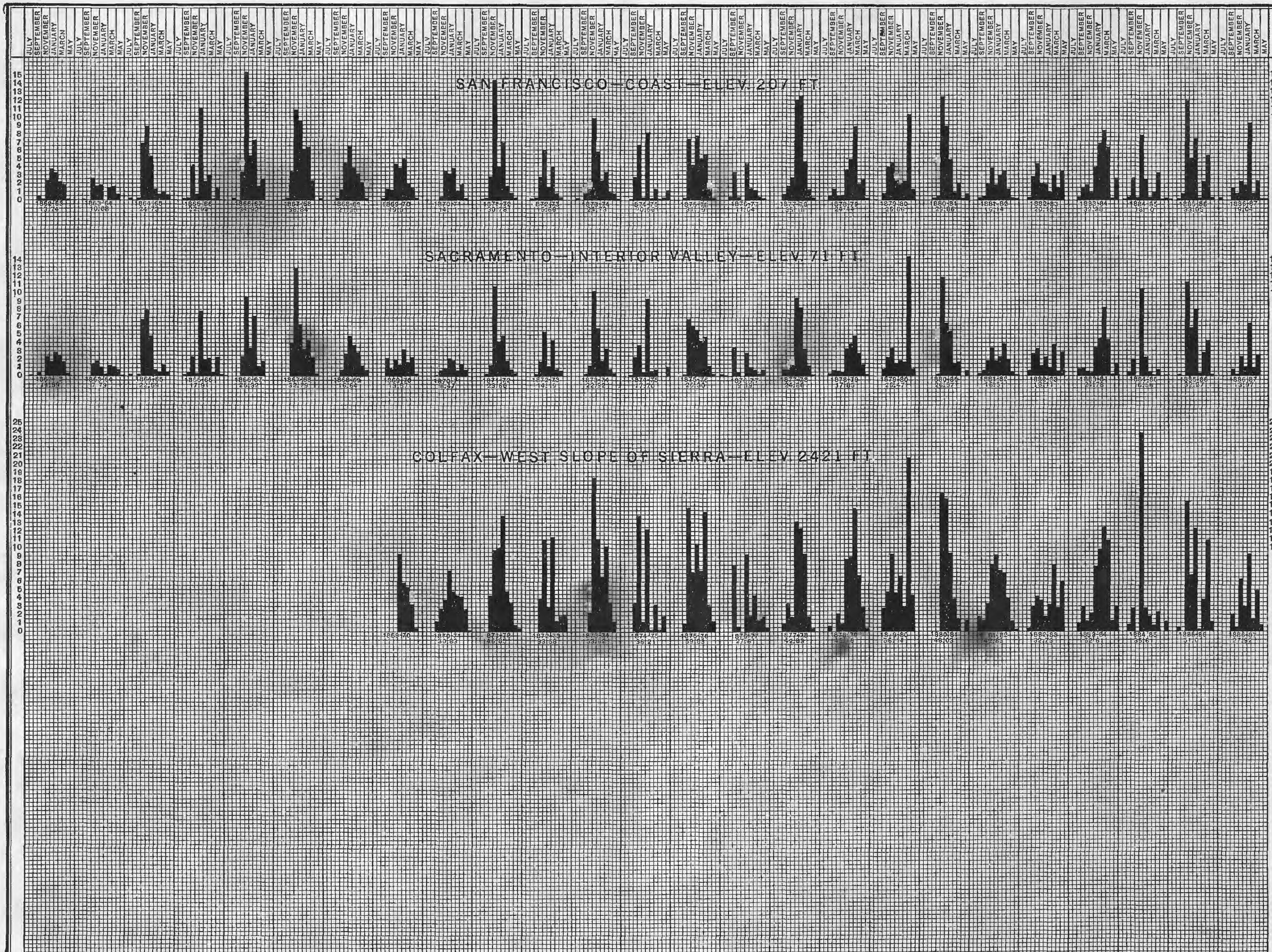


DIAGRAM SHOWING COMPARATIVE SEASONAL RAINFALL AT SAN FRANCISCO, SACRAMENTO, AND COLFAX.

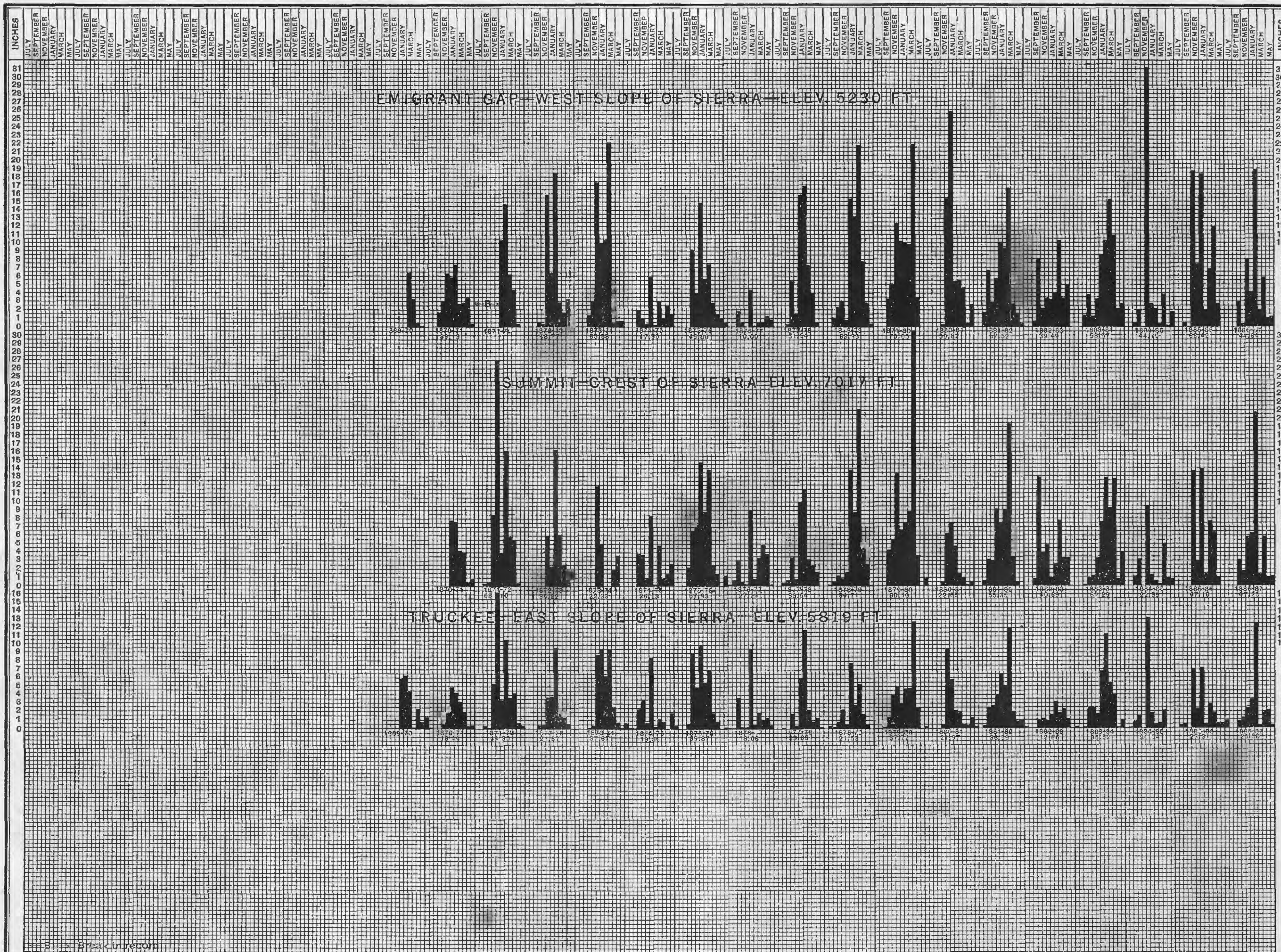
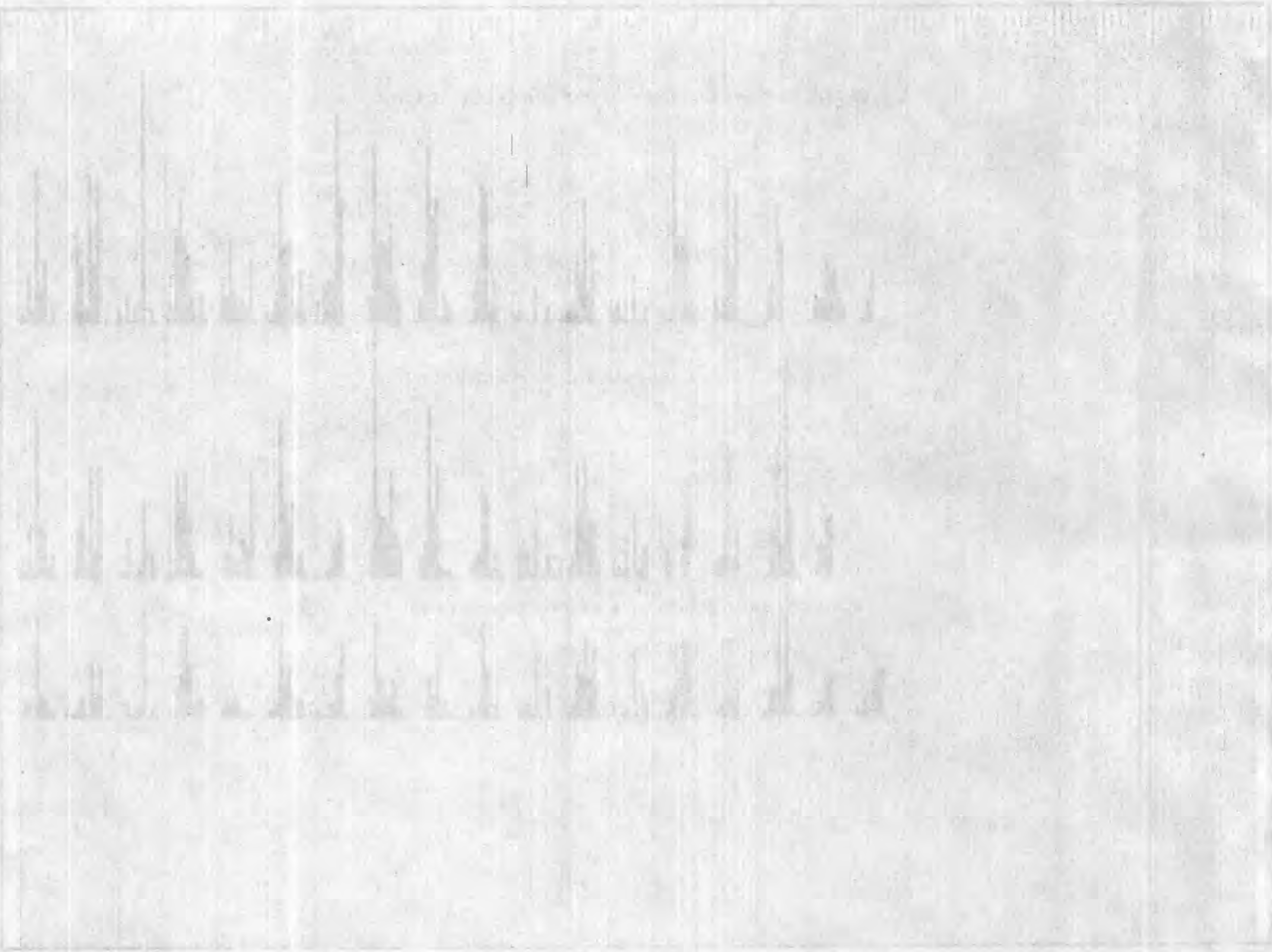


DIAGRAM SHOWING COMPARATIVE SEASONAL RAINFALL AT EMIGRANT GAP, SUMMIT, AND TRUCKEE.



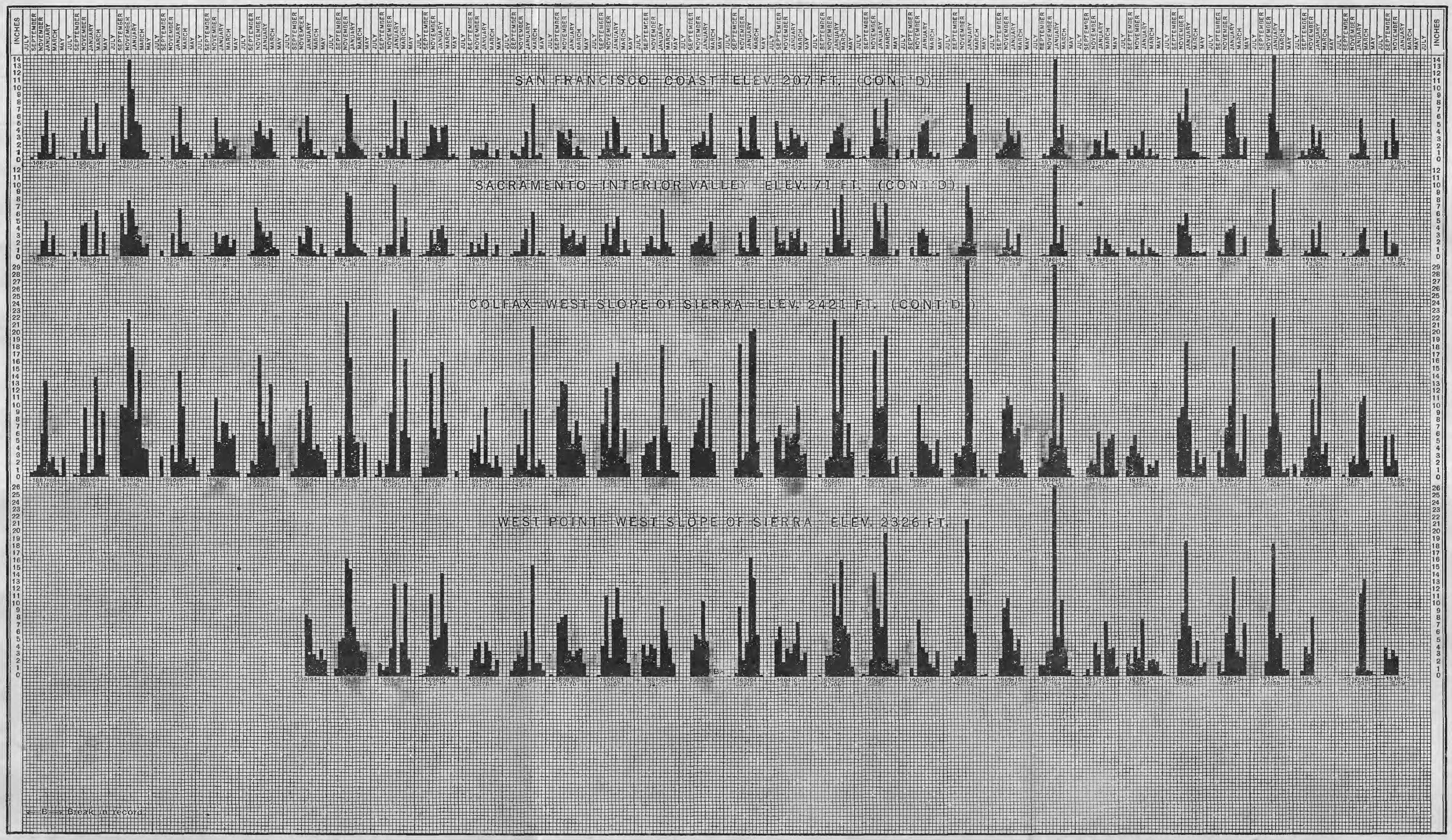


DIAGRAM SHOWING COMPARATIVE SEASONAL RAINFALL AT SAN FRANCISCO, SACRAMENTO, COLFAX, AND WEST POINT.

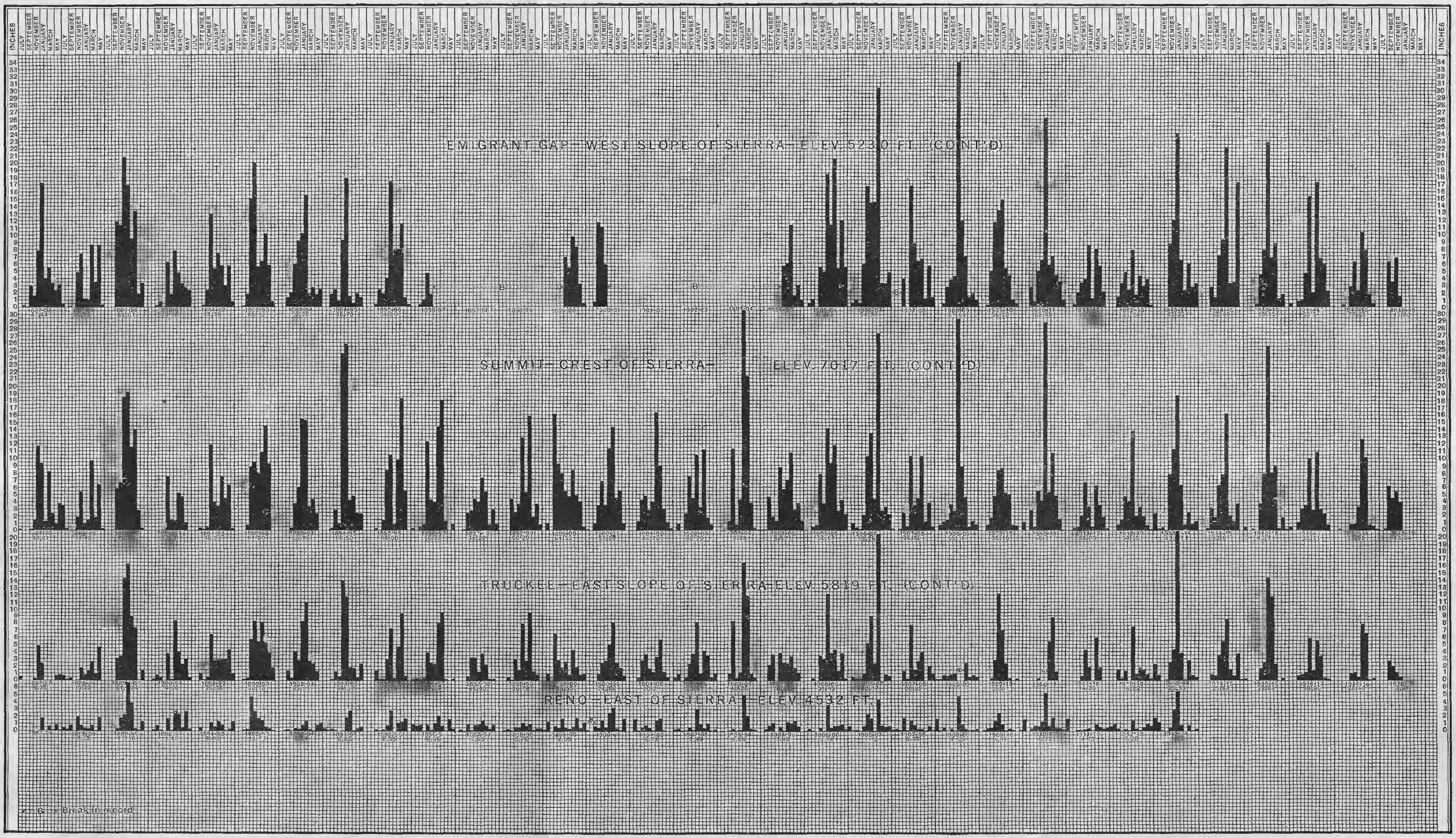
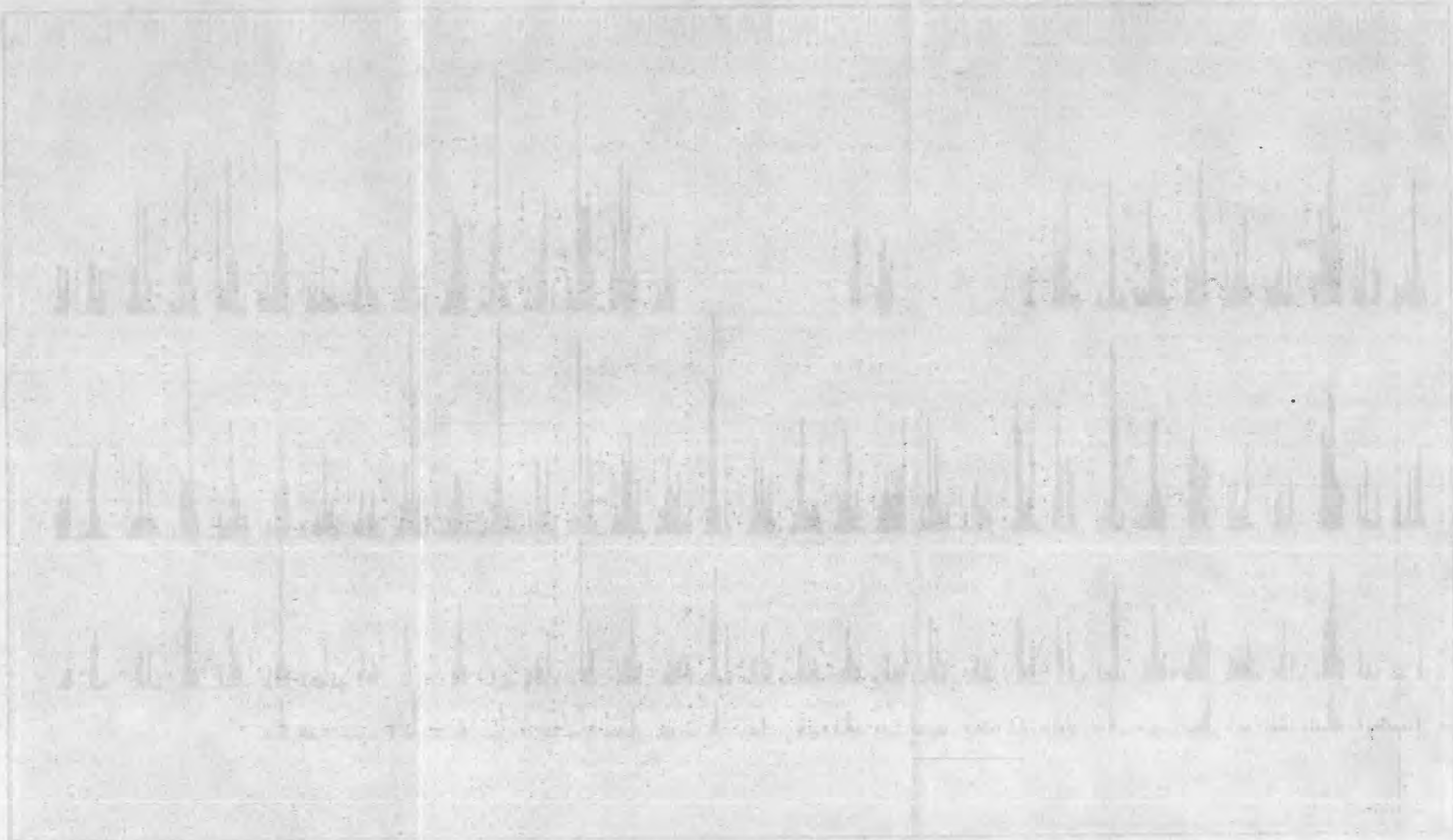


DIAGRAM SHOWING COMPARATIVE SEASONAL RAINFALL AT EMIGRANT GAP, SUMMIT, TRUCKEE, AND RENO.



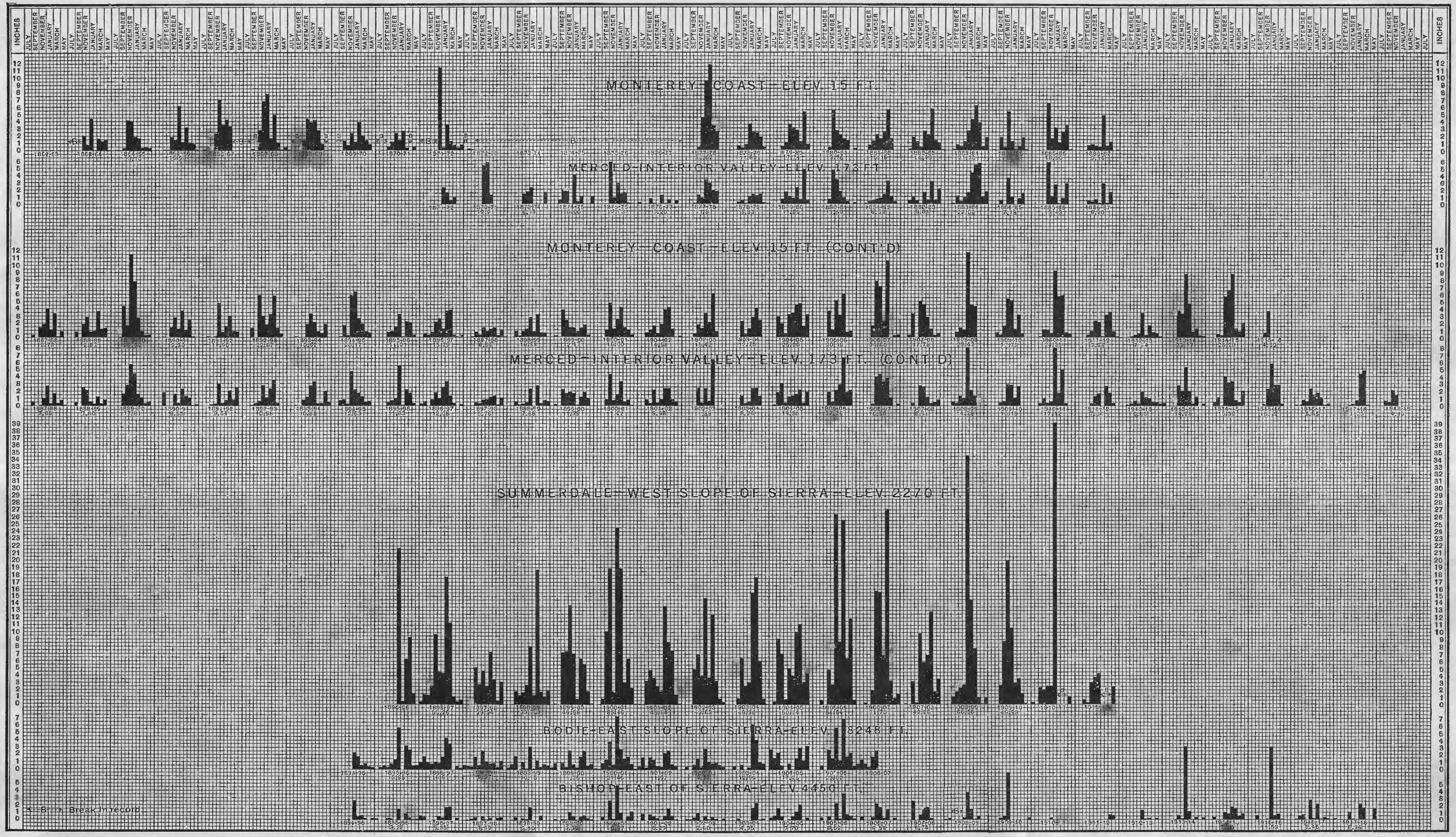


DIAGRAM SHOWING COMPARATIVE SEASONAL RAINFALL AT MONTEREY, MERCED, SUMMERDALE, BODIE, AND BISHOP.

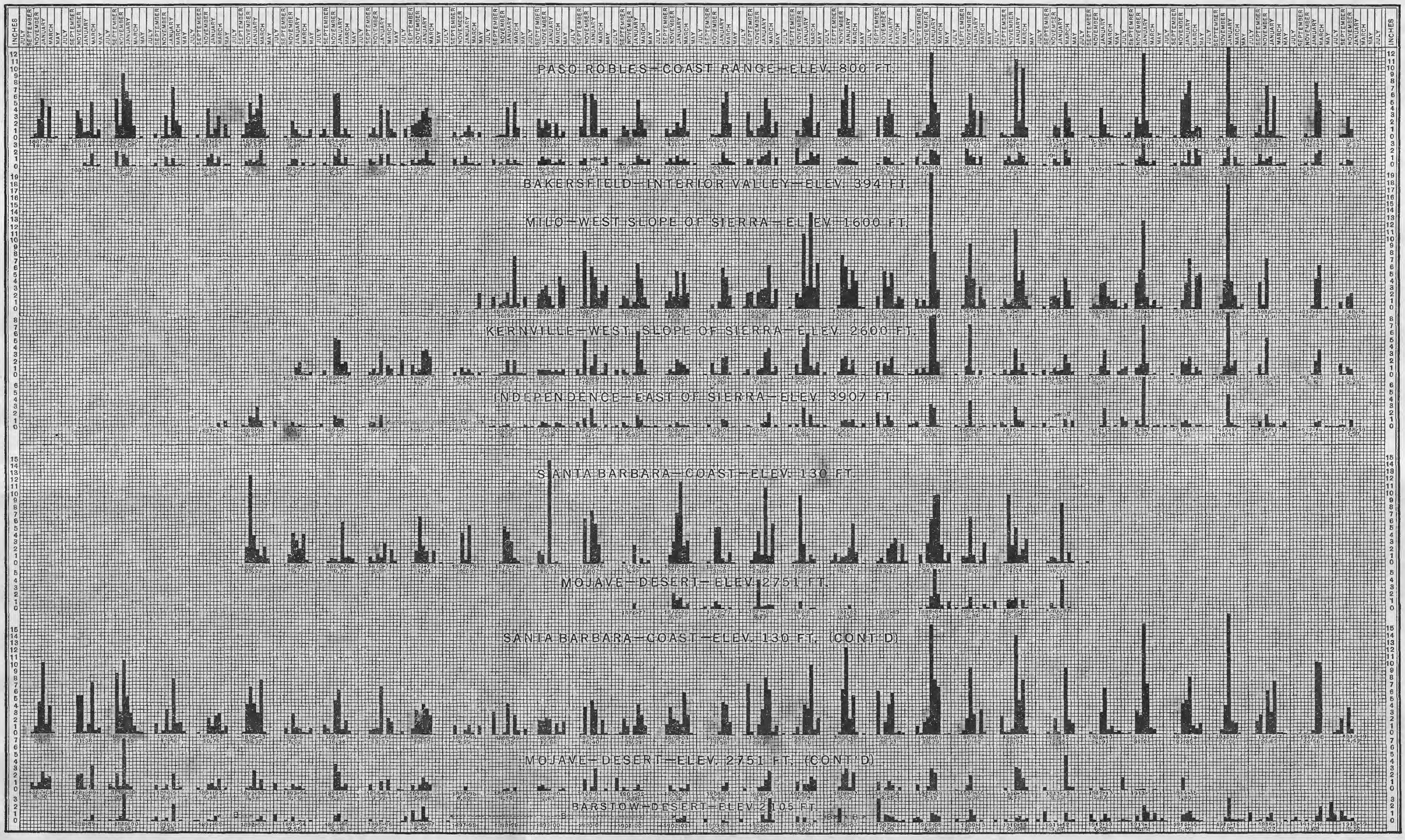


DIAGRAM SHOWING COMPARATIVE SEASONAL RAINFALL AT PASO ROBLES, BAKERSFIELD, MILO, KERNVILLE, INDEPENDENCE, SANTA BARBARA, MOJAVE, AND BARSTOW.

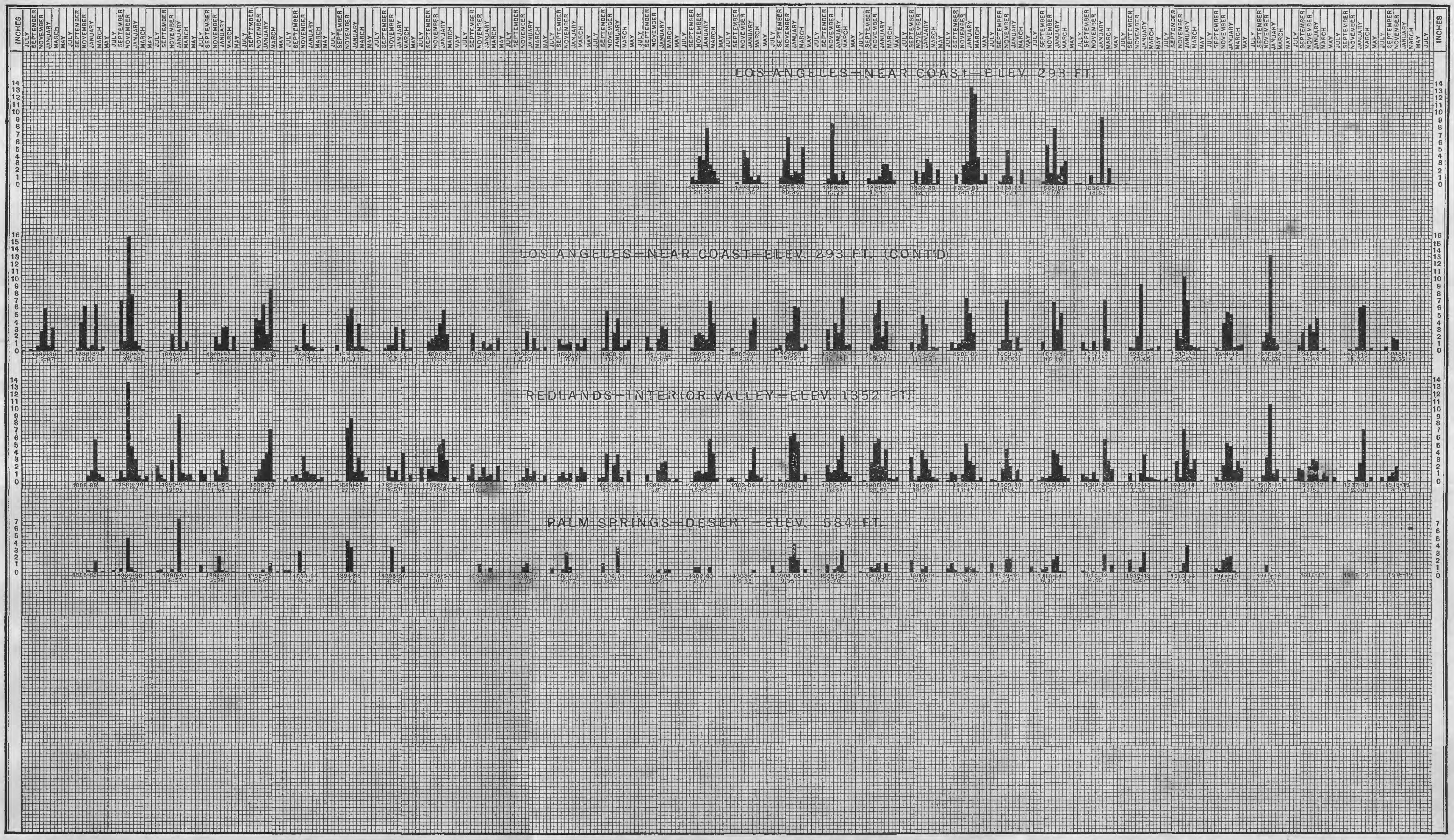


DIAGRAM SHOWING COMPARATIVE SEASONAL RAINFALL AT LOS ANGELES, REDLANDS, AND PALM SPRINGS.

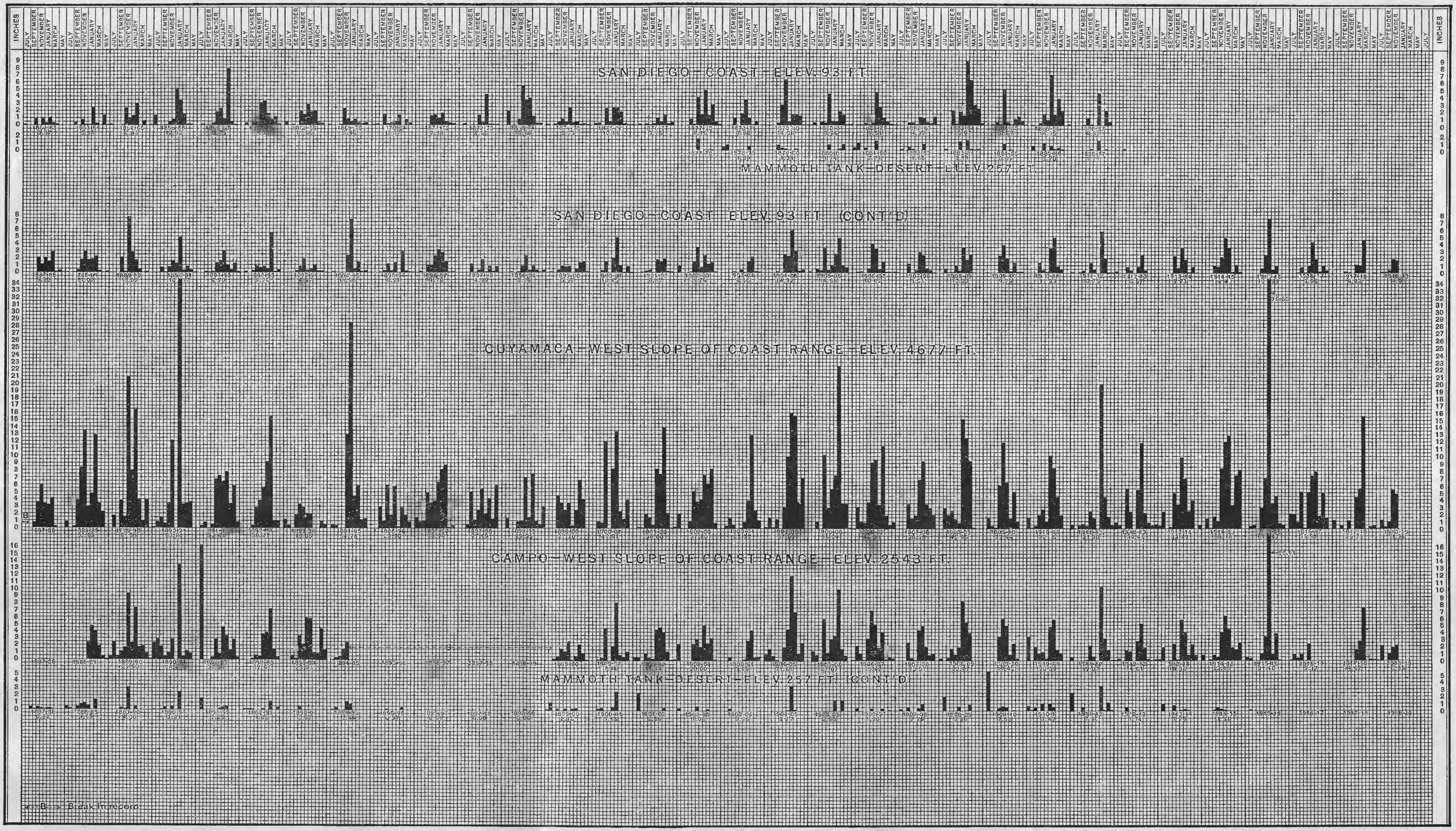


DIAGRAM SHOWING COMPARATIVE SEASONAL RAINFALL AT SAN DIEGO, MAMMOTH TANK, CUYAMACA, AND CAMPO.

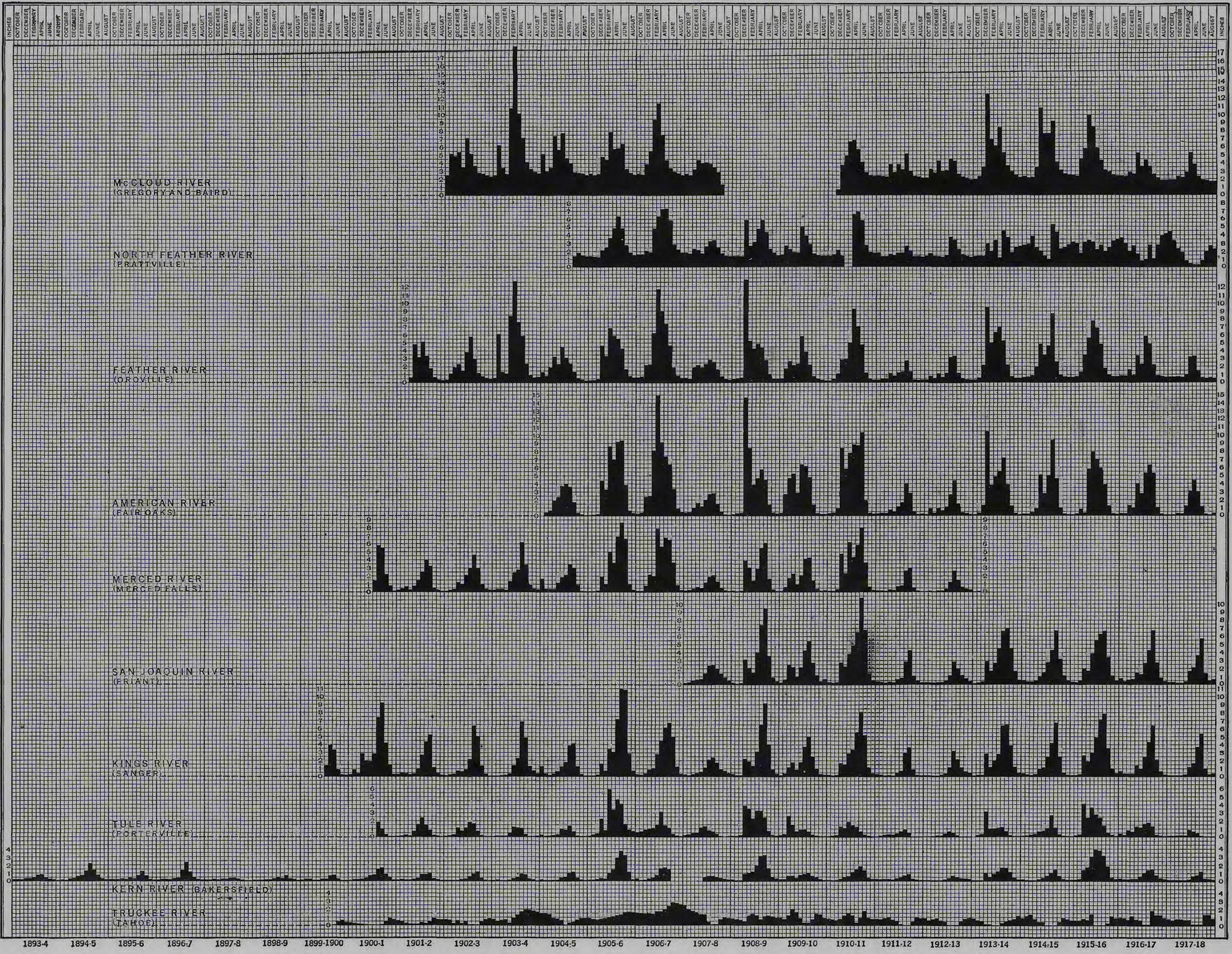


DIAGRAM SHOWING RUN-OFF (DEPTH IN INCHES) OF TYPICAL STREAMS OF CALIFORNIA.

SNOWFALL.

The precipitation classified in Plates III to XII includes snow as well as rainfall. The form in which the precipitation occurs is of great importance in water-power work. A large number of power plants in the Sierra are still without adequate artificial storage, and were it not for the regulative effect of snowfall in the higher mountains would be unable to operate through the low-flow seasons each year. It is therefore to the reports of quantity and distribution of snowfall each season that the power operator gives most anxious attention. Heavy snows early in the winter are most desirable, as these have time to pack during the months that elapse before the spring thaws begin and therefore do not go off so rapidly as the same quantity of snow falling late in the spring.

The most severe floods that have occurred in California have been caused by late snows followed by warm rains. When this condition occurs, as it did in the spring of 1907, the flood flow of a stream may far exceed that at ordinary high water, whereas the low flow, on which the power plants will have to operate during the succeeding dry, season may be no greater than usual.

EVAPORATION.

In certain regions in California, owing to the extreme dryness of the atmosphere and the intense heat, the loss of water by evaporation from the surfaces of reservoirs is very great. Most of these regions are in valleys at elevations lower than those that are available for power storage, so that the irrigator suffers greater losses by evaporation than the developer of power.

At Indio, in the Colorado Desert, the Weather Bureau recorded in one year an evaporation of 200.39 inches from a pan 2 feet in diameter set on a stand 10 feet above the ground. At a number of other stations in the same region the annual evaporation ranged from 150 to almost 200 inches.[7]

Unfortunately most of the reservoirs for power storage are at elevations so high or in places so inaccessible that no extended records of evaporation from their surfaces have been made. The evaporation data available for these reservoirs are therefore much more meager than those for stream flow or even those for rainfall in similar places. Some of the available records are fragmentary, covering only the summer season in certain years; others lack sufficient notes to give a clear idea of the location of the pan or the methods of observation.

A general study of evaporation from a pond on the North Fork of Feather River about 4,400 feet above sea level, in the vicinity of Big

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[7] A provisional statement regarding the total evaporation by months at 23 stations in the United States in 1909-10 is given in abstract of data No. 4 of the Climatological Division, U. S. Weather Bureau, Department of Agriculture.

Meadows, the most notable power reservoir site in the State, was made by Mr. John R. Freeman, who estimated the evaporation from the proposed reservoir at 30 inches a year.

Records taken at Lake Tahoe by the United States Weather Bureau during 1910 showed an annual evaporation of 42.21 inches from a 4-foot pan 2 feet above the lake surface, and 47.37 inches from a 3-foot pan 10 feet above the lake surface. Measurements were made only during the months of high evaporation—July to November, inclusive—the loss for the rest of the year, which is about 39 per cent of the total, being estimated.

Records of evaporation obtained by the San Joaquin Light & Power Corporation from pans floating on the surface of the Crane Valley reservoir, on the North Fork of San Joaquin River, at an elevation of 3,400 feet above sea level, indicate an annual loss of 36.76 inches from the surface of the lake, a loss which, in view of the topographic and climatic conditions, seems rather small.

A general study of the records indicates that the loss of water by evaporation from the surface of the California storage reservoirs used for power ranges from about 30 to 45 inches a year.[7a]

STREAM FLOW.

GENERAL CONDITIONS.

Discharge measurements have been made on California streams by the Federal Government, by the State, and by private parties for many years. Most of the gaging stations, however, have been maintained primarily to determine the total run-off available in the settled valleys in the lower parts of the drainage basins and not to determine the possible use of the streams for developing power. The stations at which the longest records are available are therefore those established near points at which the streams leave the mountains and enter the valleys, and most of them are at lower elevations than the principal power plants. The parts of the drainage basins that lie above the gaging points therefore usually include large areas of foothills, and the stream-flow data collected do not represent exactly quantities of water available for the operation of the power plants. They do, however, show the general conditions in the upper parts of the drainage basins. Within the last 10 years a number of stations that were required primarily for power gagings have been established at higher elevations, but the records at many of these stations are either broken or are too short to be of much service.

Table 4 gives a general idea of the flow of the principal power streams for which consecutive records are available. In drawing

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[7a] For fuller information concerning this subject see Grunsky, C. E., Figuring evaporation from temperature records: Jour. Electricity, vol. 46, pp. 23-26, 1921; Barre, H. A., Evaporation from reservoirs; Idem, pp. 489-490; Lee, C. H., Evaporation from the standpoint of the hydraulic engineer: Idem, pp. 490-491; Cummings, N. W., Evaporation from water surfaces: Idem, pp. 491-496.

general conclusions from this table the reader must carefully keep in view two points—first, that the records for several of the stations are short, and second, that the flow of several of the streams is more or less affected by the release or the holding back of stored water. The table probably gives, however, fairly accurate information as to average conditions throughout the periods covered.

Those who are familiar with the flow of streams in more humid regions will be greatly impressed by the extreme variations in the flow of streams in California, not only between different years, but between different seasons in the same year. These wide variations prevail throughout the West; the stream flow is characterized by very high floods in the spring and very marked drops late in the summer and early in the fall. The fluctuations in the mean monthly flow of a number of large rivers are shown in Plate XIII. On account of their value as power streams some of these rivers are included in Table 4; others are not included in the table, but are shown in the plate on account of their geographic position, so that, as the records show run-off in depth on the drainage areas, the graphic representation of the stream flow may be compared directly with the rainfall charts, Plates III to XII.

TABLE 4.—*Characteristics of flow of typical streams of California.*

Low flow.

Stream.	Gaging station at or near—	Elevation at gaging station in feet.	Drainage area above station in square miles.	Length of record utilized.[a]	Daily minimum flow.			Monthly minimum flow and run-off.					
					Date or period.	Second feet.	Second-feet per square mile.	Month.	Second-feet.	Second-feet per square mile.	Acre-feet.	Acre-feet per square mile.	Inches.
Pit River	Ydalpom	750	5,260	7 seasons (1911–1918)	July 12 to Sept. 11, 1918.	2,450	0.466	Aug., 1918	2,450	0.466	151,000	28.7	0.54
North Fork of Feather River.	Prattville	4,200	506	12 seasons (1905–1910 and 1911–1918.)	Sept. 2, 1913 [b]	465	.9	Sept., 1913	554	1.9	33,000	65.2	1.22
Feather River	Oroville	150	3,640	16 seasons (1902–1918)	Aug. 26–Sept. 1, 1912	820	.225	Aug., 1912	969	.266	59,600	16.4	.31
North Fork of Yuba River.	Goodyear Bar.	2,650	214	7 seasons (1911–1918)	Aug. 8–17, 24–31, and Sept. 1, 1918.	109	.509	Oct., 1913	116	.542	7,130	33.3	.62
Yuba River	Smartville	250	1,220	15 seasons (1903–1918)	Aug. 14, 15, 23–31, 1918.	165	.135	Aug., 1918	176	.144	10,800	8.85	.17
American River	Fairoaks	70	1,910	13 seasons (1905–1918)	Aug. 5, 10, 12–31, and Sept. 1–2, 1918.	65	.034	Aug., 1918	69.9	.037	4,300	2.25	.04
Mokelumne River	Clements	100	631	13 seasons (1905–1918)	Dec. 17 and 24, 1917	20	.032	Jan., 1918	51.5	.082	3,170	5.02	.09
Tuolumne River	LaGrange dam	360	1,500	23 seasons (1895–1918)	(c)			(c)					
San Joaquin River	Friant	450	1,640	10 seasons (1908–1918)	Oct., 1913 (12 days)	170	.104	Oct., 1913	2.08	.127	12,800	7.80	.15
Kings River	Sanger	350	1,740	23 seasons (1895–1918)	Jan. 21, 1904	130	.075	Dec., 1912	167	.096	10,300	5.92	.11
Kaweah River	Three Rivers	700	520	15 seasons (1903–1918)	Sept. 21, 22, 1912; Aug. 22, 1914.	30	.058	Sept., 1912.	37.1	.071	2,210	4.25	.08
Kern River	Kernville	2,550	[d] 1,027	13 seasons (1905–1918)	Jan. 6, 1913	142	.167	Sept., 1912	178	.173	10,600	10.3	.19
Santa Ana River	Mentone	2,150	[e] 189	15 seasons (1902–1915; 1916–1918.)	Nov. 21–22, 1909	3	.016	Nov. 1904	20	.110	1,190	6.54	.12
San Gabriel River	Azusa	750	222	23 seasons (1895–1918).	Oct., 1901; Jan. 14, 1912.	0	0	July, 1899	3.6	.016	221	.995	.02
Truckee River	Tahoe	6,225	519	18 seasons (1900–1918)	June, 1918.	0	0	May, 1901 [f].	0	0	0	0	0
Do	Iceland	5,100	[g] 995	19 seasons (1899–1918)	Sept. 24–26, and Dec. 1–3, 1900.	205	.215	Dec., 1899	295	.31	18,100	19.0	.36

[a] Year beginning Oct. 1 and ending Sept. 30.
[b] For period prior to completion of storage, after which low flow has been uncertain.
[c] Indeterminate.
[d] Records for station at Fairview beginning Oct. 1, 1912; drainage area, 848 square miles.
[e] 182 square miles at site used until Oct. 1, 1914; 189 square miles at site Oct. 1, 1914, to Sept. 30, 1918.
[f] River dry during part of 1900, 1901, 1914, and 1918, due to storage.
[g] 965 square miles at site used June 14, 1909, to Aug. 31, 1912.

Flood flow.

Stream.	Gaging station at or near—	Elevation at gaging station, in feet.	Drainage area above station, in square miles.	Length of record utilized.[a]	Daily maximum flow.			Monthly maximum flow and run-off.					
					Date or period.	Second-feet.	Second-feet per square mile.	Month.	Second-feet.	Second-feet per square mile.	Acre-feet.	Acre-feet per square mile.	Inches.
Pit River	Ydalpom	750	5,260	7 seasons (1911–1918)	Feb. 25, 1917	35,600	6.77	Jan., 1914	17,500	3.33	1,080,000	205	3.84
North Fork of Feather River	Prattville	4,200	506	12 seasons (1905–1910; 1911–1918).	Mar. 19, 1907	9,850	19.5	Apr., 1907	3,290	6.50	196,000	387	7.25
Feather River	Oroville	150	3,640	16 seasons (1902–1918)	Mar. 19, 1907	187,000	51.4	Jan., 1909	39,900	11.0	2,450,000	673	12.7
North Fork of Yuba River	Goodyear Bar.	2,650	214	7 seasons (1911–1918)	May 11, 1915	11,000	51.4	June, 1911	3,330	15.6	198,000	925	17.40
Yuba River	Smartville	250	1,220	15 seasons (1903–1918)	Jan. 15, 1909	111,000	91.0	Jan., 1909	23,000	18.9	1,410,000	1,160	21.79
American River	Fairoaks	70	1,910	13 seasons (1905–1918)	Mar. 19, 1907	105,000	55.0	Mar., 1907	24,700	12.9	1,520,000	796	14.87
Mokelumne River	Clements	100	631	13 seasons (1905–1918)	Jan. 30, 1911	16,700	26.5	June, 1906	6,020	9.54	358,000	567	10.64
Tuolumne River	La Grange dam	360	1,500	[b] 23 seasons (1895–1918)	Jan. 30, 1911	52,600	35.1	June, 1906	13,900	9.27	827,000	551	10.34
San Joaquin River	Friant	450	1,640	10 seasons (1908–1918)	Jan. 31, 1911	38,800	23.7	June, 1911	15,900	9.70	946,000	577	10.82
Kings River	Sanger	350	1,740	23 seasons (1895–1918)	Jan. 7, 1901	43,930	25.2	June, 1906	17,100	9.83	1,020,000	586	11.00
Kaweah River	Three Rivers	700	520	15 seasons (1903–1918).	Jan. 17, 1916	10,100	19.4	June, 1906	4,670	8.98	278,000	535	10.02
Kern River	Kernville	2,550	[c] 1,027	13 seasons (1905–1918)	Jan. 14, 1909	10,400	10.1	June, 1909	6,400	6.23	381,000	371	6.95
Santa Ana River	Mentone	2,150	[d] 189	15 seasons (1902–1915; 1916–1918).	Apr. 1, 1903	[e] 4,910	27.0	Mar., 1916	768	4.06	47,200	250	4.68
San Gabriel River	Azusa	750	222	23 seasons (1895–1918)	Jan. 18, 1916	22,300	100.0	Jan., 1916	2,410	10.9	148,000	667	12.57
Truckee River	Tahoe	6,225	519	18 seasons (1900–1918)	July 13–20, 1907	1,340	2.58	July, 1907	1,300	2.50	79,900	154	2.88
Do	Iceland	5,100	[f] 955	19 seasons (1899–1918)	Mar. 18, 1907	15,300	16.0	June, 1911	4,170	4.32	248,000	257	4.82

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[a] Year beginning Oct. 1 and ending Sept. 30.

[b] Total run-off estimated for the following periods for which no records are available: Oct. 1–21, 1912, 2,320 acre-feet; Sept. 15–30, 1913, 20,600 acre-feet. See U. S. Geological Survey Water-Supply Paper 361, p. 204.

[c] Records for station at Fairview beginning Oct. 1, 1912; drainage area, 848 square miles.

[d] 182 square miles at site used until Oct. 1, 1914; 189 square miles at site used Oct. 1, 1914, to Sept. 30, 1918.

[e] Highest actually recorded—rough estimates for Jan. 18, 1916, give 15,000 second-feet.

[f] 965 square miles at site used June 14, 1909, to Aug. 31, 1912.

TABLE 4.—*Characteristics of flow of typical streams of California*—Continued.

Flood flow—Continued.

Stream.	Mean annual flow and run-off during period.					Maximum annual flow and run-off.						Minimum annual flow and run-off.					
	Second feet.	Second-feet per square mile.	Acre-feet.	Acre-feet per square mile.	Inches.	Year.[a]	Second-feet.	Second-feet per square mile.	Acre-feet.	Acre-feet per square mile.	Inches.	Year.[a]	Second-feet.	Second-feet per square mile.	Acre-feet.	Acre-feet per square mile.	Inches.
Pit River	4,830	0.918	3,500,000	665	12.46	1914	6,450	1.23	4,670,000	888	16.70	1918	3,660	0.696	2,650,000	504	9.45
North Fork of Feather River	1,110	2.19	807,000	1,590	29.73	1907	1,700	3.36	1,230,000	2,430	45.47	1912	727	1.44	527,000	1,040	19.54
Feather River	7,710	2.12	5,580,000	1,530	28.78	1907	13,000	3.56	9,340,000	2,570	48.07	1912	2,880	.791	2,090,000	574	10.74
North Fork of Yuba River	663	3.10	480,000	2,240	42.08	1914	1,040	4.86	753,000	3,520	66.05	1912	388	1.81	281,000	1,310	24.64
Yuba River	3,760	3.08	2,720,000	2,230	41.81	1907	6,220	5.10	4,560,000	3,740	68.58	1912	1,560	1.28	1,130,000	926	17.42
American River	4,610	2.41	3,330,000	1,740	32.71	1907	7,930	4.15	5,710,000	2,990	56.02	1912	1,740	.911	1,260,000	660	12.40
Mokelumne River	1,300	2.06	940,000	1,490	27.96	1907	2,314	3.67	1,670,000	2,650	49.68	1912	541	.857	393,000	623	11.67
Tuolumne River	2,880	1.92	2,090,000	1,390	26.06	1907	5,180	3.45	3,760,000	2,510	46.96	1898	1,330	.887	960,000	640	11.86
San Joaquin River	2,960	1.80	2,143,800	1,310	24.43	1911	4,920	3.00	3,560,000	2,170	40.73	1913	1,200	.732	868,000	529	9.91
Kings River	2,670	1.53	1,940,000	1,110	20.77	1906	5,300	3.05	3,860,000	2,220	41.61	1898	1,220	.70	881,000	506	9.29
Kaweah River	652	1.25	473,000	910	16.97	1906	1,497	2.88	1,090,000	2,100	39.25	1912	285	.548	207,000	398	7.46
Kern River	1,000	....	725,000	....	....	1909	1,960	1.91	1,420,000	1,380	25.93	1913	423	.499	306,000	361	6.74
Santa Ana River	106	.579	75,900	415	7.86	[b] 1907	226	1.24	163,000	896	16.82	1904	42.2	.232	30,600	168	3.14
San Gabriel River	174	.784	126,000	568	10.64	1907	485	2.18	350,000	1,580	29.54	1899	13.5	.061	9,630	43.4	.83
Truckee River	371	.715	269,000	518	9.71	1907	906	1.74	657,000	1,270	23.72	1901	133	.256	96,700	186	3.50
Do	1,040	1.09	751,000	786	14.80	1907	1,980	2.07	1,430,000	1,500	28.14	1913	593	....	429,000	....	....

[a] Year beginning Oct. 1 and ending Sept. 30.

[b] Discharge for 1916 was greater (record for that year not quite complete).

MEAN RUN-OFF.

Of the streams listed in Table 4, North Fork of Yuba at Goodyear Bar gives the greatest mean annual run-off per square mile for its period of record. The records embrace seven seasons, for which period the average discharge is 3.10 second-feet per square mile, equivalent to 42.08 inches a year in depth on the drainage area. The main Yuba at Smartsville had the maximum rate of run-off for any one season—a mean discharge of 5.10 second-feet per square mile, or 68.58 inches in depth on the drainage basin. The rate of discharge during the minimum season of record on the North Fork at Goodyear was greater than the corresponding discharge from any other stream, a mean discharge of 1.81 second-feet per square mile, equivalent to 24.64 inches in depth on its drainage area.

The lowest mean annual run-off per square mile for the entire period of record of any stream shown is that of the Santa Ana River at Mentone. The mean discharge of this stream for 14 seasons was 0.579 second-feet continuous flow per square mile above the gaging station, or the equivalent of 7.86 inches run-off per season from the drainage area. The greatest annual discharge for this period of record gave 1.24 second-feet continuous discharge per square mile, equal to 16.82 inches on the drainage area, and the minimum season a discharge of 0.232 second-feet per square mile or 3.14 inches run-off from the drainage area.

FLOODS.

The San Gabriel near Azusa leads in the rate of flow during the maximum recorded daily floods, giving a discharge of 100 second-feet per square mile on January 18, 1916, the day of maximum flow, but ranks only fifth in the mean flow for the maximum month, the greatest average discharge being on the Yuba at Smartsville—18.9 second-feet per square mile for January, 1909. The lowest rate of discharge for the day of maximum flow on any stream included in the list is 2.58 for the Truckee River at Tahoe, but this figure can not be trusted, for it is probably affected by storage. The next lowest figure is 6.77 second-feet per square mile for Pit River at Ydalpom. The record for Pit River is comparatively short, but the low figure per square mile—6.77 second-feet—is probably due more to the geologic conditions in the drainage basin than to the dryness of the seasons covered by the records. The maximum day on the Pit was February 25, 1917, and the maximum month was January, 1914, with a continuous discharge of 3.33 second-feet per square mile from the extremely large drainage area—5,260 square miles.

The rates of discharge per square mile for the day of maximum flow of the streams listed exhibit wide variation, the highest being San Gabriel with 100 and Yuba River with 91 second-feet. Several of the streams (Feather River, North Yuba River, and American River) give between 50 and 60 second-feet; one (Tuolumne River) about 35, and a number (Mokelumne, San Joaquin, Kings, and Santa Ana rivers) between 20 and 30.

The mean monthly discharge of the Feather, North and Main Yuba, American, and San Gabriel rivers for the months of greatest flow ranges from 11 to nearly 19 and that of the other streams is not above 10 second-feet per square mile.

LOW FLOWS.

A glance at the table showing the low flow will disclose the discouraging conditions with which water users in California are frequently confronted. San Gabriel and Santa Ana rivers, for example, were practically dry on several dates. No water was flowing in the Truckee, but the discharge was probably under control at the Tahoe outlet and therefore should not be considered.

The mean discharge for the month of July, 1899, for the San Gabriel, the lowest stream in California, was 0.016 second-feet per square mile. American, Kings, and Kaweah rivers also show extremely low flows, and many of the others are not much better. The highest rate of discharge for any stream on the list for the minimum day and the minimum month is shown by streams in the northern part of the State, the North Fork of Feather River at Prattville giving the highest minimum daily discharge with 0.9 second-feet per square mile, and the highest minimum monthly mean, 1.9 second-feet per square mile; the North Fork of Yuba with 0.509 second-feet per square mile for the lowest day and 0.542 second-feet per square mile for the lowest month ranks next. It is obvious that the high minimum flow for the last-mentioned streams is due to the natural regulative effect of the geologic structure of a large part of the drainage area.

STORAGE RESERVOIRS.

Even a brief study of Table 4 will convince the reader that a vast improvement is possible in the use of California streams by a judicious system of storage in the upper drainage basins. On very few of the larger basins is the annual run-off in average seasons below the available capacity of storage sites that are rapidly becoming economically feasible. Very early in the mining days—say in the early fifties—extensive water-supply systems were constructed on the drainage basins along the Mother Lode. In many of these systems primitive storage reservoirs played an important part, their construction being delayed usually until the bitter experience of lack of water in dry seasons had taught the miners a lesson which in recent years has been relearned by the power companies. The most extensive early system of reservoirs was in the Yuba River basin, where a large number of lakes were dammed to afford additional storage. Many of these reservoirs are still used by the Pacific Gas & Electric Co.; one of them—Lake Spaulding—was enlarged in 1912 and 1913 to afford a capacity of about 43,500 acre-feet, and still further enlarged in 1917 to a capacity of 64,000 acre-feet and in 1919 to 74,000 acre-feet. The most noteworthy artificial reservoir in the State is Lake Almanor, formed by the Big Meadows dam of the Great Western Power Co. of California on the North Fork of Feather River, where at an exceptionally favorable site an earth dam 90 feet high has created a reservoir of 300,000 acre-feet capacity; the capacity of the site with a dam 120 feet to spillway is 1,250,000 acre-feet. The California Oregon Power Co., Pacific Gas & Electric Co., Western States Gas & Electric Co., Sierra & San Francisco Power Co., Utica Gold Mining Co., San Joaquin Light & Power Corporation, The Nevada-California Power Co., and Southern California Edison Co. have also constructed reservoirs for use in connection with their power plants, and several plants are benefiting by storage reservoirs which are not owned by the power companies but were put in primarily for irrigation and contribute incidentally to plants between the reservoirs and the irrigation intakes. A résumé of storage reservoirs now used and directly controlled by the various power companies is given in Table 5.

TABLE 5.—*Résumé of storage reservoirs operated for power development.*

Company.	Number of reservoirs.	Total capacity.	
		Acre-feet.	Cubic feet.
The California Oregon Power Co.	2	202,000	8,799,120,000
Pacific Gas & Electric Co.	41	153,737	6,696,830,296
Sierra & San Francisco Power Co. (leased to Pacific Gas & Electric Co.)	4	36,525	1,591,035,000
Great Western Power Co. of California	2	300,560	3,092,393,600
Western States Gas & Electric Co.	3	7,947	345,200,000
Snow Mountain Water & Power Co.	2	73,966	3,221,980,280
Coast Counties Gas & Electric Co.	2	490	21,322,620
Utica Mining Co	3	8,977	386,682,120
City of San Francisco	1	22,000	958,320,000
San Joaquin Light & Power Co.	2	38,180	663,120,800
Southern California Edison Co.	5	89,990	3,919,964,400
Escondido Mutual Water Co.	1	3,800	165,528,000
The Nevada-California Power System	7	45,230	1,970,260,000
Sierra Pacific Electric Co. (used in connection with irrigation)	1	741,000	32,277,960,000
	76	1,724,402	64,109,717,116

STREAM-FLOW RECORDS AVAILABLE.

Stream-flow records for California up to June 30, 1912, have been published in Water-Supply Papers 298, 299, and 300. Records from October 1, 1911, to September 30, 1918, have been published in the water-supply papers listed below:

330. Surface water supply of the United States, 1912, Part X, The Great Basin. 1914.

331. Surface water supply of the United States, 1912, Part XI, Pacific coast basins in California. 1914.

360. Surface water supply of the United States, 1913, Part X, The Great Basin. 1916.

361. Surface water supply of the United States, 1913, Part XI, Pacific slope basins in California. 1916.

390. Surface water supply of the United States, 1914, Part X, The Great Basin. 1917.

391. Surface water supply of the United States, 1914, Part XI, Pacific slope basins in California. 1917.

410. Surface water supply of the United States, 1915, Part X, The Great Basin. 1918.

411. Surface water supply of the United States, 1915, Part XI, Pacific slope basins in California. 1917.

440. Surface water supply of the United States, 1916, Part X, The Great Basin. 1919.

441. Surface water supply of the United States, 1916, Part XI, Pacific slope basins in California. 1918.

460. Surface water supply of the United States, 1917, Part X, The Great Basin. 1921.

461. Surface water supply of the United States, 1917, Part XI, Pacific slope basins in California. 1920.

481. Surface water supply of the United States, 1918, Part XI, Pacific slope basins in California. 1921.

Water-Supply Paper 480, containing the results of stream measurements in the Great Basin in California in 1918, is now in press.

One or two of the large power companies have made extensive series of measurements, the results of which have not been published. The publication and general distribution of these records would undoubtedly greatly further the cooperative work that has already accomplished so much.

ECONOMIC FACTORS IN HYDROELECTRIC DEVELOPMENT.

SUPPLY OF FUEL.

In 1892, when the first hydroelectric power plants were constructed in California, the State may be considered to have fully passed through its pioneer days. For a number of years it had had the advantage of two transcontinental railroad lines, and the Coast line, running northward to Portland, had been completed; but up to that time the advantages to be gained from these improvements in means of transportation had been decidedly curtailed by one great handicap—the lack of an adequate supply of cheap fuel for use in the development of power.

Despite this drawback the manufacturing necessary to supply local demands was, of course, carried on, mines were run on hydromechanical power or on steam generated with wood fuel, and in the most favored parts of the State some agricultural pumping was done, though inefficiently, by isolated steam plants. The first hydroelectric power developments were undertaken to replace power already generated by more expensive methods, and nearly all the plants supplied were provided in advance with their own loads.

The two most potent factors leading to the earlier hydroelectric developments were therefore a ready market for power and the entire absence of an adequate supply of fuel; and the chief problems to be solved by the early promoters of hydroelectric systems in the State originated in the uncertainties of the new arts of electric generation and transmission. By the time production of oil in the California fields had attained sufficient magnitude to furnish a cheap and reliable supply of fuel hydroelectric transmission was well established. Oil, however, has locally been used for operating auxiliary and stand-by plants which give security to large systems that are operated principally by hydroelectric energy. The relation of fuel oil to the hydroelectric power supply is described on pages 854–876.

It is evident that the industrial and agricultural prosperity of the State depends on its utilization of hydroelectric power and of its fuel oil. The supply of hydroelectric power is inexhaustible, but the duration of the supply of fuel oil can not yet be determined.

MARKETS.

GROWTH AND DISTRIBUTION OF POPULATION.

Contemporaneously with the firm establishment of hydroelectric power systems in the State there began a vast increase in its population and its industries.

The population of the State, by decades, from 1850 to 1920, was as follows:

1850	92,597
1860	379,994
1870	560,247
1880	864,694
1890	1,213,398
1900	1,485,053
1910	2,377,549
1920	3,426,861

These figures show that the increase in population between 1900 and 1910 was nearly three times the average increase per decade for the three preceding decades, and that the increase from 1910 to 1920 was more than three times that average. This large increase has been due, of course, to many causes, but undoubtedly it would never have occurred if a cheap and reliable source of power had not been discovered.

The density of population varies between wide limits, as noted in detail in the tables covering the various markets (Tables 9, 76, and 174). In some parts of the region the population is very sparse and almost all rural; in others—notably in and around Los Angeles and in the Bay region near San Francisco—the population is extremely dense and largely urban.

The growth of municipalities in California, as elsewhere, has depended largely upon transportation facilities and on the nature of the tributary country. There are in the State 25 municipalities which in 1920 had a population of 10,000 or more, as shown by Table 6. A glance at this table shows that the largest towns are concentrated in the region around San Francisco Bay, in the southern part of the State from the coast near Los Angeles to the head of Santa Ana River valley, and along the east side of the Sacramento and San Joaquin valleys.

TABLE 6.—*Population of principal cities in California.*

City.	County.	Population.		
		1900	1910	1920
Los Angeles	Los Angeles	102,479	319,198	576,673
San Francisco	San Francisco	342,782	416,912	506,676
Oakland	Alameda	66,960	150,174	216,261
San Diego	San Diego	17,700	39,578	74,683
Sacramento	Sacramento	29,282	44,696	65,908
Berkeley	Alameda	13,214	40,434	55,036
Long Beach	Los Angeles	2,252	17,809	55,593
Pasadena	do	9,117	30,291	45,354
Fresno	Fresno	12,470	24,892	45,086
Stockton	San Joaquin	17,506	23,253	40,296
San Jose	Santa Clara	21,500	28,946	39,642
Alameda	Alameda	16,464	23,383	28,806
Vallejo	Solano	7,965	11,340	21,107
Santa Barbara	Santa Barbara	6,587	11,659	19,441
Riverside	Riverside	7,973	15,212	19,341
San Bernardino	San Bernardino	6,150	12,779	18,721
Bakersfield	Kern	4,836	12,727	18,638
Richmond	Contra Costa	....	6,802	16,843
Santa Ana	Orange	4,933	8,429	15,485
Santa Monica	Los Angeles	3,057	7,847	15,252
Glendale	do	....	2,746	13,536
Pomona	do	5,526	10,207	13,505
Eureka	Humboldt	7,327	11,845	12,923
Santa Cruz	Santa Cruz	5,659	11,146	10,917
Venice	Los Angeles	....	3,119	10,385
Total population of cities having 10,000 or more by census of 1920		711,739	1,285,424	1,947,316
Total population of State		1,485,053	2,377,549	3,426,861
Population of cities listed above in percentage of total population of State by same census		47.2	52.8	56.8

LENGTH OF TRANSMISSION LINES.

The Sierra may be regarded as the generating region. In order to reach the excellent markets of the Bay region transmission lines from the Sierra must exceed 110 miles in length. The markets in the central parts of the State offer an advantage that is not afforded by those in some other parts; distribution may be begun at the power houses and continued from center to center all the way to the ends of the lines. This advantage is not possessed by the transmission lines that run from the southern Sierra to Los Angeles, which range in length from 110 to 250 miles and, except for intercompany connections, distribute power practically only at their termini. The systems in central California have therefore gradually branched out and now form an extended network, whereas those in southern California consist of long transmission trunk lines carried to comparatively few terminal distribution networks.

USES OF POWER.

POWER FOR LIGHTING AND DOMESTIC USE.

As the use of power in lighting depends largely on the density of population, it is hardly necessary to call attention to the fact that the heaviest lighting loads are found at the places listed in Table 6.

RAILWAY POWER.

The heaviest railroad load in the State is that on the urban and suburban railway lines around Los Angeles. The load in San Francisco is about the same, but the southern territory has an advantage in the large number of suburban lines that radiate from Los Angeles through the valley to the east and north and to the beach towns to the south and west. Across the bay from San Francisco an extensive network of lines radiate from Oakland to the many suburban towns, and one interurban line runs to Sacramento. South of San Francisco there is an urban system in San Jose with radiating suburban lines, and there is a small system at Monterey.

For the years ending June 30, 1916 and 1917, the electric railways in California reported the following traffic:

	1916.	1917.
Passenger car mileage	116, 938, 313	117, 078, 989
Freight, mail, and express car mileage	7, 419, 885	8, 411, 291
	124, 358, 198	125, 490, 280

About 52 per cent of the total traffic was on lines in and near Los Angeles and 38 per cent on those in the San Francisco Bay region.

In the Great Valley, Sacramento, Stockton, and Modesto are connected by an electric line, and urban and short suburban lines center at Fresno, Visalia, and Bakersfield. There is also a trunk line extending from Sacramento northward via Marysville to Chico and Hamilton, with branches to Woodland, Colusa, and Oroville. North of San Francisco Bay a line connects Vallejo, Napa, and Calistoga; another connects Petaluma and Santa Rosa; and a short isolated system operates in the vicinity of Vacaville. A list of electric railways operating in California in 1917 is given in Table 7. There has been no very marked change in mileage since the table was prepared.

TABLE 7.—*Electric railroads operating in California Dec. 31, 1917.*

Company.	Miles of main line owned.	Total mileage.
Angels Flight Ry. Co	0.0634	0.0767
Bakersfield & Kern Electric Ry. Co	5.87	10.51
The California Street Cable R. R. Co. in San Francisco	11.00	11.00
Castro Point Ry. & Terminal Co		.31
Central California Traction Co	65.647	77.817
Fresno City Ry. Co	7.35	8.14
Fresno Interurban Ry. Co	17.00	18.00

TABLE 7.—*Electric railroads operating in California Dec. 31, 1917*—Continued.

Company.	Miles of main line owned.	Total mileage.
Fresno Traction Co.	34.928	45.013
Glendale & Montrose Ry.	8.292	8.942
Humboldt Transit Co.	11.27	13.00
Los Angeles Ry. Corporation	325.74	390.98
Modesto & Empire Traction Co.	5.20	6.55
Monterey & Pacific Grove Ry. Co.	5.50	5.50
Nevada County Traction Co.	5.65	5.71
Northern Electric, Marysville & Colusa branch	23.50	26.62
Northern Electric Ry. Co.	182.41	157.01
Oakland & Antioch Ry.	34.21	41.46
Oakland, Antioch & Eastern Ry.	58.78	122.67
Pacific Electric Ry. Co.	871.039	1,076.593
Peninsular Ry. Co.	71.336	80.767
Petaluma & Santa Rosa Ry. Co.	37.02	43.48
Point Loma R. R. Co.	9.91	10.16
Sacramento Gas & Electric Ry.	42.59	43.90
Sacramento Terminal Co.	5.74	6.04
Sacramento & Woodland R. R. Co.	17.11	19.70
San Diego Electric Ry. Co.	69.61	84.96
San Francisco, Napa & Calistoga Ry.	41.60	44.52
San Francisco-Oakland Terminal Rys.	239.12	262.88
San Jose R. Rs. Co.	39.01	42.62
Santa Barbara & Suburban Ry. Co.	8.22	8.99
San Ramon Valley R. R. Co.	10.15	10.65
South San Francisco Power Co.	3.259	3.484
Southern Pacific Co. Electric Suburban Lines	101.04	121.10
Stockton Electric R. R. Co.	18.874	25.513
Tidewater & Southern Ry.	58.83	77.08
Union Traction Co.	13.76	14.67
United Railroads of San Francisco	244.02	285.021
Visalia Electric R. R. Co.	28.061	50.024
	2,680.6594	3,261.447

PUMPING FOR IRRIGATION.

The power market for irrigation pumping centered originally along the east side of San Joaquin Valley and in the citrus regions south of the San Bernardino Mountains. In most of this country the water has been pumped from wells, but in the north end of the San Joaquin Valley there are several large pumping systems that draw water from the rivers and deliver it to gravity canals.

North of the deltas of the Sacramento and the San Joaquin the development of irrigation by pumping, or indeed, by any other method, has been much slower than in the San Joaquin Valley. During the last three or four years, however, the development has been more rapid because of the introduction of the cultivation of rice.

It is obvious that water can be pumped to much higher heads (or delivered under the same head at a much higher cost for power) for the production of high-priced crops, such as oranges and lemons, than for the production of low or moderate priced crops, such as alfalfa and garden truck.

OIL-WELL PUMPING.

A market for power for another form of pumping, which is very similar in many respects to pumping for irrigation, is found in the oil fields along the south and southwest side of San Joaquin Valley and at one or two places along the coast near Ventura and Whittier. To the power company oil pumping offers one advantage not offered by irrigation—it knows no season, for the wells are pumped throughout the year. In each oil field, in addition to the power used for pumping the oil itself, a large amount of power is employed in drilling new wells.

RECLAMATION PUMPING.

In the lowlands at the south end of the Sacramento Valley and the north end of San Joaquin Valley there are large areas of fertile farm lands that are reclaimed solely by the use of heavy dikes to restrain the flood waters and made cultivable only by the removal of seepage water. In this region hydroelectric power is much used in what is termed "reclamation pumping." The power used in this work varies between wide limits, the amount being large on some islands or in some reclamation districts and very small in others. The reclamation load is attractive to the power companies chiefly because it comes at flood time, when most of the companies are wasting water that could be used very advantageously, even if the plants have to work for short periods at slightly above their rated capacities. Its most unattractive feature is its poor annual load factor.

MINING.

In the extreme northern part of California, in the mountains at the north end of the Sacramento Valley, and in a belt of moderate width that extends laterally from the eastern edge of the Great Valley well up into the foothills and as far south as the Merced River region, there are extensive mining operations. There are two other fields of the same sort east of the mountains, one near Virginia City and the other near Tonopah.

Probably no load is more attractive to the power operator than a heavy mining load. Regulation does not have to be brought to the same degree of nicety as ordinarily, and as most large mines work three shifts the load factor of any considerable group is excellent, averaging from 80 to 87 per cent. A special type of mining load is found along the eastern edge of the Great Valley as far south as Stanislaus River, where the use of electric power for gold dredging offers the same attractive market as its use in ordinary mining.

MANUFACTURING.

California can not be considered a manufacturing State in the sense in which that term is used in New England, where each small town has its little group of factories. In several cities, however, the industrial load is large. Of these San Francisco and Los Angeles are notable, chiefly on account of their size and their importance as distributing centers. Along the east shore of San Francisco Bay is a belt of land which, having the advantage of both deep-water and rail transportation, supports extensive manufactories. This belt extends well up to the Sacramento marshes and is familiar to all travelers who enter San Francisco by either of the transcontinental roads. The same advantages—water and rail transportation—have concentrated a large amount of manufacturing in Sacramento and Stockton. In all the thriving towns of the State a certain amount of power is, of course, used for manufacturing, but most of the products are intended for local rather than for general use.

WHOLESALING.

Most of the hydroelectric companies are general distributors of power, but three or four, from one cause or another, have become extensive wholesalers to other generating companies. Notable examples have been furnished by the Northern California Power Co. Consolidated, which disposed of a very large proportion of its output to the Pacific Gas & Electric Co. before it was absorbed by the latter; and the Great Western Power system, which sells as much or more power but a smaller percentage of its output, to the Pacific Gas & Electric Co. The Snow Mountain Water & Power Co., with an installed capacity of 9,000 kilovolt-amperes, operates exclusively as a wholesaling company, thus occupying a unique position among the hydroelectric companies of the State.

TABLE 8.—*Installed capacity of generating stations of hydroelectric systems of California.*

Northern California market.

Company and plant.	Hydroelectric.		Steam-electric.	
	Kilovolt-amperes.	Horse-power.	Kilovolt-amperes.	Horse-power.
The California Oregon Power Co.:				
Fall Creek	2,750	3,685	....	....
Shasta River	360	482	....	....
Carrville	400	536	....	....
Copco	12,500	16,750	....	....
Gold Ray	1,500	2,010	....	....
Prospect No. 1	4,750	6,365	....	....
Klamath Falls, west side	600	804	....	....
Keno [a]	900	1,206	....	....
	23,760	31,838	....	....
Pacific Gas & Electric Co.:				
Alta	2,000	2,680	....	....
Centerville	6,400	8,576	....	....
Coal Canyon [b]	1,000	1,340	....	....
Colgate	15,575	20,870	....	....
Deer Creek	5,500	7,370	....	....
De Sabla	13,000	17,420	....	....
Drum	25,000	33,500	....	....
Electra	20,000	26,800	....	....
Fall River (Nos. 1 and 2)	950	1,273	....	....
Folsom	3,000	4,020	....	....
Halsey	12,500	16,750	....	....
Hat Creek No. 1	12,500	16,750	....	....
Hat Creek No. 2	12,500	16,750	....	....
Lime Saddle [b]	2,000	2,680	....	....
Spaulding No. 1	3,750	5,025	....	....
Spaulding No. 2	1,000	1,340	....	....

[a] Operated under lease from Keno Power Co. Capacity given does not include one unit no longer in operation.

[b] Purchased with other properties of Oro Electric Corporation.

TABLE 8.—*Installed capacity of generating stations of hydroelectric systems of California*—Continued.

Northern California market—Continued.

Company and plant.	Hydroelectric.		Steam-electric.	
	Kilovolt-amperes.	Horsepower.	Kilovolt-amperes.	Horsepower.
Pacific Gas & Electric Co.—Continued.				
Wise	12,500	16,750		
Inskip [c]	6,000	8,040		
South [c]	4,000	5,360		
Kilarc [c]	3,000	4,020		
Volta [c]	6,250	8,375		
South Cow Creek [c]	1,500	2,010		
Coleman [c]	15,000	20,100		
Stanislaus [d]	34,000	45,560		
Phoenix [d]	1,875	2,512		
La Grange [d]	900	1,206		
Spring Gap [d]	7,500	10,050		
Station A, San Francisco			[e] 57,000	[e] 76,380
Station B, Oakland			33,500	44,890
Station C, Sacramento			5,000	6,700
North Beach, San Francisco [d]			27,000	36,180
Total for system, 351,700 kilovolt-amperes, or 471,277 horsepower.	229,200	307,127	122,500	164,156
Coast Valleys Gas & Electric Co.:[f]				
Monterey			1,000	1,340
Salinas			300	402
King City			75	100
			1,375	1,842
Great Western Power Co. of California:				
Big Bend	65,000	87,100		
Caribou	44,000	58,960		
Bush Street, San Francisco			[g] 5,000	[g] 6,700
North Beach, San Francisco			[h] 16,000	[h] 21,440
Phelan, San Francisco			1,500	2,010
Oakland			10,500	14,070
St. Marks, Oakland			75	100
Total for system, 142,075 kilovolt-amperes, or 190,380 horsepower.	109,000	146,060	33,075	44,320
Western States Gas & Electric Co.:				
Eureka system—				
Junction City	2,150	2,881		
Eureka steam plant			2,000	2,680
Total for system, 4,150 kilovolt-amperes, or 5,561 horsepower.	2,150	2,881	2,000	2,680
Stockton system—				
American River	41875	6,533		
Stockton steam plant			2,250	3,015
Total for system, 7,125 kilovolt-amperes, or 9,548 horsepower.	4,875	6,533	1,250	3,015
Snow Mountain Water & Power Co.:				
Potter Valley plant	9,000	12,060		
Coast Counties Gas & Electric Co.:				
Swanton plant	990	1,326		
Santa Cruz			860	1,152
Watsonville			750	1,005
Total for system 2,600 kilovolt-amperes, or 3,483 horsepower.	990	1,326	1,610	2,157
Utica Mining Co.: Utica	1,500	2,010		
City of San Francisco: Cherry Creek	3,000	4,020		

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[c] Purchased with other properties of Northern California Power Co. Consolidated.
[d] Sierra & San Francisco Power system operated under lease.
[e] Turbo-generators only. Does not include two 3,500-kilovolt-ampere reciprocating units.
[f] Coast Valleys Gas & Electric Co. here included because it has since its organization practically formed an extension of Sierra & San Francisco Power system, a hydroelectric utility.
[g] Limited to 2,000 kilovolt-amperes by boiler capacity.
[h] Limited to 14,000 kilovolt-amperes by boiler capacity.

TABLE 8.—*Installed capacity of generating stations of hydroelectric systems of California*—Continued.

Southern California market.

Company and plant.	Hydroelectric.		Steam-electric.	
	Kilovolt-amperes.	Horsepower.	Kilovolt-amperes.	Horsepower.
San Joaquin Light & Power Corporation:				
San Joaquin No. 1	16,000	21,440	....	....
San Joaquin No. 1-A	425	570	....	....
San Joaquin No. 2	3,000	4,020	....	....
San Joaquin No. 3	2,000	2,680	....	....
Crane Valley	1,000	1,340	....	....
Kerckhoff	42,600	57,804	....	....
Kern Canyon	10,600	14,204	....	....
Tule River	6,000	8,040	....	....
Merced Falls	450	603	....	....
Kittredge	375	502	....	....
Betteravia	....	....	2,500	3,350
Bakersfield	....	....	26,550	35,577
Fresno	....	....	700	938
Buttonwillow	....	....	12,500	16,750
Total for system, 124,700 kilovolt-amperes, or 167,098 horsepower.	82,450	110,483	42,250	56,615
Southern California Edison Co.:				
Big Creek No. 1	35,000	46,900	....	....
Big Creek No. 2	52,500	70,350	....	....
Big Creek No. 8	25,000	33,500	....	....
Borel	10,000	13,400	....	....
Kern River No. 1	20,000	26,800	....	....
Kern River No. 3	35,000	46,900	....	....
Mill Creek No. 1	750	1,005	....	....
Mill Creek No. 2	250	335	....	....
Mill Creek No. 3	3,000	4,020	....	....
Lytle Creek	500	670	....	....
Fontana	2,400	3,215	....	....
Santa Ana No. 1	3,000	4,020	....	....
Santa Ana No. 2	1,000	1,340	....	....
Santa Ana No. 3 (or Mentone)	1,500	2,010	....	....
Sierra	600	800	....	....
Azusa	1,500	2,010	....	....
Tule River [i]	2,500	3,350	....	....
Kaweah No. 1 [i]	1,350	1,809	....	....
Kaweah No. 2 [i]	2,000	2,680	....	....
Kaweah No. 3 [i]	3,500	4,690	....	....
Redondo	....	....	[j] 30,000	[j] 40,200
Los Angeles No. 3	....	....	10,000	13,400
Long Beach	....	....	58,750	78,725
Oxnard [k]	....	....	800	1,072
Visalia [i]	....	....	6,937	9,296
Tulare [i]	....	....	1,500	2,010
Santa Barbara [l]	....	....	2,120	2,841
Total for system, 311,457 kilovolt-amperes, or 417,352 horsepower.	201,350	269,808	110,107	147,544
Ontario Power Co.:				
Ontario No. 1	750	1,005	....	....
Ontario No. 2	500	670	....	....
	1,250	1,675	....	....
Escondido Mutual Water Co.:				
Rincon	300	402	....	....
Bear Valley	300	402	....	....
	600	804	....	....

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[i] Purchased with other properties of Mount Whitney Power & Electric Co.
[j] Turbo-generators only. Does not include three 5,000-kilovolt-ampere reciprocating units.
[k] Purchased with other properties of Ventura County Power Co.
[l] Operated under lease from Santa Barbara Gas & Electric Co.

TABLE 8.—*Installed capacity of generating stations of hydroelectric systems of California*—Continued.

Southern California market—Continued.

Company and plant.	Hydroelectric.		Steam-electric.	
	Kilovolt-amperes.	Horse-power.	Kilovolt-amperes.	Horse-power.
City of Los Angeles, department of public service:				
Cottonwood Creek n	1,500	2,010		
Division Creek No 1 m	120	161		
Division Creek No 2 m	600	804		
Haiwee m	1,050	1,407		
San Francisquito No. 1 n	28,090	37,740		
San Francisquito No. 2 n	35,000	46,900		
River power n	3,600	4,825		
Franklin Canyon n	2,500	3,350		
	72,460	97,097		
The Nevada-California Power Co. (including The Southern Sierras Power Co. and Holton Power Co.):				
Bishop Creek No. 2 o	6,000	8,040		
Bishop Creek No. 3 o	6,750	9,045		
Bishop Creek No. 4 p	6,000	8,040		
Bishop Creek No. 5 q	3,350	4,490		
Bishop Creek No. 6 q	2,000	2,680		
Owens River q	3,000	4,020		
Mill Creek o	3,000	4,020		
Rush Creek p	10,000	13,400		
El Centro steam plant r			350	469
El Centro gas-engine plant r			950	1,273
San Bernardino steam plant q			8,500	11,390
Tonopah steam plant s			500	670
Blythe gas-engine plant q			250	335
	40,100	53,735	10,550	14,137
Total for system, 50,650 kilovolt-amperes, or 67,872 horse-power.				

Nevada market.

Company and plant.	Hydroelectric.		Steam-electric.	
	Kilovolt-amperes.	Horse-power.	Kilovolt-amperes.	Horse-power.
Sierra Pacific Electric Co. (Reno Power, Light & Water Co. and Truckee River General Electric Co.):				
Farad	1,500	2,010		
Fleish	2,000	2,680		
Verdi	3,000	4,020		
Washoe	1,500	2,010		
Reno	700	938		
	8,700	11,658		

Summary.

Market.	Hydroelectric.		Steam-electric.		Total.	
	Kilovolt-amperes.	Horse-power.	Kilovolt-amperes.	Horse-power.	Kilovolt-amperes.	Horse-power.
Northern California	383,475	513,855	162,810	218,164	546,285	732,019
Southern California	398,210	533,602	162,907	218,296	561,117	751,898
Nevada	8,700	11,658			8,700	11,658
	790,385	1,059,115	325,717	436,460	1,116,102	1,495,576

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m Operated by Bureau of Water Works and Supply.
n Operated by Bureau of Power and Light.
o Plant owned by The Nevada-California Power Co. but operated under lease by The Southern Sierras Power Co.
p Plant owned and operated by The Nevada-California Power Co.
q Plant owned and operated by The Southern Sierras Power Co.
r Plant owned and operated by Holton Power Co.
s Plant owned by Deseret Water, Oil & Irrigation Co. and operated by The Nevada-California Power Co.

PUBLIC CONTROL OF HYDROELECTRIC SYSTEMS.

NATIONAL CONTROL.

Up to the present time Federal control of hydroelectric companies in California has been confined wholly to the water-power rights of way across the public domain, though if necessary more stringent control might probably be exercised over interstate companies under the commerce clause of the Constitution and over all companies through the provisions of trust legislation which has been passed during recent years.

Rights of way for power development have been or may be obtained across the public lands in California under eight acts which are of general application and one act which was passed especially for certain plants belonging to a single company, as follows: Act of July 26, 1866 (sec. 2339, Rev. Stat.), act of March 3, 1891 (26 Stat. L., p. 1095), as amended by act of May 11, 1898 (30 Stat. L., p. 404), act of May 14, 1896 (29 Stat. L., p. 120), act of February 15, 1901 (31 Stat. L., p. 790), act of February 1, 1905 (33 Stat. L., p. 628), act of March 4, 1911 (36 Stat. L., p. 1253), act of June 10, 1920 (41 Stat. L., p. 1063), special act of May 1, 1906 (34 Stat. L., p. 163).

The act of July 26, 1866, was passed to confirm to miners in the Western States the rights (which they had already obtained by use and which had been recognized and acknowledged by local custom) to ditch systems run across the public domain in the early days of the gold excitement. This act provides for the "use of water for mining, agricultural, manufacturing, or other purposes," and was passed long before the days of hydroelectric power development.

The act of March 3, 1891, granted rights of way for irrigation only, but was amended by the act of May 11, 1898, to such an extent that the rights of way granted thereunder might also be used for the development of electric power "as subsidiary to the main purpose of irrigation."

The act of May 14, 1896, is the first one that specifically mentions electrical development. By it the Secretary having jurisdiction is authorized and empowered "under general regulations to be fixed by him to permit the use of rights of way to the extent of 25 feet, together with the necessary grant not to exceed 40 acres upon public lands, and various reservations on the United States by any citizen or associated citizens of the United States, for the purpose of manufacturing or distributing electric power."

The act of February 15, 1901, extended the act of May 14, 1896, to the Yosemite, Sequoia, and General Grant national parks, in California, and specified more closely the purpose for which the rights of way might be used. Rights of way under this act do not amount to easements but are revocable.

The act of February 1, 1905, is restricted in its scope, in that it grants rights of way to citizens and to corporations only for municipal or mining uses and for the milling and reduction of ores during a beneficial use and under such rules and regulations as may be prescribed by the Secretary.

The act of March 4, 1911, applies only to telephone, telegraph, and power transmission lines; under it a 50-year easement may be obtained by complying with regulations laid down by the Secretary.

By the special act of May 1, 1906, Edison Electric Co. (now Southern California Edison Co.) was granted rights of way on what are now the Angeles and Sequoia national forests for the lands occupied by its plants on Mill Creek (Nos. 2 and 3), Santa Ana River (Nos. 1 and 2), Lytle Creek, and Kern River (No. 1). By the provision of the act these rights of way are not revocable. The term of permit was left to the discretion of the Secretary, who fixed it at 40 years. Aside from the nonrevocable feature, the company is subject to practically the same conditions that are imposed by the act of February 15, 1901.

On June 10, 1920, a Federal water-power act was approved, which, from the date of its passage, governed all new rights of way for hydroelectric purposes over the public lands and on navigable streams of the United States but which, by later amendment, is not effective within the boundaries of national parks and monuments. The act establishes a Federal Power Commission, consisting of the Secretary of War, the Secretary of the Interior, and the Secretary of Agriculture, and provides for an executive secretary and the establishment of a central office in Washington. The act contemplates, however, that the field work of the commission shall be carried on by the administrative and technical personnel of the three departments. It authorizes the commission to issue preliminary permits for the purpose of enabling applicants for license to procure the necessary data, and also authorizes the commission, under certain limitations set forth in the act,

> to issue licenses to citizens of the United States, or to any association of such citizens, or to any corporation organized under the laws of the United States or any State thereof, or to any State or municipality for the purpose of constructing, operating, and maintaining dams, water conduits, reservoirs, power houses, transmission lines, or other project works necessary or convenient for the development and improvement of navigation, and for the development, transmission, and utilization of power across, along, from, or in any of the navigable waters of the United States, or upon any part of the public lands and reservations of the United States (including the Territories), or for the purpose of utilizing the surplus water or water power from any Government dam.

Outstanding permits under the older acts are not affected, but it is provided that upon filing formal request and complying with certain requirements, permittees may obtain the benefits of the new act.

The Federal water-power act is the product of nearly a decade of congressional study and debate, and the powers of the commission determined by it are far-reaching. Those interested in water-power legislation should procure a copy of the rules and regulations published by the commission.[7b]

STATE CONTROL.

State control of public utilities, including electric generating and transmission systems, has been vested in the Railroad Commission of the State of California only since March 23, 1912. Prior to that date the only public control was that vested by franchise laws or by special charters in the county and municipal governments, notwithstanding the fact that the State Railroad Commission had been in existence since the adoption of the constitution of 1879. In 1911, on account of the proposed extension of the powers of the Railroad Commission, it became necessary to submit three constitutional amendments at a special election.

These constitutional amendments made radical changes in sections 20, 21, 22, and 23 of article 12 of the constitution of 1879. In brief, the matters covered in the sections as they were in their original forms were as follows: Sections 20 and 21 related wholly to the duties of common carriers and are, therefore, of no present interest. Section 22 provided for the establishment of a railroad commission of three members, each of whom should be elected for four years, from one of three districts equal in population into which the State should be divided. This commission was to have power only to regulate rates and prescribe a uniform system of accounts for common carriers. Section 23 formed the State into provisional districts from which the three railroad commissioners should be elected.

The three constitutional amendments changing these clauses were introduced into the legislature in March, 1911, and voted upon by the people in October, 1911, at a special election on constitutional amendments. The object of the amendment was to give the Railroad Commission complete and effective control over common carriers of the State, and what is of most direct interest to the readers of this report, to extend its powers to include public utilities—among which the most prominent in the State are the hydroelectric systems.

The results attained by the adoption of the three amendments were as follows:

Assembly amendment No. 50 changed sections 20 and 21 of article 12, which, relating to common carriers, are of no present interest.

Assembly amendment No. 6 changed section 22, article 12. It "increased the members of the Railroad Commission from three to five, provided for their appointment by the governor from the State at

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[7b] Federal water-power rules and regulations, as amended by order No. 11 of June 6, 1921.

large instead of election from specified districts, increased the term of office from four to six years after January 1, 1915, gave single commissioners the power, when designated by the commission, to hold hearings, and removed all possible doubt as to the commission's power to fix the actual moving rate." (Rept. California Railroad Comm., January, 1911, to June 30, 1912, p. 18.)

Senate amendment No. 47 changed section 23 of article 12, which originally provided for temporary districts. The amendment defined public utilities so as to include among others "heat, light, water and power companies" and gave to the legislature the right to confer on the Railroad Commission power to supervise and regulate all public utilities. All powers over public utilities theretofore vested in any political subdivision of the State, except those vested in incorporated cities and towns, were to be vested in the Railroad Commission on the passage by the legislature of an act conferring such powers upon the commission.

The adoption of these amendments left the way clear for the passage of the public-utilities act which was introduced in the State senate at the extraordinary session of 1911 on November 28, was passed by the assembly December 12, by the senate December 16, signed by the governor December 23, 1911, and became effective March 23, 1912.

As the public-utilities act of 1911 provided that incorporated cities and towns including the "city and county" of San Francisco should retain the powers of regulation which they had at the time of the passage of the act, but that they could surrender them to the commission upon a vote of the people, it was necessary to frame a proper election act governing such transfers of authority. This measure, known as the Hewitt election act, was passed by the legilature in 1911 and approved by the governor January 2, 1912.

The election act provided that any city and county or incorporated city or town might retain its powers of control respecting any one or more classes of public utilities; might surrender such control to the Railroad Commission; and having surrendered it, might reinvest itself with the powers of control according to the terms provided by the act. The act also provided the time and manner in which the question of control might be submitted to the people, the procedure in the preliminaries and the election itself, the style of ballot, instructions to voters, canvassing the returns and notification of results, both for elections to transfer control and for elections to reinvest the municipality with powers to control. By further amendments to section 23, article 12, of the constitution, adopted November 3, 1914, the powers of the Railroad Commission to supervise and regulate public utilities and fix rates and standards of service were extended to include all powers respecting such utilities as had been vested in boards of supervisors, municipal councils, or other governing bodies of counties, cities and counties, and cities and towns, except such powers as related to the making and enforcement of local police, sanitary, and other regulations other than fixing of rates, and excepting further the right "of any city and county, or incorporated city and town, to grant franchises for public utilities upon the terms and conditions, and in the manner prescribed by law." Sec. 23*a* was also added, conferring upon the Railroad Commission such power as might be given it by the legislature to fix the value of any public utility in proceedings of eminent domain instituted by the State or by any county, city and county, incorporated city or town, or municipal water district. The legislature revised the public-utilities act by amendments approved April 23, 1915, and effective August 8, 1915, so as to include the power granted by the above constitutional amendments. The legislature also empowered the commission "to employ during its pleasure examiners who shall have power to administer oaths, summon witnesses, issue subpœnas, and receive evidence, under such rules and regulations as the commission may adopt."

The Railroad Commission, as reorganized, consists of five members. The terms of all these officials, as provided in the act, expired January 1, 1915, and the governor then made five appointments, one for two years, two for four years, and two for six years. The terms thereafter were to be six years uniformly, which, with the varying dates of appointments, would give continuity to the organization. The salary of the commissioners was fixed at $6,000 in the utilities act, but was raised to $8,000 in 1913. The commissioners may hold hearings separately, but all orders and opinions are handed down in the name of the commission as a whole. The old name, Railroad Commission, was preserved because it was used in the constitution to designate the body upon which the legislature was authorized to confer these additional powers.

Sections 31 to 52 of the public-utilities act delegate to the Railroad Commission aside from powers that relate only to railroads the following powers relating in part or in whole to electric generating and transmission systems[8]:

To fix all rates and charges.

To prescribe just, reasonable, safe, and proper service, equipment, facilities, and methods.

To prescribe additions, extensions, repairs, and improvements.

To direct the use by one public utility of a part of the property of another utility, on, over, or under any street or highway.

To direct the installation of safety appliances and other devices to safeguard the health and safety of employees and patrons and the public.

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[8] California Railroad Comm. Second Rept., 1911-12, pp. 522-536; also Public-utilities act of California, pp. 20-21, San Francisco, Louis Sloss & Co., 1912.

To investigate the cause of accidents and to take steps to prevent their recurrence.

To fix standards, classifications, measurements, and practices of gas, electrical, and water corporations.

To ascertain the value of the property of every public utility.

To establish uniform systems of accounts for each class of public utility.

To permit or refuse to permit a new street-railroad, gas, electrical, telephone, or water corporation to enter a field already served by an existing corporation of like kind.

To permit or to refuse to permit corporations mentioned in the preceding article to exercise rights under new franchises or permits.

To regulate transfers of the property used in the public service of public utilities, except express corporations, wharfingers, and warehousemen, and the acquisition by one public utility of stock in another utility.

To regulate and control the issue of stock, bonds, and other evidences of indebtedness of all public utilities within the State.

WATER LAWS.

A large part of the water law of California is the outgrowth of the practices and customs of the very early mining days.[9] Gold was discovered in Alta California in 1848, and on July 4 of that year a great extent of territory, which included what is now the State, was ceded by Mexico to the United States under the terms of the treaty of Guadalupe Hidalgo. Nearly all the early mining operations were carried on by the placer or hydraulic method, which required the construction of extensive ditch systems and the use of large quantities of water in sluicing the gold from the earth and gravel of the hillsides in the mining region. The water laws made by the Mexicans during their occupation of the country were either inapplicable or were totally disregarded by the new settlers. Most if not all the mining was done on the public domain, and no laws had been passed by Congress that were applicable either to the land or the right to and use of the water thereon. Nor were there any laws passed by the State for a number of years. The tenure of water and ditch rights therefore followed local customs and rules drawn up in the different mining districts by the miners or the miners' associations. Litigation of course arose, and the State courts handed down a number of decisions that were based chiefly on a study of local customs and regulations in the mining region. In 1866 and 1870 Congress enacted two statutes which now form sections 2339 and 2340 of the Revised Statutes and read as follows:

Rev. Stat., sec. 2339: Whenever, by priority of possession, rights to the use of water for mining, agricultural, manufacturing, or other purposes, have vested and accrued and the same are recognized and acknowledged by the local customs, laws, and decisions of courts, the possessors and owners of such vested rights shall be maintained and protected in the same; and the right of way for the construction of ditches and canals for the purposes herein specified is acknowledged and confirmed; but whenever any person, in the construction of any ditch or canal, injures or damages the pos-

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[9] Weil, S. C., Water rights in the Western States, 3d ed., San Francisco, Calif., vol. 1, p. 67, 1911.

session of any settler on the public domain, the party committing such injury or damage shall be liable to the party injured for such injury or damage.

Rev. Stat., sec. 2340: All patents granted, or preemption or homesteads allowed, shall be subject to any vested and accrued water rights, or rights to ditches and reservoirs used in connection with such water rights as may have been acquired under or recognized by the preceding section.

The common law had been adopted in California by the statute of April 13, 1850, and with it the doctrine of riparian rights. For many years, however, the State in general, and the mountain district in particular, was sparsely settled, and the title to most of the land was in the United States Government. Under these conditions comparatively few cases involving riparian rights came before the courts. As the population increased and agriculture began to develop, in the early seventies, cases involving riparian rights became more numerous. Within late years the doctrine to be applied in any given case had depended largely on local conditions. The ditch systems of the hydroelectric generating companies diverting, as they do, chiefly in the mountains, have certainly been more vitally affected by the doctrine of appropriation than by that of riparian rights except in a few places where hydroelectric appropriations in the upper drainage basins have been in conflict with riparian uses for irrigation in the valley.

In 1872 the State adopted its civil code, in which were inserted, as sections 1410 to 1422, inclusive, the first State legislation applicable directly or specifically to water rights and the appropriation of water. These sections merely embodied in legislative form the customs which had grown up in the mining districts and which, as before noted, had been recognized by the courts in extensive litigation. From 1872 to 1911 there was practically no additional legislation on this subject in California, although several of the clauses of the laws of 1872 were slightly amended from time to time.

The sections of the State laws mentioned above provide—

That the right to the use of running water flowing in rivers or streams or down canyons or ravines may be acquired by appropriation; that the appropriation must be for some useful or beneficial purpose, and that when the appropriator or his successors cease to use it for such purpose the right ceases; that the persons entitled to use may change the place of diversion if others are not injured by such change and may extend the ditch, flume, pipe, or aqueduct by which the diversion is made to places beyond that where the first use was made; that the water appropriated may be turned into the channel of another stream and mingled with its waters and then reclaimed, but in reclaiming it the water already appropriated by another must not be diminished; that the first appropriator in time is the first in right; that a person desiring to appropriate water must post a notice in writing in a conspicuous place at the point of intended diversion, stating therein (*a*) that he claims the water there flowing to the extent of a certain number of miner's inches measured under a 4-inch pressure;

(*b*) the purpose for which he claims it and the place of intended use; and

(*c*) the means by which he intends to divert it and the size of flume, ditch, pipe, or aqueduct in which he intends to divert.

That a copy of this notice must, within 10 days after it is posted, berecorded in the office of the recorder of the county in which it is posted, but after the filing of such copy the place of intended diversion or intended use or the means by which it is intended to divert the water may be changed if others are not injured by such change.[10]

That within 60 days after the notice is posted the claimant must commence the excavation or construction of the works, or the survey, road or trail building necessary to the construction, and must prosecute the work diligently and uninterruptedly to completion unless temporarily interrupted by snow or rain; completion is defined as the conducting of the waters to the place of intended use. By compliance with the above rules the claimant's right to the use of water relates back to the time the notice was posted; a failure to comply with such rules deprives the claimant of the right to the use of the water as against a subsequent claimant who complies therewith. It was also provided that persons who had theretofore claimed right to water and who had not constructed works in which to divert it and had not diverted nor applied it to some useful purpose must, after this law took effect and within 20 days thereafter, proceed as therein provided or forfeit their right; that the recorder of each county must keep a book in which he must record the notices provided for; that if the place of intended diversion or any part of the route of intended conveyance of the water so claimed be within or part of any national park, forest reservation, or other public reservations, and be so shown in the notice of appropriation of the said water, the claimant shall have 60 days after the grant of authority to occupy and use such park or reservation within which to commence the excavation or construction of the works, providing that within 60 days after the posting of the notice of appropriation as provided above, the appropriators shall commence in good faith to obtain the necessary rights of way under the regulations governing such park or reservation and continue in good faith the collection of such material and application to the officers or governing body having charge of the park or reservation, and shall thereafter prosecute the application with reasonable diligence.

If the erection of a dam has been recommended by the California Débris Commission at or near the place where it is intended to divert

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[10] This provision was retroactive in its effect.

the water, the claimant shall have 60 days after the completion of such dam in which to commence the excavation or construction of the works in which he intends to divert the water.

A manifestation of the conservation movement of recent years is to be found in chapters 408 and 406 of the statutes of 1911. Chapter 408 created a State Conservation Commission and chapter 406 a State Board of Control, Water Power. The duties of the first commission were to investigate and gather data and information concerning the subjects of forestry, water, the use of water, and water power, electricity, and other power, mines, mining, and related subjects.

The creation of the State Board of Control, Water Power, was simply a temporary expedient to prevent the acquisition of further water rights for power development under the old law, pending the drafting of an adequate water law by the State Conservation Commission. The statute creating the State Board of Control (Stat. 1911, ch. 406) provides that water or the use of water for the generation of electricity, or of electrical or other power shall not be appropriated for a longer period than 25 years; that the appropriation of water or the use of water for the generation of electricity shall be under the act and not otherwise; that water appropriated for uses other than the generation of electricity or other power shall not be used for such generation of power except under a separate and distinct appropriation as provided in the act; that all water or the use of water that has not been heretofore, is not now, or has ceased to be put to some useful or beneficial purpose with due diligence in proportion to the magnitude of the work necessary for its proper utilization is declared to be unappropriated; that all the appropriations of water for power development are subject to the right of the State to regulate the price for which the power is to be sold; that no extensions of present power systems shall be undertaken nor new ones begun without appropriation under the act; that every application for a permit to appropriate water for the generation of power shall set forth certain specific data; that certain official procedure shall be followed; that construction work shall begin within six months, be prosecuted with reasonable diligence in proportion to the magnitude of the undertaking, and shall be completed within a period not to exceed five years from the date of approval (the board may, however, extend the time within which such work shall be completed, upon proper showing, but in no case shall such extension be for a longer period than one year); that when the works for the diversion are complete they shall be inspected by the board or its employees, and when it is reported that the law has been fully complied with, the board shall allow or issue a license allowing the applicant to divert the water for a certain period, not to exceed, however, 25 years.

The act further prescribes the information that is to be contained in this license; provides that every license shall be for the use of the water for the purpose set forth therein and not in any other manner, and that the license shall not impair or affect any rights which have become vested previously. Any licensee or appropriator under the act shall, not less than one nor more than two years prior to the termination of the license, notify the board of control that a renewal and extension is desired. The board shall then issue the renewal and extension of the license for a fixed period, in no case to exceed 25 years, and in compliance with such laws of the State as shall then be in force regulating the renewal, issuing, and granting of license for water or the use of water for generating electric power; no license shall be valid as to any excess of the capacity of the work actually constructed. The board of control is empowered, upon proper application, to grant a license to store, for the purpose of generating electricity, the waters of any stream during flood or during such portions of the year as such water is not required or being stored for irrigation, and for the purposes of the act all such waters not in use during flood season are declared surplus; all appropriations of water for power development are subject to the right of the State to impose fees and charges, and such fees and charges as were provided in the law are subject to change from time to time.

A filing fee of $10 was provided, and an additional fee of $100 upon receipt of license, with an annual charge thereafter, under which the first 100 theoretical horsepower was to be free and 10 cents was to be charged for each theoretical horsepower above 100 horsepower; these fees were to be returned to the general fund of the State treasury. The board was to consist of five persons, three to be appointed by the governor for a term of four years, provided that the first members should be so appointed that one of them should go out of office at the end of one year, one at the end of two years, and one at the end of three years; the governor and the State engineer were made ex officio members of the board of control in addition to the three members appointed. The appointed members of the board were to receive a compensation of $10 per day for each day's service actually rendered. It was further provided that if any State board or commission having the power to regulate or fix rates for services rendered or for commodities furnished by public utility should be created, or such power given to any existing board, that the duties of the State Board of Control, Water Power, should cease, and that the duties should vest in such board or commission; the State Board of Control, Water Power, was authorized to do all things required by the act and to adopt such regulations as were necessary; members were authorized to administer oaths and to cause the production of personal papers, records, and books in all matters of business transacted before the board; a full and accurate record of business transacted was to be kept; the board was authorized to employ such expert technical and professional and clerical assistance as necessary; and $50,000 was appropriated to carry out the provisions of the act during the sixty-third and sixty-fourth fiscal years; traveling expenses of the officers of the board and those persons employed by it while actually engaged in business were to be paid; provision was made for annual reports of water-power appropriators; the office of the board was to be maintained in Sacramento.

It was also provided that within the State no illegal combination or trust having for its purpose the limiting of the output of electricity or increasing the price or preventing the lowering of said price was to be formed upon pain of forfeiture of water rights attained under the act; violations of the provision of the act or orders or regulations of the board were declared misdemeanors and a fine not to exceed $5,000 or imprisonment not to exceed one year, or both, was prescribed as punishment; the provisions of the act were not to apply to municipal corporations other than irrigation districts or lighting districts, nor to the use of waters by irrigation districts for the generation of electricity for distribution within their limits and as subsidiary to and mainly for the purpose of serving and carrying out irrigation, nor to the use by any lighting district for generation of electricity for sale within its own limits. But municipal corporations and lighting and irrigation districts wishing to appropriate water for power uses other than those noted above were required to file with the board a copy of the posted notice of water appropriation within 10 days of posting of such notice and to furnish the board certain data. It was also provided that wherever in the act the performance of certain acts by any firm, association, or corporation was made a misdemeanor, any officer, member, agent, or employee ordering or voting to have such an act performed should be guilty of a misdemeanor and should be punished in the same manner as the corporation; all conflicting acts were repealed and it was provided that the new act should go into operation immediately.

The State Board of Control, Water Power, as organized under this act, assumed its duties on May 4, 1911. During the next session of the legislature the conservation commission introduced a hastily prepared bill which it had drawn up in collaboration with the Board of Control; this measure was defeated. An act, however, did pass that session of the legislature and was approved January 2, 1912 (Stat. 1911–12, chap. 41). This act changed the name and slightly changed the organization of the State Board of Control, Water Power.

The change in name was from "State Board of Control, Water Power" to "State Water Commission," and was made because of confusion with another State commission bearing the name "State Board of Control." By the new act the maximum period for which licenses could be granted was extended from 25 to 40 years. Such licenses were made "subject to vested and existing rights in so far as such vested and existing rights are based upon actual need in application to useful or beneficial purposes." The provision of the original bill which read "if, however, there shall hereafter be created by law any State board or commission having power to regulate or fix rates to be charged for service rendered or commodities furnished by public utilities, or by persons or corporations engaged in public service business, or if any State board or commission now existing shall hereafter have such power conferred upon it, then the powers and duties of this board of control herein created shall vest in and be exercised by such board or commission, and such Board of Control shall thereupon cease to exist" was omitted and the State Water Commission became a permanent body. The unexpended balance, amounting to $37,083.79, of the original $50,000, which had been appropriated to defray the expenses of the State Board of Control, Water Power, was made available for the State Water Commission by the terms of the new act, but no additional appropriation was made. The act which had created the State Board of Control, Water Power, was specifically repealed, and the State Water Commission as organized under the new act assumed its duties March 24, 1912.

During the year 1912 the Conservation Commission and the State Water Commission, working together, drew up a very comprehensive act which was introduced in the legislature as Assembly bill No. 642 January 23, 1913. This measure was entitled the "Water Commission act" and embraced many of the features found in the more modern laws of several of the Western States, notably Oregon. The act passed both houses and was approved June 16, 1913. It did not, however, go into effect, having been held up by a referendum petition. The result of the referendum proceedings was that the State Water Commission as organized under the act approved January 2, 1912, had to run along as best it might on the $37,000 that remained over from the original appropriation for the State Board of Control, Water Power, until the measure was approved by a referendum election November 3, 1914.

In response to the writer's request, Commissioner A. E. Chandler kindly furnished, on May 17, 1916, the following notes and comments on the act:

> The present water commission act aims to cover the three main features of modern water-right legislation—(1) the control of new appropriations, (2) the adjudication of existing rights, and (3) the distribution of water among those entitled to its use.

The real goal of such legislation is the third point, and the other features are but incidental. The water-commission act, however, has but five lines (section 37) regarding this point. Among the amendments to be suggested to the next session of the legislature will be one providing the necessary machinery for the division of the waters of streams among those entitled to their use. This system was worked out at so early a date (1881) in Colorado, and has been so successfully followed by a number of Western States that we do not believe there will be any difficulty in securing the necessary amendment.

Before dividing the waters of a stream it is necessary to secure an ascertainment or adjudication of all the existing rights. This is the most vexatious issue dealt with in such legislation. Sections 24 to 36 inclusive of the water commission act provide for an ascertainment by the State Water Commission and subsequent court proceedings. When the act was originally drawn the Oregon procedure was followed—that is, it was provided that after a determination of the rights upon a stream had been made by the water commission such determination would be immediately acted upon by the superior court having jurisdiction, such court either confirming or modifying the determination. The procedure was so changed in legislative committees that the ascertainment of the commission has no greater worth than that of prima acie evidence in subsequent proceedings. After the ascertainment has been made no action, so far as the division of waters, can be taken under it, but a suit has to be initiated (section 32) in the superior court in the ordinary way and all claimants brought in as parties thereto. When an ascertainment is made the subsequent court decree "shall in every case declare as to the water right adjudged to each party, whether riparian or by appropriation * * *" (section 36). As on most streams there are many riparian tracts, the owners of which will not at the present time object to upper diversions, the commission believes that the ascertainment as provided, necessitating as it does, a finding of riparian rights in such tracts, will be more productive of harm than of good. Those who have petitioned the commission to make an ascertainment have concurred in the above opinion when the riparian right situation was explained to them. The commission is therefore recommending action under the following sentence of section 24:

"In case suit is brought in the superior court for determination of rights to water or the use of water, the case may, in the discretion of the court, be transferred to the State Water Commission for investigation, as referee."

Although a number of sections are now considering having reference made under the above sentence, the only case thus far referred is one involving the waters of Red Rock Creek in Lassen County.

The commission will make a very definite recommendation to the next legislature regarding the amendment of the method of ascertainment. The exact nature of the recommendation, however, will depend upon the decision of the United States Supreme Court in a case now before it (Pacific Live Stock Co. *v.* John H. Lewis et al.) involving the question of the constitutionality of the Oregon water code.

The only restriction of the riparian doctrine contained in the act is found in the following words in section 11:

"If any portion of the waters of any stream shall not be put to a useful or beneficial purpose to or upon lands riparian to such stream for any continuous period of 10 consecutive years after the passage of this act, such nonapplication shall be deemed to be conclusive presumption that the use of such portions of the waters of such stream is not needed upon said riparian lands for any useful or beneficial purpose * * *."

The control of new appropriations is provided for in sections 16 to 23, inclusive, which sections provide for somewhat the same procedure as the water commission act of 1912 analyzed by you.

Section 20 is noteworthy for two reasons: First, it prohibits the capitalization of water rights for either rate-fixing purposes [11] or for purposes of sale to political units; and, second, it provides that—

"The application for a permit by municipalities for the use of water for said municipalities or the inhabitants thereof, for domestic purposes shall be considered first in right, irrespective of whether they are first in time * * *."

The first provision follows the noncapitalization clause of the permits of your department and of the Interior Department. The second provision is practically new in water-right legislation. Although Colorado, Idaho, and other States have constitutional provisions recognizing a preference right for domestic purposes, such provisions have generally been interpreted to mean that one could condemn an irrigation or power right for domestic purposes, and not that the right to divert for domestic purposes should be considered first in right, irrespective of whether it was first in time.

Section 23 provides for filing fees and annual license charges. The filing fee is small except for power purposes, and the difference in the two fees seems to the present commission to be unjustifiable. Undoubtedly a recommendation will be made to the next session equalizing somewhat the filing fees for applications for the various purposes. A recommendation will also be made eliminating the annual license charge. Although Oregon, in 1909, passed an act fixing an annual license charge for appropriations for power purposes, the act was repealed in 1913. California is at present the only State making this annual license charge.

Section 12 provides that the commission shall have authority to fix the time within which water appropriated prior to the passage of the act should be applied to beneficial use, when requested to do so by the appropriator. In passing upon such applications the commission is restricted to the consideration of the question of reasonable diligence.

Section 42 eliminates percolating waters from the jurisdiction of the commission by the following language:

"Whenever the term stream, stream system, lake or other body of water, or water occurs in this act, such term shall be interpreted to refer only to surface water, and to subterranean streams flowing through known and definite channels."

Further changes in the water-commission act, made during the sessions of the legislature held in 1917, 1919, and 1921, are as follows:

AMENDMENTS OF 1917.

Section 15 was amended to provide that the commission may reject applications deemed by it detrimental to the public welfare.

Section 15*a*, added to act, provides for the appropriation of water in this State for use in another State.

Section 20*a*, added to act, provides that when a party entitled to the use of water fails for a period of three years to beneficially use all or any part of the water claimed by him, for which a right of use has vested, for the purpose for which it was appropriated or adjudicated, such unused water shall revert to the public and shall be regarded as unappropriated public water. This provision merely restricts the period of nonuse from five years, as originally held, to three years.

Section 23 was amended to equalize more closely the filing and permit fees for appropriations for different purposes and to eliminate the annual license charges.

Assembly bill No. 118 amended sections 24 to 36 of the water-commission act, making the main steps in the procedure as follows:

1. The commission enters an order granting the petition requesting a determination of rights and publishes notice thereof.

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[11] California Railroad Commission also has announced the principle that in fixing rates no allowance for water-right values in excess of the actual cost of acquiring such rights will be sustained. The policy applies to rights acquired both before and after the establishment of the State Water Commission.

2. The commission makes surveys and maps showing location and capacity of ditches and area of irrigated and irrigable land under ditches.

3. After completion of surveys, maps, and other procedure, the commission prepares notice stating date prior to which proofs of appropriation must be filed. The notice must be published and a copy sent by registered mail to each claimant. The blank form "Proof of appropriation" is enclosed with the notice to each claimant. A fee, the amount depending upon the nature and extent of the right claimed, is required at the time of filing proofs.

4. The commission prepares an abstract of all proofs of appropriations filed and a notice fixing time and place, reasonably convenient to claimants, when and where evidence that is taken by or filed with it shall be open to inspection of all interested persons. A copy of this notice and a printed copy of the abstract of proofs are sent by registered mail to each claimant.

5. Any claimant desiring to contest any claim notifies the commission which, after notice, fixes the time and place for hearing the contest.

6. After hearing all contests, the commission makes an order determining rights by appropriation. A printed copy of the order of determination is sent to each claimant.

7. A certified copy of the order is filed by the commission with the clerk of the superior court of the county in which any part of the stream system is situated, and the court issues an order setting time for hearing. A copy of this order is sent by registered mail to each claimant and is also published.

8. Any person dissatisfied with the order of determination of the commission files with the clerk of court notice of exceptions to the order, and the later court proceedings regarding the hearing of such exceptions are in accordance with the rules governing civil actions. After the hearing the court enters a decree determining the right of each claimant. If no exceptions are filed, the decree is simply an affirmance of the order of determination of the commission.

9. A certified copy of the court decree is filed in the office of the commission, and the commission issues a water-right certificate to each claimant represented in the determination.

As shown under section 3 above, it is not necessary to file any claim of "proof of appropriation" until all the field data have been assembled and filed by the commission and the notice required by section 28 has been given. Before preparing his "proof" each claimant is afforded ample opportunity to go over the maps and measurements made by the commission regarding his diversion and use, so that all necessary corrections of such maps and measurements can be made and also so that the proofs filed shall be in accord with the maps and measurements, as corrected if necessary. No claimant need go to the expense of having surveys or measurements made unless he is unable to agree with the commission as to the accuracy of the surveys or measurements made by it.

The act provides for the determination by the commission of a right by appropriation of any person who neglects or refuses to file proof of his claim and also provides for the intervention of a claimant having no notice of pendency of proceedings.

The decree is conclusive as to the rights by appropriation of all existing claimants lawfully embraced in the determination.

The commission is authorized in making determination, to fix a time limit for the completion of all appropriations of water from the stream system involved, where such rights of appropriation were initiated prior to December 19, 1914, and prosecuted thereafter with reasonable diligence.

The statute restricts the determination to rights by appropriation, and only those riparian owners who desire to appear as appropriators need file claims. No riparian right can be in any way affected by the determination.

The statute is patterned after the procedure adopted in Oregon and Nevada. The validity of the Oregon procedure was upheld by the United States Supreme Court in Pacific Live Stock Co. *v.* Lewis et al., 241 U. S., 440.

AMENDMENTS OF 1919.

Senate bill No. 420 amended section 1 of the water-commission act by providing that the commission shall consist of the same ex officio members as at present (the governor and the State engineer) and three appointed members, one of whom shall be the executive member and the other two shall be associate members. The executive member shall be president of the commission and shall receive a salary of $5,000 per annum. Each of the associate members shall receive $15 per day while actually engaged in the duties of the office. The executive member shall consider and act upon all applications for permits to appropriate water. The commission of three shall sit as a board of appeal in cases where appeal is necessary from the decision of the executive member on applications to appropriate and shall exercise all other duties of the commission now provided in the water-commission act. Briefly the change provided by the amendment results in a commission of three, with one member on full time and two members on per diem, instead of a commission of three with all members on full time as at present.

Senate bill No. 523 amended section 11 of the water-commission act by exempting from the period of ten years regarding the nonuse of water on riparian land, those lands in connection with which there is pending litigation that was initiated prior to June 16, 1913.

AMENDMENTS OF 1921.

Senate bill 197 amended section 15 of the water-commission act to read as follows:

"SEC. 15. The State Water Commission shall allow, under the provisions of this act, the appropriation for beneficial purposes of unappropriated water under such terms and conditions as in the judgment of the commission will best develop, conserve, and utilize in the public interest the water sought to be appropriated. It is hereby declared to be the established policy of this State that the use of water for domestic purposes is the highest use of water and that the next highest use is for irrigation. In acting upon applications to appropriate water the commission shall be guided by the above declaration of policy. The commission shall reject an application when in its judgment the proposed appropriation would not best conserve the public interest."

Senate bill 197 amended section 16 of the water-commission act so that the provision governing the change in point of diversion under permits and licenses now applies likewise to change in place of use.

Senate bill 193 amended section 23 of the water-commission act by the inclusion of the following proviso:

"*Provided*, That only one fee shall be paid upon issuance of two or more permits for the irrigation of the same land, whether said permits be issued simultaneously or otherwise; and that only one fee shall be paid upon issuance of two or more permits for water to be applied to the same power-generating machinery or appliance, whether said permits be issued simultaneously or otherwise."

Senate bill 198 amended section 32 by changing the fees provided to be paid at the time of submission of proofs of appropriation, in connection with the determination of water rights by the State Water Commission.

The water-commission act of 1913 had but five lines (section 37) in regard to the distribution of water among those entitled to its use. In 1917 a bill following the method used in Colorado and other Western States was introduced to amend this defect but did not pass. Senate bill 199, covering this matter, was passed at the 1921 session. It provides for the division of the State by the State Water Commission into water districts and for the appointment by the commission of water masters to divide the water of the State "among the water users entitled to its use, according to the rights of such water users as determined by court adjudication either under the procedure provided for in the water-commission act or otherwise and permits and licenses issued by the State Water Commission after such adjudication." The bill provides machinery for the police regulation of streams similar to that first adopted in Colorado and now in force in practically every Western State. The noteworthy feature of the bill is that it provides for the payment of the water masters by the State and not by the water users through some form of county taxation.

Through the passage of Senate bill 896 by the legislature of 1921 the executive and technical force of the former State Water Commission was carried into the Bureau of Public Works on July 29, 1921, as the Division of Water Rights, with the former executive member of the Water Commission as chief of the division. The work of this newly created Bureau of Public Works is divided by the act into at least five divisions, each under the head of a division chief, the entire department being under control of an executive officer designated by the bill the Director of Public Works (and also, through provision of the bill, acting as chief of the Division of Highways and State highway engineer).

Section 363c of the act provides that

"For all quasi judicial functions relating to irrigation or water rights the director may appoint a board of three engineers of the department to sit as a board of review or appeal wherever a review or appeal, other than review by or appeal to the courts, is provided for under the laws relating to any of the boards, officers, or commissions whose functions are transferred to the department."

Among the provisions investing the Board of Public Works with the duties, powers, purposes, responsibilities, and jurisdiction hitherto exercised by the State water and other commissions, the act specifies that

"Whenever in any statute or law the term 'executive member of the State Water Commission' or 'State Water Commission' is used, it shall be construed to mean and refer to the chief of the Division of Water Rights, except as otherwise provided in this article."

COUNTY AND MUNICIPAL CONTROL OF PUBLIC UTILITIES.

Control of electric corporations by counties and municipalities has been exercised largely through those provisions of the State constitution that covered franchises for municipal lighting and those provisions in the general laws of the State that covered pole-and-wire franchises for uses other than lighting within municipalities and for all uses outside of municipalities. Section 19, article 11, of the constitution conferred on municipal authorities the right to regulate rates charged for lighting, and many of the freeholders charters granted by the legislature to California municipalities have contained special provisions regarding the regulation of rates of electric corporations. No specific power for regulating rates has ever been conferred on county authorities, and so far as the writer is able to ascertain no governing body or board of supervisors of any county has undertaken to regulate rates under the general police powers conferred by the constitution.

Prior to November 4, 1884, the right to lay pipes in the streets of California municipalities rested in grants from the legislature which could either act directly or delegate the power to the municipalities. In order to remedy certain abuses which had arisen, the California constitution of 1879 was amended November 4, 1884, by inserting in article 11 a section reading as follows:

> Section 19. In any city where there are no public works owned and controlled by the municipality for supplying the same with water or artificial light, any individual, or any company duly incorporated for such purpose under and by authority of the laws of this State, shall, under the direction of the superintendent of streets, or other officer in control thereof, and under such general regulations as the municipality may prescribe for damages and indemnity for damages, have the privilege of using the public streets and thoroughfares thereof, and of laying down pipes and conduits therein and connections therewith, so far as may be necessary for introducing into and supplying such city and its inhabitants either with gaslight or other illuminating light, or with fresh water for domestic and all other purposes, upon the condition that the municipal government shall have the right to regulate the charges thereof.

It should be noted that this section of the constitution did not cover similar franchises outside of municipalities and did not specifically cover electric-power circuits within such municipalities. All franchises for the purpose of supplying water and artificial light thereafter became the subject of a direct grant by the constitution and did not require any special act of the legislature (People *v.* Stephens, 62 Calif., 209).

The status of the rights granted by the article quoted above was for many years subject to various controversies in the State courts, but a great many moot points in regard to its interpretation were set at rest by a decision handed down on April 6, 1914, by the Supreme Court of the United States in the case of Russel *v.* Sebastian. It is pointed out by the United States Supreme Court in this case, and also by the State supreme court in various other cases, that this section of the constitution was general in regard to persons and included all cities "where there are no public works owned and controlled by the municipality for supplying the same with water or artificial light." It did not provide for any formal or written acceptance of the offer; and when the offer was accepted by such city, the grant became as effective as if it had been made specially to the accepting individual or corporation. It was, in fact, construed (*In re* Johnston, 137 Calif., 115, quoting People *v.* Stephens, 62 Calif., 209)

> to be a direct grant from the people to the persons therein designated of the right to lay pipes in the streets of a city for the purpose specified, without waiting for legislative authority or being subject to restrictions from that branch of the government.

The only restriction contained in the section was that the work should be done

> under the direction of the superintendent of streets, or other officer in control thereof, and under such general regulations as the municipality may prescribe for damages and indemnity for damages.

Since this constitutional provision was in effect during the period of most active electric extension—namely, from 1884 to 1911—it can readily be seen that there are now a vast number of municipal franchises for pole-and-wire lines which have been granted under it. These franchises will, without doubt, become very valuable,[12] since in the case of Russel *v.* Sebastian the Supreme Court has declared that the State having made the offer of privileges which plainly contemplated the establishment of a plant, and a utility having accepted this offer, the grant resulting from the acceptance constitutes a contract and vests a property right in the accepting party. The court held further that the breadth of the offer was commensurate with the requirements of the undertaking invited; that the

> grant to lay pipes and conduits in the streets of a municipality, dependent only upon acceptance, is not to be regarded as accepted foot by foot as pipes are laid, but is an entirety for all the streets of the municipality, and after acceptance and preparation for compliance with the offer the grant can not be withdrawn as to the streets in which pipes have not been laid. Such an action would impair the contract.

Furthermore,

> the duty of a public-service corporation to extend its service to meet reasonable demands of the community is correlative to the obligation of the municipality to allow the service extended as required by the public needs.

so that a company

> having by accepting the offer of the State and making the investment committed itself irrevocably to the undertaking, it was entitled to continue to lay pipes in the streets wherever necessary to extend its service, and that it could not be prevented from doing so by subsequent legislation impairing the grant.

Franchises granted under the section are therefore perpetual.

Section 19 of article 11 of the constitution as amended October 10, 1911 (superseding sec. 19, art. 11, as amended Nov. 4, 1884) reads as follows:

> Any municipal corporation may establish and operate public works for supplying its inhabitants with light, water, power, heat, transportation, telephone service, or other means of communication. Such works may be acquired by original construction or by the purchase of existing works, including their franchises, or both. Persons or corporations may establish and operate works for supplying the inhabitants with such services upon such conditions and under such regulations as the municipality may prescribe under its organic law, on condition that the municipal government shall have the right to regulate the charges thereof. A municipal corporation may furnish such services to inhabitants outside its boundaries, provided, that it shall not furnish any service to the inhabitants of any other municipality owning or operating works supplying the same service to such inhabitants, without the consent of such other municipality, expressed by ordinance.

The terms of section 19, article 11, of the constitution as amended in 1884 ceased to be of effect October 10, 1911, on the passage of this amendment. Since that date pole-and-wire franchises within municipalities have been granted only under the general State law,

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[12] The Railroad Commission of the State of California has announced the principle that in fixing rates "no allowance for franchises can properly be made in excess of the amount paid to the public authority which granted the franchise, together with the incidental advertising and similar expenses."

(outlined in the following pages) or under the terms of special city charters.

The granting of pole-and-wire franchises outside of municipalities has been under legislative enactment, the first general law covering the sale of such franchises having passed in 1893 (Stat. 1893, p. 288) practically at the beginning of hydroelectric development. Since that time various amendments and new laws have been passed, which are outlined in the following pages.

The law approved March 23, 1893, provided that every franchise proposed "to be granted by the governing or legislative body of any county, city and county, city, town, or district within the State," should be granted under the terms of the act and not otherwise; that the fact that an application for a franchise had been made must be advertised in a daily or in other papers of local circulation; that the advertisement must appear every day for 10 days, beginning at least 30 days before any further action of the governing body; that the advertisement must state the character of the franchise, its term (and if a street railroad, the route to be traversed), and the date on which tenders would be received; that on the stated day the governing body must meet in open session, read the tenders and award the franchise to the highest bidder. It was provided, however, that nothing in the above should affect a special privilege granted for less than two years. It was also provided that any member of a governing body who attempted by his vote to violate the act should be guilty of misdemeanor and, on conviction, should be deprived of office. The act was to take effect immediately.

On March 19, 1897, article 1 of this act of 1893 was amended (Stat. 1897, p. 176) so as to change the list of governing bodies that may grant franchises to the "governing or legislative body of any county or district." The only other changes were in provisions concerning renewals of certain kinds of franchises and a change in the provision for advertising, both of which points are not of vital interest in this discussion.

However, even before this amendment of March 19, 1897, had been adopted, a more general act, approved March 13, 1897, had passed the legislature (Stat. 1897, p. 135, in effect May 12, 1897). It was held in the case of Horton *v.* Los Angeles that this act superseded the act of 1893. The act of March 13, 1897, was more specific in its wording and more general in its scope than the earlier act. It covered, among others,

> Every franchise or privilege to * * * lay gas or water pipes, to erect poles or wires for transmitting electric power or for lighting purposes along or upon any public street or highway, or to exercise any other privilege whatever, hereafter proposed to be granted by the * * * governing or legislative body of any city and county, city or town within the State.

The provisions of the act are practically the same as those of the act of 1893 as amended in 1897, except for changes in method of advertising—up to the provision for the submission of tenders by bidders for franchises. These tenders, according to the act under consideration (and this is a radical change), were not to be for the payment of a certain fixed sum but were to be for the payment of a given percentage of the gross annual receipts arising from the use of the franchise. It was provided that no percentage should be paid for the first five years, but thereafter the payment should not be less than 3 per cent, and the franchise should be forfeited if such payments were not made. The board might, however, provide that payments for renewals of old franchises should begin sooner than five years. All bids could be rejected. No franchise was to be awarded unless the bidder filed with his bid a satisfactory bond with two sureties in amounts to be set forth by the board in the advertisement of the franchise as surety that the bidder would fulfill all conditions of the franchise if it were awarded him. If no bond accompanied the bid, even though the highest, no award was to be made to the bidder, but the board could award to the next highest who had conformed with the proviso or might, in its discretion, set aside all bids and advertise for others. No extension or renewal of an existing franchise was to be offered for sale by any governing body until within one year of the expiration of such franchise, unless the franchise was surrendered by its holders. It was provided, however, that no franchise could be surrendered without the consent of the board which had the authority to grant it, and provided furthermore that upon application of a majority of the board of supervisors or governing body, it should be the duty of the attorney general to sue for forfeiture of any franchise, alleging in such suit noncompliance with the terms of the franchise. The act also contained a provision concerning malfeasance of members of the granting bodies and a provision repealing all acts or parts of acts conflicting with the law. On July 31, 1900, in the case of Pereria *v.* Wallace the law was declared unconstitutional as far as lighting franchises within municipalities were concerned, and was a year later repealed by the act of 1901 (Stat. 1901, p. 265, in effect Mar. 11).

This act of 1901 covers among other rights, "pole or wires for transmitting electric heat and power" to be granted by the governing or legislative body of any "city and county, city or town." The act provides that applications for franchises must be filed with a legislative or governing body which

> shall *in its discretion*[13] and when the application is accompanied with a petition praying that the same be granted, signed by the owners of three-fourths of the frontage of the real property * * * must advertise the fact of said application * * *.

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[13] The italics are the author's.

It should be noted that this act states that the advertising of a franchise is in the discretion of the legislative board (except when accompanied by petition), whereas the act of 1897, by its wording, apparently made it mandatory on the board to advertise whenever applications were received. In the act of 1901 the clauses concerning publication were largely the same as in the act of March 13, 1897. It was stated that the period of advertisement must be completed not less than 20 or more than 30 days before further action by the board. The advertisement was to state the character, terms, and other conditions; bids were to be put in, and the successful bidder was to pay 2 per cent of the gross receipts in addition to his cash bid. This is a distinct change from the method of the act of 1897 (Stat. 1897, p. 135). The same provision that no payment was to be made for five years except on renewals was contained in the act. It was provided that the advertisement should state that the franchise would be granted to the highest cash bidder, provided that at the time of opening bids, the highest bid might be raised 10 per cent by any responsible party, and that the said bid, so made, raised by 10 per cent—the final bid, to be awarded the franchise, for which a deposit of 10 per cent of the bid must be paid in cash, and the other 90 per cent within 24 hours. If the bidder failed to pay, the award was to be made to the next highest bidder. Construction work must begin within four months on pain of forfeiture and must be completed within three years thereafter (also on pain of forfeiture), provided, however, that the board might extend the time for completion not more than three months. The bond, as outlined in the act of 1901, was to be filed within five days. It was, by the terms of the act, the duty of the attorney general to sue for the forfeiture of the franchise on complaint of the municipality, or, in his discretion, upon the complaint of any taxpayer. It was provided that no clause should be inserted in the franchise or advertisement which would restrict bidding or favor one firm as against another. There were also provisions concerning malfeasance in boards of trustees. All preceding acts, except two unimportant measures which do not affect electric companies, were repealed.

In 1903 the franchise law of 1901 was still further amended in certain particulars (Stat. 1903, p. 90). The provision concerning a petition signed by owners of three-fourths of the abutting property was omitted. The other important change was in the manner of filing bonds. It was provided that each sealed bid must be accompanied by cash or certified check to the full amount of the bid, and that the highest bidder must, after the auction, deposit at least 10 per cent of his final bid with the clerk of the municipality before the franchise could be struck off to him. In case of failure to make a deposit the franchise could then be offered for sale to the bidder who would make the highest cash bid with necessary deposit as above. The same process would be repeated until the franchise was sold. The remaining 90 per cent of the final bid was to be deposited within 24 hours, and if this payment was not made, the 10 per cent originally paid was to be forfeited, the award was to be void, and the franchise had to be reoffered for sale. If upon this reoffer the highest bidder should fail to make the deposit of 90 per cent after having made a deposit of 10 per cent, the 10 per cent was to be forfeited and no further proceedings could be taken without readvertising. It was also provided that if a bond was filed within five days, the franchise should be "granted by ordinance" to the firm or person to whom it was "sold or struck off." If the bond was not so filed, the award was to be set aside and the money paid was to be forfeit, and the franchise was in the discretion of the board to be readvertised for sale in the same manner. The law was not again amended until 1905.

The statutes of 1905 (Stat. 1905, p. 777) change the act of 1901 as amended in 1903 so as to include county in addition to "city and county, cities and towns," as the political divisions which may grant franchises. In 1907 a short supplementary act (Stat. 1907, p. 404) was passed, which provided for the change of bondsmen, and in 1909 a slight amendment (Stat. 1909, p. 125) to the provisions; except for these the law of 1905 still stands.

CHAPTER III.—NORTHERN CALIFORNIA MARKET.

TERRITORY COVERED.

AREA AND POPULATION.

The northern California market includes the region extending southward from the northern boundary of the State to and through Tuolumne, Stanislaus, San Benito, and Monterey counties, and northward into the southern tier of the counties of Oregon.

The transmission lines cover, more or less thoroughly, Josephine, Jackson, and Klamath counties, Oreg., and the following counties in California:

Alameda.
Amador.
Butte.
Calaveras.
Colusa.
Contra Costa.
Eldorado.
Glenn.
Humboldt.
Lake.
Marin.
Mendocino.
Monterey.
Napa.
Nevada.
Placer.
Plumas.
Sacramento.
San Benito.
San Francisco.
San Joaquin.
San Mateo.
Santa Clara.
Santa Cruz.
Shasta.
Sierra.
Siskiyou.
Solano.
Sonoma.
Stanislaus.
Sutter.
Tehama.
Trinity.
Tuolumne.
Yolo.
Yuba.

To these may be added, for the purpose of classification, Alpine, Del Norte, Lassen, and Modoc counties. The total area of the counties actually entered by the interconnected systems is 69,020 square miles, and the area of all the counties included in the market is 78,973 square miles.

The maximum distance between a hydroelectric plant and the most remote point of distribution, during normal operation, is probably the 530 miles from the Prospect power house of The California Oregon Power Co. to King City on the lines of Coast Valleys Gas & Electric Co., through Chico, Mission San Jose, and Guadalupe and Salinas substations.

The area and population of the counties served are shown in Table 9, and the physical features and industrial conditions are briefly described in the text that follows the table.

TABLE 9.—*Area and population of counties in northern California market.*

Counties in southern Oregon.

County.	Area.	Population.				Urban population.						Rural population.					
		1890	1900	1910	1920	1900		1910		1920		1900		1910		1920	
	Sq. mi.						*Per cent*		*Per cent*		*Per cent*		*Per cent*		*Per cent*		*Per cent*
Klamath	5,999	2,444	3,970	8,554	11,413	....	....	2,758	32.2	4,801	42.1	3,970	100	5,796	67.8	6,612	57.9
Jackson	2,794	11,455	13,698	25,756	20,405	2,634	19.2	13,860	53.8	10,039	49.2	11,064	80.8	11,896	46.2	10,366	50.8
Josephine	1,637	4,878	7,517	9,567	7,655	....	....	3,897	40.7	3,151	41.2	7,517	100	5,670	59.3	4,504	58.8
	10,430	18,777	25,185	43,877	39,473	2,634	....	20,515	....	17,991	....	22,551	....	23,362	....	21,482	....
Counties in California.																	
Alameda	732	93,864	130,197	246,131	344,177	96,638	74.2	222,821	90.5	314,575	91.4	33,559	25.8	23,310	9.5	29,602	8.6
Alpine	776	667	509	309	243	....	....	....	....	....	....	509	100	309	100	243	100
Amador	601	10,320	11,116	9,086	7,793	....	....	....	....	....	....	11,116	100	9,086	100	7,793	100
Butte	1,698	17,939	17,117	27,301	30,030	2,640	15.4	7,609	27.9	12,679	42.2	14,477	84.6	19,692	72.1	17,351	57.8
Calaveras	1,027	8,882	11,200	9,171	6,183	....	....	....	....	....	....	11,200	100	9,171	109	6,183	100
Colusa	1,140	14,640	7,364	7,732	9,290	....	....	....	....	....	....	7,364	100	7,732	100	9,290	100
Contra Costa	714	13,515	18,046	31,674	53,889	....	....	6,802	21.5	25,416	47.2	18,046	100	24,872	78.5	28,473	52.8
Del Norte	1,024	2,592	2,408	2,417	2,759	....	....	....	....	....	....	2,408	100	2,417	100	2,759	100
Eldorado	1,737	9,232	8,986	7,492	6,426	....	....	....	....	....	....	8,986	100	7,492	100	6,426	100
Glenn	1,337	....	5,150	7,172	11,853	....	....	....	....	....	....	5,150	100	7,172	100	11,853	100
Humboldt	3,575	23,469	27,104	33,857	37,413	7,327	27	11,845	35	12,923	34.5	19,777	73	22,012	65	24,490	65.5
Lake	1,238	7,101	6,017	5,526	5,402	....	....	....	....	....	....	6,017	100	5,526	100	5,402	100
Lassen	4,531	4,239	4,511	4,802	8,507	....	....	....	....	....	....	4,511	100	4,802	100	8,507	100
Marin	529	13,072	15,702	25,114	27,342	3,879	24.7	8,485	33.8	10,856	39.7	11,823	75.3	16,629	66.2	16,486	60.3
Mendocino	3,539	17,612	20,465	23,029	24,116	....	....	....	....	2,616	10.8	20,465	100	23,929	100	21,500	89.2
Modoc	3,823	4,986	5,076	6,191	5,425	....	....	....	....	....	....	5,076	100	6,191	100	5,425	100
Montery	3,330	18,637	19,380	24,146	27,980	3,304	17	8,659	35.9	12,671	45.6	16,076	83	15,487	64.1	15,219	54.4
Napa	783	16,411	16,451	19,800	20,678	4,036	24.5	5,791	29.2	6,757	32.7	12,415	75.5	14,009	70.8	13,921	67.3
Nevada	974	17,369	17,789	14,995	10,850	7,969	44.8	7,209	48.2	4,006	36.9	9,820	55.2	7,746	51.8	6,844	63.1
Placer	1,411	15,101	15,786	18,237	18,584	....	....	2,608	14.3	4,477	24.1	15,786	100	15,629	85.7	14,107	75.9
Plumas	2,593	4,933	4,657	5,159	5,681	....	....	....	....	....	....	4,657	100	5,259	100	5,681	100
Sacramento	983	40,339	45,915	67,806	91,029	29,282	63.8	44,696	65.9	65,908	72.4	16,633	36.2	23,110	34.1	25,121	27.6
San Benito	1,392	6,412	6,633	8,041	8,995	....	....	....	....	2,781	30.9	6,633	100	8,041	100	6,214	69.1
San Francisco	42	298,997	342,782	416,912	506,676	342,782	100	416,912	100	506,676	100	....	....	....	....	....	....
San Joaquin	1,448	28,629	35,452	50,731	79,905	17,506	49.4	25,950	51.2	45,416	56.5	17,946	50.6	24,781	48.8	34,759	43.5
San Mateo	447	10,087	12,094	26,585	36,781	....	....	4,384	16.5	22,296	60.6	12,094	100	22,201	83.5	14,485	39.4
Santa Clara	1,328	48,005	60,216	83,539	100,676	25,150	41.8	37,780	45.2	53,624	53.3	35,066	58.2	45,759	54.8	47,052	46.7

Santa Cruz	435	19,270	21,512	26,140	26,269	9,187	42.7	15,592	59.6	15,930	60.6	12,325	57.3	10,548	40.4	10,339	39.4
Shasta	3,858	12,133	17,318	18,920	13,361	2,946	17	3,572	18.9	2,962	22.2	14,372	83	15,348	81.1	10,339	77.8
Sierra	923	5,051	4,017	4,098	1,783	....	....	....	....	....	....	4,017	100	4,098	100	1,783	100
Siskiyou	6,256	12,163	16,962	18,801	18,545	....	....	....	....	2,528	13.6	16,962	100	18,801	100	16,017	86.4
Solano	822	20,946	24,143	27,559	40,602	10,716	44.4	11,340	41.1	23,800	58.6	13,427	55.6	16,219	58.9	16,802	41.4
Sonoma	1,582	32,721	38,480	48,394	52,090	10,544	27.4	13,697	28.3	14,984	28.8	27,936	72.6	34,697	71.7	37,106	71.2
Stanislaus	1,450	10,040	9,550	22,522	43,557	....	....	4,034	17.9	12,635	29	9,550	100	18,488	82.1	30,922	71
Sutter	608	5,469	5,886	6,328	10,115	....	....	....	....	....	....	5,886	100	6,328	100	10,115	100
Tehama	2,925	9,916	10,996	11,401	12,882	2,750	25	3,530	31.	3,104	24.1	8,246	75	7,871	69	9,778	75.9
Trinity	3,096	3,719	4,383	3,301	2,551	....	....	....	....	....	....	4,383	100	3,301	100	2,551	100
Tuolumne	2,190	6,082	11,166	9,979	7,768	....	....	....	....	....	....	11,166	100	9,979	100	7,768	100
Yolo	1,014	12,264	13,618	13,926	17,105	2,886	21.2	3,187	22.9	4,147	24.2	10,732	78.8	10,739	77.1	12,958	75.8
Yuba	632	9,636	8,620	10,042	10,375	3,497	40.6	5,430	54.1	5,461	52.6	5,123	59.4	4,612	45.9	4,914	47.4
California market	68,543	906,880	1,054,774	1,405,326	1,745,686	583,039	....	871,933	....	1,189,048	....	471,735	....	533,393	....	556,638	....
Oregon market	10,430	18,777	25,185	43,877	39,473	2,634	....	20,515	....	17,991	....	22,551	....	23,362	....	21,482	....
Entire market	78,973	925,657	1,079,959	1,449,203	1,785,159	585,673	....	892,448	....	1,207,039	....	494,286	....	556,755	....	578,120	....

NOTE.—See pp. 66–72 for additions to and eliminations from county areas.

PHYSICAL AND INDUSTRIAL CONDITIONS IN COUNTIES.

Counties in Oregon.—Klamath, Josephine, and Jackson counties, Oreg., which are served by the lines of The California Oregon Power Co., lie along the Oregon-California boundary. Klamath County includes Klamath Lake basin and a large part of the surrounding mountains. Jackson County includes much of the Rogue River valley. The chief industries of the three counties are lumbering, agriculture, dairying, cattle raising, and some mining. The agricultural industries show the most rapid growth, and these and the needs of the small towns for power and light will furnish the future market for power. The California Oregon Power Co.'s lines barely reach Douglas County. Part of Douglas County was annexed to Jackson County and part of Jackson annexed to Douglas in 1915. Part of Josephine County was annexed to Curry County and part of Curry annexed to Josephine between 1910 and 1920.

Alpine County, Calif.—Comprises an area consisting almost entirely of high rugged mountains on the headwaters of Mokelumne, Stanislaus, and Carson rivers, south of Lake Tahoe. The county is not reached by transmission lines of any of the large companies but is included to complete the classification of counties in the northern California market.

Alameda County.—Includes a strip of country about 25 miles wide, north and south, bordering San Francisco Bay on the west and extending eastward over the Coast Range to the western border of San Joaquin Valley. The mountains of the central part of the county contain several long fertile valleys, such as Livermore Valley. The population is concentrated in these valleys and on the coastal belt along the shores of the bay and is especially dense in the suburban zone including Oakland, Berkeley, and Alameda. The market for power is diversified and includes large demands for lighting, electric railways, and manufacturing. Power is supplied by Pacific Gas & Electric Co. and Great Western Power Co. of California.

Amador County.—About two-thirds of Amador County is in the foothill belt on the eastern side of San Joaquin Valley; the other third extends eastward along the ridge between Cosumnes and Mokelumne rivers. The population is concentrated chiefly at the mines along the Mother Lode, which runs north and south through the western part of the county. The demands of these mines and attendant uses furnish the principal market for power, which is supplied by Pacific Gas & Electric Co. and Western States Gas & Electric Co. (Stockton system).

Butte County.—The western half of Butte County is in the level stretches of the Sacramento Valley; the eastern half is in the foothills and western slope of the Sierra. Part of Glenn County was annexed to Butte County in 1915. Except for a few lumbering and mining settlements, nearly the entire population is in the western half of the county. The greatest demand for power has come from mines, from the gold dredges along the edge of the foothills, from agricultural industries, and from railways. Power is supplied by Pacific Gas & Electric Co.

Calaveras County.—Extends eastward from the edge of the foothills well up toward the main crest of the Sierra. Conditions as regards market for power are similar to those in Amador County. Served by Pacific Gas & Electric Co., Western States Gas & Electric Co. (Stockton system), Sierra & San Francisco Power Co. (leased to Pacific Gas & Electric Co.), and Utica Mining Co.

Colusa County.—The eastern part of Colusa County is in the Sacramento Valley; the western part slopes up through the foothills to the main ridge of the Coast Range. In 1891 a part of Colusa County was taken to form Glenn County. Considerable power is used for irrigation and for lighting. Power supplied by Pacific Gas & Electric Co.

Contra Costa County.—Except in a strip along the northeastern margin of San Francisco Bay and the southern margin of Suisun Bay Contra Costa County is hilly. Market for power is large and diversified owing to the excellent harbor facilities for ocean-going vessels and the many shipping points that have been established. Power is supplied by Pacific Gas & Electric Co., by Great Western Power Co. of California, by an isolated distributing system of Western States Gas & Electric Co., and by Sierra & San Francisco Power Co. (leased to Pacific Gas & Electric Co.).

Del Norte County.—Includes an area of rough country on the western side of the Coast Range in the extreme northern corner of the State. The principal available market for power is in lumbering and mining operations, but the county is not yet reached by any general transmission system.

Eldorado County.—Extends from the western foothills of the Sierra eastward to Lake Tahoe and the State line. It is hilly and mountainous throughout. Populated chiefly in the foothill belt at the west. Part of Eldorado County was annexed to Placer County and part of Placer annexed to Eldorado in 1913. Power supplied by Western States Gas & Electric Co. (Stockton system) and Great Western Power Co. of California has been used almost entirely for mining.

Glenn County.—Glenn County was organized from part of Colusa County in 1891, and part of Glenn County annexed to Butte County in 1915. Served by Pacific Gas & Electric Co. (*See* Colusa County.)

Humboldt County.—Includes lower parts of the basins of Trinity and Eel rivers and small streams that flow directly into the Pacific on the west slope of the Coast Range. Most of the county is heavily timbered and the population is largely concentrated around Humboldt Bay. Power used in lumbering operations and the lighting of lumbering towns is supplied by the Eureka system of Western States Gas & Electric Co.

Lake County.—Comprises an area in the Coast Range north of Napa County and includes nearly all the Cache Creek basin and parts of the basins of Eel River and Putah Creek. A part of this county was annexed to Napa County in 1872, and part of Mendocino annexed in 1917. The only areas suitable for future settlement are around Clear Lake and in some of the valleys on Cache Creek below the lake. There is very little demand for power. Served by Snow Mountain Water & Power Co., through California Telephone & Light Co., a distributing company.

Lassen County.—Comprises an area in the northeastern part of the State, south of Modoc County, the conditions in the two counties being similar. In general the country is broken and more arid than that farther west. The chief industries are cattle raising and lumbering. The county is not reached by any general transmission system but contains one or two small isolated plants.

Marin County.—Includes the mountains and hills of the Coast Range just north of San Francisco Bay. Extreme southern part of the county important chiefly as a summer suburban section for San Francisco. Chief industry, fruit growing and farming. The electric load may be classed as miscellaneous power and light. Served by Pacific Gas & Electric Co.

Mendocino County.—Borders the coast but is mountainous except in the valleys of Russian and Eel rivers. Part of this county was annexed to Lake and Sonoma counties and parts of Lake and Sonoma annexed to Mendocino in 1917. Chief industries, lumbering, grazing, and agriculture, lumbering being by far the most important. Small demand for power. Served by Snow Mountain Water & Power Co.

Modoc County.—Extreme northeastern corner of the State. Conditions in general similar to those in Lassen County but with less lumbering. Not reached by any general transmission system. Several small local plants.

Monterey County.—Except in the valley of Salinas River, which traverses its entire length from the southeast tip northwestward to Monterey Bay, Monterey County is mountainous throughout. A part of Monterey County was taken in 1874 to form San Benito County. Largest demand for power has been for agriculture and attendant uses in the lower part of the valley, for municipal uses in the towns, and for street railways in Monterey and near-by summer resorts. The demand for power for agriculture is likely to increase. The county is served by Coast Valleys Gas & Electric Co., which receives hydroelectric power from Sierra & San Francisco Power Co.

(now leased to Pacific Gas & Electric Co.). Small sections are served by Coast Counties Gas & Electric Co. and San Joaquin Light & Power Co.

Napa County.—Is a region of hills and low mountains in the Coast Range, north of Carquinez Straits. The county contains several very rich valleys in which agriculture and fruit raising have been highly developed. A part of Lake County was annexed to Napa County in 1872. Power for agriculture, lighting, and other miscellaneous uses is supplied by Pacific Gas & Electric Co., Snow Mountain Water & Power Co., and Great Western Power Co. of California.

Nevada County.—Contains a few small valleys and a little foothill country in the west, but is almost entirely mountainous. The chief industry is mining, which furnishes an excellent demand for power. Power is also supplied for lighting and miscellaneous uses. Served by Pacific Gas & Electric Co.

Placer County.—About one-fifth of the area of Placer County is in Sacramento Valley. From the valley the county extends eastward in a long strip through a foothill belt and then up over the main ridge of the Sierra to the eastern boundary of the State. Part of this county was annexed to Eldorado County and part of Eldorado annexed to Placer in 1913. In the valley and foothill region agriculture and attendant miscellaneous uses have furnished the chief demand for power; in the foothills very little power has been used for pumping, as most of the water used for irrigation is discharged through the hydroelectric plants higher up. Served by Pacific Gas & Electric Co. and Great Western Power Co. of California.

Plumas County.—A mountainous area for the most part well forested. About 10 per cent of the area is in mountain valleys, several of which afford excellent storage sites. Lumbering, mining, and cattle raising are the chief industries, and the first two are the only industries that are likely to afford a market for power. The only operating lines in the county are from the system of Great Western Power Co. of California and from small plants at Indian Valley, Big Meadows, and Quincy.

Sacramento County.—All except the extreme northern point of Sacramento County, embracing about one-fifth of its area, is in the lowlands of the Sacramento Valley, and nearly all the area is under cultivation. The market for power is diversified, as is usual in densely populated districts. In the long westward-stretching belt of the county there is a large demand for power for reclamation pumping. Power is supplied by Pacific Gas & Electric Co., Great Western Power Co. of California, and Western States Gas & Electric Co.

San Benito County.—The mountainous district between Salinas and San Joaquin valleys, which formed a part of Monterey County until 1874, is now San Benito County. The chief industries have been agriculture, mining, and grazing, and heretofore the only demand for power has been in the vicinity of Hollister in the lower part of San Benito Valley and in the mines of the southern part of the county. Served by Coast Counties Gas & Electric Co and Coast Valleys Gas & Electric Co.

San Francisco County.—Includes the metropolitan district and city of San Francisco on the extreme north end of the peninsula west of San Francisco Bay. Power market large and diversified. Served by Pacific Gas & Electric Co., Great Western Power Co. of California, and Sierra & San Francisco Power Co. (now leased to Pacific Gas & Electric Co.).

San Joaquin County.—Consists for the most part of a low alluvial plain and extends entirely across the northern end of San Joaquin Valley but includes also a foothill section on the east slope of the Coast Range and another on the west slope of the Sierra. The chief market for power is in the agricultural industries, reclamation pumping, manufacturing and lighting in cities like Stockton, and the lighting of small communities. Served by Pacific Gas & Electric Co., Western States Gas & Electric Co., Sierra & San Francisco Power Co. (now leased to Pacific Gas & Electric Co.), and Great Western Power Co. of California.

San Mateo County.—Includes an area of foothills and mountains extending southward from San Francisco down the peninsula west of San Francisco Bay and also narrow coastal belts along the bay and the ocean. Demand for power for manufacturing along the coast is small because of the poor harbor facilities, but along the bay the population is dense and the suburban towns afford an excellent market for miscellaneous power and lighting. Served by Pacific Gas & Electric Co. and Sierra & San Francisco Power Co. (now leased to Pacific Gas & Electric Co.).

Santa Clara County.—Extends from the crest of the main Coast Range eastward across Santa Clara Valley, at the south end of San Francisco Bay, to the crest of the Mount Hamilton Range. The central third of this area is one of the most fertile and productive sections of California, and the growing of fruit is carried well up on the hillsides. Hydroelectric power is used in the agricultural industries, manufacturing in various towns and the city of San Jose, for the urban and interurban electric lines radiating from that point, and for the usual amount of lighting. Served by Pacific Gas & Electric Co. and Coast Counties Gas & Electric Co.

Santa Cruz County.—Comprises an area on the west slope of the Coast Range north of Monterey Bay. Practically the entire northern part of the county is in the mountains, where the chief industry is lumbering; the southern third is on the coastal belt and on the lowlands north of Salinas River. The chief market for power has been in connection with the manufacture of cement in the vicinity of Santa Cruz, and in agriculture and attendant industries farther south. Served by Coast Counties Gas & Electric Co. and Pacific Gas & Electric Co.

Shasta County.—In the mountains surrounding the northern part of Sacramento Valley. Mining and lumbering are the chief industries, and practically the entire demand for power has been for mining. Served by Pacific Gas & Electric Co. Lines of The California Oregon Power Co. reach the extreme northern end.

Sierra County.—Comprises an area of mountains and small intervening valleys. The chief industries are mining and lumbering. Reached by a branch transmission line of Pacific Gas & Electric Co.

Siskiyou County.—Comprises a mountainous area along the California-Oregon boundary but includes several valleys, the largest being Shasta and Scott valleys. Chief market for power has been in mining operations and in lighting of mining towns; there is also a demand for power used in agriculture and lumbering. Served by The California Oregon Power Co.

Solano County.—The western third of the county is in the foothills of the Coast Range just north of Suisun Bay, and the rest is in the lowlands along Sacramento River. Excellent market for power in the cement and other manufacturing industries in the northern part of the county, and a good market in connection with irrigation and agriculture in the eastern part, in addition to the usual demand for power for miscellaneous uses and for lighting. Served by Pacific Gas & Electric Co. and Great Western Power Co. of California.

Sonoma County.—Includes a rolling and mountainous country on the western slope of the Coast Range, in which are interspersed many rich valleys extending northwest and southeast parallel to the coast. Part of this county was annexed to Mendocino County and part of Mendocino annexed to Sonoma in 1917. Agriculture and fruit raising and the manufacturing and municipal uses connected with them form the market for power. Served by Pacific Gas & Electric Co., Great Western Power Co. of California, Snow Mountain Water & Power Co., and California Telephone & Light Co., a distributing company.

Stanislaus County.—Extends eastward from the crest of Mount Hamilton across the San Joaquin Valley into the foothills of the Sierra. About two-thirds of the total area of the county is a region of foothills and mountains and is not important as a power market. The low-lying valley section is being developed into a well-cultivated agricultural district with a growing population and an increasing demand for power. Served by Sierra & San Francisco Power Co. (now leased to Pacific Gas & Electric Co.) and by Pacific Gas & Electric Co.

Sutter County.—Entirely in the lowlands along the eastern side of Sacramento River and partly in the basin or overflow lands.

Chief demand for power is in connection with agriculture. Reclamation pumping for unwatering of lands that would otherwise be too wet for farming is one of the important power loads in these low-lying counties. Served by Pacific Gas & Electric Co.

Tehama County.—Embraces the northern end of Sacramento Valley and the parts of the west slope of the Sierra and east slope of the Coast Range which flank the valley. The chief industries have been lumbering and grazing, but agricultural activity is increasing. The most promising market for power is in agricultural industries and the lighting of small towns. Served by Pacific Gas & Electric Co.

Trinity County.—In the Coast Range in the northern part of the State between Humboldt County and Sacramento River. A large part of the county is heavily timbered and as a whole is very sparsely settled. There has been a small market for power for use in mining; future market will probably be for mining and lumbering. Served by the Eureka system of Western States Gas & Electric Co., The California Oregon Power Co., and Pacific Gas & Electric Co.

Tuolumne County.—Extends eastward from the west border of the Sierra foothills to the main divide; entirely hilly or mountainous. Market for power concentrated in a district of the Mother Lode in the western part of the county. Served by Sierra & San Francisco Power Co. (now leased to Pacific Gas & Electric Co.), Pacific Gas & Electric Co., and Utica Mining Co. (See Amador and Calaveras counties.)

Yolo County.—The eastern half of the county is in Sacramento Valley; the western half extends up the eastern slope of the Coast Range foothills. The demand for power is largely for irrigation and for miscellaneous uses and lighting of small towns. Served by Pacific Gas & Electric Co. and Great Western Power Co. of California.

Yuba County.—The western third of the county is in the level lands of Sacramento Valley; the rest extends northeasterly into the foothills and the west slope of the Sierra. The chief demand for power has been in connection with mines and gold dredges, but demand for power for use in the agricultural industries is increasing. Served by Pacific Gas & Electric Co.

COMPANIES OPERATING HYDROELECTRIC SYSTEMS.

The very large number of hydroelectric companies formerly operating in the northern California market have by consolidation been reduced to the seven corporations listed below, all of which were operating hydroelectric plants October 1, 1921:

The California Oregon Power Co.
Pacific Gas & Electric Co.
Sierra & San Francisco Power Co. (now leased to Pacific Gas & Electric Co.) and Coast Valleys Gas & Electric Co.

Great Western Power Co. of California.
Western States Gas & Electric Co.
Snow Mountain Water & Power Co.
Coast Counties Gas & Electric Co.
Utica Mining Co.

A brief history of each company forms part of the detailed description of its market and properties that is presented in the following pages. The city of San Francisco has also installed a construction plant as the first unit of its Hetch Hetchy municipal water and power system. This plant has been interconnected with the transmission systems serving the northern California market.

Several minor hydroelectric companies serve small local markets in various parts of the State from isolated plants having very short transmission lines. These plants are not described in the text but are listed in Table 10, which follows. (See also Table 312.)

Condensed information concerning all steam-electric utilities and all distributing companies reporting to the Railroad Commission of the State of California December 31, 1920, is given in Tables 313 and 314.

TABLE 10.—*Hydroelectric plants serving power for local distribution.*

[Not described in text.]

Company or owner.	Plant.	Location.	Source of power.	Rating of generators.	
		T. R.		Kilovolt-amperes.	Horsepower.
Alturas Electric Light & Power Co.	Alturas	42 N., 13 E.	Pine Creek	300	402.0
Jensen, N. P	Jensen's	48 N., 15 E.	New Pine Creek	75	100.5
Weaverville Electric Co	Weaverville	33 N., 10 W.	Weaver Creek	50	67.0
Santa Cruz County Utilities Co	Boulder Creek	9 S., 2 W.	Boulder Creek	35	47.9
Downieville Electric Light Co	Downieville	20 N., 10 E.		45	60.3
Forest Hill Electric Co	Forest Hill	13 N., 10 E.	Dardanelles Canyon.	80	107.2
Lassen Electric Co.[a]	Bunnell Springs	30 N., 10 E.	Bunnell Spring	150	201.0
Do	Susan River	30 N., 12 E.	Susan River	50	67.0
Northwestern Redwood Lumber Co.	Northwestern	18 N., 14 W.		325	435.0
Plumas Light & Power Co	Greenville	26 N., 9 E.	North Canyon Creek.	30	40.2
Quincy Electric Light & Power Co.	Quincy	24 N., 9 E.	Gansner Creek	100	134.0
Sierra City Electric Light Co	Sierra City	20 N., 12 E.		37.5	50.2
Soulsbyville Electric Light Co	Soulsbyville			30	40.2
Cain, J. S	Green Creek	4 N., 25 E.	Green Creek	360	482.5
Truckee Electric Light & Power Co.	Truckee	17 N., 16 E.	Truckee River	150	201.0
State of California, Folsom Prison.	Folsom Prison.	10 N., 7 E.	American River	400	536.0
Red River Lumber Co.[a]	Red River Lumber Co.	28 N., 8 E.	Hamilton Branch, North Fork of Feather River.	6,000	8,040.0
Loyalton municipal plant	Loyalton	3 miles south of Loyalton.	Loyalton Creek	45	60.0
Healdsburg municipal plant	Healdsburg	10 N., 9 W.	Sausal Creek	300	402.0
Engels Copper Co	Engels	27 N., 11 E.	Lights Creek	390	523.0
Melones Mining Co.[b]	Melones	2 N., 13 E.	Stanislaus River	1,000	1,340.0
Mountain King Mining Co	Mountain King	4 S., 17 E.	Merced River	350	469.0
Mariposa Commercial & Mining Co.	Bagby	4 S., 17 E.	do	400	536.0
Original Mining & Milling Co	Clearinghs	3 S., 19 E.	do	100	134.0
National Park Service	Cascade	2 S., 21 E.	do	2,000	2,680.0
				12,802.5	17,156.0

[a] Lines of Red River Lumber Co. and Lassen Electric Co. are interconnected at Westwood, Plumas County.

[b] Melones Mining Co. delivers surplus power to lines of Sierra & San Francisco Power Co., operated under lease by Pacific Gas & Electric Co.

THE CALIFORNIA OREGON POWER CO.

HISTORY.

The isolation of the load centers in the valleys of northern California and southern Oregon led to the formation of a number of small and widely separated electric systems. Some of these were owned by private individuals; others were the property of small companies; some were supplied by steam-electric and others by small hydroelectric plants.

Consolidation of the various systems was begun in 1902 with the incorporation of the Siskiyou Electric Power Co. which purchased Yreka Electric Light Co., at that time supplied from a small plant which had been constructed on Shasta River by a Mr. Quinne about 1895. The new company rebuilt this plant during 1902 and 1903, and in September 1902, started construction on the Fall Creek plant, completing the conduit system in April, 1903, and putting the first unit into service in September of the same year. On May 8, 1903, the Siskiyou Electric Power Co. purchased stock control of the Ashland Electric Power & Light Co., then operating a small hydroelectric plant, and a steam auxiliary plant of 75-kilowatt capacity.

Soon after the Siskiyou Electric Power Co. was organized, it purchased the Montague Electric Light Co. and the Little Shasta Power Co. which had generated power for use in Montague and vicinity at a small plant containing a single 1,000-volt 3-phase Stanley inductor generator of 100-kilowatt capacity, about 15 miles from town. The Siskiyou company connected this system to the main transmission lines and permanently closed the plant.

In 1904 the company purchased the Etna Electric Light Co. and Kappler Electric Power Co., and with them acquired the two small hydroelectric plants that had been installed on a tributary of Scott River flowing through Etna Mills. One of these plants, the property of the Etna Development Co., contained a 45-kilowatt direct-current generator; the other, owned by the Kappler Brewing Co., contained a 75-kilowatt generator. The distribution systems were connected to the main transmission system and the plants were closed.

The Fort Jones Electric Light Co. was purchased and connected to the main system in 1904, after which the small plant of 45-kilowatt capacity, belonging to Manuel Periera, which had supplied the system, was shut down.

The Siskiyou Electric Power & Light Co. succeeded the Siskiyou Electric Power Co. in 1908 as a result of a reorganization made necessary by proposed hydroelectric developments and extensions. The main line of the company was run southward from Fall Creek to Dunsmuir, and the electric systems of Herman Sherer and Mossbrae Falls Light & Water Co., which had been supplied from two small water-power plants near Dunsmuir, were purchased. The plants were shut down when the transmission system reached the territory in the fall of 1908 or spring of 1909.

April 1, 1911, the Siskiyou Electric Power & Light Co. also acquired the plants operating in and around Klamath Falls. The first plant at Klamath Falls, which went into operation November 1, 1895, and is said to have had only sufficient capacity to carry three hundred and sixty 16-candlepower lights, was replaced in 1906 by what is called the east-side plant, constructed by the Klamath Falls Light & Water Co. In 1908 the west-side plant was built by Moore Bros., who in 1910 purchased the Klamath Falls Light & Water Co. and consolidated, under the corporate designation Klamath Power Co., the developed powers that had operated variously under the names Klamath Falls Light & Water Co., Klamath Falls Power Co., Klamath River Power Co., and Klamath Light & Power Co., and then transferred the system to the Siskiyou Electric Power & Light Co.

In December, 1911, the California-Oregon Power Co. was incorporated to continue the work of the Siskiyou Electric Power & Light Co. and its subsidiaries in extension of the Rogue River systems. It purchased February 20, 1912, the property of Rogue River Electric Co., including the plant at Gold Ray, also the properties of Prospect Construction Co., which was then installing a plant at Prospect on upper Rogue River. This plant had already been connected to the Rogue River system by a transmission line in 1911, in which year also the Gold Ray and the Fall Creek plants had been connected by a transmission line. In 1912 the Klamath Falls system also was connected to Fall Creek. California Oregon Power Co. also purchased in 1912 the water system of Dunsmuir Water, Light & Power Co., which, despite its name, did not operate an electric utility.

The California Oregon Power Co. extended the transmission system, the reconstruction of which had been begun under the Siskiyou Electric Power & Light Co., and completed the first unit of the Copco plant on Klamath River a short distance east of the Fall Creek plant. The company also purchased and connected to the main transmission lines small electric plants and distribution systems formerly belonging to Glendale Light & Power Co.; George H. Johnson at Sisson; and R. E. Cavanaugh at Edgewood; and a 400-kilowatt plant of the Trinity Gold Mining & Reduction Co. on Coffee Creek, a tributary of Trinity River.

Permission to reorganize California-Oregon Power Co. as The California Oregon Power Co. was granted by the California Railroad Commission March 10, 1921, satisfactory evidence having been submitted that the reorganization of the affairs of the company was necessary for the reason that it had not been able to pay coupon interests on its outstanding bonds since July 1, 1915; to make sinking-fund payments under the provisions of the deed of trust executed by California-Oregon Power Co. due May 1, 1917; nor to procure additional capital to expend for plant extensions, additions, and betterments. The company introduced a statement showing that of the $10,000,000 par value common stock originally outstanding $1,717,000 had been surrendered to avoid payment of assessments, and that $538,230 had been collected through such assessments.

The California Oregon Power Co. was incorporated October 16, 1920, under the laws of California, for a term of 50 years, with an authorized stock issue of $15,000,000, divided into $7,500,000 of 7 per cent nonassessable preferred stock and $7,500,000 of common stock. In the reorganization $2,220,000 of preferred stock and $4,440,000 of common stock was issued in exchange for the $4,440,000 par value California-Oregon Co. bonds and unpaid interest coupons deposited with the reorganization committee. According to the plan of reorganization, the new company was to take over properties that had cost or been valued at $7,693,070.84. Against these there had been outstanding $16,225,496.75 in stock, bonds, and other indebtedness. Through the reorganization the outstanding indebtedness was reduced by $7,475,252.97, leaving outstanding against the properties

Common stock	$4,440,000.00
Preferred stock	2,220,000.00
Bonds	1,151,000.00
Other indebtedness	939,243.78
	8,750,243.78

MARKET.

TERRITORY AND POPULATION.

The transmission lines of The California Oregon Power Co. supply power in Klamath, Jackson, and Josephine counties, Oreg., and Siskiyou County, Calif., and reach but do not cover large areas in Trinity and Shasta counties, Calif., and Douglas County, Oreg. Information in regard to the area and population of these counties is given in Table 9, and the general features of the counties are briefly characterized in the notes on pages 66–72. Power is wholesaled to Pacific Gas & Electric Co. at Kennett and is thus available throughout the interconnected systems serving northern California.

The population of the cities and towns served by the company is shown by Table 11.

TABLE 11.—*Incorporated communities served with hydroelectric power by The California Oregon Power Co.*

City or town.	Population.			
	1890	1900	1910	1920
CALIFORNIA.				
Siskiyou County:				
Dorris	....	....	214	424
Dunsmuir	....	....	1,719	2,528
Etna	271	500	518	425
Fort Jones	266	356	316	331
Montague	....	....	274	453
Sisson	....	....	636	542
Yreka	1,100	1,254	1,134	1,277
	1,637	2,110	4,811	5,980
OREGON.				
Jackson County:				
Ashland	1,784	2,634	5,020	4,283
Central Point	534	322	761	582
Gold Hill	....	385	423	422
Jacksonville	743	653	785	489
Medford	967	1,791	8,840	5,756
Phoenix	....	....	250	159
Talent	....	....	....	278
Josephine County: Grants Pass	1,432	2,290	3,897	3,151
Klamath County:				
Klamath Falls	364	447	2,758	4,801
Bonanza	....	....	....	77
	5,824	8,522	22,734	19,998
Total California and Oregon	7,461	10,632	27,545	25,978

The following unincorporated places are also served: In California, Ager, Bogus, Cantara, Greenview, Henley, Hornbrook, Igerna, Klamathon, Mugginsville, Retreat, Roselawn, Shasta Springs, Thrall, Trinity Center, Weed; in Oregon, Green, Woodville.

LOAD.

Prior to 1916 the company's reports did not classify sales in kilowatt-hours and connected load. The classification for 1916–1920 is shown in Table 12.

Wholesale delivery of power to Pacific Gas & Electric Co. through a connection established with Northern California Power Co. Consolidated began on January 6, 1919, although the load was small or intermittent until April, 1919, when it became continuous. On June 16, 1919, continuous deliveries through this connection were increased to nearly 10,000 kilowatts thus forming by far the largest outlet for power from the system.

TABLE 12.—*Sales and connected load, The California Oregon Power Co., 1916–1920.*

Class of load.	Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
1916.				
Lighting:				
Residence	2,862,085	9.9	2,721.8	18.3
Commercial	2,327,184	8.1	1,471.5	9.9
Municipal	533,378	1.8	157.5	1.0
All other	1,574,209	5.5	1,039.2	7.0
Power:				
Industrial	9,474,119	32.9	6,210.2	41.7
Agricultural	3,601,056	12.5	752.8	5.1
All other	8,458,185	29.3	[a]2,521.3	17.0
	28,830,216	100.0	14,874.3	100.0
Number of consumers			7,478	
1917.				
Lighting:				
Residence	5,411,000	17.4	3,159.8	17.1
Commercial	2,881,000	9.3	1,645.5	8.9
Municipal	479,000	1.6	146.5	.8
All other				
Power:				
Industrial	12,112,000	38.9	8,597.6	46.6
Agricultural	3,510,000	11.3	1,261.4	6.8
All other	6,701,000	21.5	[a]3,656.7	19.8
	31,094,000	100.0	18,467.5	100.0
Number of consumers			7,646	
1918.				
Lighting:				
Residence	4,391,000	12.8	4,284.4	21.0
Commercial	3,309,000	9.6	1,932.4	9.5
Municipal	1,251,000	3.6	231.9	1.1
All other				
Power:				
Industrial	14,704,000	42.9	8,189.7	40.2
Agricultural	3,950,000	11.5	2,109.7	10.4
All other	6,711,000	19.6	[a]3,623.2	17.8
	34,316,000	100.0	20,371.3	100.0
Number of consumers			7,432	
1919.				
Lighting:				
Residence	4,797,000	6.8	5,478.3	17.3
Municipal	1,390,000	2.0	161.8	.5
Commercial	3,647,000	5.0	1,641.9	5.2
Power:				
Industrial	51,276,000	72.3	18,595.2	58.8
Agricultural	3,419,000	4.8	3,756.3	11.9
Municipal	10,000	.1	150.1	.5
Railway	5,647,000	8.0	216.3	.7
Other			655.2	2.0
Other electrical corporations	710,000	1.0	1,020.1	3.1
	70,896,000	100.0	31,675.2	100.0
Number of consumers			8,807	
1920.				
Lighting:				
Residence	4,528,597	4.4	7,920.3	21.4
Municipal	558,488	.5	187.0	.5
Commercial	1,710,449	1.7	1,780.1	4.8
Power:				
Industrial	22,704,653	22.2	21,924.9	59.5
Agricultural	3,989,761	3.9	3,339.1	9.1
Municipal	254,611	.2	213.0	.6
Railway	1,593,046	1.6		
Other	957,896	1.0	486.2	1.3
Other electrical corporations	65,959,292	64.5	1,020.0	2.8
	102,256,793	100.0	36,870.6	100.0
Number of consumers			8,825	

[a] Includes other electric corporations.

Monthly outputs of power for the California-Oregon system prior to 1913 are not available, but the mean monthly loads on the generating stations from January, 1913, to June, 1921, are shown in figure 2. Curves showing daily load on the system for two days each year from 1915 to 1921 are shown in figure 3.

ELECTRIC SYSTEMS.

SHASTA RIVER PLANT.

LOCATION.

The Shasta River plant is on Shasta River about 4 miles northwest of the town of Yreka, Siskiyou County, Calif., in sec. 1, T. 45 N., R. 7 W., Mount Diablo base and meridian, at the point where Shasta River leaves the level stretches of the Shasta Valley and enters the canyon through which it flows to its junction with Klamath River.

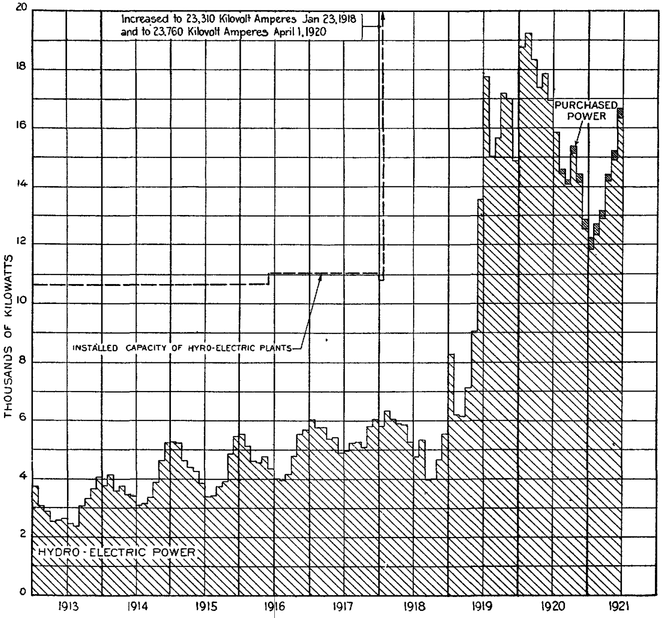


FIGURE 2.—The California Oregon Power Co., mean monthly loads, 1913–1921.

The plant occupies the site of a smaller plant which served Yreka with light from a single 150-kilowatt generator, installed by Frank Quinne about 1895. The present plant was built by Yreka Electric Light Co. and was opened for operation late in 1903. It was remodeled in 1913.

SOURCE OF WATER SUPPLY.

The headwaters of Shasta River are the spring-fed streams on the northwest side of Mount Shasta, and its general course is nearly due north. Little Shasta River, the only noteworthy tributary, joins the main stream from the east, in the lower end of the valley. The basin of the river south of the point of diversion is about 25 miles wide (east

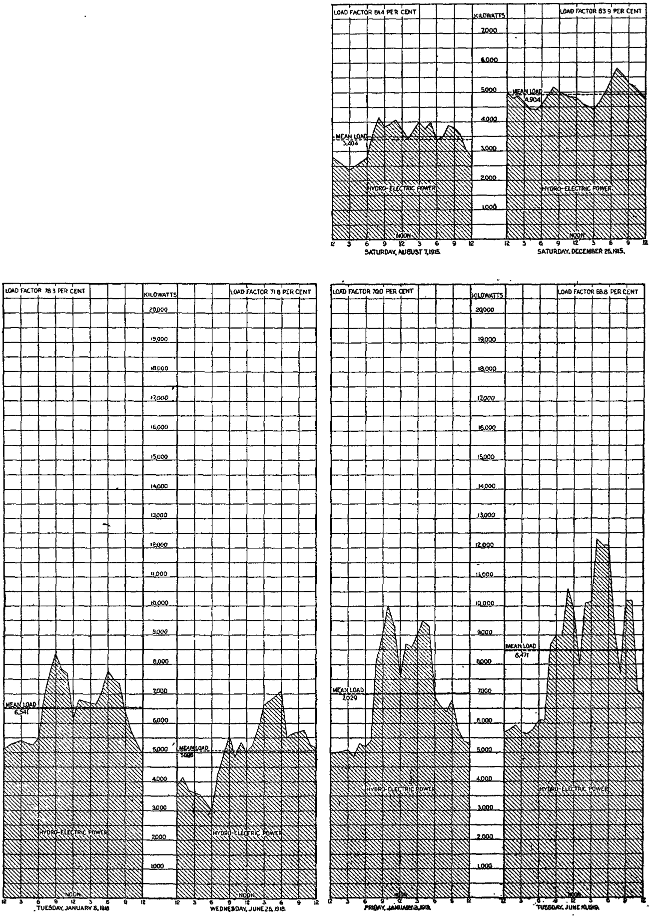
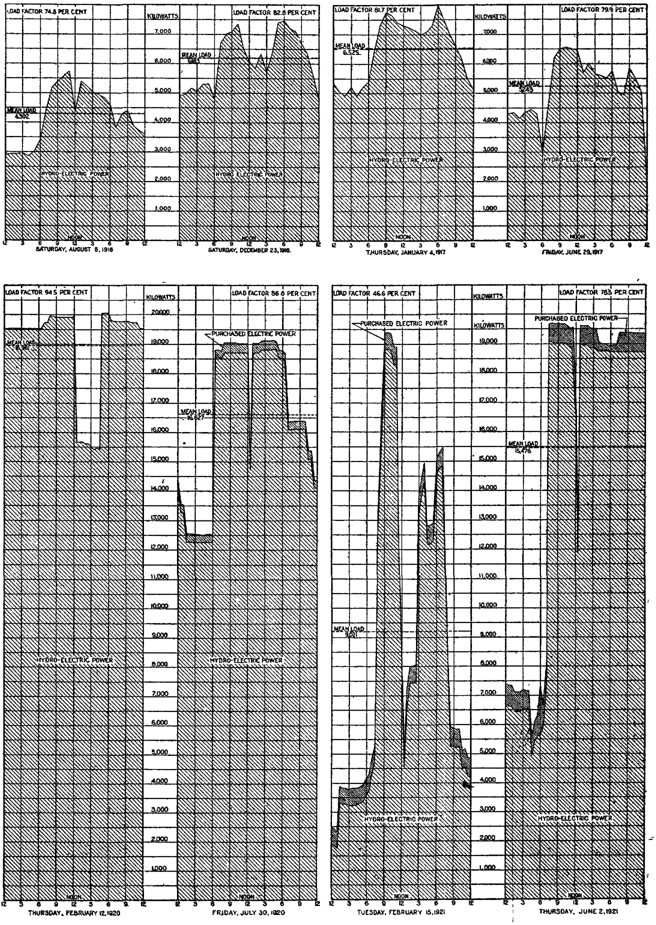


FIGURE 3.—The California Oregon Power Co.

and west) by 30 long (north and south) and its area is 734 square miles. (See Pl. XIV, in pocket.) The valley is very regular in its topography except for the numerous cone-shaped volcanic hills in its southern half, and its floor is in general open and arid, except where irrigated, as are the lower foothills to the east and west.



daily load curves, 1915–1921.

Elevations in the basin range from 2,450 feet above sea level to 14,380 feet at the top of Mount Shasta, the average altitude of a large part of the basin being about 3,000 feet. In the southern part of the basin, on the headwaters, there are sections that until recently have been well forested, but most of these areas have been cut over and the remaining forest cover is only fair or scattering.

Seasonal precipitation at Sisson from October, 1889, to September 30, 1918, is shown graphically in Plate III (p. 20). The average for 29 seasons, ending September 30, 1918, is 37.78 inches.

Stream-flow data for the Shasta Basin consists of records of flow obtained at one station near Montague from 1911 to 1913 and from 1916 to 1918.[1]

No artificial storage is used in connection with the plant.

CONDUIT.

A rock-filled timber-crib dam about 150 feet long and 4 feet high crosses the river at a slight angle and turns the flow into a canal on the southwest side. This canal is about 15 feet wide on the surface and 8 feet wide on the bottom, and was designed for an average depth of water of 4½ feet. Its maximum capacity is reported as 200 second-feet. The elevation at the point of diversion is 2,450 feet. At the head of the canal are two timber head gates, 10 feet wide by 6 feet high, which are supported by concrete abutments and are lifted by means of a hand windlass operated from a bridge across the canal.

The canal is built along the southwest side of the stream, and for nearly its entire length the earth of its outside embankment is supported by a rock retaining wall. The waste water flows over a wooden gate at the extreme lower end of the conduit, just below the penstock. The penstock heads in a pit excavated slightly below the normal level of the lower end of the canal. The bell ends of the pressure pipes are carried through a concrete wall in the outer bank of the ditch and the frame for the timber head gates and waste gate is built into this wall. The depth of the penstock below water surface is 7 feet 9 inches, which gives a little over 3 feet of water above the head of the bell mouths of the two 48-inch pressure pipes, which are constructed of lap-riveted steel plates five-sixteenths of an inch thick and are 50 feet long. There is a trash rack in the ditch just above the head of the pipes.

GENERATING STATION.

Power house.—The power house is a corrugated galvanized-iron building with wooden frame, 48 feet long and 33 feet 6 inches wide, set on concrete foundations, on the west bank of the stream. It contains a single room with two floor levels. The back part of the house contains the generators and electrical equipment and is 7 feet above the front or lower part, which runs along the river side of the room.

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[1] U. S. Geol. Survey Water-Supply Papers as follows: 300, pp. 884-913; 331, p. 389; 361, p. 452; 481, pp. 292-293.

Two horizontal turbines are set in line in this lower part of the power house. The generators and the turbines are set on separate concrete-block foundations. The turbines are about 10 feet above low water, and wasteways are cut into the rock below them, so that the lower end of the 12-foot draft tubes will be submerged about 2 feet at extreme low stages. When operating with draft the working head on the turbines is about 37 feet; the static head is 40 feet.

Hydraulic equipment.—The two 24-inch turbines, designed by the Stillwell-Bierce & Smith-Vaile Co., are of the single horizontal type, with cylinder gates, and are rated at 250 horsepower each; their speed is 430 revolutions per minute and they are regulated by Woodward governors. One of the exciter sets is driven by a 12-inch Victor turbine with register gates, the other by a 15-horsepower motor.

Generators.—The two generators, which are driven by belts from their respective turbines, are Westinghouse revolving-field 3-phase 60-cycle 2,300-volt[2] 180-kilovolt-ampere alternators, giving a total station capacity of 360 kilovolt-amperes, or 480 horsepower. Their speed is 600 revolutions per minute.

Exciters.—The two exciters, identical in type, are 90-ampere 125-volt 11.25-kilowatt Westinghouse direct-current generators, operated at 1,200 revolutions per minute.

Transmission line.—The length of the double-circuit transmission line to Yreka is about 5 miles and its potential is 2,300, as the generator voltage is not stepped up.

The plant is provided with three General Electric multigap lightning arresters with disconnecting switches.

FALL CREEK PLANT.

LOCATION.

The Fall Creek plant diverts water from Fall Creek and its tributary, Spring Creek, near the boundary between Oregon and California, at a point about 7 miles due east of that at which the Southern Pacific Railroad crosses the boundary. The power house is on the north side of the canyon of Klamath River, to which Fall Creek is tributary from the north.

Water is diverted from Spring Creek in the NE. ¼ NW. ¼ sec. 3, T. 41 N., R. 4 E., into a ditch that traverses sec. 3. The Fall Creek diversion dam is in the NW. ¼ NW. ¼ sec. 19, T. 48 N., R. 4 E., and the conduit traverses secs. 19 and 30, T. 48 N., R. 4 E., and secs. 24 and 25, T. 48 N., R. 5 E.

The forebay is in the SE. ¼ SE. ¼ sec. 24, T. 48 N., R. 5 E., and the power house in the SW. ¼ NW. ¼ sec. 30, T. 48 N., R. 4 E.

The plant was constructed in 1902–3 and put into operation by Siskiyou Electric Power Co. September 12, 1903.

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[2] Changed to 2,300 instead of 6,600 volts from the plant to Yreka in 1913.

SOURCE OF WATER SUPPLY.

The drainage basin of Fall Creek, including that of its tributary, Spring Creek, above the points of diversion, comprises 200 square miles of country lying north of Klamath River and west of Klamath Lake basin. (See map of Klamath River basin, Pl. XV, in pocket.) Between Fall Creek basin and the lake is an area drained by Clear Creek, another tributary of the Klamath, and directly north and west of the Fall Creek basin are the upper headwaters of the small streams draining the southeastern part of Rogue River basin.

Elevations range from 3,200 feet above sea level to somewhat less than 6,200 feet, the altitude of most of the area being about 4,000 feet. The western part of the area is the most broken, its eastern part containing numerous upland prairies.

The rocks of the country are volcanic and favor the occurrence of the many springs to which the streams owe the regularity of their flow.

There are no reservoirs or lakes on the courses of either of the streams used. No records of the discharge of Fall Creek are available.

CONDUIT.

A small wing dam in Spring Creek diverts its flow into a ditch about 3,000 feet long leading to Fall Creek. From Fall Creek the water is again diverted by a concrete dam 4 feet high and 115 feet long into the main conduit, which is 4,650 feet long. The Spring Creek diversion ditch is 6 feet wide on top, 3 feet wide on the bottom, and 3½ feet deep; its grade is 0.5 per cent. The main ditch is 12 feet wide on top, 6 feet on bottom, and 5 feet deep, and its grade is 0.5 per cent. Its capacity is about 50 second-feet. The intake is about 3,200 feet above sea level. Both conduits are entirely in ditch except for a small stretch of flume about 100 feet long in the main line. At the lower end of the main conduit is a timber forebay box, 14 by 14 feet in plan and 16 feet deep, built of 2 by 6 inch timbers laid as cribwork and bolted firmly together.

A single riveted pressure pipe, laid in a trench and buried throughout its entire length, runs from the forebay box to the power house. The line consists of 37 feet of pipe tapering from 40 to 30 inches in diameter and 2,800 feet of 30-inch pipe, the thickness ranging from No. 10 to 0.625-inch.

At the power house the pressure line terminates in receiver, 60 feet long and 30 inches in diameter, built of seven-sixteenths-inch lap-riveted plates. From this receiver branches are taken to the wheels at right angles. A gate valve with a 4-inch by-pass is installed in the main pressure line just before it reaches the receiver. The total static head is 730 feet.

GENERATING STATION.

Power house.—Fall Creek power house (Pl. XVI, *B*) is a corrugated galvanized-iron steel-framed building 65 feet long by 32 feet wide. A Louvre ventilator runs along the peak of the roof. A few feet from the generating station is a second building of the same type containing a transformer room 32 feet long by 20 feet wide and a storeroom 20 feet long by 14 feet wide. The high-tension circuits from the transformers pass through tiled outlets at the end of the transformer room to oil switches in corrugated-iron switch shelters supported on steel frames, and thence to a system of pole-top disconnecting switches in front of the power house, where the Fall Creek lines connect to the 34,000-volt transmission lines serving the northern part of the system. The receiver at the lower end of the pressure pipe runs along the side of the power house that is toward the transformer house.

The main building houses three units of 1,250, 1,000, and 500 kilovolt-amperes capacity, respectively, installed with shafts in line along the downstream side of the power house. Along the opposite side of the room is the switchboard, with the rheostats behind it and the exciter sets at each end. At the end of the room opposite the 500-kilovolt-ampere unit; and between it and the end of the switchboard, is a glass-inclosed office.

Hydraulic equipment.—Each of the three units is operated by a single Pelton wheel; the supply for which is led across the power house under the floor to the nozzles. The wheels discharge through tunnel tailraces that open directly into the bed of the small stream below the power house. The discharge is not intercepted by baffles.

The 500-kilovolt-ampere unit is operated by an impulse wheel 63 inches in diameter rated at 1,000 horsepower; the 1,000-kilovolt-ampere unit by a wheel 60½ inches in diameter rated at 1,500 horsepower; and the 1,259-kilovolt-ampere unit by a wheel 82½ inches in diameter rated at 1,800 horsepower. The 1,250-kilovolt-ampere unit has a deflecting needle nozzle controlled by a Pelton governor; the other two units are provided with plain deflecting nozzles, controlled on the 1,000-kilovolt-ampere unit by a Lombard governor, type R, and on the 500-kilovolt-ampere unit by a Lombard governor, type F.

Generators.—The 1,250-kilovolt-ampere unit is a Westinghouse 3-phase 60-cycle 2,300-volt 315-ampere alternator, operating at 300 revolutions per minute. The 1,000-kilovolt-ampere machine is a General Electric ATB 3-phase 60-cycle 2,300-volt 251-ampere alternator, operated at 400 revolutions per minute; the 500-kilovolt-ampere machine is a General Electric ATB 3-phase 60-cycle 2,300-volt 126-ampere unit, operating at 360 revolutions per minute; the three units give a total capacity of 2,750 kilovolt-amperes or 3,685 horsepower. The first two are direct-connected on the same shaft as their respective water wheels, which are overhung; the third unit is connected to its impulse wheel through a flexible leather coupling.

Exciters.—Exciting current for the plant is furnished by two sets. Set No. 1 has a General Electric class 50 form A 40-kilowatt 125-volt 320-ampere continuous-current generator mounted on the same shaft with a 36-inch Pelton impulse wheel, and a 60-horsepower induction motor. Set No. 1 operates at 720 revolutions per minute. Exciter set No. 2 consists of a Westinghouse continuous-current generator and induction motor of the same capacities as the General Electric machines of set No. 1. The speed of set No. 2, however, is 856 revolutions per minute.

Transformers.—The single bank of three General Electric 1-phase 60-cycle 850-kilowatt water-cooled transformers connected delta on the low-tension side and Y-grounded on the high-tension side step the 2,300-volt generator potential up to the 39,000 line voltage.

Wiring.—The high-tension leads for two 3-phase circuits are carried out of the transformer house through inclined tile outlets to insulators supported on steel framework at the end of the building. From this frame the lines pass to double pole-top busses. The 34,000-volt transmission lines of the Rogue River, Klamath Falls, and Yreka districts are interconnected through these busses and a pole-top switching system. The 34,000-volt system serving the northern division and the 66,000-volt trunk line running southward are not interconnected at Fall Creek power house but at Copco, although the only outgoing 66,000-volt line from Copco runs west to Fall Creek power house and there turns southward.

General Electric aluminum 40,000-volt lightning arresters are mounted in the end of the transformer house.

KLAMATH RIVER PLANTS.

SOURCE OF WATER SUPPLY.

The part of Klamath River basin (Pl. XV) supplying water for power plants in operation September 1, 1921, lies in and east of the Cascade Range, chiefly in Klamath County, Oreg., though the extreme western part of the area extends into Jackson County, Oreg., and the southern part crosses the interstate boundary into Modoc and Siskiyou counties, Calif.

Klamath River is properly considered as rising in upper Klamath Lake at an elevation of 4,142 feet[3] above sea level. The principal streams that flow into the lake from the broad basin lying to the northeast and north are (in order of size of areas drained) Williamson River, Wood River, and Sevenmile Creek. From the outlet of Upper Klamath Lake to the Copco dam, the lowest power diversion,

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[3] United States Reclamation Service datum.

the streams flow southwesterly through several long bends. The 1½-mile stretch of river from the outlet of Upper Lake to Lake Ewauna, just below the town of Klamath Falls, is usually called Link River and has a total fall of about 56 feet, partly utilized by the Klamath Falls plant. Lower Klamath Lake was formerly connected with the main river by sloughs in which the direction of flow depended on the stage in the main stream but was finally isolated by dikes constructed by the United States Reclamation Service and closed in the fall of 1917.

The total area above Keno drained by the main river is 3,150 square miles. At Keno the river enters the canyon through which it flows to the coast. Clear Creek from the north and Shovel Creek from the south are the only two noteworthy tributaries that enter between Keno and Copco dam. The drainage area below Keno and above Copco is 416 square miles, which, added to the 3,150 square miles above Keno, gives a total of 3,566 square miles.

Elevations within the area above Copco range from 2,500 feet at the power house to nearly 10,000 feet at the summits of the volcanic peaks along the western and northwestern boundaries of the basin. The large shallow lakes and the extensive bordering marshes and broad valleys which characterize and comprise most of the area lie between 4,000 and 4,600 feet above sea level. The entire region is made up of volcanic rocks, varying from hard lava to pumice and ash. These rocks have a marked effect on the flow of the streams, many of which derive their entire supply from springs.

A dense forest of conifers covers the mountain slopes in the western part of the basin; in the eastern part the forest is thinner.

Annual precipitation probably does not exceed 10 to 15 inches in the lower parts of the basin, but in the mountains (especially toward the west) probably reaches 50 inches or more. The natural regulative effect of the geological structure of the basin is augmented by natural storage in the large lakes and marshes and by artificial regulation at the outlet of Upper Klamath Lake and by the pondage above the Copco dam.

Gaging stations have been maintained by the United States Geological Survey at several places on Klamath River and its tributaries.[4] The records obtained near Keno show a mean annual run-off of approximately 1,600,000 acre-feet, the discharge varying between 8,440 and 730 second-feet.

The operating plants on the main stream are, in downstream order, the Klamath Falls west-side plant, Keno plant, and Copco

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[4] For records of stream flow on the Klamath River basin above the point of diversion see U. S. Geol. Survey Water-Supply Papers as follows: 300 (records up to June 30, 1912), pp. 800–818; 331, pp. 361–388 (1911–12); 361, pp. 420–427 (1912–13); 370, pp. 682–691; 391, pp. 282–288 (1913–14); 411, pp. 285–307 (1914–15); 441, pp. 256–278 (1915–16); 461, pp. 253–289 (1916–17); 481, pp. 244–291 (1917–18).

plant. The Keno plant is owned by Keno Power Co., and operated under lease by The California Oregon Power Co., to which all the other plants belong. The Klamath Falls east-side plant of The California Oregon Power Co. is no longer in operation.[4a]

RESERVOIRS.

On February 24, 1917, California-Oregon Power Co. entered into a 50-year contract with the United States Reclamation Service, by which the company is allowed to regulate the water level of upper Klamath Lake through a rise and fall of 6.3 feet or between 4,137 and 4,143.3 above sea level. In accordance with this contract the company began constructing a temporary crib dam at the outlet April 10, 1919, and completed it about May 1, 1919. This temporary dam was 500 feet long, averaged 5 feet in height, and was composed of rectangular cribs or pockets which measured 10 feet up and down stream by 5 feet in width and were constructed of 4-inch by 4-inch timbers, filled with rock. The elevation of the crest of the dam was 4,144 feet. In order to provide the necessary outlet the company expected to blast a channel extending down to an elevation of 4,130 feet above sea level. The storage capacity thus made available has not been accurately determined but is about 200,000 acre-feet. Through a change in program the dam was removed in January, 1921.

The construction of a permanent concrete regulator below the temporary wood-crib dam was started August 1, 1920, but little was accomplished before work was suspended for the season. Construction was resumed in the summer of 1921, and the work was completed about October 15. The concrete regulator crosses the river on the line of the Keno canal headgates, which are connected with the structure and form its west end. The regulator proper is 377.5 feet long from the eastern abutment to the outside of the embankment of the Keno canal; the total length of the entire structure between abutments, including Keno canal headgates, is 445 feet.

[4a] The east-side Klamath Falls plant was built by the Klamath Falls Light & Water Co. in 1906, but the first generating station on the site was constructed in 1895. The power house is in the town of Klamath Falls, in the SE. ¼ SE. ¼ sec. 30, T. 38 S., R. 9 E., Willamette base and meridian. The east-side plant diverted from the river at a point about 4,140 feet above sea level, three-eighths of a mile above the power house. Water was delivered through 3,000 feet of 6-foot wood-stave pipe, or wooden flume of equivalent capacity, to a wooden forebay measuring 20 feet by 30 feet in plan by 7 feet deep. A 5-foot wood-stave penstock, about 60 feet long, delivered water to the turbine under a gross head of nearly 34 feet. The power house is an ell-shaped, wood-floored, shingle-roofed frame building, about 20 by 40 by 40 feet in plan. The plant houses a single generating unit and the necessary exciter and switching equipment. The transmission line crossed the river to the west bank, where, at a second power house, the necessary transformers were installed and connection was made to the main system. The water wheel is a Stillwell-Bierce & Smith-Vaile 320-horsepower Victor horizontal turbine, belt-connected to the generator. The speed of the unit was controlled by a Replogle governor. The generator is a General Electric ATB 240-kilowatt (320-horsepower) 3-phase 60-cycle 2,300-volt alternator, operated at 600 revolutions per minute. The exciter is a General Electric 11-kilowatt 125-volt direct-current generator, driven by a belt on the water-wheel shaft at 1,250 revolutions per minute. The station was provided with meters and with very simple switching equipment to connect it with the west-side plant. The plant was last operated in 1917, but the flume was not torn out until later.

At the east end of the channel section are seven gates 5 feet wide by 7 feet deep, and at the west side of the river channel are six gates of the same dimensions. These two gate sections are connected by a weir section with 25 openings, 5 feet in clear width between concrete piers 2 feet thick. The piers of the weir section are slotted to receive stop logs, and those of the gate sections are provided with channels for vertical sliding gates and emergency slots for flash boards or stop logs.

The elevation of the bottom of the channel through the two sets of river gates is 4,130 feet above sea level; the top of the gate openings 4,137 feet, and the top of the gate structure 4,145 feet. The solid concrete of the weir section extends up to an elevation of 4,135 feet, above which stop logs will ordinarily be used to a height of 7.5 feet. The bottom of the gate channel of the Keno canal is at elevation 4,129 feet.

The base thickness of the concrete weir up and down stream is 15 feet, and the width of the concrete foundation in the gate section up and down stream is 18 feet. A concrete cut-off wall 2 feet thick is carried down vertically under the upstream face of both weir and gate foundations a depth of 1.5 feet below the rest of the structure. The width of the concrete platform running along the top of the regulator is 8 feet, and its floor elevation is 4,145 feet above sea level.

A channel about 30 feet wide has been excavated from deep water at the lower end of Upper Klamath Lake through the rock reef on the east side of Link River to the east-side river gates of the regulator, and a similar channel about 42 feet in bottom width along the west side of the stream to the headgates of the Keno canal. A cross channel 23 feet in bottom width has been excavated 10 feet from and parallel to the upstream face of the regulator, connecting the lower end of the east and west channels. The bottom elevation of all these channels has been carried down to 4,130 feet, or the same elevation as the bottom of the east and west side river gates.

Records taken since 1906 by the United States Reclamation Service show that without regulation the elevation of the lake surface has varied between 4,143.3 in May, 1907, and 4,139.7 in July, 1918.

From April 1 to May 15, 1919, the surface of the lake was raised from 4,141.4 to 4,142.25 by the dam and drawn down to 4,140.4 by the middle of August.

The second storage reservoir operated by the company is above the Copco dam and has a greater capacity than is needed for daily regulation. (See pp. 94–95.)

KLAMATH FALLS WEST-SIDE PLANT.

Location.—The west-side plant at Klamath Falls was constructed in 1908 by Moore Bros. The power house is in the town of Klamath

Falls, in lots 1 and 12, sec. 32, T. 38 S., R. 9 E., Willamette base and meridian.

Conduit.—By special agreement with the United States Reclamation Service the west-side plant receives a supply of 205 second-feet at a head gate above the power house from the Keno ditch of the Klamath reclamation project. This right was exchanged for certain water rights needed by the Government and claimed by the power company at the time that the reclamation project was begun. The Keno ditch diverts from Link River and has a total capacity of 600 second-feet.

At a point on Keno ditch directly above the power house, there is a wood and concrete forebay box, from which water is conducted to the wheels through a 6½-foot steel pipe about 140 feet long. Flow in the pipe is controlled by sliding gates, and the forebay is provided with a spillway section to take care of overflow and surges. The elevation of the water surface in the forebay is 4,135.4 feet above sea level, of the power-house floor 4,091.4 feet, and of mean water surface in the tailrace 4,087.4 feet, giving a mean static head of 48 feet.

Power house.—A shingle-roofed frame building, about 30 feet by 60 feet in plan and 15 feet in clear height, floored with concrete (over about one-third of its area) and wood, contains a single generating unit. The transformers are in a separate building, 30 feet by 36 feet in plan.

Hydraulic equipment.—A single Pelton-Francis turbine, rated at 1,050 horsepower with a speed of 350 revolutions per minute, operating under a 48-foot head and controlled by a Pelton governor type O-4, is connected to the generator through a flexible leather coupling. A heavy flywheel is mounted on the main shaft between the generator and turbine bearings.

Generator.—The single unit is a Westinghouse 600-kilovolt-ampere (805 horsepower) 2,200-volt 158-ampere 3-phase 60-cycle alternator, designed to operate at 350 revolutions per minute.

Exciter.—The exciter is a Westinghouse 30-kilowatt 125-volt direct-current generator, belt-driven from the main unit at a speed of 850 revolutions per minute.

Transformers.—The power house is connected to the 34,000-volt transmission system through a bank of three single-phase 60-cycle 200-kilowatt General Electric transformers, with a ratio of 2,300/20,000–34,000 volts, Y connected.

The incoming 11,000-volt line from the Keno plant connects with the power-house busses through a bank of three single-phase 60-cycle 185-kilovolt-ampere Westinghouse transformers.

A third bank, of three single-phase 60-cycle 300-kilowatt General electric transformers, with a ratio of 2,300/34,600–60,000 volts, Y connected, is connected to the high-tension lines to feed a 4,000-volt power circuit supplying Klamath Falls.

In addition to this power circuit there are two 2,300-volt lighting circuits leaving the plant, and three 34,000-volt transmission lines, one running northward to Algoma, one eastward to Bonanza, and the third to the Fall Creek plant.

KENO PLANT.

Location.—The Keno plant, in the SW. ¼ sec. 36, T. 39 S., R. 7 E. Willamette meridian, on Klamath River a short distance below the town of Keno, was constructed and is owned by Keno Power Co., a small Oregon corporation. It was leased during 1920 by California Oregon Power Co., which installed a new unit and operates the plant at the expense of Keno Power Co., purchasing the surplus energy. The date of construction of the first power house on the site is not available.

Conduit.—Water is diverted from Klamath River into a conduit on the north bank by a rough composite dam extending diagonally downstream along the crest of a riffle. The first section of the dam, beginning at the south abutment, is 3 to 8 feet high and 170 feet long and consists of 17 sluices and 17 cribs, each 5 feet wide. The cribs are constructed of 4 by 4 inch timbers and measure 8 feet long downstream by 5 feet wide; they are divided transversely into two equal bays, which are filled with rock. The sluices or spillway openings between the cribs are provided with slots for flashboards.

The second section of the dam is from 6 to 12 feet high, 120 feet long, including end cribs, and contains four 20-foot spillways separated from one another and from the first and third sections of the dam by cribs 8 feet wide built of 8 by 8 inch timbers. A timber frame at the center of each spillway opening divides it into two 10-foot sections, and a removable post at the center of each of these still further divides the entire opening into four 5-foot sluices. A rock-filled log crib was built on the bed of the river under the second section of the dam with top elevation (or floor of sluices) at 4,040.63 feet; the elevation of the lower side of timbers in the top of the sluice frame is 4,046.63 feet.

The third or solid section of the dam serves to connect the spillway section with the outer bank of the conduit on the north side of the river. This section is 7 feet in maximum height, 170 feet long, 12 feet in crest width, with an upstream slope of ½ to 1 and a downstream slope of 1 to 1. It is built of log cribs with pockets 10 feet wide, filled with earth and rock; the upstream side is faced with 2-inch plank.

At 90 feet down the canal from the north end of the dam is a timber frame, heavily weighted with rock, supporting five gates, each about

6 feet wide by 10 feet high, that may be raised vertically by rack and ratchet. The outlet into the No. 3 or newest power house is 340 feet and the outlet to No. 2 power house 380 feet below the headgates; the extreme lower end of the canal at power house No. 1 is 415 feet from the gates. From a point 125 feet below the gates to its extreme lower end the sides of the canal are faced with concrete.

The static head is 27 feet.

Power houses.—The No. 1 or oldest power house was supplied from the extreme lower end of the canal through a timber headrace 93 feet long, 12 feet wide, and 10 feet deep, to which water was admitted through two gates 5 feet wide by 8 feet high, sliding in a timber frame. This head race terminates in a turbine pit 11 feet 7 inches square and 17 feet 9 inches deep from the floor of the head race to the normal tailwater surface. A wooden trash rack is installed immediately above the gates. Halfway between the head gates and turbine pit a wasteway 8 feet deep by 9 feet wide, its bottom flush with that of the main headrace, branches off at an angle of 45° downstream; flow through the race is controlled by two hinged gates that can be drawn upstream by a hand-operated hoisting gear.

The lower end of the head race and the turbine-pit structure support the power house, 60 feet long, 12 feet wide, 8 feet 3 inches from floor to top of walls, and 13 feet 6 inches to peak of roof. The generator room, 14 feet wide by 40 feet long, occupies the lower end of the power house; the vertical shaft from the turbine rises through the floor in the downstream end of the room and connects through beveled gears to a large pulley with horizontal shaft, belted to a Westinghouse 180-kilovolt-ampere alternator. The exciter for this unit was driven by pulley and belt from the end of the main generator shaft. The generator and exciter are still in position but no longer in use.

The No. 2 or central power house of the group of three is entirely below the level of the canal and is supplied through two sliding wooden gates, installed in a concrete gate structure and raised and lowered by rack and ratchet; a trash screen of 1 by 8 inch wooden bars, spaced about 6 inches, protects the upstream side of the gates. A short pressure pipe incased in concrete and of about 6 feet outside diameter runs down the outer bank of the canal at an angle of about 45° and connects at the back wall of the power house with a large cylindrical turbine casing. The turbine and generator are placed longitudinally down the center of the power house, with governor, exciter, and other auxiliary equipment along the sides. The building measures 16.5 by 50 feet in plan. The lower end of the house is partitioned off as switchboard room and office. The transformers are installed in a small frame ell adjoining the office.

Power house No. 3, like the others, is of frame construction; it is 43 feet long by 32.5 feet wide, with an extension 19 feet square on its downstream side. It rests on the concrete of the turbine pit and concrete base walls. Water is admitted to each of the two vertical turbines in a pit at the outer side of the canal through two sliding wooden gates protected by inclined trash racks constructed of ½ by 3 inch flat steel bars. The wicket gates of the turbines are controlled from the switchboard in power house No. 2 by a system of cables and pulleys. The vertical shafts of the turbines connect through gears to a horizontal pulley shaft supported by steel-beam bearings and concrete pedestals; the generator is operated by a rope drive placed in the lower end of the power house, below the level of the canal.

All three power houses are operated from the switchboard in the lower end of the central building.

Hydraulic equipment.—The vertical turbine installed in power house No. 1 was a 250-horsepower flume-type machine.

The generator in power house No. 2 was operated by a double horizontal 600-horsepower James Leffel & Co. turbine, controlled by a Woodward type LR 7 by 12 6,700-foot-pound vertical governor.

The two turbines in power house No. 3 are 25-inch 325-horsepower McCormick wheels with manual control by wires and pulleys from the main switchboard.

Generators.—The generator in power house No. 1 is a Westinghouse 180-kilovolt-ampere 2,300-volt 3-phase 60-cycle alternator; it is still in position but is not in use.

The generator in power house No. 2 is a General Electric ATB 450-kilovolt-ampere 2,300-volt 113-ampere 3-phase 60-cycle Form S alternator, designed to operate at 225 revolutions per minute. It is direct-connected to its turbine through a flanged coupling.

The generator in power house No. 3 was moved from the Gold Ray plant after the Keno development was leased by The California Oregon Power Co.; it is a General Electric ATB 450-kilovolt-ampere 2,300-volt 113-ampere 3-phase 60-cycle alternator operated by rope drive at 360 revolutions per minute; the generator and pulley for the rope drive are both mounted on the same heavy cast bedplate with three pedestal bearings.

Exciters.—The exciter in power house No. 1 is a Pacific Electric Engineering Co. type CQ 125-volt 4-kilowatt continuous-current generator designed to operate by belt drive from the end of the main generator shaft at 1,700 revolutions per minute.

The exciter in power house No. 2 is a General Electric type CBC 20-kilowatt 125-volt 160-ampere continuous-current generator operated by belt drive from the main generator shaft at 1,200 revolutions per minute.

The exciter in power house No. 3 is a General Electric 11-kilowatt 125-volt continuous-current generator driven by belt from the main generator shaft at 1,250 revolutions per minute.

Transformers.—All the transformer equipment for the three power houses is installed in a small frame building at the lower end of power house No. 2. The single bank of three transformers contains one Bullock self-cooled 300-kilovolt-ampere single-phase 60-cycle transformer and two General Electric water-cooled form HRP single-phase 60-cycle 300-kilovolt-ampere transformers with a ratio of 2,300/6,600–14,000 volts, Y connected. They are connected to give a line voltage of 14,000 on the outgoing line connecting with the main system at Klamath Falls. A set of General Electric type I form CD aluminum lightning arresters is installed in the transformer house.

COPCO PLANT.

Location.—The Copco dam and power house are in the SE. ¼ SW. ¼ sec. 29, T. 48 N., R. 4 W., on Klamath River 10 miles northeast of the point at which that stream is crossed by the San Francisco-Portland line of the Southern Pacific Railroad.

Construction of the Copco dam was begun by Siskiyou Power & Light Co. in 1911, but the first unit was not completed and put into service until January 23, 1918.

Reservoir.—Copco dam (Pl. XVI, *A*) is constructed of concrete, is arched on a radius of 356 feet, and, including gate structures, contains approximately 70,000 cubic yards of material. Deep pockets in the foundation made it necessary to excavate to a maximum depth of 120 feet and greatly increased the total yardage. The river bed at the dam is about 2,472 feet above sea level and the lowest point of the foundation about 2,352 feet. The width of the canyon at the ultimate crest level of the dam (including the gate structures) is 420 feet and the width at the river bed is 60 feet. The dam is 95 feet thick at base and 30 feet at the spillway level; the piers rising above the spillway lip are, however, only 15 feet thick at their bases. An outlet tunnel, 16 feet square and 13 feet above the original river bed, pierces the rocky point 85 feet in from the south end of the dam, and in the top of the dam are 16 openings, 7½ feet wide and 8 feet deep, which are provided with flashboards that may be removed to allow floods to pass over the crest of the dam.

The present area of the reservoir, with flashboards in place, is about 850 acres, and the maximum draw-down 4 feet. The available storage with 8-foot flashboards in place is somewhat over 2,000 acre-feet. The tops of the piers between the spillway openings are 2,582 feet above sea level, and the lip of the spillway is 2,574 feet. The height to which the dam will eventually be carried is between 2,590 and 2,596 feet above sea level. If the dam is carried to 2,590 feet, the area of the reservoir surface will be about 1,000 acres and the storage capacity 10,000 acre-feet.

Conduit.—The one unit installed is supplied by two riveted-steel pressure pipes, 10 feet in diameter and about 200 feet long, supported on masonry piers. These pipes, leaving the gatehouse of the dam, run nearly horizontal for a short distance, then bend downward and laterally through an angle of nearly 90° to the back wall of the power house, where they are tapered to a diameter of 8 feet for connection with the turbine casings. Water is admitted to the pipes through trash racks and sliding gates in the gatehouse at the north abutment of the dam, and immediately below the gatehouse there is a 30-foot standpipe in each line. The static head from the lip of the spillway (2,574 feet above sea level) to water surface in the tailrace (2,468 feet above sea level) is 106 feet. The upper lip of the draft tube is 2,466 feet, and the lower lip of the draft-tube outlet is 2,450.6 feet above sea level.

Power house.—The Copco power house (Pl. XVI, *A*) is on the north side of Klamath River immediately below Copco dam. It is built of reinforced concrete supported on heavy concrete foundations that extend down to bedrock. The corrugated galvanized-iron roof, with louver ventilator, is supported on steel trusses. The building is to be extended at the downstream end to a length of 134 feet, but in 1921 only the upstream half of the structure had been constructed. The total inside width of the power house is 57 feet 6 inches and is divided into a generator room 44 feet 6 inches and a series of bays 13 feet wide. The generator room is 26 feet high from floor to crane rail and 33 feet 1 inch from floor to the lower chord of the roof trusses. The generator room extends the entire length at the back, and the transformer and switchboard bays the entire length of the front of the building. There is a horizontal tunnel under the generator room and another under the transformer bays. The floor of the power house is 2,483.9 feet above sea level, and the generator shaft is 2,488 feet above sea level. Two 40-ton cranes command the generator floor.

Hydraulic equipment.—The single unit is operated by an Allis-Chalmers turbine of the double inflow type. As originally designed, both runners were to be under a single housing and were to be supplied by a 17-foot pressure pipe. This arrangement was changed during construction and the turbine is provided with a double-scroll case, each 120-inch runner being supplied by a 10-foot pipe. The rated capacity of the turbine is 18,600 horsepower, and it is designed to operate under the ultimate head of 125 feet.

Generator.—The single generator is a General Electric 12,500-kilovolt-ampere (16,750 horsepower) 2,300-volt 3,140-ampere 3-phase

60-cycle horizontal machine, direct-connected to the turbine shaft and operated at 200 revolutions per minute. The unit is controlled by an Allis-Chalmers governor.

Exciters.—Two General Electric 250-volt 200-kilowatt exciters, sufficient to provide exciting current not only for the present but for the ultimate installation, are now in place. Each exciter is direct-connected to an Allis-Chalmers Francis turbine, rated at 300 horsepower and designed to operate at 720 revolutions per minute under a 125-foot head. A flywheel is mounted on the shaft between the turbine and the exciter generator, and each exciter unit is controlled by an Allis-Chalmers governor.

Transformers.—The single unit now installed is connected through double busses to two banks of three General Electric 4,165-kilovolt-ampere single-phase water-cooled transformers, giving a total transformer capacity of 24,990-kilovolt-amperes, or sufficient for the development planned. One bank is delta connected, giving 34,000 volts, for delivery to the line running from the Fall Creek plant east to Klamath Falls. The other bank is Y connected, grounded, and joined by a short stub line to the 60,000-volt main transmission line running south from the Fall Creek plant.

CARRVILLE PLANT.

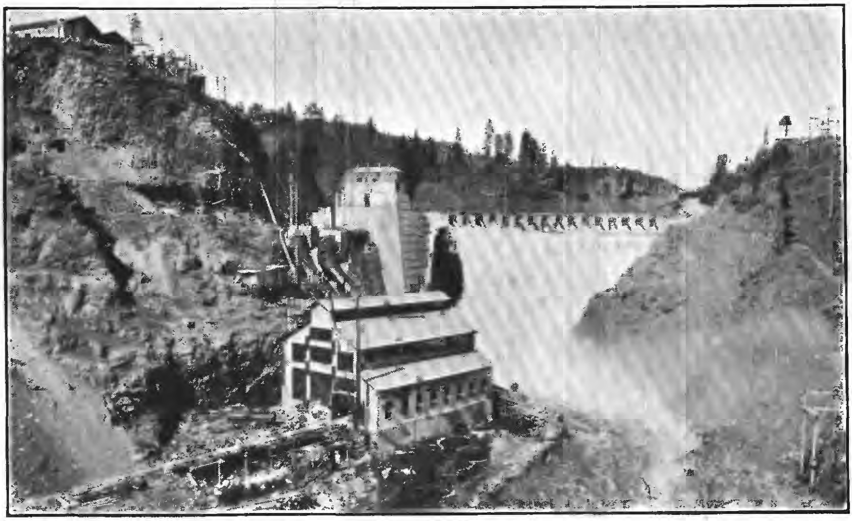
LOCATION.

The Carrville plant is near the junction of Coffee Creek with Trinity River. The intake is about 2½ miles above that junction, in the NW. ¼ sec. 7, T. 37 N., R. 7 W., the conduit traverses secs. 7 and 8 to the forebay at the head of the pressure pipe in sec. 17, and the pressure pipe runs southeasterly to the power house in the southeast corner of the NW. ¼ NW. ¼ sec. 17 of the same township.

The plant was constructed by Trinity Gold Mining & Reduction Co. It was purchased by California-Oregon Power Co. and connected June 1, 1916, to its transmission line serving the Trinity River mining district.

SOURCE OF WATER SUPPLY.

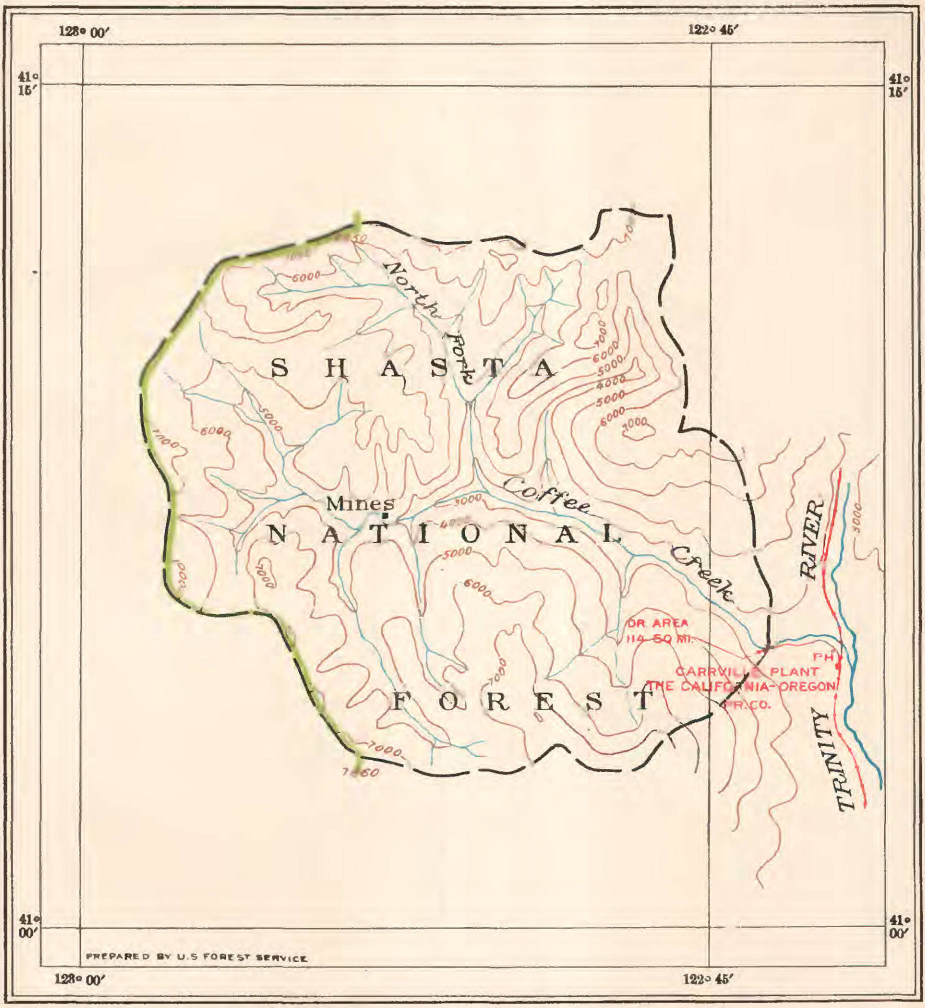
Coffee Creek, from which the Carrville plant obtains its water supply, drains an area in the northern part of Trinity County, in the northwestern part of the State (Pl. XVII). The average length and width of the basin are about equal, between 10 and 11 miles, and the total area above the intake of the power plant is 114 square miles. Elevations within the basin range from 2,500 feet up to 8,250 feet above sea level, most of the area exceeding 5,000 feet. The general course of the stream is eastward from its headwaters in the Salmon River Alps to its junction with Trinity River. Its principal tribu-



A. COPCO POWER HOUSE AND DAM.
Photograph by Miller Photo Co., Klamath Falls, Oreg.

B. GENERATOR AND TRANSFORMER HOUSES, FALL CREEK PLANT.

HYDROELECTRIC SYSTEM OF THE CALIFORNIA OREGON POWER CO.



MAP OF COFFEE CREEK BASIN, CALIFORNIA
SHOWING HYDRO-ELECTRIC DEVELOPMENTS

Scale 1 : 250,000

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

0 1 2 3 4 5 Miles

Contour interval 1,000 feet

1922

taries rise on the south slope of Scott Mountains and enter from the north.

The upper parts of the amphitheater formed by the Salmon River Alps and the Scott Mountains are extremely rugged, but in the central part of the basin the topography is more regular. The rocks in the extreme eastern and in some restricted areas in the central part of the drainage basin are granitic. The rocks of the lower part of the basin consist of metamorphic gneiss and schists, but those most widely exposed are serpentines. The entire basin is well forested with pine and fir.

The annual precipitation probably varies between 30 and 50 inches, and much of it is in the form of snow which lies throughout the year in protected places on the northern slopes of the Salmon River Alps.

RESERVOIRS.

Near the headwaters of the stream are several small lakes that are not large enough to afford any natural regulation of the flow.

Two mines operate small reservoirs that supply water for hydraulic mining and are provided with automatic waste gates which trip when the water level has risen to a certain elevation and "shoot" the contents of the reservoir into the channel. These two reservoirs, one of which has a capacity of 125 acre-feet and the other 40 acre-feet, are about 10 miles above the power house. They are operated between the months of April and July. At the beginning of the season these dams fill and "shoot" once an hour, but by the end of the season, in July, not more than once in 20 to 24 hours. During high water the effect of this action is hardly perceptible, but late in the season their discharge results in a pronounced fluctuation in the stream flow.

A gaging station was established December 16, 1910, and complete records are available up to September 30, 1914.[5]

CONDUIT.

Water is diverted from the creek at an elevation of about 2,500 feet above sea level. An outcrop of solid rock that forms the south bank and extends about half-way across the stream bed affords an excellent foundation for the concrete section of the diversion dam, about 8 feet in maximum height, 2 feet wide on top, with a vertical upstream face and 1 to 1 slope on the downstream face. A log dam with board facing connects the north end of this concrete section with the north bank of the stream. A higher water level at the head gate than that due to the dam is obtained by placing two logs, partly covered with vertical boards, diagonally across the streams deflecting the current toward the wooden head gates at the south bank.

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[5] U. S. Geol. Survey Water-Supply Papers as follows: 300, pp. 901–904 (reports up to June 30, 1912); 331 pp. 404–406 (1911–12); 361, pp. 477–481 (1912–13); 391, pp. 319–320 (1913–14).

The entire conduit from the intake to the head of the pressure pipe is a flume laid on a bench excavated in the hillside or supported on short trestles, and running almost due east to a point about half-way to the power house, where it turns nearly due south. Its length from intake to the head of the pressure pipe is 8,852 feet. The flume box is 4 feet wide and 2 feet 10½ inches deep inside, and its grade is 10.56 feet per mile (2 feet per thousand). Measurements taken in the flume when flowing three-quarters full have shown a velocity of 5 feet per second and a capacity of 51.6 second-feet.

At the lower end of the flume a forebay box 20 feet long, 12 feet wide, and 8 feet deep, provided with screens and wasteway, serves as a heading for the pressure pipe. A box flume 2 feet square and 100 feet long carries off any discharge from the wasteway. The first 250 feet of the pressure pipe is 32 inches, and the last 330 feet is 30 inches in diameter, the total length being 580 feet. The entire pipe is of riveted steel and is laid in a trench and buried for most of its length. The static head between water surface at the box forebay and the tail water at the power house is 107 feet.

GENERATING STATION.

Power house.—The power house is a wooden structure, about 40 feet long by 25 feet wide and 12 feet high to the eaves. A 2-ton hand operated chain-block is supported from the wooden roof system. The single unit is placed with its shaft parallel to the main axis of the power house but toward the back of the station. The pressure pipe, entering through the back wall at north side of the building, runs directly to the turbine.

Hydraulic equipment.—Inside the power house the pressure line passes through a hydraulic gate valve before connecting with the turbine, which discharges through a draft tube into a tailrace, about 100 feet long, leading to the creek. The single horizontal unit is operated by a 460-horsepower 24-inch Francis turbine (designed by O. C. Goeriz and constructed by the Joshua Hendy Iron Works Co.) connected to the generator through a flexible coupling. Both generator and turbine are set on concrete foundations and there is a bearing between them. The scroll case of the turbine is constructed of riveted steel plates. The unit is controlled by a Lombard governor, type R.

Generator.—The General Electric ATB 400-kilovolt-ampere (536 horsepower) 2,300-volt 100-ampere 3-phase 60-cycle alternator, operated at 514 revolutions per minute, is supported by ring-oiling bearings set on a cast bed plate.

Exciter.—The exciter is a General Electric 125-volt 64-ampere 8-kilowatt direct-current machine mounted on a steel bracket on the end of the unit and is operated by the main generator shaft.

Wiring.—The original potential of the generator was 4,000 volts and its entire output was transmitted a distance of only 7,600 feet to a mine. The power house is now connected to the California-Oregon transmission system by a line running 2 miles south to the Coffee Creek substation.

A single set of General Electric aluminum-cell lightning arresters is installed on the outgoing circuit of No. 6 copper wire which is operated at the generator potential—2,300 volts.

ROGUE RIVER PLANTS.

SOURCE OF WATER SUPPLY.

Rogue River furnishes water for two plants operated by The California Oregon Power Co.—the Prospect and Gold Ray plants. The river heads in volcanic country on the west slope of the mountain surrounding Crater Lake and its general course is westerly to the ocean, which it enters near the town of Gold Beach in Curry County, Oreg. (See Pl. XVIII, in pocket.) Elevations within the part of the drainage basin above the power plants range from 1,200 feet above sea level to 9,760 feet on Mount Pitt or Mount McLaughlin. The area of the drainage basin above Prospect plant is 263 square miles and above the Gold Ray plant 2,020 square miles.

The rocks of the basin are volcanic and the forest cover over most of the area is excellent. Precipitation probably ranges from 30 inches in the lower reaches to 100 inches in the vicinity of Crater Lake. The low flow of the stream is derived principally from spring-fed tributaries.

Stream-flow records are available for a station near Prospect from 1905 to 1920.[6]

The only artificial storage reservoir in the drainage basin is the pond above the Gold Ray dam.

PROSPECT PLANT.

Location.—The Prospect plant is on the north bank of Rogue River in the SW. ¼ NW. ¼ sec. 6, T. 33 S., R. 3 E., Willamette base and meridian, about 2 miles above the mouth of the Middle Fork, some 40 miles northeast of Medford.

The station was put into operation by Prospect Construction Co. in February, 1911.

Conduit.—A masonry head dam, about 80 feet long by 6 feet high, diverts from the west side of North Fork of Rogue River into a flume of varying width, depth, and grade, 10,024 feet long, with a carrying capacity of 200 second-feet. At its lower end the flume discharges into a concrete forebay 120 feet long, 50 feet wide, and

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[6] U. S. Geol. Survey Water-Supply Papers 177, 214, 252, 272, 292, 312, 332, and 362 (consolidated in Water Supply Paper 370, pp. 631-638), 394, 414, 464, 484, 514 (in preparation)

10 feet deep, from which water is admitted through sliding gates and a 96–60-inch taper joint to a riveted steel pressure pipe about 1,034 feet long; the pipe itself varies in diameter from 60 to 48 inches and in thickness from one-fourth inch at the upper end to three-fourths inch at the lower end. The effective head is about 500 feet.

Power house.—The power house is a temporary wooden structure built on concrete foundations, is covered with composition paper roofing, and measures 50 by 80 feet in plan and 21 feet in clear height. It contains one unit with necessary exciters and auxiliary equipment.

Hydraulic equipment.—An Allis-Chalmers Francis horizontal turbine, rated at 7,000 brake horsepower under a 525-foot head at a speed of 514 revolutions per minute, is direct-connected to the generator. The turbine is controlled by a No. 3 Allis-Chalmers governor with synchronous by-pass. There is also a hydraulically operated gate valve in the pressure pipe.

Generator.—The main unit is a General Electric 4,700-kilovolt-ampere (3,760 kilowatt, or 5,040 horsepower, at 80 per cent power factor) 2,300-volt 3-phase 60-cycle alternator.

Exciter.—No. 1 exciter, belt-connected to the main unit, is an Allis-Chalmers 45-kilowatt 360-ampere 125-volt direct-current generator, operated at 900 revolutions per minute; No. 2 exciter unit is an Allis-Chalmers impulse wheel, rated at 450 brake horsepower with a speed of 500 revolutions per minute, direct-connected to an Allis-Chalmers direct-current generator with a capacity of 1,600 amperes at 125 volts, giving 200 kilowatts. The exciter unit is controlled by an Allis-Chalmers governor, size 0.

Transformers.—The transformer equipment consists of three 1,566-kilovolt-ampere General Electric water-cooled oil-insulated single-phase transformers, with a ratio of 33,000 and 66,000 to 2,300 volts. The outgoing line is operated at 66,000 volts.

Wiring.—The 5-panel switchboard contains one generator, one transformer, one voltage regulator, and two exciter panels. Hand operated oil switches are installed on both high and low tension circuits. The power house is connected to the main transmission system at the Gold Ray power house by a single 3-phase circuit of No. 0 seven-strand aluminum cable.

GOLD RAY PLANT.

Location.—Gold Ray plant was built by Condor Water Co. in 1903 and 1904. The power house and the diversion dam are both in the SW. ¼ sec. 18, T. 36 S., R. 2 W., Willamette base and meridian.

Conduits.—The Gold Ray plant obtains all its drop from a rock-filled timber-crib diversion dam on Rogue River at an elevation of about 1,200 feet above sea level. The dam is arched in plan and is about 420 feet long by 20 feet in maximum height and has a concrete cut-off along its lower and a plank facing on its upstream side. A concrete wall, running upstream from its north end, forms a forebay or headrace, 60 feet wide by about 12 feet deep, leading to the power house, which is just below the dam on the north bank of the stream. The static head is merely that available from the dam, about 20 feet.

Power house.—The power house is a concrete building, about 85 feet long by 35 feet wide at operating level, containing two units operated by turbines. In addition to the main power house there is a repair shop 12 by 20 feet in plan and 24 feet high, constructed of concrete; and a transformer house 32 by 26 feet in plan and 24 feet high, constructed of corrugated iron on a wood frame.

Hydraulic equipment.—Each of the two original 750-kilovolt-ampere units was operated through rope drive by a pair of 42-inch horizontal McCormick turbines, rated at 1,000 horsepower with a speed of 145 revolutions per minute. A 450-kilovolt-ampere unit, operated also through a rope drive by a pair of 25-inch vertical McCormick turbines, was moved to Keno plant in 1920. Admission of water to the turbines is controlled partly by Taintor gates and partly by sliding gates.

Generators.—The first and second units are 750-kilovolt-ampere General Electric ATB 3-phase 60-cycle 2,300-volt alternators; the third unit was a 450-kilovolt-ampere General Electric ATB 3-phase 60-cycle 2,300-volt alternator, with a speed of 360 revolutions per minute; the total capacity of the station was therefore 1,950 kilovolt-amperes, or 2,613 horsepower, until 1920, when it was reduced to 1,500 kilovolt-amperes, or 2,010 horsepower, by the removal of one 450-kilovolt-ampere unit to the Keno plant.

Exciters.—An 11-kilowatt 125-volt direct-current exciter is belted to each main unit.

Transformers.—Six 250-kilowatt 2,300/20,000-volt water-cooled transformers are installed out of doors, and the corrugated-iron transformer house contains a bank of three 1,566-kilovolt-ampere 6,600/33,000–20,000-volt General Electric water-cooled transformers.

Wiring.—The switching equipment is in the transformer houses and is controlled from the power house by a switchboard containing two generator panels, one exciter panel, and one Tirrill voltage-regulator panel.

TRANSMISSION AND DISTRIBUTION LINES.

Data concerning the transmission lines of The California Oregon Power Co. are given in Table 13. The capacities of the substations of the California division of the company are shown in Table 14.

TABLE 13.—*Transmission lines operated by California-Oregon Power Co. Dec. 31, 1920.*

District.	Miles constructed.	District.	Miles constructed.
Hornbrook	51.2	Sisson	13.6
Montague	25.9	Dunsmuir	4.6
Yreka	15.4	Castella	26.8
Fort Jones	12.5	Carrville	22.5
Greenview	5.1	Trinity	1.7
Etna	7.9	Dorris	20.9
Dwinell	4.0	Mileage in California	243.1
Grenada	3.8	Mileage in Oregon	222.6
Big Springs	15.2	Total mileage	465.7
Weed	12.0		

NOTE.—All lines are supported on wooden poles; one circuit from each station.

TABLE 14.—*Rated capacity of substations operated by California-Oregon Power Co. Dec. 31, 1920.*

	Kilovolt-amperes		Kilovolt-amperes.
Hornbrook	200	Weed	3,000
Hilt	900	Sisson	300
Montague	225	McCloud	600
Yreka	630	Dunsmuir	600
Mount Vernon	270	Maxwell	600
Fort Jones	189	Castella	225
Greenview	100	Carrville	750
Etna	72	Trinity	900
Walker Bryan	36	Dorris	1,340
Dwinell	666	Rogue River division (Oregon)	6,444
Grenada	750	Klamath River division (Oregon)	3,030
Lucerne	600		
Big Springs	600		23,027

PACIFIC GAS & ELECTRIC CO.

HISTORY.

ORGANIZATION.

Pacific Gas & Electric Co. operates the largest transmission network in California and one of the largest in the world. It is a preeminent example of the great tendency toward consolidation that has been manifest in nearly all hydroelectric development on the Pacific coast. The company was incorporated October 10, 1905, with a capitalization of $30,000,000[7] as a holding and operating company to take over California Gas & Electric Corporation and San Francisco Gas & Electric Co. California Gas & Electric Corporation had already absorbed many systems of moderate size, which, in the early days of electric transmission in California, began operations by building power plants along the west slope of the Sierra from Mokelumne River northward to Butte Creek, and San Francisco Gas & Electric Co. had consolidated several steam-electric systems operating in San Francisco. Among the properties thus acquired by Pacific Gas & Electric Co. were the Folsom, Nevada, Yuba, Newcastle, Auburn, Alta, Colgate, Centerville, De Sabla, and Electra hydroelectric generating stations and several steam plants. In addition to the properties that came into its possession when it was formed, the company has purchased from time to time the stock and properties of minor generating and distributing concerns with which it came into contact at

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[7] Subsequent changes in the capitalization of the company are reported in Appendix A and in Table 191.

various points, and it has also acquired title in fee to the properties of companies that were formerly controlled only by stock ownership. Recent noteworthy acquisitions include the stock and properties of Oro Electric Corporation, which was merged in 1917, and those of Northern California Power Co. Consolidated, which became part of the system in 1919.

On January 17, 1920, the Railroad Commission of California approved the lease of the system of Sierra & San Francisco Power Co. to Pacific Gas & Electric Co. for a period of 15 years beginning January 1, 1920, Pacific Gas & Electric Co. agreeing to properly maintain and operate the properties; to pay the cost of such maintenance and operation; to pay all taxes and governmental expenses; to pay annually $30,000 into a fund to amortize bond discount and expense (this amount to be increased if additional bonds are issued by Sierra & San Francisco Power Co. for certain specified purposes); to pay into a special depreciation fund an amount equal to 2 per cent of the gross revenues obtained by Pacific Gas & Electric Co. from the leased properties, or such other amount as may be fixed by the Railroad Commission; to pay bond interest; and to pay as rental $50,000 during the first year of the lease, $50,000 the second year, $100,000 the third year, and $150,000 annually thereafter during the life of the lease. Pacific Gas & Electric Co. is to undertake all necessary extensions of the Sierra & San Francisco system and will hold a lien upon Sierra & San Francisco Power Co. for such expenditures, subject, of course, to that company's first and second mortgages. The lease was prepared on the theory that Sierra & San Francisco Power Co. would from time to time issue and be able to sell its first-mortgage bonds, the proceeds of which must be used to reimburse Pacific Gas & Electric Co., and that if it is impossible to sell the bonds, they shall be delivered to Pacific Gas & Electric Co. and held by it as collateral security for the payment of any advances made during the period of the lease. The issue of such bonds is, however, to be subject to future authorization by the Railroad Commission.[7a]

[7a] Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co. were, up to Jan. 1, 1920, operated practically as a single system, although they were distinct corporations, both under control of the same holding company. Coast Valleys Gas & Electric Co. was not leased by Pacific Gas & Electric Power Co.

The history, market, and electric properties of the combined Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co. are covered by pp.286–338. Operating data in the text and tabulations are carried up to the end of 1920 for Coast Valleys Gas & Electric Co., but only to the end of 1919 for Sierra & San Francisco Power Co., the operation for the year 1920 for the Sierra & San Francisco Co. being in the tables consolidated with that of Pacific Gas & Electric Co. The descriptions of the power plants belonging to Sierra & San Francisco Power Co. have been brought up to Oct. 1, 1921, although the plants have, since Jan. 1, 1920, been operated by Pacific Gas & Electric Co.

Data covering transmission system and substations of Sierra & San Francisco Power Co. are shown as of Dec. 31, 1919, on pp. 328–338. The lines and substations of Sierra & San Francisco Power Co. are also included as they stood Dec. 31, 1920, in Pacific Gas & Electric Co. text and tabulations on pp. 278–285.

Financial data for both Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co. are given in Tables 205 to 215, inclusive, Appendix A. The marked change in earnings and expenses of Sierra & San Francisco Power Co. for 1920, as compared with previous years, is due to the fact that on Dec. 31, 1919, it ceased to be an operating company.

On October 1, 1920, Pacific Gas & Electric Co. was operating 27 hydroelectric plants with a combined installation of 229,200 kilovolt-amperes, or 307,127 horsepower, and four steam plants with a combined installation of 122,500 kilovolt-amperes, or 164,150 horsepower, giving a total rated generating capacity of 351,700 kilovolt-amperes, or 471,277 horsepower for the system. Four of the hydroelectric and one of the steam-electric plants were operated under a lease from Sierra & San Francisco Power Co. Eight of the plants owned by Pacific Gas & Electric Co. were put into operation after it acquired the properties of California Gas & Electric Corporation. Of these eight, the Deer Creek plant began to operate in 1908, the Drum plant in 1913, the Halsey plant in 1916, the Wise and Spaulding No. 1 plants in 1917, the Spaulding No. 2 plant in 1920, and the Hat Creek Nos. 1 and 2 plants in 1921.

Pacific Gas & Electric Co. has also made large additions to its great transmission network. Aside from interconnection to the Great Western and other systems serving central California, Pacific Gas & Electric Co.'s transmission ties into that of The California Oregon Power Co. in the north, and that of San Joaquin Light & Power Corporation in the south, thus being a connecting link in transmission lines extending from southern Oregon to the Mexican boundary.

The company would have long since been unable to meet the demands of its market had it not purchased power from Great Western Power Co. of California, Northern California Power Co. Consolidated (which now forms part of the system), and minor generating companies.

The relations of the corporations that have been combined to form Pacific Gas & Electric Co. are shown in Table 15, and the finances of the system are covered by Appendix A, Tables 191–205. A brief account of the organization and development of the systems acquired by the company is presented in the following pages. Figure 4 shows the growth of earnings from 1904 to 1920.

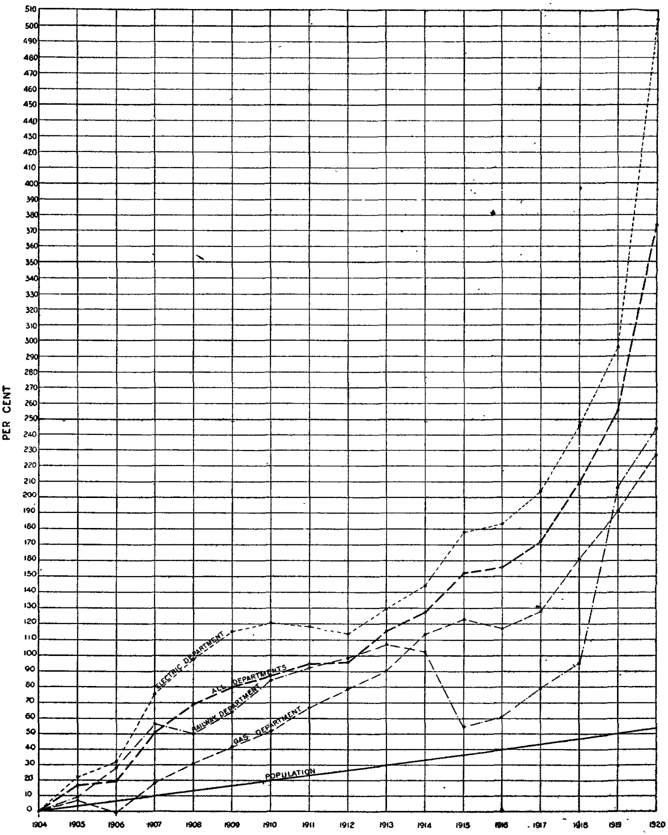

FIGURE 4.—Pacific Gas & Electric Co., growth of earnings by departments, 1904-1920.

TABLE 15.—*Pacific Gas & Electric Co., its predecessors and components, Dec. 31, 1920.*

Name of corporation.	Date of incorporation.[a]	Control of stock obtained by successor.	Properties deeded to successor.
Pacific Gas & Electric Co.	Oct. 10, 1905		
California Gas & Electric Corporation	Dec. 6, 1901	Dec. 30, 1905	Jan. 28, 1908
California Central Gas & Electric Co.	Mar. 25, 1901	Aug. 24, 1903	Dec. 18, 1905
Marysville Gas & Electric Co.	Nov. 12, 1895		July 31, 1901
Marysville Coal Gas Co.	June 10, 1858		Nov. 30, 1895
Nevada County Gas & Electric Co.	May 28, 1901		Nov. 24, 1908
Nevada City Gas Co.	(1885)		1901
Grass Valley Gas Co.	(1885)		1901
Napa Gas & Electric Co.	July 8, 1899		Oct. 7, 1901
Napa Thomson-Houston Light Co.	(1887)		Sept. 12, 1899
Napa Gas Light & Heating Co.	Dec. 4, 1888		Oct. 30, 1899
Napa City Gas Light Co.	May 28, 1867		1889
Colusa Gas & Electric Co.	July 31, 1901		Dec. 18, 1905
Colusa Light & Power Co.	Aug. 11, 1900		1901
Colusa Gas Co.	Mar. 5, 1886		1900
Colusa Gas Co.	Apr. 28, 1881		Mar. 5, 1886
Woodland Gas & Electric Co.	Jan. 9, 1901		Nov. 24, 1908
Consolidated Electric Light, Gas & Power Co.	Feb. 1, 1888		July 12, 1901
Woodland Gas Co.	(1874)		1888
Chico Gas & Electric Co.	Jan. 30, 1901		July 31, 1901
Chico Gas Co.	(1872)		1901
Petaluma Gas & Electric Co.	Apr. 15, 1899		Nov. 24, 1908
Western Refrigerating Co.	(1898)		Oct. 2, 1901
San Rafael Gas & Electric Co.	Nov. 13, 1887		Do.
San Rafael Gas Co.	(1883)		1887
Merchants Lighting Co. of Santa Rosa	Feb. 17, 1892		Dec. 24, 1908
Santa Rosa Lighting Co.	Sept. 15, 1888		Oct. 19, 1901
Santa Rosa Gas Light Co.	Apr. 23, 1876		Feb. 2, 1889
Fresno Gas & Electric Light Co.	Dec. 21, 1888	Feb. , 1902	Dec. 20, 1905
Fresno Gas Light Co.	Dec. 15, 1882		Dec. 27, 1888
Fresno Gas Co.	Apr. 4, 1881		1883
Edison Electric Light & Power Co. of Fresno	Aug. 10, 1891		Dec. 17, 1892
Sacramento Electric, Gas & Railway Co.	Apr. 4, 1896		Oct 23, 1907
Sacramento Electric Power & Light Co.	Nov. 5, 1892		June 30, 1896
Central Electric Railway Co.	Apr. 20, 1891		May 3, 1894
Sacramento Railway & Improvement Co	Aug. 30, 1890		1891
Folsom Water Power Co.	Oct. 18, 1881		June 30, 1896
Natoma Water & Mining Co.	July 13, 1853		Dec. 8, 1881
Capitol Gas Co.	Jan. 4, 1875		Aug. 15, 1902
Sacramento Gas Co.	(1854)		1875
Citizens Gas Light & Heat Co.	Jan. 18, 1872		1875
Citizens Gas Light Co.	Mar. 21, 1871		1872
Pacific Thomson Electric Light & Power Co.	Apr. 26, 1884		July 22, 1887
Sacramento Electric Light Co.	(1884)		Nov. 2, 1889
South Yuba Water Co.	Aug. 3, 1891		Dec. 31, 1910
South Yuba Water & Mining Co.	Apr. 1, 1880		Aug. 3, 1891
South Yuba Canal Co.	Feb. 7, 1870		Apr. 1, 1880
Rock Creek, Deer Creek & South Yuba Canal Co.	(1850)		1860
Dutch Flat Canal System and predecessors	(1855)		1880
Bear River & Auburn Water & Mining Co.	(1851)		1890
Central California Electric Co. (incorporated June 6, 1895, New Jersey).	May 11, 1904	June 6, 1895	Dec. 31, 1910
San Francisco Gas & Electric Co.	Dec. 11, 1896	Dec. 31, 1905	Nov. 27, 1911
San Francisco Gas Light Co.	Mar. 17, 1873		Jan. 21, 1897
San Francisco Gas Co.	Sept. 29, 1852		Apr 18, 1873
Citizens Gas Co.	Jan. 5, 1863		1866
Aubin Gas Co.	Mar. 16, 1857		1857
Metropolitan Gas Co.	May 13, 1863		1873
City Gas Co.	Apr. 6, 1870		Apr. 9, 1873
Edison Light & Power Co.	July 1, 1891		Jan. 21, 1897
California Electric Light Co.	June 30, 1879		July 2, 1891
Electric Improvement Co.	Mar. 21, 1887		1892
Harbor Light & Power Co.	Jan. 10, 1894		Jan. 21, 1897
Western Light & Power Co.	Apr. 30, 1893		Do.
Pacific Gas Improvement Co.	Oct. 1, 1884		Sept. 1, 1903
United Gas Improvement Co.	1882		July 16, 1900
Central Gas Light Co.	Mar. 25, 1882		1882
Central Gas Co.	Mar. 24, 1881		1882
Equitable Gas Light Co.	Feb. 21, 1898		Aug. 31, 1903
Independent Electric Light & Power Co.	Mar. 29, 1899	July 2, 1903	Nov. 9, 1903
Independent Gas & Power Co.	Jan. 5, 1901	do.	Do.
United Pacific Power Co.	Nov. 17, 1902		Jan. —, 1903
Commercial Light & Power Co.	(1895)		Aug. —, 1898
California Hotel Co. (plant)	Feb. 15, 1904		Apr. 5, 1905
Central Light & Power Co.	Aug. 18, 1897		Mar. 6, 1907

[a] Dates given are dates articles of incorporation were received by the Secretary of State.

TABLE 15.—*Pacific Gas & Electric Co., its predecessors and components, Dec. 31, 1920*—Continued.

Name of corporation.	Date of incorporation.	Control of stock obtained by successor.	Properties deeded to successor.
Pacific Gas & Electric Co.—Continued.			
Metropolitan Gas Corporation	Nov. 22, 1911		Nov. 29, 1911
Metropolitan Light & Power Co	Mar. 7, 1907		Nov. 23, 1911
San Francisco Coke & Gas Co	Oct. 31, 1899		Do.
Mutual Electric Light Co	Dec. 15, 1894		Nov. 27, 1911
Sacramento County Water Co	Nov. 5, 1892		Sept. 22, 1909
Solano Electric Light & Gas Co	May 7, 1895		May 14, 1910
Benicia Gas Co	Apr. 19, 1881		Dec. 6, 1896
Dixon Electric Power & Water Co	Feb. 26, 1903		May 14, 1910
Dixon Light & Water Co	Aug. 5, 1891		1903
Isaac Hyman properties (Folsom)	(1901)		May 13, 1910
E. D. N. Lehe properties (Cordelia, Davis, Dixon, etc.)	(1901)		May 16, 1910
Oakland Gas Light & Heat Co	July 18, 1884	Oct. 23, 1907	Mar. 9, 1908
Oakland Equitable Gas Co	Jan. 13, 1899		Oct. 28, 1907
Berkeley Electric Lighting Co	June 6, 1894		Oct. 23, 1907
Berkeley Electric Light, Heat & Power Co.	(1891)		1894
San Francisco Electric Co	(1891)		1894
Oakland Gas Light Co	June 15, 1866		Aug. 29, 1884
Alameda Gas Co	(1883)		1884
Oakland Electric Light & Motor Co	Nov. 2, 1887		Nov. 29, 1907
Bay Counties Power Co	June 4, 1900		Oct. 23, 1907
Yuba Electric Power Co	Jan. 30, 1899		May 25, 1900
Yuba Power Co	Oct. 27, 1897		Feb. 4, 1899
Nevada County Electric Power Co	Sept. 22, 1892		May 25, 1900
Valley Counties Power Co.[b]	Jan. 25, 1902		Oct. 23, 1907
Butte County Power Co	Feb. 25, 1901		Feb. 11, 1902
Butte County Electric Power & Lighting Co.	Apr. 12, 1899		Nov. 24, 1908
Cherokee Mining Co	1858		1902
The Standard Electric Co. of California	Nov. 27, 1897		Mar. 1, 1904
Blue Lakes Water Co	Apr. 17, 1890		1897
The Blue Lakes Water Co	Feb. 25, 1887		1890
Amador Canal & Mining Co	July 1, 1873		Feb. 28, 1887
Stockton Water Co	Oct. 25, 1890		Oct. 23, 1907
Stockton Water Works Co	Aug. 3, 1867		Mar. 21, 1891
P. E. O'Connor	(1859)		1868
Sierra Nevada Irrigation & Power Co	Apr. 1, 1893		Mar. 19, 1895
California Exploration Co. (Ltd.)	1898		Feb. 27, 1903
California Exploration Co	Apr. 13, 1896		Jan. 27, 1898
San Mateo Power Co.[c]	Jan. 26, 1905	Jan. 26, 1905	Oct. 23, 1907
Pyramid Power Co	Nov. 1, 1902		Do.
Standard Electric Distributing Co.[d]	June 3, 1901		Do.
United Gas & Electric Co	Apr. 19, 1902	Apr. 1, 1904	Do.
Consolidated Light & Power Co	Jan. 2, 1900		July 18, 1902
San Mateo Gas Light Co	Mar. 15, 1892		Feb. 13, 1902
Redwood City Electric Co	do		1900
Peninsular Lighting Co	Aug. 26, 1896		1900
San Mateo Electric Light Co	1895		1900
Electric Improvement Co. of San Jose	Oct. 12, 1889		June 19, 1902
San Jose Light & Power Co	June 21, 1889		June 23, 1902
San Jose Brush Electric Light Co	1882		1889
San Jose Gas Co	1860		1889
Vallejo Gas Co	Oct. 20, 1904	Mar. 1, 1905	Dec. 18, 1905
Vallejo Gas Light Co	Sept. 14, 1867		Nov. 10, 1904
M. P. Young	(1861)		1867
Leonard Prior (Suisun Light & Power Co.)	(1901)		June 1, 1910
Newman Light & Power Co	Dec. 19, 1904		May 18, 1910
Suburban Light & Power Co	Mar. 11, 1908		Dec. 29, 1910
San Leandro Gas & Electric Co	Nov. 27, 1889		Aug. 13, 1908
Suburban Electric Light Co	June 14, 1901		Aug. 3, 1908
Contra Costa Electric Light & Power Co	Oct. 19, 1903		Sept. 22, 1910
Redwood Manufacturers Co. (Black Diamond)	Sept. 25, 1903		Sept. 30, 1910
Live Oak & Encinal Light & Power Co	Sept. 25, 1908		Dec. 16, 1911
Daniel C. Gillen (Colfax)	(1904)		July 1, 1913
Sebastopol Light, Power & Water Co	Mar. 7, 1905		Apr. 1, 1911
South San Francisco Power & Light Co	June 25, 1900		Mar. 14, 1911
Los Gatos Ice, Gas & Electric Co	Mar. 9, 1907		Oct. 11, 1912
Livermore Water & Power Co	June 12, 1896		May 1, 1913
United Water & Power Co. of California	July 2, 1907		July 18, 1913
Cataract Gold Mining & Power Co.[e]	1909	Feb. 1, 1916	Jan. 8, 1917
Butte & Tehama Power Co.[e]	Apr. 17, 1909	do	Do.
Sierra Irrigation Co	Jan. 6, 1910	do	Do.
West Sacramento Electric	Sept. 5, 1913		Sept. 5, 1915

[b] Valley Counties Power Co. owned and organized by Bay Counties Power Co.

[c] Incorporated and entire stock owned by United Gas & Electric Co.

[d] Holding company only, controlled The Standard Electric Co. of California.

[e] Oro Water, Light & Power Co. owned controlling interest in stock of Cataract Gold Mining & Power Co. and Butte & Tehama Power Co.

TABLE 15.—*Pacific Gas & Electric Co., its predecessors and components, Dec. 31, 1920*—Continued.

Name of corporation.	Date of incorporation.	Control of stock obtained by successor.	Properties deeded to successor.
Pacific Gas & Electric Co.—Continued.			
Oro Electric Corporation	Mar. 11, 1911		Jan. 8, 1917
Oro Water, Light & Power Co	Feb. 24, 1905		Mar. 12, 1912
Oroville Water Co	Jan. 10, 1878		Aug. 15, 1905
Lava Bed Dredging Co	May 18, 1900		1912
Marigold Dredging Co	July 10, 1901		1912
Rio Rancho Co	Nov. 26, 1897		1912
Oroville Light & Power Co	Nov. 5, 1901		Apr. 16, 1917
Oroville Gas, Electric Light & Power Co	(1895)		Dec. 10, 1902
Oroville Electric Light Co	(1889)		July 10, 1895
Northern California Power Co. Consolidated	Oct. 12, 1908	Aug. 28, 1919	Oct. 3, 1919
Northern California Power Co	Mar. 14, 1902		Nov. 9, 1908
Keswick Electric Power Co.	Aug. 30, 1900		Oct. 26, 1908
Redding Electric Light & Power Co	Jan. 7, 1891		Oct. 31, 1908
Redding Gas Co	May 14, 1886		June 9, 1898
Redding Water Co	Dec. 30, 1886		Oct. 31, 1908
Red Bluff Electric Light & Gas Co	May 10, 1889		Nov. 28, 1908
Tehama Electric Co	June 8, 1899		1902
Bellevue Irrigation Co	Mar. 23, 1899		1904
Battle Creek Power Co	Mar. 6, 1905		Nov. 9, 1908
Willows Water & Electric Light Co.	Jan. 23, 1887		Oct. 31, 1908
The Sacramento Valley Power Co	Dec. 17, 1910		Feb. 1, 1912
Sacramento Valley Power Co	Mar. 17, 1909		Jan. 7, 1911
Northern Light & Power Co.	Jan. 30, 1907		Mar. 24, 1909
Shasta Power Co	June 3, 1904		Do.
Tehama County Power & Transportation Co.	Sept. 30, 1903		Nov. 18, 1912
Mount Shasta Power Corporation [f]	Dec. 21, 1909		Nov. 16, 1917

[f] Construction organization, subsidiary of Pacific Gas & Electric Co.

CALIFORNIA GAS & ELECTRIC CORPORATION.

CONSOLIDATION EFFECTED BY INCORPORATION.

California Gas & Electric Corporation, one of the two large companies merged into Pacific Gas & Electric Co., was incorporated December 6, 1901, to effect the consolidation of Sacramento Electric Gas & Railway Co., Bay Counties Power Co., Valley Counties Power Co., California Central Gas & Electric Co., Oakland Gas, Light & Heat Co., and Fresno Gas & Electric Light Co. Funds for the purchase of the capital stock of these companies were not, however, available until after the sale of the general mortgage and collateral trust bond issue of March 1, 1903.[8]

Of the companies merged, the Valley Counties Power Co. had been controlled since its formation through ownership of its entire capital stock by Bay Counties Power Co., and Fresno Gas & Electric Light Co. had been controlled since February, 1902, through stock ownership by California Central Gas & Electric Co., though the Fresno company, unlike other small concerns purchased by the California Central, had not been merged.

During the period extending from March, 1903, to December 30, 1905—the date when stock control of California Gas & Electric Corporation passed to Pacific Gas & Electric Co.—the former consoli-

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[8] See Appendix A.

dated and extended its system by purchasing the stock, or the stock and properties, of Vallejo Gas Co., The Standard Electric Co. of California and its subsidiaries, Blue Lakes Water Co. and Stockton Water Co., together with their holding company, Standard Electric Distributing Co., United Gas & Electric Co. and (on its formation in 1905) the latter's subsidiary, San Mateo Power Co., South Yuba Water Co. and its subsidiary, Central California Electric Co., and Pyramid Power Co. The dates at which these companies passed to the control of California Gas & Electric Corporation are shown in Table 15, and their histories are sketched in the following pages.

SACRAMENTO ELECTRIC, GAS & RAILWAY CO. AND ITS SUBSIDIARIES.

INCORPORATION.

Sacramento Electric Gas & Railway Co. was incorporated April 1, 1896, for the purpose of purchasing all the property rights, privileges, and franchises of Sacramento Electric Power & Light Co., Folsom Water Power Co., and Central Electric Railway Co. The new company was capitalized at $2,500,000. A circular published just before this merger was completed, advertising the bonds of the new company, contained the following very interesting figures:[9]

Hydraulic works at Folsom (cash outlay)		$524,837.41
Convict labor performed by the State for certain rights, 700,000 working days at $1		700,000.00
Sacramento Street R. R. system		610,650.00
Toboggan Ry., at East Park, Sacramento		3,946.00
Transmission plant at Folsom and transmission line to Sacramento and buildings and lands		496,289.49
Power and distribution station in Sacramento		73,284.40
Arc and incandescent light distribution system, Sacramento		25,000.00
Total security for bonds		2,434,007.30
Authorized bonds (which when sold will be the only debt)		1,500,000.00
Gross income		212,962.36
Operation	$97,697.11	
Interest on $1,500,000	90,000.00	
		187,697.11
Balance		25,265.25

ORIGINAL DEVELOPMENTS.

To the forerunner of Sacramento Electric Gas & Railway Co.—Sacramento Electric Power & Light Co.—belongs the honor of having put into operation the Folsom plant, the first hydroelectric generating station in central California. This development is often accredited to Folsom Water Power Co., but such a statement needs revision and explanation.[10]

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[9] Jour. Electricity, p. 123, November, 1905.

[10] History largely on the authority of Mr. Robert Devlin and of articles in Jour. Electricity, September, 1895, and Engineering Record, vol. 31, p. 457, 1895. In a general way the published accounts agree with information from other sources.

The foundations of the Folsom dam were laid in 1866 by Natoma Water & Mining Co. for the purpose of generating hydromechanical power in the town of Folsom. A few years later the company made a contract with the State, under which the State was to furnish convict labor for the construction of the dam in return for the prison site and certain water-power privileges. The diversion point was about 2 miles above Folsom. About 2,000 feet from the upper end of the canal there was a drop which was to be utilized for power by the State prison, and 7,500 feet farther down was the terminal drop into the canal of an irrigation system.

The work dragged along through the seventies under an occasional additional contract for labor, which was slow in being supplied, and work was not actively begun by the State until 1881. In that year Natoma Water & Mining Co. was reorganized as Folsom Water Power Co., which took over the privileges and the contract for labor, but it was not until May, 1888, after years of litigation, that a valid contract between the State and the company was finally signed and continuous work was begun. The new contract provided for an increase in the size of the dam and surrendered to the State proportionately larger water-power privileges.

During the years in which the plant was under construction, hydroelectric power had come into use, and Folsom Water Power Co, finally leased the power rights at the lower end of the canal to Sacramento Electric Power & Light Co., which built the station and established the transmission line to Sacramento—the first line in what is now the Pacific Gas & Electric system. The plant utilized a 55-foot drop through four turbines at the upper power house and a 26-foot drop through a single turbine at the lower power house, which was put into commission in 1897. The lower-level plant was dismantled in 1920. The original equipment consisted of the four 750-kilowatt generators in the upper station. The potential was stepped up from 800 to 11,000 volts, and energy was transmitted over a pole line 21.52 miles long to Sacramento. The first power was delivered July 13, 1895, when one-half of the double forebay was completed; the second half of the plant went into service October 1, 1895. The chief user of power in Sacramento was Central Electric Railway, which consumed 650 horsepower at peak load and had an installed motor capacity of 900 horsepower.

The principal stockholders in Sacramento Electric Power & Light Co. as well as in Central Electric Railway Co. were Albert Gallatin, Horatio G. Livermore, C. E. Livermore, and Joshua Barker, whose control of the two corporations led to their consolidation into Sacramento Electric, Gas & Railway Co. This company controlled most of the electric, gas, and railway business in the city for the eight years of its independent existence and absorbed several competitors. In

1899 the system began to receive power delivered over the Bay Counties Power Co.'s new line from the Colgate power house on Yuba River. It was also connected with the plants of Central California Electric Co. The company remained in business in its own name until October, 1907, when it sold out to California Gas & Electric Corporation.

BAY COUNTIES POWER CO.

PROPERTIES ACQUIRED.

Bay Counties Power Co. was incorporated June 4, 1900, to take over Nevada County Electric Power Co. and Yuba Electric Power Co. Its authorized capital stock was $5,000,000, of which $3,000,000 was immediately issued.

EARLY DEVELOPMENTS.

Nevada plant.—Nevada County Electric Power Co. had constructed and put into operation in February, 1896, a small plant on South Yuba River near Nevada City, intended to furnish local service. Notwithstanding the fact that the promoters of the Nevada plant had made their plans to generate hydroelectric power some time before the builders of the Folsom plant finally decided to change from hydromechanical to hydroelectric, the Folsom plant went into operation first.

The installation of a hydroelectric station on the site of the Nevada plant was planned in 1891 when an attempt was made to dam the South Yuba and to divert its waters for power development. The first dam was taken out by a freshet in the spring of 1892, and September 22 of that year Nevada County Electric Power Co. was organized to resume construction. As it is hard to get the point of view of pioneers in hydroelectric transmission in these days of its assured success, the following prospectus [11] published by the Nevada County Electric Power Co. in October, 1892, is of special interest.

PROSPECTUS OF THE NEVADA COUNTY ELECTRIC POWER CO., GRASS VALLEY, NEVADA COUNTY, CALIF.

Incorporated September 22, 1892.

The Nevada County Electric Power Co. was incorporated under the laws of California on the 22d day of September, 1892.

OBJECT.

The company is organized for the purpose of utilizing the water power of the South Yuba River by generating electricity and transmitting it to Nevada City and Grass Valley for distribution for light and power purposes.

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[11] Pacific Gas & Electric Mag., July, 1911.

PLACE OF BUSINESS.

The principal place of business will be Grass Valley, Nevada County, Calif.

OFFICERS.

At a meeting of the stockholders, held October 10, 1892, the company was regularly organized, and the following officers elected: President, Alfonso A. Tregidgo; vice president, Eugene J. De Sabla, jr.; general manager and treasurer, Dr. Hulbert H. Clark; secretary, John H. Moss; attorney, Fred Searls. These officers form the board of directors.

PROPERTY OF THE COMPANY.

The company has purchased the following property in T. 17 N., R. 8 E. Mount Diablo meridian:

All the mining claims on the South Yuba River, in secs. 23, 24, and 26.

The N. ½ NE. ¼ sec. 24.

All the land east of the South Yuba River in sec. 23.

The right of way for a flume and ditch through sec. 26.

The company also owns a water right on the South Yuba River, giving a minimum supply of 10,000 miner's inches of water.

The company further has secured the right of way for their pole lines and permission to erect poles in both Grass Valley and Nevada City.

PROPOSED PLAN.

The water will be diverted at a point on the NE. ¼ of sec. 24, and carried nearly 3 miles through a flume to a point in sec. 27, thereby gaining a head of 250 feet.

The flume will be designed to carry sufficient water to generate 4,000 horsepower under this pressure.

For the present, machinery to generate 2,000 horsepower will be installed, and lines will be built to Nevada City and Grass Valley for lighting the towns and operating the adjacent lines.

UTILIZATION OF THE POWER.

The distance from the power station to Nevada City is only 3½ miles, and almost on the direct line are the Champion, Wyoming, Merrifield, Mountaineer, and Providence mines, for the operation of which over 500 horsepower is required.

In the town of Nevada City 250 horsepower will be required for lighting streets and buildings.

The distance from the power station to Grass Valley is only 6½ miles.

Within a radius of 1 mile from the center of Grass Valley, over 1,250 horsepower is required for mines now in operation. Seventy-five per cent of this power is obtained from water, the remainder is steam power. About 300 horsepower will be required for lighting streets and buildings in Grass Valley.

The Narrow Gauge Railroad Co., has applied to this company for an estimate of cost of erecting a trolley line and furnishing power for the operation of cars between Grass Valley and Nevada City, a distance of about 6½ miles. The central and highest point of this line is scarcely 5 miles from the power station and the line is practically a continuation of the one running to the mines near Nevada City.

There are at present two petitions before the board of supervisors for franchises to construct tramways over the county road between the two towns. Either of these lines will be but 4 miles in length, and the operating company will depend upon this company for power.

PRESENT COST OF POWER.

Power generated by water costs from $100 to $300 per horsepower per annum. When generated by steam it costs $150.

Mines, requiring in the aggregate 1,250 horsepower, that may be worked profitably with power not costing more than $90 per horsepower per annum are now lying idle.

WORK NOW IN OPERATION.

Immediately after organization the company commenced erection of the dam on the South Yuba River.

The dam is to be 57 feet long at the bottom and 151 feet on top. Its height is to be 27 feet and 10 inches. The remainder of the work will be pushed to a rapid completion.

STOCK, ETC.

The capital stock is $500,000, divided into 100,000 shares, $5 each—all to be fully paid up.

The total investment it is estimated will be about $300,000; and the net income is estimated at $140,000.

The fact that the power exists—the demand for it is at hand—that the distances are small, requiring comparatively small expense for copper, together with the permanency of the water power, renders this a most advantageous investment.

The second dam was not started until August, 1895; it was completed November 20 of the same year, and operation of the plant was begun in February, 1896. The dam was 28 feet high and 107 feet long on the crest. The flume was 18,400 feet long and 4½ feet deep, with a capacity of 141 second-feet. The pressure pipe had a total length of 320 feet (120 feet of 48-inch, 100 feet of 44-inch, and 100 feet of 42-inch pipe) to a receiver 19 feet long and 48 inches in diameter at the side of the power house. The static head was 206 feet. The original installation at this plant consisted of one 300-kilowatt 133-cycle 2-phase Stanley inductor generator with a voltage of 5,500. The capacity of the plant was doubled in the spring of 1897 by adding another generator. In both these units the generator was direct-connected to a pair of 34½-inch Pelton impulse wheels. On March 1, 1898, the company began constructing a timber-crib dam in a basin on Rock Creek, in order to increase the water supply for the plant. This dam was 54 feet high and 327 feet long on the crest and formed the reservoir named Lake Vera. It was completed November 27 of the same year. The head from the new reservoir to the plant was 785 feet, and to accommodate the high and the low heads each unit was provided with two impulse wheels of different design. Despite the increased water supply the plant was unable to keep up with the power demands. The market had to be supplied with additional power by lines brought across from Colgate power house, which was completed in 1899.

Although the Nevada plant was the only one constructed by Nevada County Electric Power Co. in its own name, the promoters of that company proceeded to organize other corporations to construct plants in the same district, supply the same demands, and operate in harmony with the original company. The first of these to be organized was Yuba Power Co., with whose successor, Yuba

Electric Power Co., Nevada County Electric Power Co. was soon merged. The Nevada power house went out of commission in 1910.

Yuba plant.—Yuba Power Co. was incorporated in October, 1897, to generate power for general use in Marysville and for mining and other uses in Browns Valley. Construction of the Yuba plant was begun November 15, 1897, and the plant went into operation March 21, 1898. It utilized a fall in the ditch system that diverted water from the North Fork of Yuba River for irrigation in Browns Valley. The conduit, which was 29.3 miles long, consisted of 7.9 miles of flume, and 21.4 miles of canal. Five miles of the flume was 5 feet wide and 3 feet deep; the rest was 4 feet wide and 3 feet deep, but its grade was sufficiently greater to give a flow equal to that in the larger flume. The canal was 9 feet wide on top, 5 feet wide on bottom, 2½ feet deep, and its grade was 9.6 feet per mile. At the lower end of the conduit, the water discharged into a box forebay with just sufficient capacity to keep the pipe covered. The pressure pipe was 850 feet long and 42 inches in diameter, except for the first four lengths at the upper end, which tapered down from 54 inches to 42 inches. The thickness of the plates varied from one-eighth to one-fourth inch. At the power house there was a receiver 50 feet long and 42 inches in diameter constructed of ¼-inch plates. The effective head developed was 292 feet. The station was equipped with 3 units each operated by a Pelton impulse wheel with two 40-inch rotors, each of which carried 14 buckets and received water through two 4-inch nozzles. The speed of the wheels was 400 revolutions per minute, and the normal rating of each pair 700 horsepower. Regulation was secured by governors which moved deflecting hoods over the jets. Flexible couplings connected the wheels and generators and each wheel shaft carried a 6,000-pound flywheel.

The generators were both of the same type—Stanley inductor 2-phase 133-cycle 2,400-volt 360-kilowatt units, operated at 400 revolutions per minute. There were three Eddy 4-brush 60-volt 5-kilowatt exciters. The generator potential of 2,400 volts was stepped up to 16,700 volts for transmission by six Stanley oil-insulated water-cooled 125-kilowatt transformers with regulator heads.

Power was transmitted from the power house to Browns Valley, 7¾ miles, and to Marysville, 18½ miles. The plant went into operation with contracts signed for 68 per cent of its power. Two large single users were the Browns Valley Mines, with motors aggregating 300 horsepower installed, and the Marysville flour mills, with 225 horsepower. The plant was shut down December 29, 1911.

Colgate plant.—After the Yuba plant was completed, Yuba Power Co. was succeeded by Yuba Electric Power Co., which was incorporated for that purpose January 30, 1899, with larger capitalization. The new company immediately proceeded to construct the

Colgate plant, which was only partly finished September 5, 1899, when the company began to transmit power to Sacramento from three 900-kilovolt-ampere generators over a line 73.6 miles long. In Sacramento the power was delivered to Sacramento Electric Gas & Railway Co. Two hydroelectric plants—the Folsom and Colgate—and the steam plant in Sacramento were thus put into operation on the same system.

Before the Colgate plant was completed, Yuba Electric Power Co. and Nevada County Electric Power Co. were merged into Bay Counties Power Co. The Colgate plant was installed under a contract to deliver power to Sacramento, but additional lines were soon constructed from the plant to supply local demands in the region to the northwest. As the load in the vicinity of the Nevada power house on the South Yuba had outgrown the possible installation at that point, a single 720-kilowatt generator, operating 133 cycles, was installed at the Colgate power house in 1900 and connected to the system then supplied from the Nevada plant. By 1901 the capacity of the Colgate plant had been increased to 9,420-kilovolt-ampere by the addition of three 2,000-kilovolt-ampere units. In 1911 a 5,500-kilovolt-ampere unit (7,370 horsepower) was added and the old 720-kilovolt-ampere machine shut down. During the year 1918 this 5,500-kilovolt-ampere generator was rewound, its capacity being increased to 6,875 kilovolt-amperes. The total capacity of the plant is now 15,575 kilowatts.

The two transmission lines from the Colgate power house to Oakland (see pp. 269–272) began operations April 27, 1901. Shortly afterward the lines were connected in Oakland to a branch of The Standard Electric Co.'s line, which had been completed from Mission San Jose to Oakland in anticipation of the main trunk line from Electra power house to San Francisco. The total distance from Colgate to Mission San Jose over this route is 184 miles.

The independent existence of Bay Counties Power Co. ended in March, 1903, when the company was purchased by California Gas & Electric Corporation.

VALLEY COUNTIES POWER CO.

While the promoters of Bay Counties Power Co. were developing their properties on Yuba River, local capitalists in Chico formed Butte County Electric Power & Lighting Co., and in 1898 built the original Centerville plant on Butte Creek. Early in 1902 Butte County Electric Power & Lighting Co. and the Centerville plant were sold to Butte County Power Co.

By the end of 1901 it became necessary for Bay Counties Power Co. to enlarge its generating system. To accomplish this purpose, its promoters incorporated Valley Counties Power Co. January

24, 1902, which immediately purchased Butte County Power Co. and its properties, including the control of Butte County Electric Power & Lighting Co. and the Centerville plant.

The newly formed corporation also obtained water and ditch rights above the Centerville plant, and, to utilize these, began to construct a larger station which was christened the De Sabla plant. The new power house was placed just above the head of the Centerville ditch, and obtained water both from the Butte Creek basin and the West Branch of North Fork of Feather River, through an extensive system of ditches, that had been built by the Cherokee Mining Co. for hydraulicking in the days of placer mining.

When the Centerville plant passed into the hands of the Valley Counties Power Co., it was enlarged by adding a 900-kilovolt-ampere unit to the two 400-kilovolt-ampere units already installed, and, with De Sabla power house, was connected to the Colgate system by a new transmission line. The ditch was enlarged and the plant was remodeled in 1906 and 1907 by replacing the two small impluse units by a single 5,000-kilovolt-ampere generator (see p. 214), operated by an Allis-Chalmers Francis inward-flow turbine under what was at the time the highest known head for such an installation—585 feet.

The properties of the Valley Counties Power Co. were finally transferred with those of its owner, the Bay Counties Power Co., to California Gas & Electric Corporation on October 23, 1907.

CALIFORNIA CENTRAL GAS & ELECTRIC CO.

When the Colgate plant had proved itself a complete success, its owners began to seek the necessary market for its power. One of their first moves was the purchase of a large number of electric-light and gas plants scattered among the small cities of the lower Sacramento Valley. The most important companies[12] thus acquired were Chico Gas & Electric Co., Colusa Gas & Electric Co., Marysville Gas & Electric Co., Napa Gas & Electric Co., Nevada County Gas & Electric Co., Petaluma Gas & Electric Co., San Rafael Gas & Electric Co., Santa Rosa Lighting Co., and Woodland Gas & Electric Co. These corporations were consolidated into California Central Gas & Electric Co., incorporated March 25, 1901. The policy of developing a diversified market, initiated by the formation of California Central Gas & Electric Co., has been actively pursued ever since and has placed Pacific Gas & Electric Co. in an exceptionally strong position.

The company was organized by certain directors of Bay Counties Power Co. as a marketing company allied to the Bay Counties Co. It was in no sense an electric generating company, as were most of the corporations acquired by Bay Counties Power Co., although in many of the towns the new company continued the manufacture of

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[12] See Table 15 for several smaller concerns not here listed.

gas. In February, 1902, the company obtained control of the stock of Fresno Gas & Electric Light Co., which was transferred with its other properties December 20, 1905 (see Table 15), to the California Gas & Electric Corporation.

SOUTH YUBA WATER CO. AND CENTRAL CALIFORNIA ELECTRIC CO.

South Yuba Water Co. operated a system which was begun in the old mining days. In the early fifties many ditch systems were constructed in northern Placer and southern Nevada counties for the purpose of supplying water for hydraulic mining. Several of these systems were consolidated, and the resulting South Yuba Canal Co. gradually absorbed smaller systems until it had control of most of the supply ditches in the region. A new corporation, which took the name South Yuba Water & Mining Co., was formed April 1, 1880, and on August 3, 1891, this name was changed to South Yuba Water Co. In 1886 the passage of the débris act, prohibiting the dumping of débris from hydraulic mines into navigable streams, automatically stopped the operation of most of the mines supplied by South Yuba Water & Mining Co., and it had to find a new market for its water. The company turned its attention to irrigation, since at that time the long-distance transmission of hydroelectric power was not considered feasible. By 1895, however, electric transmission had attained a reality, and Central California Electric Co. was formed as a subsidiary to utilize several power sites on the South Yuba Water Co.'s system.

The first plant constructed by the company was that at Newcastle, which began to transmit power to Sacramento December 31, 1896, and went into regular operation January 1, 1897. The power house was in the SW. ¼ sec. 19, T. 12 N., R. 8 E. Water was supplied through Bear River canal and the lower part of the Boardman ditch (see pp. 159–160), both of which discharged into natural watercourses from which the supply was delivered to Newcastle forebay through Fiddler Green canal. From the forebay a single riveted-steel pressure pipe, 6,605 feet long and 24 inches in diameter (except immediately above the power house, where it is reduced to 18 inches), connected to one branch of the Y leading to a receiver lying along the back wall of the building. The static head developed was 464 feet.

The power house was a wooden-frame structure, with corrugated-iron roof and walls, and measured 80 feet long by 30 feet wide. The station contained two 400-kilowatt 500-volt 400-ampere 2-phase 60-cycle Westinghouse revolving-armature alternators. Each unit was driven by a single Pelton impulse wheel, mounted between bearings, connected to the generator shaft by bolted flanged couplings and operated by a double 3¼-inch stationary nozzle. The front nozzle in each set was controlled by a hand-operated hood deflector. The back nozzle could be put out of operation by closing a 6-inch gate valve in its base. Two Westinghouse multipolar 7½-kilowatt 125-volt exciters were driven by Pelton impulse wheels at a speed of 1,050 revolutions per minute. The power house originally transmitted energy to Sacramento over a single 3-phase circuit of copper wire operated at a potential of 16,000 volts, through four 150-kilowatt transformers connected 2-phase—3-phase on the Scott system. These transformers were later exchanged for more modern units which stepped up the generator potential to 60,000 volts to connect with the main transmission system to Sacramento, and to 10,000 volts for local service to Auburn and Rocklin. The Newcastle plant went out of commission on January 11, 1918.

The second plant constructed by the company was about a mile northeast of Auburn, higher up on the canal system, and began transmitting power on October 2, 1898. The Auburn power house, long since out of commission, was a small corrugated-iron building with wooden frame, which housed a single unit. Water supplied by the ditch system reached the power house through a single 36-inch lap-riveted pressure pipe 3,300 feet long. The hydraulic equipment was arranged to pass a uniform flow to the canal below whether the unit was operating or not. The single Westinghouse 500-kilowatt 550-volt 2-phase 60-cycle revolving-armature generator was set in a 5-foot pit in the floor of the power house and was connected to the impulse wheels by a flexible leather coupling. The wheel shaft carried a 6,000-pound flywheel, 6 feet in diameter, and the unit operated at a normal speed of 300 revolutions per minute. Excitation was provided by a 7½-kilowatt 125-volt Westinghouse continuous-current generator, and two pairs of Westinghouse 125-kilowatt transformers connected on the Scott system to give 3-phase current for transmission from the 2-phase current supplied by the generator stepped the potential up from 550 to 15,000 volts; an extra transformer was installed for use in emergency. The length of the line from Auburn to Newcastle was 5.5 miles.[13] This plant was abandoned in 1911.

In 1902 a plant capable of supplying more power than those at Auburn and Newcastle combined was constructed at Alta (see pp. 187–191). The Alta plant was connected with Auburn by a pole line, 27 miles long, carrying a single 3-phase circuit of No. 6 copper wire, and the potential of the system was raised to 30,000 volts.

THE STANDARD ELECTRIC CO. OF CALIFORNIA.

While the organizers of Bay Counties Power Co. were engaged in their operations north of Sacramento, Blue Lakes Water Co. (incorporated April 17, 1890, to supply water to mines in Amador

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[13] Van Norden, R. W., Jour. Electricity, vol. 13, p. 67, January, 1903.

County) began hydroelectric operations on Mokelumne River, in the Mother Lode district, where there was already a large demand for power.

As a preliminary move, Blue Lakes Water Co. entered into a 30-year contract with California Exploration Co., which granted to the latter the exclusive right to transmit and supply electric power to the mines of Calaveras County from the plant which the Blue Lakes Co. proposed to build. On the strength of this contract the projected plant was financed and built by Blue Lakes Water Co. The first station was completed in 1897 at a point about 4 miles below the present Electra power house.

The power house [14] was 35 by 100 feet and contained three 48-inch Doble impulse wheels, each driven by a 4-inch nozzle, and connected to a Stanley inductor generator delivering 2-phase current at 2,000 to 2,400 volts when operating at 600 revolutions per minute. The three generators were excited by two 10-horsepower multipolar exciters, driven by impulse wheels. In the spring of 1898 the voltage was raised from 2,400 to 18,000 for transmission.

The pressure pipe was 3,240 feet long, varied in diameter from 48 to 16 inches, and in plate thickness from No. 10 to one-half inch. Part of the pipe was riveted and part lap-welded. It developed a static head of 1,042.75 feet. Lines were built into Amador County and southward into the lower part of the mining district in Calaveras County. In 1900 a transmission line was constructed down the river and across the valley to Stockton, where power was delivered to Stockton Gas & Electric Co., now part of the system controlled by Western States Gas & Electric Co. The demand for power [15] so far exceeded the anticipation of the promoters of the Blue Lakes plant that enlargement had been considered even before the plant was completed. To take care of the additional demands The Standard Electric Co. of California was incorporated November 27, 1897, and began constructing the Electra plant, which was not only to use the ditch system of the original Blue Lakes plant but also to obtain a higher head from another system lying above it. The Electra plant was completed and transmission of power to the mines was begun May 6, 1902.[16] In the meantime, November 1, 1899, the original Blue Lakes plant had burned but had been repaired and was operated until the Electra plant went into commission.

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[14] Jour. Electricity, Oct. 2, 1897.

[15] Up to the time that the Blue Lakes plant went into operation power for working mining machinery in this region had been generated by steam or by the direct application of water power. Even in the more accessible mines, the wood used cost $6 per cord and crude oil $1.50 per barrel.

The usual rate for water from the ditch systems in the district was 20 cents per miner's inch per month, regardless of the head available at its point of use. In very few places did the head exceed 500 feet, and in many it was far less. The rate charged for electric power from the Blue Lakes plant was $6.50 per horsepower per month.—Jour. Electricity, vol. 13, p. 150, 1903.

[16] Notes of the late W. R. Eckart, engineer in charge of the hydraulic development.

Before the Electra plant was completed the Standard Electric Co. decided to extend the transmission system to supply the market around San Francisco Bay. It therefore built a transmission line by way of Stockton and Mission San Jose to south San Francisco and a branch north from Mission San Jose to Oakland, and wholesaled the first hydroelectric power to San Francisco Gas & Electric Co. early in November, 1902. The Electra plant originally contained five 2,000-kilovolt-ampere units, which could be operated under either 1,466 or 1,266 foot heads. Its present equipment is described on pages 194–203.

At the time of its completion the Electra plant embodied the best features in high-head power development and its transmission system was of noteworthy excellence, but its preeminence has since been overshadowed by more modern plants. The system was taken over by California Gas & Electric Corporation March 1, 1904, and passed with it under the control of Pacific Gas & Electric Co. in January, 1906, though final deeds for the property were not signed until October 23, 1907.

UNITED GAS & ELECTRIC CO. AND ITS SUBSIDIARIES.

United Gas & Electric Co. had its genesis in the small isolated steam-electric light and power companies of the peninsula towns from San Francisco south to San Jose. These companies were already in operation when power from The Standard Electric Co.'s lines first reached the bay in November, 1902, and several minor consolidations had taken place. One of these combinations resulted from the formation of the Consolidated Light & Power Co., which was incorporated in January, 1900, and acquired Peninsular Lighting Co., San Mateo Electric Light Co., and San Mateo Gas Light Co. At the time of its acquisition Peninsular Lighting Co.'s plant in Redwood was operating three single-phase generators—a Westinghouse 45-kilowatt, a Westinghouse 75-kilowatt, and a Brush 50-kilowatt. The connected lighting load was 3,000 lamps on a midnight service. San Mateo Electric Light Co.'s plant was operating two Westinghouse single-phase generators, one of 60-kilowatt capacity and the other 45-kilowatt, and carried an all-night lighting load of 3,000 lamps in San Mateo, Burlingame, and Belmont.

When the systems were consolidated, a feeder was run from the Redwood to the San Mateo plant and operated at the generator voltage of 5,500. At San Mateo this was stepped down to 2,200 volts for distribution. The San Mateo station ceased operation, except on peak, and was used as a substation. The main line extended south from Redwood to Palo Alto substation, from which a main feeder continued down the peninsula to a little below Mountain

View. A 2-phase 4-wire line also left Palo Alto substation for Stanford University.

At first the system was operated in opposition to a municipal plant at Redwood, a municipal plant at Palo Alto, a private plant at Stanford, and a small plant at Belmont School. In 1900 contracts were entered into which closed all these plants except that at Palo Alto. The load on the system had increased from an equivalent of 6,000 16-candlepower lights in January, 1900, to an equivalent of 19,000 16-candlepower lights in April, 1901.

The power load was fast outgrowing the equipment, and a contract was made with The Standard Electric Co. for power. Delays in the building of the line from the Electra plant to the Bay, however, forced the new owners to add to the steam-electric equipment of the Redwood plant, 2 Stanley 150-kilowatt 2-phase generators, 1 Stanley 72-kilowatt 2-phase generator, and 1 Westinghouse 60-kilowatt 1-phase generator, and necessary boiler equipment.[17]

United Gas & Electric Co. was formed to absorb and merge Consolidated Light & Power Co. with two companies that had been operating for some time in San Jose and vicinity—San Jose Light & Power Co. and Electric Improvement Co. of San Jose. When these various systems were brought under a single management and their lines connected the transmission and distribution net work covered the territory lying along the Bay Shore from the southern boundary of San Francisco southward to and including San Jose. Consolidated Light & Power Co., United Gas & Electric Co., and The Standard Electric Co. of California were controlled chiefly by the Crocker banking interests. The Standard and United Gas and Electric companies were not actually combined into a single corporation before they were acquired by California Gas & Electric Corporation, but they always operated in harmony.

OAKLAND GAS LIGHT & HEAT CO.

Oakland Gas Light & Heat Co. was incorporated in July, 1884, to consolidate several minor gas and electric companies (see Table 15) operating in Oakland and vicinity, on the east side of San Francisco Bay.

SAN FRANCISCO GAS & ELECTRIC CO.

San Francisco Gas & Electric Co. was incorporated December 11, 1896, to acquire the stocks and properties of San Francisco Gas Light Co., Edison Light & Power Co., and several other small companies, which had for some time been engaged in a very bitter and disastrous rate war. The consolidation took place several years

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[17] Jour. Electricity, vol. 11, p. 75, April, 1901.

before hydroelectric power reached the Bay region, and by the year 1900 San Francisco Gas & Electric Co. had an excellent electric light, power, and gas business in the city, being subject at times, however, to more or less vigorous competition. In the spring of 1899 a more formidable competing concern than any yet encountered was organized—the Independent Electric Light & Power Co. of San Francisco—which was incorporated with a capitalization of $10,000,000 and was financed and controlled by the Spreckels. The first board of directors consisted of Claus Spreckels, John D. Spreckels, Adolph B. Spreckels, Charles E. Hume, and W. K. Gibson. This company immediately proceeded to construct the steam-electric plant in the Potrero district, San Francisco, which is now Station A of Pacific Gas & Electric Co. Its organizers also incorporated the Independent Gas & Power Co., which constructed at the same site a gas plant, the first units of which were completed early in 1902. Other active though smaller competitors of San Francisco Gas & Electric Co. were Equitable Gas Light Co. and Pacific Gas Improvement Co. From the date of completion of the plants belonging to the Spreckels companies there was active competition between the four concerns, and this competition involved several still smaller rivals. Early in 1903 it was reported that Stone & Webster had taken an option on Independent Electric Light & Power Co. and on Independent Gas & Power Co., and that local San Francisco capitalists had received an option on the stock of Equitable Gas Light Co. Both these options would, without extension, have expired in May, 1903, but neither was exercised at the time. San Francisco Gas & Electric Co. soon obtained the option on Equitable Gas Light Co., and about the same time it agreed to take over the stock and properties of Pacific Gas Improvement Co. Equitable Gas Light Co.'s stock outstanding amounted to 138,820 shares. The Equitable properties were deeded to San Francisco Gas & Electric Co. August 31, 1903. Pacific Gas Improvement Co. received for 35,000 shares of its stock (par $100, paid in $50) 28,000 shares of the stock of San Francisco Gas & Electric Co., and the latter company, in addition, assumed its bonded debt. Negotiations between San Francisco Gas & Electric Co. and the stockholders of the other concerns followed, and on July 2, 1903, the former made first payments on the stock and properties of Independent Electric Light & Power Co. and Independent Gas & Power Co. During the last part of the year all these transactions were completed. The properties of Pacific Gas Improvement Co. were deeded to San Francisco Gas & Electric Co. September 1, 1903, those of Equitable Gas Light Co. August 31, 1903, and those of Independent Electric Light & Power Co. and Independent Gas & Power Co. November 9, 1903. (See Table 15.)

The annual report of San Francisco Gas & Electric Co. for 1903 stated that the actual costs to the respective companies of the properties and assets taken over were:

Pacific Gas Improvement Co.	$4, 675, 905
Equitable Gas Light Co.	445, 393
Independent Gas & Power Co. and Independent Electric Light & Power Co.	5, 499, 374
	10, 620, 672

For these properties San Francisco Gas & Electric Co. paid:

Equitable Gas Light Co., cash	$708, 850
Independent Gas & Power Co. and Independent Electric Light & Power Co.:	
Cash	6, 000, 000
An interest payment of	89, 229
Assumption of floating debt	625, 000
Pacific Gas Improvement Co.:	
Bonded debt assumed	1, 190, 000
28,000 shares of treasury stock in San Francisco Gas & Electric Co., par value	2, 800, 000
	11, 413, 079

The report stated that the difference between the cost of the properties to their builders and the price paid—$792,407—was charged against the accumulated surplus of San Francisco Gas & Electric Co. In addition to the above amount, $100,000 was paid in notes to the holders of the option on Equitable Gas Light Co.

In order to provide the necessary funds for the foregoing consolidation, San Francisco Gas & Electric Co. voted its 4½ per cent bond issue dated November 1, 1903. The total par value of bonds authorized under this mortgage was $10,000,000 of which $7,000,000 par value were sold at $95, netting $6,650,000. This amount, with other cash payments, brought the total cash involved in the purchase of the four systems to $7,423,079, according to the company's report.

San Francisco Gas & Electric Co. had also absorbed (January, 1903) United Pacific Power Co., which operated a steam-electric central station on the block bounded by First, Mission, Stephenson, and Ecker streets.

The company received its first hydroelectric power and became a factor in the hydroelectric market when The Standard Electric Co. of California put its main transmission line into operation early in November, 1902. The purchase of The Standard Electric Co. of California by California Gas & Electric Corporation in March, 1904, established the first direct connection between the latter and San Francisco Gas & Electric Co. Since California Gas & Electric Corporation was generating power chiefly from hydroelectric sources and was in search of a market, whereas San Francisco Gas & Electric Co. had at the time a large market which it was compelled to serve with more expensive power generated by steam, or with purchased hydroelectric power, it was to the advantage of the two concerns to combine. Pacific Gas & Electric Co., which was formed to effect this combination, secured stock and control of San Francisco Gas & Electric Co., December 31, 1905, but did not acquire the properties in fee until November 27, 1911, since which time they have formed the San Francisco division of the company.

ORO ELECTRIC CORPORATION.

Oro Electric Corporation, incorporated under the laws of California, March 11, 1911, is the direct successor of Oro Water, Light & Power Co., which on its formation, February 24, 1905, consolidated certain gold-dredging and electric properties in Oroville and vicinity. The new corporation was formed when the old company determined to expand its electric generating business, which was at the time far less important than the gold dredging.

Oro Water, Light & Power Co. acquired on its formation in 1905 all the capital stock ($225,000 par value) of Oroville Light & Power Co., which had conducted since November 5, 1901, a lighting and gas business in the town of Oroville. It united with these properties the Lava Beds Dredging Co. (incorporated May 18, 1900, and capitalized at $500,000), Marigold Dredging Co. (incorporated July 10, 1901, and capitalized at $10,000), Rio Rancho Co. (incorporated November 26, 1897, and capitalized at $64,000), and Oroville Water Co. (organized January 10, 1878, and capitalized at $50,000). These concerns owned at the time about 1,200 acres of dredging lands, several operating dredges, and the gas, electric, and water systems in Oroville. The chief work accomplished by Oro Water, Light & Power Co. was the construction of two small hydroelectric stations to supply the power needed in and around Oroville and in the operation of the dredges.

In 1912, when the plans for expansion into a general hydroelectric generating company were perfected, the $3,250,000 outstanding stock of the Oro Water, Light & Power Co. was sold to Oro Electric Corporation, carrying with it control of the subsidiaries.

The largest project contemplated by Oro Electric Corporation was the construction of a hydroelectric system to utilize extensive storage sites on Yellow Creek—a tributary of the North Fork of Feather River—through a plant of very high head at the junction of the two streams. To carry out the construction of this plant the electric corporation formed Oro Development Co.[18] In anticipation of the construction of the new hydroelectric system, the corporation obtained franchises for the distribution of electric power in several

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[18] See Appendix A.

of the counties in the southern part of the Sacramento and northern part of the San Joaquin valleys, and applied to the recently organized Railroad Commission for a certificate of public convenience and necessity to exercise its rights under these franchises. Hearings on this application were held early in 1912, and the application was sharply contested by Western States Gas & Electric and several other operating companies. The battle centered chiefly on the Western States' field in and around Stockton, where the Oro corporation was constructing a steam plant to carry such load as it had acquired until its hydroelectric plant and transmission lines should be constructed. An adverse decision by the Railroad Commission in regard to the Stockton market, coupled with the stringency of the money market in 1912 and 1913, put an effectual end to the proposed hydroelectric plant; a small territory near Stockton was, however, granted to the company and was supplied from the steam plant for a short time. With this restricted load, most of which consisted of irrigation pumping, the company found it necessary to close the steam plant and purchase power from Pacific Gas & Electric Co. rather than to incur high operating expenses under a very poor load factor.

In July, 1916, Pacific Gas & Electric Co. requested permission of the Railroad Commission to take over the Oro Electric public utilities properties, having already obtained control of the system through purchase of outstanding securities in the open market. The contract covering transfer of properties was dated January 15, 1916, but on and after February 1, 1916, the properties were actually operated to the credit of Pacific Gas & Electric Co., although the transfer was not finally approved by the Railroad Commission of California until January 8, 1917 (Decision 3987). It included, with few exceptions, all the public-utility properties, both operative and nonoperative.

Statements were submitted showing that Oro Electric Corporation owned the entire issued capital stock of Oro Water, Light & Power Co., which in turn owned the entire issued capital stock of Oroville Water Co. and Oroville Light & Power Co., as well as 22,206 shares of the total issue of 33,106 shares of the capital stock of Butte & Tehama Power Co., and 1,265,300 shares of the total issue of 1,826,987 shares of the capital stock of Cataract Gold Mining & Power Co.; both of the latter held prospective hydroelectric developments. Butte & Tehama Power Co. owned the entire issue of capital stock of Sierra Irrigation Co. In addition to the public-utility properties belonging to the various companies mentioned above, Pacific Gas & Electric Co. acquired the capital stock of all of them except Oro Electric Corporation and Oro Water, Light & Power Co.

The undeveloped hydroelectric sites belonging to Butte & Tehama Power Co. are on Deer Creek; the old mining ditch and power site belonging to Cataract Gold Mining & Power Co. are on Yellow Creek, a tributary of Feather River.

Evidence was also produced to show that up to December 31, 1915, the entire cost of the properties had been as follows:

Operative	$2,141,898
Nonoperative	1,346,352
	3,488,250

The $1,830,000 par value outstanding bonds of Oro Electric Corporation had been purchased by Pacific Gas & Electric Co. for $1,491,151.35. The properties were subject, however, to the mortgages of the Oroville Light & Power Co. and Oro Water, Light & Power Co. Financial arrangements were entered into between the parties to the contract providing for the cancellation of these underlying bonds.

NORTHERN CALIFORNIA POWER CO. CONSOLIDATED AND ITS PREDECESSORS.[19]

In the early part of 1900 Mr. H. H. Noble conceived the plan of installing a plant on Battle Creek, Shasta County, to supply electric power in the mining regions at the north end of the Sacramento Valley, where there was an excellent market. As a preliminary to launching the enterprise Mr. Noble obtained a long-time contract with Mountain Copper Co., which was operating a large smelter at Keswick, north of Redding. The first hydroelectric development was begun at Volta, near Shingletown, in Shasta County in 1900. The installation, consisting of two 750-kilovolt-ampere units, began operation November 28, 1901, supplying electrical energy to Redding and Keswick through a double-circuit transmission line operated at 22,000 volts. Shortly after the system began to generate power, control of Redding Electric Light & Power and Redding Water companies was acquired through the purchase of all their capital stock. Redding Electric Light & Power Co. had for some time been operating the local system, obtaining part of the power from a very small low-head power plant on Sacramento River near the town.

In 1902 Keswick Electric Power Co. extended a line to Red Bluff and Tehama and acquired the properties of Tehama Electric Co. The expenditures necessary for the various purchases and extensions had nearly reached the authorized capitalization of the company, and it therefore became necessary to reorganize in order to carry out plans for future expansion.

Northern California Power Co. was incorporated March 13, 1902, by the same interests that had controlled Keswick Electric Power Co. The stockholders of the Keswick company were offered in exchange for their holdings stock in the new company at $6 a share.

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[19] For most of the historical notes relating to the Northern California Power Co. Consolidated the writer is indebted to its former secretary and general manager, Mr. Edward Whaley.

A syndicate which included, among others, Messrs. Edward Coleman, Antoine Borel, and H. H. Noble, also offered any stockholders who did not care to make this exchange, $6 cash per share for their stock in the old company. The syndicate agreed furthermore to purchase any stock left in the treasury after the Keswick stockholders had exercised their option. Every share of Keswick Electric Power Co. was exchanged for stock in the new company instead of cash, and a bond issue of $1,000,000 was authorized.

A third 750-kilovolt-ampere unit was installed at Volta, and in 1903 a line was built from Palo Cedro to the Bully Hill smelter at Delamar. Another line was extended from Red Bluff to Willows, and work was begun on a new generating station on old Cow Creek, almost due north of the Volta plant on Battle Creek. On completion of this station—Kilarc plant—in May, 1904, it was connected with the Bully Hill smelter.

In 1903 the company purchased the entire capital stock of Red Bluff Electric Light & Gas Co., which was then operating a gas plant and a small direct-current lighting system in the town of Red Bluff. Early in 1904 the company entered into a power contract with Mammoth Copper Mining Co., which contemplated building a smelter at Kennett, and in order to furnish power on this contract extended its transmission lines from Keswick to Kennett.

The foregoing extensions had absorbed the proceeds of the $1,000,000 bond issue authorized in 1902. Conditions made it seem advisable to increase the capacity at Volta by adding a 2,000-kilowatt machine, and a contract entered into with Pacific Gas & Electric Co. made it necessary to extend a transmission line from Volta to Chico, where deliveries were to be made. To furnish additional capital Battle Creek Power Co. was incorporated March 6, 1905, and all its capital stock was turned over to Northern California Power Co., which, in return, guaranteed Battle Creek Power Co.'s bonds. From the sale of a part of these bonds the line to Chico was completed in 1906. In 1906 or 1907 an additional line had been run from Palo Cedro diagonally across the country to Kennett and a connection made between the Kilarc and Volta plants.

In 1907 the company purchased the entire capital stock of Willows Water & Electric Light Co. and began constructing the South power house on South Battle Creek. Owing to stringent financial conditions in 1907 it was found impossible to dispose of the balance of the Battle Creek bonds. It was decided therefore to form a new company which should take over all the properties of both Northern California Power Co. and Battle Creek Power Co., weld them into a unit as regards corporate ownership, and properly finance the necessary extensions then under way or contemplated.

Northern California Power Co. Consolidated was therefore incorporated August 28, 1908, for $10,000,000, and issued its entire capital stock to the stockholders of Northern California Power Co., acquiring in return the entire stock of the latter; transfer of stock and properties was not finally completed, however, till 1911. In addition, it took deeds of transfer from all the subsidiary or allied companies holding title to any of the properties acquired. These deeds of transfer were of course subject to outstanding bond issues and to the issue of bonds of Northern California Power Co. Consolidated, of which a sufficient number were reserved to cover underlying issues.

South power house began operation in January, 1910, and negotiations for an additional contract with the Pacific Gas & Electric Co. warranted the construction of the Inskip plant, which was finished in July of the same year.

At this time the company was notified by nearly all the smelters in Shasta County that their plants would be very materially enlarged in the immediate future, and in order to take care of this additional load and to meet the growing demands of the agricultural business in the southern territory, it was decided to start work on the Coleman plant below the Inskip plant. The proposed installation of 15,000 kilovolt-amperes in the Coleman plant was considerably larger than any previous installation. When the work was half completed the Federal court issued injunctions that closed every smelter in Shasta County except that of Mammoth Copper Co. of Kennett. It was, however, necessary to finish the Coleman plant despite the fact that there was a decrease instead of an increase in the market for its power, and the plant was completed late in 1911.

The system was competing with The Sacramento Valley Power Co., and it soon became apparent that with the closing of the smelters the remaining territory did not offer a sufficient business to support two competing companies with duplicate overhead charges. As a consequence of a sharp rate war with The Sacramento Valley Power Co., the latter company was bought out by Northern California Power Co. Consolidated in January, 1912, and the systems of the two companies connected so as to operate as a physical unit.

In 1911, also, a main trunk line was built through Hamilton, Maxwell, Arbuckle, and College City down the west side of the Sacramento Valley. This extension delivered electrical power into a very rich and fertile section, which at the time was not very highly developed. Except at the town of Williams this territory was then unsupplied with electric power.

Stock control of Northern California Power Co. Consolidated passed to Pacific Gas & Electric Co. August 28, 1919, the Railroad

Commission granted the necessary permission for the merger September 27, 1919, and the properties were transferred October 3, 1919.

MINOR PROPERTIES ACQUIRED BY PACIFIC GAS & ELECTRIC CO.

In addition to the properties that came into its possession on its formation, Pacific Gas & Electric Co. purchased, from time to time the stock and properties of minor generating and distributing concerns, and it also acquired title in fee to properties of companies which were formerly controlled only by stock ownership. The date of acquisition of such properties is shown in Table 15, but the following notes may give a clearer idea of their relative importance:

Newman Light & Power Co., a small company operating at Newman, Stanislaus County.

Contra Costa Electric Light & Power Co., a small company operating in Contra Costa County.

Redwood Manufacturers Co., operating at Black Diamond, Contra Costa County.

Suburban Light & Power Co., incorporated March 11, 1908, successor of Suburban Electric Light Co. and San Leandro Gas & Electric Co. (with capital of $1,000,000, par value $10), which supplied parts of Alameda County with electricity and gas.

Sebastopol Light, Power & Water Co., a company operating in and around Sebastopol, Sonoma County.

Mutual Electric Light Co., a steam-electric corporation with an authorized capital of $500,000, which owned an electric plant at the corner of Spear and Folsom streets, San Francisco, from which it supplied a part of the city with light and power.

Metropolitan Gas Corporation (successor by change of name to the Metropolitan Light & Power Co., which in turn succeeded San Francisco Coke & Gas Co., organized October 31, 1899), owner of a system which in its early days furnished gas wholesale to San Francisco Gas & Electric Co. but later retailed gas as a public utility through its own distribution system; its capitalization was $10,000,000; the bonds outstanding under the issue of the Metropolitan Gas Corporation, dated November 25, 1911, were assumed when it was purchased.

Live Oak & Encinal Light & Power Co., a small company with a capital of $20,000, operating in the rural districts around Live Oak and Encinal in Sutter County.

South San Francisco Power & Light Co., a distribution system in South San Francisco.

Los Gatos Ice, Gas & Electric Co., incorporated March 2, 1907, with a capital stock of $200,000, operated a small electric system in the vicinity of Los Gatos, Santa Clara County, part of the power for which was supplied from a very small plant on a creek near the town; the Pacific Gas & Electric Co. acquired the property for $187,762.51.

Livermore Water & Power Co., incorporated June 9, 1896, with a capital of $200,000 and engaged later in the operation of an electric system in and near Livermore and Pleasanton and in operating a water system in Livermore; the stock and property of the company were acquired for $242,000 paid by giving a promissory note of $51,000, 1,105½ shares of common stock at an assumed value of $80 a share, and the assumption of $100,000 in 6 per cent bonds.

United Water & Power Co. sold to the Pacific Gas & Electric Co. certain water and ditch rights on the South Fork of Yuba River.

Dixon Electric Power & Water Co. owned a small electric distribution and water supply system in the town of Dixon, Solano County.

West Sacramento Electric, organized September 5, 1913, to construct and operate a distributing system in Broderick and adjacent territory in Yolo County. The authorized capital stock was $100,000 divided into 1,000 shares of the par value of $100 each. The company constructed a system, sold out the interest, and on July 23, 1915, became involved in litigation with the purchasers. Pacific Gas & Electric Co., the principal creditor of the company, was authorized by the Railroad Commission of California to purchase the properties for $30,000 cash, the purchasers agreeing to purchase with this cash first preferred stock of Pacific Gas & Electric Co. at $82.50 per share, the transaction amounting to the purchase of the distribution system by payment of stock of Pacific Gas & Electric Co. The articles of incorporation of West Sacramento Electric were so amended that the company passed out of existence September 5, 1915. Pacific Gas & Electric Co. succeeded to its properties through liquidation proceedings September 30, 1915.

Sacramento County Water Co., incorporated November, 1892, was purchased in September, 1909.

Solano Electric Light & Gas Co., successor to Benicia Gas Co., was purchased in May, 1910.

Pacific Gas & Electric Co. has also purchased certain small properties belonging to private individuals, including those of D. C. Gillen, E. D. N. Lehe and wife, Isaac Hyman, and Leonard Prior.

All the properties listed above are now owned in fee and form part of the company's main system.

In 1917 Pacific Gas & Electric Co., through purchase of Mount Shasta Power Co., acquired the entire outstanding capital stock of Mount Shasta Power Corporation.

MARKET.

TERRITORY AND POPULATION.

The transmission lines of Pacific Gas & Electric Co. form an extensive network entering practically every county in north-central California. These counties are listed in Table 9 (p. 64), which includes statement of their area and population. Their chief features are briefly characterized in the notes on pages 66–72.

Population of the cities and towns served is shown in Table 16.

TABLE 16.—*Incorporated places served by Pacific Gas & Electric Co.*

Places served directly.

City or town.	County.	Population.				Class of service.[a]
		1890	1900	1910	1920	
Alameda	Alameda	11,165	16,464	23,383	28,806	1
Albany	do			808	2,462	2
Alviso	Santa Clara			402	517	
Antioch	Contra Costa	635	674	1,124	1,936	
Belvedere	Marin		434	481	616	
Benicia	Solano	2,361	2,751	2,360	2,693	
Berkeley	Alameda	5,101	13,214	40,434	56,036	2
Burlingame	San Mateo			1,565	4,107	2
Ceres	Stanislaus				637	
Chico	Butte	2,894	2,640	3,750	9,339	2
Colfax	Placer			621	573	5
Colusa	Colusa	1,336	1,441	1,582	1,846	2
Concord	Contra Costa			703	912	
Corning	Tehama			972	1,149	
Corte Madera	Marin				607	
Daly City	San Mateo				3,779	2
Davis	Yolo				939	2
Dixon	Solano				926	5
Emeryville	Alameda	228	1,016	2,613	2,390	2
Fairfield	Solano			834	1,008	
Fresno	Fresno				45,086	1
Hayward	Alameda	1,419	1,965	2,746	3,487	2
Hillsborough					931	2
Kennett	Shasta				464	
Larkspur	Marin			594	612	2
Lincoln	Placer	961	1,061	1,402	1,325	5–8
Livermore	Alameda	1,391	1,493	2,030	1,916	5
Los Gatos	Santa Clara	1,652	1,915	2,232	2,317	2
Manteca	San Joaquin				1,286	
Martinez	Contra Costa	1,600	1,380	2,115	3,858	
Marysville	Yuba	3,991	3,497	5,430	5,461	2
Mayfield	Santa Clara			1,041	1,127	
Mill Valley	Marin			2,551	2,554	
Modesto	Stanislaus				9,241	
Mountain View	Santa Clara			1,161	1,888	
Napa	Napa	4,395	4,036	5,791	6,757	2
Nevada City	Nevada	2,524	3,250	2,689	1,782	3–8
Newman	Stanislaus			892	1,251	
Oakdale	Stanislaus				1,745	
Oakland	Alameda	48,682	66,960	150,174	216,261	2
Orland	Glenn			836	1,582	
Oroville	Butte			3,859	3,340	3
Palo Alto	Santa Clara		1,658	4,486	5,900	2–7
Patterson	Stanislaus				694	
Petaluma	Sonoma	3,692	3,871	5,880	6,226	2
Piedmont	Alameda			1,719	4,282	2
Pittsburg	Contra Costa				4,715	
Pleasanton	Alameda		1,100	1,254	991	
Red Bluff	Tehama	2,608	2,750	3,530	3,104	2
Redding	Shasta	1,821	2,946	3,572	2,962	3
Redwood	San Mateo	1,572	1,653	2,442	4,020	2
Rio Vista	Solano	648	682	884	1,104	
Rocklin	Placer	1,056	1,050	1,026	643	5
Ross	Marin			556	727	4

[a] 1, Gas only; 2, gas and electricity; 3, gas, electricity, and water; 4, gas, electricity, and street railways; 5, electricity and water; 6, electricity supplied through other companies; 7, gas supplied through other companies; 8, water supplied through other companies. Blanks indicate that only electricity is supplied.

TABLE 16.—*Incorporated places served by Pacific Gas & Electric Co.*—Continued.

Places served directly—Continued.

City or town.	County.	Population.				Class of service.
		1890	1900	1910	1920	
Sacramento	Sacramento	26,386	29,282	44,696	65,908	2
San Anselmo	Marin			1,531	2,475	2
San Bruno	San Mateo				1,562	2
San Francisco	San Francisco	298,997	342,782	416,912	506,676	2
San Jose	Santa Clara	18,060	21,500	28,946	39,642	2
San Leandro	Alameda		2,253	3,471	5,703	2
San Mateo	San Mateo		1,832	4,384	5,979	2
San Rafael	Marin	3,290	3,879	5,934	5,512	2
Santa Rosa	Sonoma				8,758	2
Sausalito	Marin	1,334	1,628	2,383	2,790	
South San Francisco	San Mateo			1,989	4,411	2
Sebastopol	Sonoma			1,233	1,493	2
Suisun	Solano	499	625	641	769	
Sunnyvale	Santa Clara				1,675	
Tehama	Tehama			221	196	
Tracy	San Joaquin				2,450	
Turlock	Stanislaus				3,394	
Vallejo	Solano	6,343	7,965	11,340	21,107	2–6
Walnut Creek	Contra Costa				538	
Wheatland	Yuba	630	492	481	435	
Willows	Glenn	1,176	893	1,139	2,190	3
Winters	Yolo		785	910	903	
Woodland	do	3,069	2,886	3,187	4,147	2
Yuba City	Sutter			1,160	1,708	2
		455,173	548,738	811,742	1,140,524	

Places served through other companies.

City or town.	County.	1890	1900	1910	1920	Class of service.
Amador City	Amador				377	6–8
Auburn	Placer	1,595	2,050	2,376	2,289	5–6
Biggs	Butte			403	683	6
Carmel	Monterey				638	6
El Cerito	Contra Costa				1,505	2–6
Gilroy	Santa Clara				2,862	6
Grass Valley	Nevada				4,006	3–8
Gridley	Butte				1,636	6
Hercules	Contra Costa				373	6
Hollister	San Benito				2,781	6
Jackson	Amador			2,035	1,601	6–8
King City	Monterey				1,048	6
Monterey	do				5,479	6
Morgan Hill	Santa Clara				646	6
Pacific Grove	Monterey				2,974	6
Pinole	Contra Costa			798	967	6
Richmond	do			6,802	16,843	2–6
Roseville	Placer			2,608	4,477	6–8
Salinas	Monterey				4,308	6
San Juan	San Benito				501	6
Santa Clara	Santa Clara	2,891	3,650	4,348	5,220	6
Santa Cruz	Santa Cruz				10,917	6
Sonoma	Sonoma	757	652	957	801	6
Sonora	Tuolumne				1,684	5–6
Stockton	San Joaquin				40,296	5–6
Sutter Creek	Amador				920	6–7
Vacaville	Solano	725	1,220	1,177	1,254	6
Vallejo	do	6,343	7,965	11,340	21,107	2–6
Watsonville	Santa Cruz				5,013	6
		12,311	15,537	32,844	143,206	

TABLE 17.—*Unincorporated places, including mines, served by Pacific Gas & Electric Co., 1920.*

Placed served directly.

City or town.	Population.[a]	Class of service.[b]	City or town.	Population.[a]	Class of service.[b]
Alvarado	1,000		Lewiston	200	
Anderson	750		Live Stock	300	
Angel Island	500		Los Altos	500	
Arbuckle	900		Los Molinos	200	
Atherton	500	2	Madison	300	
Barber	500	2	Mare Island	600	
Belmont	375	2	Maxwell	500	
Bolinas	200		Menlo Park	900	2
Brentwood	400		Meridian	200	
Broderick	700	2	Millbrae	200	2
Byron	350		Mills	400	
Campbell	600		Milpitas	300	
Cement	1,000		Mission San Jose	500	
Centerville	1,000		Mokelumne Hill	900	
College City	250		Mount Eden	200	
Collinsville	200		Newark	500	
Colma	1,500	2	Newcastle	750	5
Cordelia	300		Niles	1,000	
Cotati	200	2-6	Oakley	200	
Cottonwood	500		Pacheco	300	
Coyote	200		Paradise	500	
Crockett	1,500		Penn Grove	200	
Crows Landing	300		Penryn	250	5
Danville	400		Perkins	300	
Davenport	300		Port Costa	900	
Decoto	300		Princeton	300	
Denair	200		Ripon	500	
Durham	250		Riverbank	200	
Elmira	350		San Andreas	1,183	
Escalon	600		San Lorenzo	500	2
Esparto	200		San Quentin	3,000	2
Fairfax	250	2	Saratoga	500	
Fair Oaks	300		Shasta	200	
Fall River Mills	300		Sheridan	250	
Farmington	300		Smartsville	300	
Folsom	3,000		Standard	500	
Grimes	500		Stanford University	2,700	2-7
Hamilton City	250		Sunol	350	
Hammonton	500		Sutter City	250	
Honcut	500		Tiburon	400	
Hughson	250		Vina	300	
Irvington	1,000		Warm Springs	200	
Kentfield	500	2	Waterford	250	
Kenwood	300		Williams	650	
Keswick	200		Woodside	300	
Knights Ferry	200		Yolo	350	
Knights Landing	400				
Lathrop	600			50,058	

Places served through other companies.

City or town.	Population.[a]	Class of service.[b]	City or town.	Population.[a]	Class of service.[b]
Aptos	300	6	La Grange	200	5
Ben Lomond	400	6	Lomita Park	600	2
Capitola	300	6	Loomis	500	5
Columbia	200	5-6	Novato	400	6
Del Monte	300	6	Occidental	600	6
Dry Town	200	6	Pike City	200	6
Duncan's Mills	200	6	Rodeo	300	6
Dutch Flat	750	5-6	San Martin	250	6
Eldridge	500	6	San Pablo	500	6
El Verano	400	6	Shellville	200	6
Felton	300	6	Soledad	400	6
Forestville	250	6	Soquel	400	6
Glen Ellen	1,000	6	Tres Pinos	300	6
Gonzales	500	6	Tuolumne	1,500	5-6
Groveland	500	6	Vineburg	200	6
Guerneville	800	6			
Ione	1,000	6-8		15,200	
Jamestown	750	5-6			

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[a] As given by Pacific Gas & Electric Co. for 1920.

[b] 1, Gas only; 2, gas and electricity; 3, gas, electricity, and water; 4, gas, electricity, and street railway; 5, electricity and water; 6, electricity supplied through other companies; 7, gas supplied through other companies; 8, water supplied through other companies. Blanks indicate that only electricity is supplied.

TABLE 17a.—*Summary of communities served by Pacific Gas & Electric Co. Dec. 31, 1920.*[a]

	Directly.		Indirectly.		Total.	
	Number.	Population.	Number.	Population.	Number.	Population.
Electricity	171	1,120,503	60	153,449	231	1,273,952
Gas	56	1,127,009	2	8,600	58	1,135,609
Water (domestic)	18	61,719	8	15,488	26	77,207
Railway	1	65,908	......	....	1	65,908

[a] Company's estimate.

LOAD.

GENERAL CONDITIONS.

The character of the company's load is extremely diversified. Most of the hydroelectric plants give local service to mining districts along the foothills. In crossing the valley the trunk transmission lines furnish power for agricultural needs during the summer and carry reclamation pumping loads in the lowlands of the Sacramento and San Joaquin deltas during the spring overflows. In the Bay region and in the cities of Stockton and Sacramento the lines supply power for all the uses common in urban and manufacturing districts and, at many points on the system, for special industries, such as cement mills, rock crushers, and miscellaneous manufacturing establishments.

The principal wholesale deliveries of power from Pacific Gas & Electric to other systems have been made to Western States Gas & Electric Co., Coast Counties Gas & Electric Co., California Telephone & Light Co., Coast Valleys Gas & Electric Co., Universal Electric & Gas Co., and Snow Mountain Water & Power Co. Power was formerly delivered to Oro Electric Corporation, which was acquired by Pacific Gas & Electric Co. in 1917.

Data covering classified load on the Pacific Gas & Electric system have been compiled in several forms, and are therefore included in several tables. Readers having access to the annual report published by the company for 1913 will find a geographical segregation of connected load on the transmission and distribution system at that time; the notes following Table 18 give similar information for 1920. Classified electric operating revenues given in Table 198, Appendix A, studied in connection with Table 18, showing sales and connected load for the years 1913–1920, will give an idea of the comparative importance of the various classes of load.

TABLE 18.—*Sales and connected load, Pacific Gas & Electric Co., 1913–1920.*

Class of load.	1913				1914			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence and commercial	66,723,879	16.7	137,624	43.3	71,737,571	16.5	153,495	43.0
Municipal	8,481,975	2.1	4,179	1.3	10,969,715	2.5	4,448	1.2
All other	1,295,243	.3	....	......	1,048,134	.2	....	......
Power:								
Industrial	99,822,611	25.1	102,896	32.4	105,512,521	24.3	114,920	32.2
Agricultural	26,899,528	6.7	28,850	9.1	24,326,941	5.6	36,252	10.2
All other [a]	195,989,394	49.1	44,084	13.9	220,420,740	50.9	47,919	13.4
	399,212,630	100.0	317,633	100.0	434,015,622	100.0	357,034	100.0

Class of load.	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence and commercial	96,236,486	19.6	76,000	45.0	80,794,557	15.5	187,907	42.1
Municipal	14,858,031	3.0	4,570	1.2	15,484,788	3.0	4,235	.9
All other	984,673	.2	....	......	966,500	.2	....	......
Power:								
Industrial	111,262,476	22.6	118,600	30.3	134,875,370	26.0	103,501	23.2
Agricultural	25,068,009	5.1	37,800	9.6	38,227,199	7.3	47,141	10.5
All other [a]	243,370,459	49.5	54,500	13.9	249,355,755	48.0	104,311	23.3
	491,780,134	100.0	391,470	100.0	519,704,169	100.0	447,095	100.0

Class of load.	1917				1918			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residential and commercial	83,484,965	14.3	199,152	41.9	83,981,835	13.3	210,362	42.5
Municipal	14,791,168	2.5	[b] 3,938	.8	14,000,861	2.2	[b] 3,831	.7
All other	1,094,548	.2	....	......	1,316,792	.2	....	......
Power:								
Industrial	166,612,164	28.5	107,757	22.6	181,912,721	28.9	107,860	21.8
Agricultural	40,413,079	6.9	52,457	11.0	45,740,895	7.3	58,554	11.8
All other [a]	277,830,011	47.5	111,790	23.5	301,610,065	48.0	114,289	23.1
	584,225,935	100.0	475,094	100.0	628,563,169	100.0	494,896	100.0

[a] State, county and municipal, mining, railway, heating, other electric corporations, and miscellaneous.

[b] Street lighting only.

TABLE 18.—*Sales and connected load, Pacific Gas & Electric Co., 1913–1920*—Continued.

Class of load.	1919 sales.		1920 sales.			
	Kilowatt-hours.	Per cent of total.	Kilowatt-hours.			Per cent of total.
			Pacific Gas & Electric Co.	Sierra & San Francisco Power Co.	Total.	
Operating revenue, electric:						
State, county, and municipal street lighting—arc and incandescent	13,100,253	2.0	13,872,919	143,438	14,016,357	1.3
State, county, and municipal lighting of buildings and heat and power	9,054,391	1.4	10,348,895	1,505,466	11,854,361	1.1
Commercial:						
Flat-rate lighting	894,778	.1	802,630	......	802,630	.1
Metered lighting	89,746,267	13.8	11,153,954	4,015,524	115,169,478	11.0
Flat-rate heating	......	......	97,642	......	97,642	......
Metered heating	1,880,779	.3	3,026,559	366,910	3,393,469	.3
Metered power:						
Mining	92,579,843	14.2	87,886,941	10,966,260	98,853,201	9.5
Agricultural	58,254,808	9.0	105,740,327	11,949,274	117,689,601	11.3
Electric railway	93,063,860	14.3	95,502,670	146,157,930	241,660,600	23.2
Manufacturing	165,986,063	25.5	200,456,363	11,860,576	212,316,939	20.4
Miscellaneous	75,490,743	11.6	80,104,047	2,867,836	82,971,883	7.9
Flat-rate power:						
Agricultural	......	......	13,563,081	2,493	13,565,574	1.3
Miscellaneous	......	......	131,944	......	131,944	.1
Sales to other electric corporations	51,186,103	7.8	66,951,963	62,507,087	129,459,049	12.4
Temporary electric revenue	62,165	......	88,360	520	88,880	.1
	651,300,053	100.0	789,728,294	252,343,314	1,042,071,608	100.0

Class of load.	1919 connected load.		1920 connected load.			
	Kilowatts.	Per cent of total.	Kilowatts.			Per cent of total.
			Pacific Gas & Electric Co.	Sierra & San Francisco Power Co.	Total.	
Commercial lighting	230,239	39.9	243,936	4,201	248,137	36.1
Street lighting:						
Arc	818	.1	1,094	30	1,124	.2
Electroliers	891	.1	931	1	932	.1
Incandescent	2,237	.4	2,911	108	3,019	.4
Cooking and heating	......	......	8,028	1,161	9,189	1.3
Motors:						
Industrial	134,342	23.3	148,314	3,298	151,612	22.1
Agricultural	82,172	14.3	100,976	4,545	105,521	15.4
Other	126,562	21.9	125,708	41,837	167,545	24.4
	577,261	100.0	631,898	55,181	687,079	100.0

NOTE.—Aside from the metered sales in kilowatt-hours listed above there were certain additional deliveries of power each year which were not metered but which were estimated. These amounts, in kilowatt-hours and the resulting loads on the system were as follows:

Year.	Unmetered sales (estimated).	System sales.	Year.	Unmetered sales (estimated).	System sales.
1913	25,787,370	425,000,000	1917	2,918,126	587,144,061
1914	17,987,927	452,003,549	1918	359,741	628,922,910
1915	2,310,747	494,090,881	1919	212,825	651,512,878
1916	1,848,984	521,553,153	1920	194,331	1,042,265,939

The percentages of gross sales for each class of load in the table are expressed in terms of the metered sales in kilowatt-hours, and not of the system total.

TABLE 18.—*Sales and connected load, Pacific Gas & Electric Co., 1913–1920*—Continued.

Oro Electric Corporation, 1913–1916.

[Absorbed by Pacific Gas & Electric Co. in 1917. Includes Oro Water, Light & Power Co.]

Class of load.	1913				1914			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	17,020	0.9	453.7	5.9	216,092	1.3	534.2	6.5
Commercial			513.0	6.7	225,341	1.3	434.8	5.3
Municipal			29.6	.4	96,211	.6	43.8	.5
Power:								
Industrial	15,660,960	85.8	3,974.7	51.7	15,103,446	90.1	3,730.7	45.2
Agricultural	839,196	4.6	2,657.8	34.6	1,131,921	6.7	3,317.1	40.3
All other power	1,740,337	9.5	52.5	.7			179.0	2.2
	18,257,513	100.0	7,681.3	100.0	16,773,011	100.0	8,239.5	100.0

Class of load.	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	239,341	1.7	501.3	6.5	353,680	2.6	658.6	7.3
Commercial	240,070	1.7	437.0	5.6	270,136	2.0	446.8	5.0
Municipal	98,397	.7	46.4	.6	96,406	.7	47.3	.5
Power:								
Industrial	[a]12,181,602	85.9	2,927.9	37.7	10,933,494	81.2	3,721.8	41.3
Agricultural	1,418,959	10.0	3,621.6	46.7	1,807,657	13.4	3,888.9	43.1
All other power			227.0	2.9	7,885	.1	251.9	2.8
	14,178,369	100.0	[b]7,761.2	100.0	13,469,258	100.0	9,015.3	100.0

[a] Approximately 3,900,000 kilowatt-hours delivered to dredges in Stockton district.

[b] The connected load in the Stockton district and the number of consumers on the entire system and the Stockton district on Dec. 31, 1915, were as follows:

Class of load.	Connected load in Stockton district.	Consumers on system.	Consumers in Stockton district.
Lighting:	*Kilowatts.*		
Residence	258.2	1,386	318
Commercial	25.0	294	37
Municipal		21	
Power:			
Industrial	53.3	73	4
Agricultural	2,979.0	518	347
All other power		6	
	3,315.5	2,298	706

In addition to above figures for connected load in Stockton system there were three dredges with a total connected load of 913. The number of consumers in Stockton district includes these dredges under industrial power.

TABLE 18.—*Sales and connected load, Pacific Gas & Electric Co., 1913–1920*—Continued.

Northern California Power Co. Consolidated.

[Absorbed by Pacific Gas & Electric Co. in 1919.]

Class of load.	1913				1914			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	1,319,032	1.2	3,093	9.4	932,602	0.9	3,895	11.6
Commercial	1,196,895	1.0	1,433	4.4	1,058,895	1.0	1,622	4.9
Municipal	509,364	.4	245	.8	492,287	.5	193	.6
All other	....	......	....	......	87,388	.1	7	......
Power:								
Industrial	2,424,103	2.1	[a] 15,208	46.6	2,229,551	2.0	3,497	10.5
Agricultural	5,979,656	5.3	2,573	7.9	4,672,168	4.3	5,293	15.8
Mining	28,184,159	24.8	9,949	30.5	29,369,958	27.0	13,522	40.4
All other	74,035,081	65.2	122	.4	[b] 69,609,852	64.2	5,437	16.2
	113,648,290	100.0	32,623	100.0	108,452,701	100.0	33,466	100.0

Class of load.	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	969,057	0.9	3,928	10.7	1,071,291	0.9	4,419	11.8
Commercial	1,038,844	.9	1,539	4.2	1,112,838	.9	1,508	4.0
Municipal	686,169	.6	287	.8	777,840	.6	268	.7
All other	18,922	......	61	.2	23,697	......	64	.2
Power:								
Industrial	4,479,147	4.0	3,452	9.4	4,820,397	3.9	3,620	9.6
Agricultural	5,059,072	4.5	5,936	16.0	8,910,239	7.2	5,996	16.0
Mining	30,696,161	27.3	13,441	36.5	37,224,561	56.4	8,252	22.0
All other	[b] 69,729,174	61.8	[c] 8,164	22.2	69,929,961	30.1	13,379	35.7
	112,676,546	100.0	36,808	100.0	123,870,824	100.0	37,506	100.0

Class of load.	1917				1918			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Municipal—								
Street	552,892	0.4	201.7	0.5	671,892	0.5	168.4	0.4
Miscellaneous	82,859	.1	137.4	.3	51,366	......	99.6	.2
Commercial—								
Business	1,156,396	.9	1,555.1	3.8	1,193,311	.8	1,543.1	3.5
Residence	1,243,448	.9	4,507.9	11.2	1,087,857	.7	4,581.7	10.5
Power:								
Municipal	223,582	.2	230.8	.6	305,048	.1	249.6	.6
Commercial—								
Industrial	5,877,845	4.5	3,436.4	8.5	5,172,193	3.6	2,586.3	5.9
Agricultural	10,576,032	8.0	6,575.0	16.3	23,008,204	15.9	11,035.6	25.3
Other electrical corporations	182,049	.1	271.5	.7	402,157	.3	561.1	1.3
Mining	42,899,893	32.5	14,967.1	37.1	54,474,272	37.8	14,260.5	32.8
Other electrical corporations	69,120,842	52.4	8,460.0	21.0	58,323,420	40.3	8,472.3	19.5
	131,915,838	100.0	40,342.9	100.0	144,689,720	100.0	43,557.9	100.0

[a] Includes a 15,000-kilowatt demand by Oro Electric Corporation.
[b] Almost all delivered to Pacific Gas & Electric Co.
[c] Actual continuous delivery of 7,960 kilowatts to Pacific Gas & Electric Co.

TABLE 18.—*Sales and connected load, Pacific Gas & Electric Co., 1913–1920*—Continued.

Northern California Power Co. Consolidated—Continued.

Class of load.	1919 [d]			
	Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:				
Municipal—				
Street	456,037	0.5	130,226	0.4
Miscellaneous	42,933	....	107,217	.3
Commercial—				
Business	1,101,300	1.1	1,241,486	3.6
Residence	806,668	.8	4,597,630	13.3
Power:				
Municipal	217,361	.2	277,583	.8
Commercial—				
Industrial	4,586,073	4.4	2,880,299	8.3
Agricultural	31,338,629	30.2	19,519,205	56.3
Heating and cooking, other	353,350	.3	683,204	1.9
Mining	19,143,053	18.5	5,232,337	15.1
Other electrical corporations	[b] 45,595,244	44.0	....	....
	103,640,748	100.0	34,669,187	100.0

[b] Almost all delivered to Pacific Gas & Electric Co.

[d] Nine months to Sept. 30, 1919.

The following notes give additional information concerning load at the end of 1920:

The heaviest loads for lighting and domestic use are in the San Francisco district and in Oakland and other cities along the east shore of San Francisco Bay. There are also important load centers of this class at San Jose, Sacramento, and in the region north of San Francisco Bay. About half the total connected lighting load is in San Francisco.

The heaviest railway load is in San Francisco, where 51,744 horsepower is connected, and in Alameda, where 18,282 horsepower is connected. The total connected railway load of the entire system was 94,661 horsepower.

The heaviest connected agricultural loads were in the San Jose district (aggregating 25,729 horsepower) and Marysville district (25,061 horsepower). The Yolo district, with its extensive rice-growing industry, ranked third (with 22,123 horsepower) and the San Joaquin district fourth (with 20,342 horsepower connected). Table 18 shows that the rate of increase in agricultural load has been very rapid.

The heaviest connected mining loads were in the Marysville, Nevada, Shasta, and Electra districts, where they amounted to 12,171, 8,878, 6,173, and 5,360 horsepower respectively. The Marysville division, in addition to some mines, carries a large number of gold dredges. The Nevada division carries the important mines in and around Nevada City and Grass Valley, the Shasta division includes all of Shasta County, and the Electra division the mines on the Mother Lode near Jackson and Amador.

The heaviest miscellaneous and manufacturing loads were in San Francisco district (with 86,616 horsepower), Alameda County (with 75,990 horsepower), and San Jose (with 30,708 horsepower connected).

Table 19 shows that Pacific Gas & Electric Co. purchases from other companies far more power than it sells to smaller public-service systems. Its largest purchases have been made from Great Western Power Co. and from Northern California Power Co. Consolidated. Smaller quantities of power have been bought from Snow Mountain Water & Power Co., with which the Pacific Gas & Electric Co. has a contract to buy or sell at 0.55 cent per kilowatt-hour. From October 15, 1908, to April 30, 1910, power was purchased regularly from Sierra & San Francisco Power Co. After that date the service was intermittent until the lease of Sierra & San Francisco system by Pacific Gas & Electric Co. on January 1, 1920. The largest sales to other public-utility corporations have been to Western States Gas & Electric Co., Stockton and Richmond divisions, and to Coast Counties Gas & Electric Co. Prior to its acquisition power was also sold to Oro Electric Corporation for use in Oroville and Stockton systems.

In addition to the above companies, which are the most important customers, Pacific Gas & Electric Co. supplies numerous small public-utility distributing systems which are listed in Table 314.

TABLE 19.—*Power generated and purchased by Pacific Gas & Electric Co.*

Summary, 1906–1920.

Year.	Power generated by hydroelectric plants.	Power generated by steam-electric plants.	Total power generated by company.	Power purchased.	Total power generated and purchased.	Equivalent mean output.	
						Kilowatts.	Horsepower.
	Kilowatt-hours.	*Kilowatt-hours.*	*Kilowatt-hours.*	*Kilowatt-hours.*	*Kilowatt-hours.*		
1906	....	....	....	....	309,090,926	35,300	47,300
1907	272,025,310	110,906,803	382,932,113	23,937,877	406,869,990	46,450	62,250
1908	284,404,696	133,408,311	417,813,007	27,556,849	445,369,856	50,850	68,150
1909	255,861,874	93,612,599	349,474,473	163,013,070	512,487,543	58,500	78,400
1910	193,501,609	109,882,381	303,383,990	211,233,711	514,617,701	58,750	78,700
1911	246,065,829	108,157,064	354,222,893	178,667,082	532,889,975	60,800	81,500
1912	244,114,227	100,749,286	344,863,513	215,693,152	560,556,665	64,000	85,750
1913	239,228,562	163,886,492	403,115,054	217,537,886	620,652,940	70,850	94,950
1914	374,957,993	101,639,560	476,597,553	181,700,449	658,298,002	75,150	100,700
1915	374,650,252	166,916,794	541,567,046	184,148,574	725,715,620	82,800	111,000
1916	423,425,688	163,130,488	586,556,176	181,748,731	768,304,907	87,700	117,500
1917	478,472,679	195,032,980	673,505,659	180,593,371	854,093,030	97,500	130,650
1918	517,201,785	236,268,840	753,470,625	168,566,979	922,037,604	105,300	141,100
1919	522,234,204	315,474,601	837,708,805	141,408,224	979,117,029	111,700	149,800
1920	[a] 861,718,698	[a] 469,280,895	1,330,999,593	126,063,219	1,457,062,812	165,900	222,300

[a] Includes Sierra & San Francisco Power Co. leased.

TABLE 19.—*Power generated and purchased by Pacific Gas & Electric Co.*—Continued.

Power purchased, 1913–1920, classified by source.

Purchased from—	Power purchased.		Equivalent mean load for 12 months.	Maximum demand for 30 minutes.	Load factor.
	Kilowatt hours.	Per cent of total.			
1913.			*Kilowatts.*	*Kilowatts.*	
Great Western Power Co.	121,487,439	55.8	13,860	22,500	0.62
Northern California Power Co. Consolidated	75,986,500	34.9	8,670	16,000	.54
Snow Mountain Water & Power Co.	19,624,215	9.1	2,280	4,600	.50
Sierra & San Francisco Power Co.	420,045	.2	48	....	....
Northwestern Pacific Railroad Co.	19,687	....	....	....	....
	217,537,886	100.0	....	....	....
1914.					
Great Western Power Co.	92,602,051	51.0	10,560	19,500	0.54
Northern California Power Co. Consolidated	70,345,395	38.7	8,030	11,000	.73
Snow Mountain Water & Power Co.	18,737,614	10.3	2,140	4,212	.51
Sierra & San Francisco Power Co.	....	....	....	....	....
Northwestern Pacific Railroad Co.	15,389	....	....	....	....
	181,700,449	100.0	....	....	....
1915.					
Great Western Power Co.	91,578,344	49.8	10,450	19,000	0.55
Northern California Power Co. Consolidated	71,497,541	38.8	8,160	12,000	.68
Snow Mountain Water & Power Co.	20,872,132	11.3	2,380	4,400	.54
Sierra & San Francisco Power Co.	190,520	.1	....	....	....
Northwestern Pacific Railroad Co.	10,037	....	....	....	....
	184,148,574	....	....	....	....
1916.					
Great Western Power Co.	92,151,818	50.7	10,520	19,500	0.54
Northern California Power Co. Consolidated	71,099,650	39.1	8,120	12,800	.63
Snow Mountain Water & Power Co.	18,477,824	10.2	2,110	4,334	.49
Sierra & San Francisco Power Co.	17,001	....	....	....	....
Northwestern Pacific Railroad Co.	2,438	....	....	....	....
	181,748,731	....	....	....	....
1917.					
Great Western Power Co.	92,715,436	51.4	10,580	18,100	0.59
Northern California Power Co. Consolidated	69,934,000	38.7	7,980	13,000	.61
Snow Mountain Water & Power Co.	17,942,437	9.9	2,050	4,334	.47
Sierra & San Francisco Power Co.	110	....	....	....	....
Northwestern Pacific Railroad Co.	1,388	....	....	....	....
	180,593,371	....	....	....	....
1918.					
Great Western Power Co.	78,414,805	46.5	8,960	20,000	0.45
Northern California Power Co. Consolidated	57,514,080	34.1	6,560	13,000	.50
Snow Mountain Water & Power Co.	17,616,384	10.5	2,010	5,620	.36
Sierra & San Francisco Power Co.	15,021,710	8.9	1,715	18,800	.09
Northwestern Pacific Railroad Co.	....	....	....	....	....
	168,566,979	....	....	....	....
1919.					
The California Oregon Power Co.	39,648,090	28.0	4,520	11,750	0.38
Great Western Power Co.	35,080,072	24.8	4,000	21,400	.19
Northern California Power Co. Consolidated	44,766,700	31.7	5,110	13,300	.38
Snow Mountain Water & Power Co.	17,307,442	12.2	1,980	5,700	.35
Miscellaneous	4,605,920	3.3	526	14,000	.04
	141,408,224	100.0	....	....	....
1920.					
The California Oregon Power Co.	65,841,781	52.2	7,500	12,000	0.63
Great Western Power Co.	5,138,918	4.1	585	15,000	.04
Snow Mountain Water & Power Co.	14,844,817	11.8	1,690	5,410	.31
Western States Gas & Electric Co.	1,504,036	1.2	1,710	....	....
San Joaquin Light & Power Corporation	4,643,151	3.7	528	....	....
Coast Counties Gas & Electric Co.	251,160	.2	19	....	....
Coast Valleys Gas & Electric Co.	1,570,733	1.2	179	....	....
City of San Francisco Hetch Hetchy system	14,875,312	11.8	1,690	2,500	.68
Melones	4,356,658	3.4	496	750	.66
Utica Mining Co.	6,533,000	5.2	744	1,400	.53
West Side Lumber Co.	471,900	.4	54	....	....
Miscellaneous[a]	6,031,749	4.8	686	....	....
	126,063,215	100.0	....	....	....

[a] Includes deliveries of various small companies direct to Pacific Gas Electric Co. distribution system.

LOAD CURVES.

System load curves for Pacific Gas & Electric Co. for two days in each year from 1914 to 1921 are shown in figure 7, and similar system curves for Northern California Power Co. Consolidated, from 1914 until 1919, when it was absorbed by Pacific Gas & Electric Co., are given in figure 6. Curves in figure 7 include power generated by Pacific Gas & Electric Co. in its hydroelectric and steam-electric plants, and also power purchased from other companies, part of which came from the system of Northern California Power Co. Consolidated and therefore comprises part of that shown in the curves of figure 6 as hydroelectric power generated.

Plate XIX shows the mean monthly loads and load factors, Pacific Gas & Electric Co., from the earliest date available up to June 30, 1921.

Plate XX shows similar data for Northern California Power system up to the date of its acquisition by Pacific Gas & Electric Co.; and figure 5 shows similar data for Oro Electric system up to the date of its acquisition.

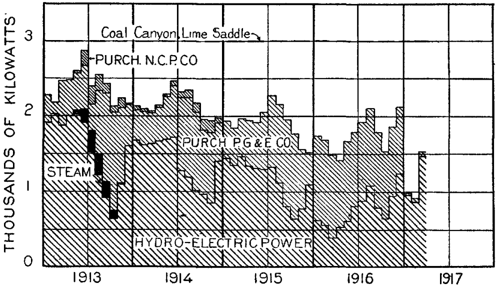


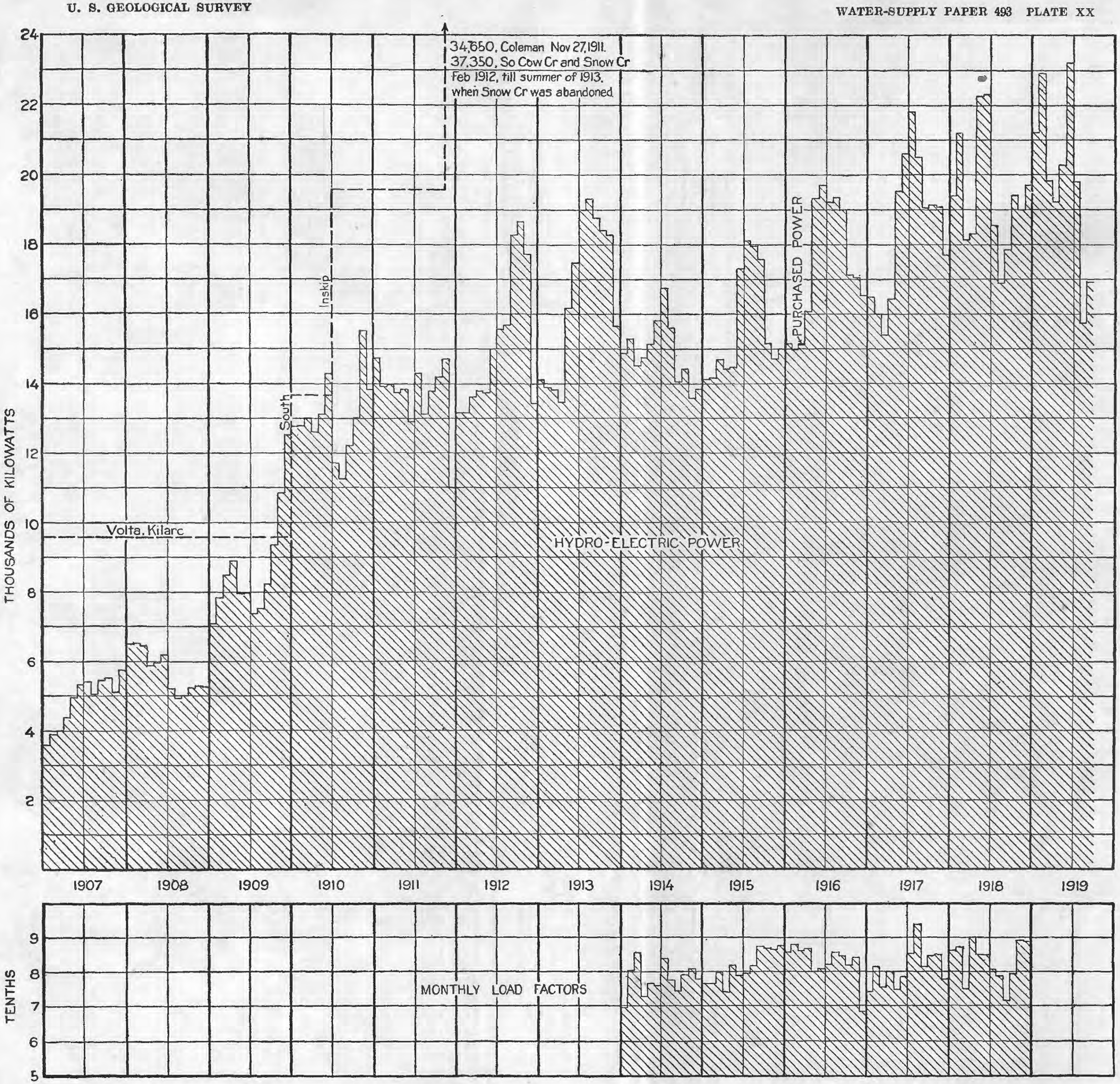
FIGURE 5.—Oro Electric system, mean monthly loads from 1913 to date of absorption by Pacific Gas & Electric Co.

Both the daily load curves and mean monthly loads of Pacific Gas & Electric system for 1920 and 1921 include all power generated at the hydroelectric and steam plants of Sierra & San Francisco Power Co., operated under lease from January 1, 1920.

In accordance with the method adopted uniformly throughout this report the heavy dash line on Plate XIX denotes total installed capacity of all hydroelectric plants on the system, computed from rated capacity of generators. The changes made from time to time in this total capacity, too numerous to be noted on the plate itself, have been as follows:

At the beginning of the record, in 1906, the following plants were in commission: De Sabla, 8,000 kilovolt-amperes; Colgate, 19,420;

PACIFIC GAS & ELECTRIC CO., MEAN MONTHLY LOADS AND LOAD FACTORS, 1909-1921.



NORTHERN CALIFORNIA POWER CO. CONSOLIDATED, MEAN MONTHLY LOADS AND LOAD FACTORS FROM 1907 TO DATE OF ABSORPTION BY PACIFIC GAS & ELECTRIC CO.

Alta, 3,000; Newcastle, 800; Yuba, 660; Nevada, 1,260; Folsom, 3,750; Electra, 20,000; and Auburn, 500 kilovolt-amperes. Centerville plant, although constructed, was for the time being out of commission during alterations. On June 26, 1906, the installation at De Sabla was increased by 5,000 kilovolt-amperes. Centerville went back into commission September 13, 1907, with an installed capacity of 6,200 kilovolt-amperes. October 23, 1907, the installation at Colgate was increased by 5,500 kilovolt-amperes. May 6, 1908, Deer Creek went into commission, with 5,500 kilovolt-amperes installed.

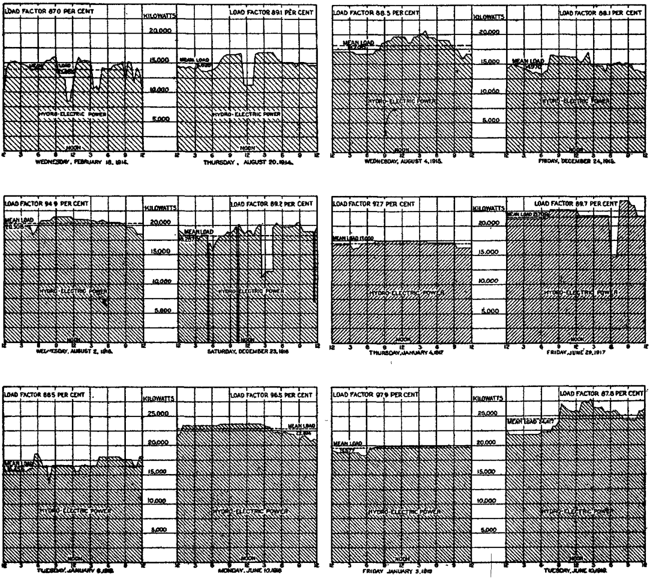


FIGURE 6.—Pacific Gas & Electric Co. (Northern California Power Co. Consolidated) daily load curves, 1914–1919.

October 28, 1910, the operating capacity of Colgate was decreased by 720 kilovolt-amperes, and Nevada plant went out of commission. About the end of December, 1911, Yuba and Auburn power houses were closed.

On November 26, 1913, Drum plant, with an installed capacity of 25,000 kilovolt-amperes, and on December 6, 1916, Halsey plant, with an installed capacity of 12,500 kilovolt-amperes, went into operation. On March 1, 1917, Lime Saddle plant (2,000 kilovolt-amperes) and Coal Canyon plant (1,000 kilovolt-amperes) were taken

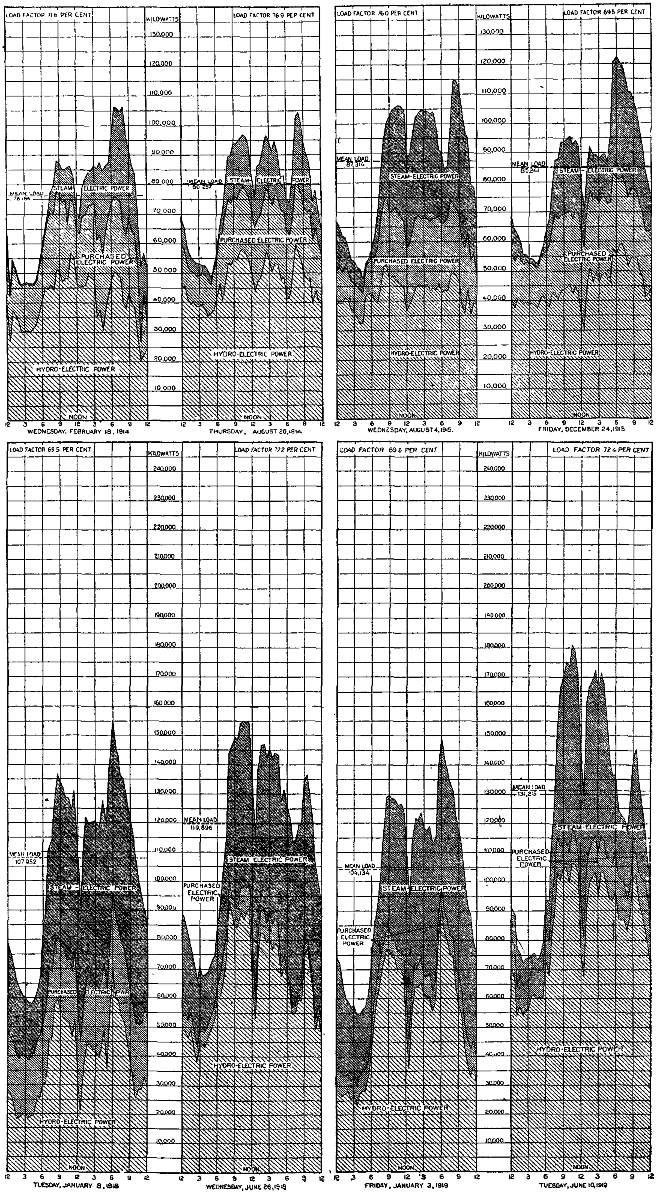
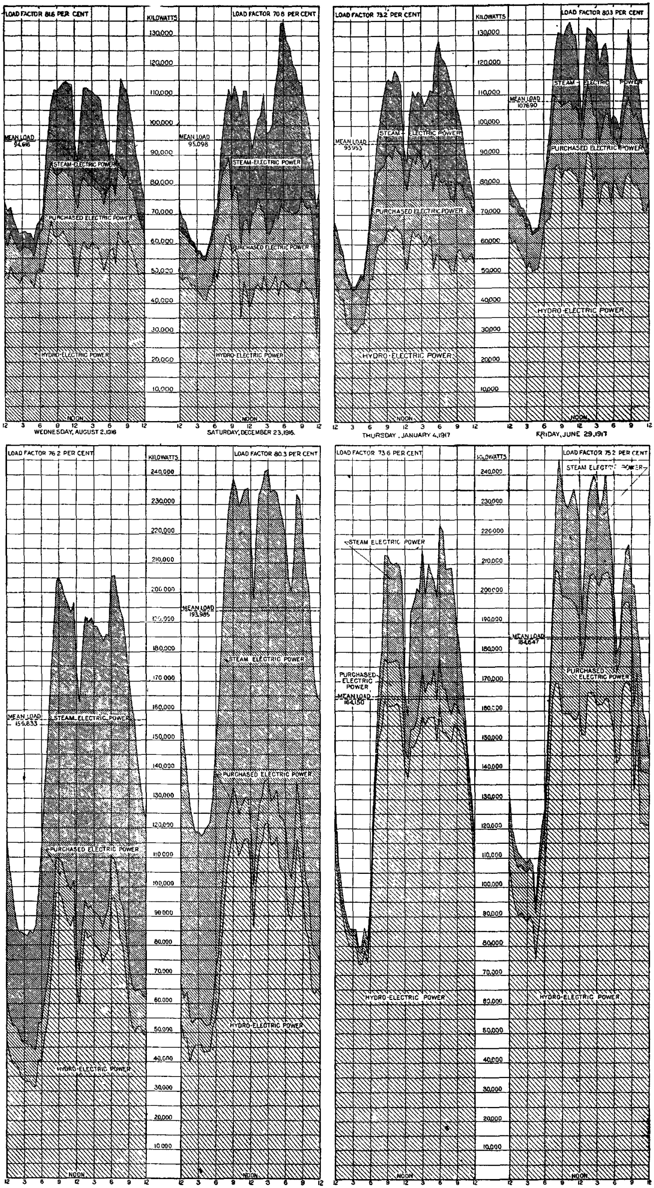


FIGURE 7.—Pacific Gas & Electric Co.



WEDNESDAY, AUGUST 2, 1916

SATURDAY, DECEMBER 23, 1916.

THURSDAY, JANUARY 4, 1917

FRIDAY, JUNE 29, 1917

THURSDAY FEBRUARY 12, 1920

FRIDAY, JULY 30, 1920

TUESDAY, FEBRUARY 15, 1921

THURSDAY, JUNE 2, 1921

daily load curves, 1914–1921.

over from Oro Electric Corporation. On March 4, 1917, Wise plant (12,500 kilovolt-amperes), and on December 16, 1917, Spaulding No. 1 plant, with an installed capacity of 3,750 kilovolt-amperes, were put into commission.

On January 11, 1918, the Newcastle plant, with an installed capacity of 800 kilovolt-amperes, was shut down. During 1918 the 5,500 kilovolt-ampere unit at Colgate was rewound to a capacity of 6,875 kilovolt-amperes, thus increasing its rating by 1,375 kilovolt-amperes. The hydroelectric system operated by Northern California Power Co. Consolidated was acquired October 3, 1919, the plants at that time having a total rated capacity of 36,150 kilovolt-amperes; their output and installed capacity before that date are shown separately in Plate XX. The plants of Sierra & San Francisco Power Co. were taken over under lease on January 1, 1920; the installed hydroelectric capacity of the Sierra & San Francisco Co. on that date (exclusive of the Knights Ferry plant, not leased and since abandoned) being 36,775 kilovolt-amperes. Spaulding No. 2, with an installed capacity of 1,000 kilovolt-amperes, was added to the system on October 29, 1920; Hat Creek No. 1, with an installed capacity of 12,500 kilovolt-amperes, on August 22, 1921; Spring Gap (on the leased system of Sierra & San Francisco Power Co.), with an installed capacity of 7,500 kilovolt-amperes, on September 16, 1921; and Hat Creek No. 2, with an installed capacity of 12,500 kilovolt-amperes, on September 28, 1921.

The annual outputs of steam-electric and hydroelectric plants owned by Pacific Gas & Electric Co. and the annual purchases in kilowatt-hours for the years 1907 to 1920, inclusive, are given in Table 19, and certain other data concerning loads and system peaks will be found in Table 20.

TABLE 20.—*Growth of load on Pacific Gas & Electric system, 1906–1920.*

Year.	Number of consumers.	Number of street lamps.		Connected load.	Average load on system.	Peak load on system.	Load factor.
		Arc.	Incandescent.				
				Horse-power.	*Horse-power.*	*Horse-power.*	*Per cent.*
1906	40,696	3,716	2,494	....	47,300	63,672	74.3
1907	54,772	4,272	5,337	....	62,250	83,908	74.2
1908	62,026	5,021	7,244	....	68,150	89,733	75.9
1909	70,515	5,506	12,878	....	78,400	134,012	58.5
1910	83,005	5,759	8,725	266,600	78,700	128,269	61.4
1911	102,024	6,119	10,191	308,041	81,500	141,469	57.4
1912	117,065	6,052	12,122	369,675	85,750	145,000	58.6
1913	132,355	6,721	21,321	425,783	94,950	160,819	59.0
1914	148,957	6,545	27,460	478,598	100,700	166,273	60.6
1915	166,149	6,001	33,978	525,541	111,000	187,051	59.4
1916	178,630	5,171	35,070	599,343	117,500	189,019	62.0
1917	194,374	3,032	46,026	636,855	130,650	212,161	61.6
1918	209,412	2,289	41,015	663,399	141,100	223,465	63.1
1919 [a]	235,719	1,818	42,630	773,808	152,189	250,850	60.7
1920 [b]	265,132	2,248	25,718	921,018	225,194	347,190	64.9

[a] Figures for Northern California Power Co. system included.
[b] Figures for Sierra & San Francisco Power Co. system included.

Pacific Gas & Electric Co., peaks and output during 1915, were affected by sales on an exclusive contract under which the company furnished all electric light and power for the Panama-Pacific International Exposition. The exposition opened on February 20, closed on December 4, and purchased about 60,000 kilowatt-hours a day near the beginning and the end of the period, and 45,000 kilowatt-hours per day during the long days of midsummer, from June 15 to July 15. Total sales to the exposition amounted to 16,921,138 kilowatt-hours of electricity and 137,406,800 cubic feet of gas. The daily peak loads for the exposition averaged approximately 7,000 kilowatts with a maximum peak of 8,200 kilowatts and a minimum peak of about 6,000 kilowatts. In addition to the power delivered while the exposition was officially open to the public there was a much smaller use during construction period and after the closing date. Curves published by the company show that on December 3, 1915, the San Francisco district carried its maximum load, with a peak of 51,000 kilowatts at 5.28 p. m., and an exposition peak of 6,400 kilowatts at 8.10 p. m. At the moment of the district peak (5.28) the exposition demand was about 5,300 kilowatts.

TABLE 21.—*Statistics of operation of water, gas, and railway departments, Pacific Gas & Electric Co., 1906–1918.*

	1906	1907	1908	1909	1910
Gas department:					
Consumers.........number..	99,095	122,304	131,235	139,503	152,395
Gas plants............do....	14	14	14	14	14
Gas sold ....cubic feet..	3,474,513,000	4,304,000,000	4,777,000,000	4,998,000,000	5,287,000,000
Gas holders:					
In use.........number..	34	35	35	37	37
Capacity.....cubic feet..	7,969,200	10,592,200	10,872,200	11,490,300	11,490,300
Gas generators—					
In use.........number..	34	38	41	41	42
Daily capacity...cu. ft..	16,440,000	27,640,000	33,980,000	34,208,000	34,680,000
Gas mains............miles..	1,147.26	1,269.62	1,329.53	1,447.03	1,634.21
Service pipes laid..number..	....	....	121,882	138,455	153,519
Gas lamps—					
Arc...............do....	....	1,634	1,878	3,352	3,810
Street.............do....	3,607	4,491	4,922	4,956	5,499
Water department:					
Consumers............do....	3,937	5,539	5,753	6,360	6,726
Pumping stations.....do....	3	3	3	3	3
Water pumped.....gallons..	946,785,062	942,515,817	1,059,933,425	1,057,552,130	1,166,756,024
Reservoirs, capacity..cu. ft..	2,457,831,500	2,459,081,500	2,459,081,500	2,463,651,500	2,463,651,500
Distribution mains...miles..	....	41.39	43.87	46.54	51.08
Electric street railway, Sacramento:					
Street-railway track..miles..	27.6	28.9	28.9	34.1	35.9
Cars owned........number..	34	44	45	51	52
Passengers carried.....do....	7,164,659	8,655,918	8,476,369	9,466,704	10,691,475
Gross revenue..............	$349,810.86	$431,800.34	$414,325.70	$452,396.07	$509,151.53
Car mileage................	1,591,324	1,803,742	1,731,311	1,895,766	2,136,494
Car hours..................	204,148	234,829	227,868	242,194	269,865
Passengers per day..........	19,629	23,715	23,223	25,936	29,292
Passenger receipts:					
Per car mile.............	$0.22	$0.223	$0.229	$0.230	$0.232
Per car hour.............	$1.71	$1.71	$1.74	$1.80	$1.84
Electric-railway systems supplied—					
Number................	11	11	11	11	11

TABLE 21.—*Statistics of operation of water, gas, and railway departments, Pacific Gas & Electric Co., 1906–1918*—Continued.

	1911	1912	1913	1914
Gas department:				
Consumers........number	176,131	194,914	208,269	220,360
Gas plants........do	16	17	17	17
Gas sold........cubic feet	5,751,000,000	6,691,000,000	7,430,000,000	7,648,000,000
Gas holders—				
In use........number	41	46	47	48
Capacity........cubic feet	18,930,300	20,078,000	20,443,300	20,943,300
Gas generators—				
In use........number	42	48	48	48
Daily capacity........cubic feet	34,680,000	43,130,000	43,130,000	43,130,000
Gas mains........miles	1,917.71	2,201	2,374.18	2,516.25
Service pipes laid........number	171,934	168,486	182,914	183,089
Gas lamps—				
Arc........do	4,932	17,242	16,189	14,971
Street........do	8,342	8,442	8,924	9,939
Water department:				
Consumers........do	7,257	8,027	8,479	9,051
Pumping stations........do	3	3	4	4
Water pumped........gallons	1,201,358,695	1,326,628,526	1,510,417,976	1,623,607,351
Reservoirs, capacity........cubic feet	2,553,651,500	2,472,509,500	....	....
Distribution mains........miles	55.79	62.77	69.92	75.93
Electric street railway, Sacramento:				
Street-railway track........miles	38.98	40	42	42.9
Cars owned........number	62	62	60	60
Passengers carried........do	11,464,696	11,926,098	12,508,744	12,256,142
Gross revenue........	$533,519.92	$547,187.32	$572,913	$556,908
Car mileage........	2,279,998	2,301,342	2,469,745	2,481,968
Car hours........	293,107	276,438	301,930	303,263
Passengers per day........	31,410	32,674	34,270	33,578
Passenger receipts:				
Per car mile........	$0.234	$0.238	$0.232	$0.229
Per car hour........	$1.91	$1.98	$1.90	$1.85
Electric-railway systems supplied—				
Number........	8	11	11	11
Mileage........	640	594	....	700

	1915	1916	1917	1918
Gas department:				
Consumers........number	227,586	232,748	243,182	254,432
Gas plants........do	16	16	17	17
Gas sold........cubic feet	8,326,000,000	8,174,000,000	8,538,000,000	9,256,000,000
Gas holders—				
In use........number	48	....	47	48
Capacity........cubic feet	20,936,300	....	19,009,500	20,009,500
Gas generators—				
In use........number	49	....	53	56
Daily capacity........cubic feet	54,220,000	54,400,000	60,744,000	72,744,000
Gas mains........miles	2,645.62	2,779.27	2,878.62	2,903.36
Service pipes laid........number	190,354	196,818	203,553	207,528
Gas lamps—				
Arc........do	....	....	10,652	6,206
Street........do	10,102	10,128	10,158	9,879
Water department:				
Consumers........do	9,432	10,025	12,655	12,705
Pumping stations........do	4	4	4	4
Water pumped........gallons	1,650,419,301	1,822,073,796	1,920,657,036	2,001,005,118
Reservoirs, capacity........cubic feet	....	....	....	....
Distribution mains........miles	108.73	115.09	141.83	177.77
Electric street railway, Sacramento:				
Street-railway track........miles	43.1	43.9	43.9	54
Cars owned........number	66	66	66	69
Passengers carried........do	9,485,490	10,044,428	10,616,953	11,331,864
Gross revenue........	$425,338	$442,303	$491,021	$534,067
Car mileage........	2,684,508	2,919,041	3,069,408	3,067,599
Car hours........	294,739	299,873	313,040	312,439
Passengers per day........	25,988	27,444	29,088	31,046
Passenger receipts:				
Per car mile........	$0.159	$0.152	$0.16	$0.174
Per car hour........	$1.45	$1.47	$1.57	$1.71
Electric-railway systems supplied—				
Number........	11	....	....	....
Mileage........	734	....	....	....

ELECTRIC SYSTEMS.

FOLSOM PLANT.

LOCATION.

The Folsom plant, the first hydroelectric station to begin operating in central California, was put into service July 13, 1895,[20] by Sacramento Electric Power & Light Co. The power house is on American River, in sec. 35, T. 10 N., R. 7 E., on the outskirts of the town of Folsom, a short distance from the Southern Pacific Railway station. The intake of the canal is in sec. 24, T. 10 N., R. 7 E.; the conduit traverses secs. 24, 25, 36, and 35 of the same township.

SOURCE OF WATER SUPPLY.

The Folsom plant is operated by water taken from American River a short distance below the junction of the South and North forks of that stream. The Middle Fork enters the North Fork 16 miles above the canal heading. The drainage basin above the intake includes 1,865 square miles, lying south of the main line of the Southern Pacific (which runs along the ridge between the North Fork of the American and the Bear River basins) and on all three forks of the river. The basin is chiefly in Placer and Eldorado counties, between Sacramento and Lake Tahoe, but a very small part of its northern edge extends into Nevada County and the extreme southeastern tip into Amador and Alpine counties. The distance from the eastern boundary of the basin at the main crest of the Sierra to the westernmost point, at the canal intake, is about 55 miles. The width of the basin due south from Emigrant Gap is about 40 miles. Elevations range from 210 feet at the intake to about 10,500 feet on the highest peaks, and the general elevation on the eastern boundary is about 8,500 feet.

From the headwaters to its junction with the Middle Fork the North Fork flows southwesterly, and the stream below the junction continues in the same direction. The Middle Fork flows almost due west from the Sierra divide, as does also the South Fork. The three forks dominate the topography of the area, dividing it into three deep canyons. West of Placerville, Georgetown, and Colfax, the lower mountains break away into a foothill belt which extends nearly as far as Folsom.

The rocks exposed along the crest of the Sierra Nevada within the basin are chiefly granites, but farther west are andesites and in certain places, chiefly along the ridges, lavas.

The central part of the basin is well forested, especially along the ridges at elevations between 3,500 and 5,000 feet. At higher elevations the soil is thin and the characteristic features of the country are

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[20] A brief history of the plant is given on pp. 109-111.

its granite domes and knobs which support little or no vegetation. In the higher foothills the timber is small and scattered. As elevations decrease, however, the brush-covered areas increase, and farther west the brush disappears and hills of the lower foothill belt are bare.

Precipitation in the basin of American River probably varies from an annual mean slightly exceeding 20 inches in the lower parts of the area to about 70 inches on the headwaters of Silver Creek and the Rubicon. Over a large part of the basin the annual mean is at least 50 inches. In the high mountains of the eastern part and on the long ridges extending toward the west the greater part of the precipitation is in the form of snow. Elevations along the main divide are sufficient to hold a part of this snow until late in the summer and, after winters when the snows have been early and plentiful, into the following winter. During less favorable years all but isolated patches of snow disappear before the end of summer, even from the highest peaks. The United States Geological Survey has maintained a gaging station on American River at Fair Oaks, 7 miles below Folsom, since 1904.[21]

RESERVOIRS.

Several lakes on the headwaters of the South Fork are used for storage to increase the flow in ditch systems that supply the mining region and a small power plant above Placerville, but even when augmented by the waters thus stored the discharge of that fork becomes very small by the end of the dry season.

On the heads of Middle and North forks there are also several reservoirs of small or moderate size. The storage on all three forks is used diversely and contributes only incidentally to the power developed at Folsom.

CONDUIT.

The Folsom head dam (Pl. XXI, *B*), a massive structure of granite laid in cement mortar, crosses American River at a point 2,000 feet above the California State prison at Folsom. The crest of the dam is straight, is 525 feet long and 24 feet wide, and its elevation is 210 feet above sea level. Its maximum height is 87 feet.

Formerly a trussed timber shutter, 180 feet long and 6 feet wide, was hinged on the upstream edge of the crest so that it could be raised by a system of hydraulic pumps; when not in use it dropped into a recess on the crest of the dam. The pondage supplied by the shutter was naturally of much greater service when the plant was on an isolated system than at present, when it is but a small unit in a great network and can be run on a flat load.

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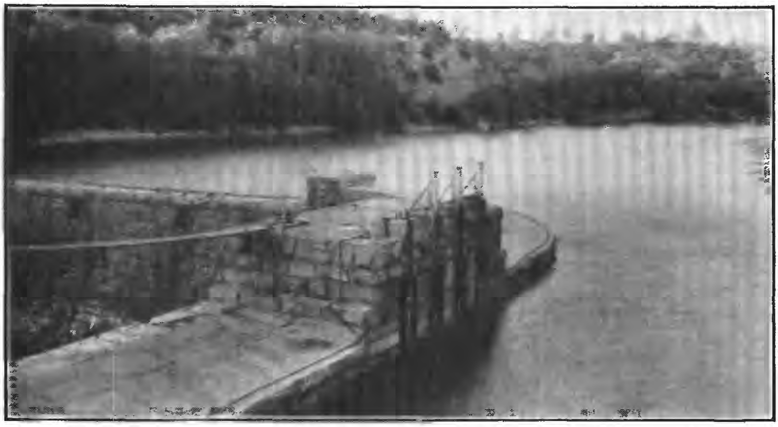
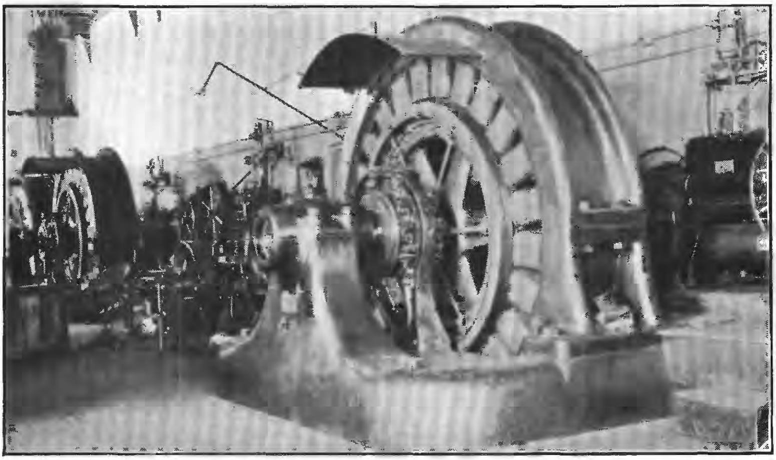
[21] For published records see U. S. Geological Survey Water-Supply Papers as follows: 298, pp. 302-314 (Nov. 3, 1904, to June 30, 1912); 331, pp. 317-319 (Oct. 1, 1911, to Sept. 30, 1912); 361, pp. 357-359 (1912-13); 391, pp. 258-361 (1913-14); 411, pp. 270-272 (1914-15); 441, pp. 246-247 (1915-16); 461, pp. 240-242 (1916-17); 481, pp. 232-233 (1917-18).

A. POWER HOUSE AND WASTEWAY.



B. HEAD DAM AND INTAKE OF CONDUIT.
Photograph by the company.



C. GENERATORS.

FOLSOM PLANT, PACIFIC GAS & ELECTRIC CO.

The maximum flood that has passed the dam was that of March 19, 1907, and was about 115,000 second-feet.

The three head gates are 16 feet high by 14 feet wide and are hydraulically operated in vertical grooves in the masonry.

The canal is the largest open conduit in California used for power development and is also one of the shortest, the total length from dam to power house being only 8,835 feet, or 1.67 miles. Throughout its length the conduit runs close to the south bank of the river. The first section is 2,000 feet long, is walled with rock on its river side, and terminates at the Folsom Prison, where a fall of 7.33 feet is used by the State; this section is 53 feet wide on top, 45 feet wide on bottom, and 8 feet deep. Section No. 2, 3,400 feet long, has an outside bank of rock and earth and an inner bank faced with rock. Section 3 (built by Folsom Water Power Co.) is an ordinary cut 3,435 feet long, with an earth and rock embankment riprapped on the river side. Sections 2 and 3 are 50 feet wide on top, 40 feet on bottom, and 8 feet deep; the operating capacity of these two sections is about 1,200 second-feet. The grade is 5.28 feet per mile.

At its lower end the canal turns nearly a right angle into a forebay, 150 feet long, containing two divisions each 50 feet wide. The division is made by a longitudinal wall running down the center of the forebay, from the canal to the inlet gates back of the power house. Each of the two half bays is again divided by a longitudinal partition, which does not quite reach to normal water surface. The depth of the forebay is 12 feet.

One unit receives its supply from the lower end of each of the four forebay sections through gates operated in vertical slides by hydraulic mechanism.

The elevation of water surface in the forebay is 200 feet and of tail-water at the main power house 145 feet above sea level. A secondary power house below the main power house receives its supply from the tailrace of the upper house and discharges into the river, whose water surface at this point is 120 feet above sea level.

The four steel pipes that supply the turbines in the upper house are 96 inches in diameter. The head developed is 55 feet, of which 35 feet 3 inches is from pressure and 19 feet 9 inches from draft. The turbine in the lower house is supplied through a 9-foot and 12-foot steel pipe. The head developed here is 25 feet—9 feet from pressure and 16 feet from draft.

GENERATING STATION.

Power house.—The upper Folsom power house (Pl. XXI, *A*), the only one now in operation, is a substantial two-story brick structure 29 feet 8 inches deep by 93 feet 4 inches long, containing four units. The lower power house, a corrugated-iron frame building, 34 by 68 feet, containing one 750-kilovolt-ampere generator, was dismantled in 1920; it normally operated only eight or nine months of the year, utilizing the 26-foot head between the main power house and the river.

The upper or main power house is so placed that its back wall is parallel to the wall that forms the lower end of the forebay. The penstocks pass through the forebay wall directly into a turbine room, which occupies the full length of the back part of the power house. The generator room is on the same level as the turbine room and occupies the entire front of the first floor of the power house. The four units are placed transversely across the building, so that the turbine shafts can be coupled to the generator shafts at the wall between the turbine and generator rooms, the shafts of the units passing through small apertures in the wall. As the shafts were made as short as possible this arrangement brings the generators along the back wall of their room. Along the center of the front wall is the switchboard and one of the exciters. The other two exciters are directly opposite the switchboard and between the central units. The high-tension switches and transformers are in a large room that occupies the entire second floor of the station.

Hydraulic equipment.—The four prime movers are S. Morgan Smith 30-inch double-horizontal McCormick turbines rated at 1,100 horsepower each. The turbines and generator shafts are connected through bolted flanged couplings, and the former carry 10,000-pound flywheels as an aid to regulation. The units discharge through draft tubes into four separate arched tailraces which run across and under the building. Each turbine is controlled by a Lombard governor, type B, which is placed beside the generator and belted to the main shaft.

The installed capacity of the plant is 3,000 kilovolt-amperes (4,000 horsepower).

Generators.—The four main generators (Pl. XXI, *C*) are of the same design General Electric AP form 4 24-pole stationary-field 750-kilovolt-ampere 3-phase 60-cycle 542-ampere 800-volt alternators, operated at 300 revolutions per minute.

Exciters.—There are two General Electric turbine-driven 4-pole 30-kilowatt 50-ampere 600-volt exciters.

Transformers.—The plant is equipped with four (one bank and a spare) Stanley 5,000 shell type 1-phase 60-cycle 1,250-kilowatt 23,100–28,870–34,640/800–11,200 water-cooled transformers, connected delta on the low and Y with grounded neutral on the high tension side. In addition to the main equipment there is a bank of General Electric 1-phase 60-cycle 75-kilovolt-ampere 2,400/240–480 volt transformers for local 2,400-volt distribution circuits.

Wiring.—The 8-panel switchboard is fitted with double busses, each of which is sectionized at its center. All the low-tension generator leads pass through single-pole double-throw knife switches. The only high-tension switch in the plant is a set of three Baum 1-phase fiber-tub 60,000-volt oil-line switches in the transformer room on the second floor.

Part of the power from the plant is transmitted over an 11,000-volt line to Station B, Sacramento, where the plant ties in with the rest of the Pacific Gas & Electric system; the rest of the power is transmitted over a 60,000-volt line toward Sacramento, although none enters the city over this line. The plant is also tied in with the 110,000-volt Wise line through the main power transformers.

COLGATE PLANT.

LOCATION.

The Colgate plant is on the north bank of the Middle Fork of Yuba River about 10 miles (in air line) nearly northwest of Nevada City. The power house is about a mile above the mouth of Dobbins Creek, which enters the main stream at Condemned Bar. The diversion dam is in the S. ½ sec. 25, T. 18 N., R. 7 E. The conduit traverses secs. 25 and 36 of the same township and secs. 1, 12, 11, 14, 10, 9, and 16, T. 17 N., R. 7 E., to the power house, which is in the SE. ¼ sec. 16.

The plant was built by Yuba Electric Power Co. and put into operation, and on September 5, 1899, it began to transmit energy to Sacramento and on April 27, 1901, to Oakland.[21a]

SOURCE OF WATER SUPPLY.

Although the power house is on the Middle Fork of Yuba River, the Colgate plant receives no water directly from that branch of the river but derives its main supply from the North Fork and an auxiliary supply from Lake Francis, on Dobbins Creek.

The drainage area of the North Yuba above Colgate (Pl. XXII, in pocket) comprises 481 square miles of mountainous country ranging in elevation from about 1,300 feet to an average of 7,900 feet along the main divide of the Sierra, between Weber Lake and Yuba Pass. The maximum elevation along this crest is 8,100 feet. In the east-central part of the area Sierra Buttes rise to 8,615 feet, but in general the isolated peaks in the drainage basin do not much exceed 6,000 feet. The northeastern and southern boundaries of the basin rise to about 6,000 feet, but elevations gradually decrease along the ridges toward the west, which are not more than 2,500 feet above the sea. In shape the area is a rough triangle with a base of 40 miles (along its southern boundary) and an altitude of 18 miles.

[21a] See pp. 143 and 146 for changes in installed capacity.

The branches of North Fork head in mountain valleys along the main divide and unite about 35 miles northeast of Colgate in the vicinity of Sierra City. Below this point the stream flows somewhat south of west until it makes a big bend just below Slate Range Bar, and from this point the course is nearly due south to the junction with the main river. Between Sierra City and the big bend the river receives from the north many small streams that flow down from the ridge that separates the Yuba Basin from that of the South Fork of Feather River. Streams from the south heading along the divide between the North and Middle Yuba are very short and comparatively unimportant.

The rocks of the greater part of the basin of the North Yuba above the Colgate plant are sedimentary.[22] In the western part of the area sedimentary rocks are interspersed with irregular beds of amphibolite and serpentine and are overlain here and there by andesitic rocks. East of the line running from Sierra City north to Lake Hawley the rocks consist of quartz porphyry and granodiorite, which in places are overlain by the same andesitic covering found in the western part of the basin, and isolated areas—especially in the vicinity of Lower Salmon and Sardine lakes—are covered with moraines and glacial drift. The Sierra Buttes, just southwest of this moraine country, are made up of an augite porphyry. The run-off from the basin is probably more affected by the large areas of granodiorite in the extreme east and the slaty formation extending over so large a part of the central area than by any of the formations less widely exposed.

Much of the region is rolling rather than rugged, and most of the streams flow at the bottoms of wide and comparatively shallow canyons. The most rugged country is found from Sierra Buttes to the southern boundary of the basin. East of Sierra Buttes and along the higher ridge to the east of Canyon Creek the basin is well forested, but over the rest of the basin forest growth is sparse at best and in the central district almost wholly wanting. In this central district a very large area is covered with brush. Above 7,000 feet, in the eastern part of the basin, the country is barren and rocky.

Rainfall on the North Yuba basin is, except in unusual years, much heavier than farther south in the Sierra. The mean annual precipitation over all the basin except the lower part is from 60 to 70 inches. In a considerable area near La Porte records seem to show a mean well above 80 inches. In the eastern third of the basin the precipitation is largely in the form of snow, but the elevations are not sufficient to hold this snowfall through the summer. The run-off is probably affected only to a very slight degree by small

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[22] U. S. Geol. Survey Geol. Atlas, Downieville folio (No. 37), structure-section sheet.

mountain ponds and lakes near the headwaters. These lakes are not so numerous as those on the South Yuba and have not been so fully used for storage. Scarcity of water late in the summer and early in the autumn would be more marked were it not for the numerous perennial springs along the North Fork of the river, but even with the aid of these the discharge falls very low after several successive dry seasons. Measurements at the head dam in 1900 gave a discharge of 270 second-feet,[23] which, though low, is probably well above the absolute minimum.

The Dobbins Creek basin above Lake Francis comprises only 6.6 square miles, ranging in elevation from 1,650 feet above sea level to slightly more than 3,400 feet at the summit of Oregon Peak, on the east boundary. The course of the stream for the 3 miles above the dam is south. No streams enter above the lake from the west, but three feeders that enter from the east drain the west slope of Oregon Peak ridge. In the western part of the basin the rocks consist of gabbro-diorite; those along the eastern side are porphyrite and diabase. No part of the basin is well forested, and a large part is covered only with brush.

RESERVOIR.

The only reservoir operated in connection with the plant is Lake Francis, on Dobbins Creek, in secs. 4 and 5, T. 17 N., R. 7 E., and sec. 32, T. 18 N., R. 7 E. The lake is formed by an earth-fill dam 70 feet high, 1,300 feet long on the crest, about 500 feet wide at the base, 6 feet wide at the top, riprapped on the inner slope, which is 3:1; the outer slope is 2:1. The maximum capacity of the reservoir is 105,000,000 cubic feet, and its area at that capacity is 115 acres. The crest of the dam is 1,650 feet above sea level, the maximum elevation of the water surface 1,647 feet, and the bottom of the outlet is 1,584 feet above sea level.

At each end of the dam is a spillway, one of wood 80 feet wide, 6 feet deep, and about 500 feet long, its bottom 1,640 feet above sea level; the other, of concrete, 16 feet wide, 10 feet deep, 200 feet long, its bottom 1,644 feet above sea level. The flow is controlled by stop planks and 3 wood-slide gates operated by standard mechanism. The water is discharged through a 6-foot concrete lined rubble culvert, 137 feet long from intake cage to gate chamber, from which a 5-foot culvert leads to Dobbins Creek.

The lake is drawn upon during a period of low flow of North Yuba River, the water being conveyed to the Colgate power-house forebay by 36-inch wood-stave pipe and rapid flume. The reservoir was

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[23] For records of discharge of North Fork of Yuba River, see U. S. Geol. Survey Water-Supply Papers; as follows: 298, pp. 271–280, 391 (up to June 30, 1912); 331, pp. 299–303 (1911–12); 361, pp. 338–342 (1912–13); 291, pp. 246–249 (1913–14); 411, pp. 257–264 (1914–15); 441, pp. 232–238 (1915–16); 461, pp. 227–231 (1916–17); 481, pp. 220–223 (1917–18).

constructed in 1898 for emergency use. The dam failed October 21, 1899, when 9 inches of rain fell in 36 hours; repairs to the break were completed October 17, 1901, 4,090 cubic yards of material being used. The main dam was completed June 30, 1902.

CONDUIT.

The main supply for the Colgate plant is diverted from the North Fork of the Yuba at a point about 2 miles above its junction with the Middle Fork and at an elevation of 1,330 feet above sea level. The original head dam, a rock-filled timber crib 157 feet long and 40 feet in maximum height, was washed out February 22, 1904, and was replaced in December of the same year with a masonry dam 41 feet high and 175 feet long on the crest and 40 feet thick at base.

The greatest flood that has passed over the dam occurred March 19, 1907, when the depth of water on the crest was 15.5 feet and the discharge was estimated at 45,200 second-feet.

Water enters the conduit at the western abutment of the dam through four head gates 3 by 5 feet. The flume from dam to forebay is 7.6 miles long and is 7 feet wide and 5 feet 6½ inches deep with an average grade of 13 feet per mile; its capacity is 300 second-feet. The elevation at the lower end of the flume is 1,231.2 feet; The line follows down the west side of the North Fork Canyon and the west side of main Yuba Canyon. At a number of places the canyon wall is decidedly rough and the trestles are of considerable height. The construction of a tunnel line to cut off some of this rough country has been contemplated.

At its lower end the section of the flume is enlarged and thence the water passes through inclined trash racks into a small masonry forebay, which the pressure pipes leave nearly at right angles.

The supply from Lake Francis reaches Colgate through a conduit 11,360 feet (2.15 miles) long, 2,840 feet being flume 4 feet wide and 3 feet deep, and 8,520 feet 36-inch wood-stave pipe. The water passes through the pipe to a timber chute (or small flume with very heavy grade) which discharges into the forebay. The grade of the flume is very irregular and rapid. Elevation at the head gate, 1,590.4 feet; at the end of the stave pipe, 1,534.5 feet; at end of the flume, 1,288.5 feet. The pipe runs up and down small hills along its course but at its lower end is 56 feet lower than the head. The staves are of 1¾-inch redwood, 6 inches wide by 10 to 20 feet long; bands are ½-inch round steel. About one-tenth of the rapid flume is covered. The stave pipe was put in for Yuba Electric Power Co. in 1899. A section near the head was afterward moved 200 feet farther west and 10,000 bands were added by Bay Counties Power Co.

There are five 30-inch pressure pipes at Colgate, the shortest of which is 1,583 feet and the longest 1,594 feet. All the lines are uncovered for nearly their entire length. One line is of riveted steel throughout; another is of riveted steel for most of its length but has some cast-iron pipe in it; the other three are cast-iron throughout except for very short lengths at their upper ends, where there is riveted pipe one-eighth inch thick. The cast-iron pipe is in 12-foot lengths and has bell and spigot joints calked with lead; the thickness of the shell varies from one-half inch to $1\frac{1}{2}$ inches. Great care has to be used in shutting down the units on the cast-iron lines to prevent water hammer which will blow out sections of the lead calking. For about half the distance from the forebay to the power house the five lines run side by side; below the lines diverge, three running to the upper and two to the lower end of the house, one passing on each side of a low, rocky hummock. At the back wall of the house each group of pressure pipes delivers its supply to a separate header. Each line is provided with a 30-inch gate valve just before reaching the header, and on the other side of the header there is a gate valve in each supply branch to the wheels. The valves in the branches to the 2,000 kilovolt-ampere units are hydraulically operated.

The static head is 702 feet and the effective head 680 feet.

GENERATING STATION.

Power house.—The power house (Pl. XXIII, *C*), which extends along the bank of the river, is a single, very long and narrow one-story masonry building, 264 feet long and 40 feet wide, roofed with corrugated iron supported on steel trusses. The seven units are placed in line along the front of the building (Pl. XXIII, *D*), with their shafts parallel to its long axis. The three 900 kilovolt-ampere units that form the original installation are at the downstream end; next to these is the last machine installed, originally rated at 5,500 kilovolt-amperes but rewound during 1918 for a rated capacity of 6,875 kilovolt-amperes; and in the upstream end are the three 2,000-kilovolt-ampere machines which were the first material addition to the original plant. Prior to the installation of the three machines last mentioned, a single 720 kilovolt-ampere unit had been purchased to work in parallel with the Nevada plant at 133 cycles. This unit occupied the extreme upstream end of the power house but has been dismantled.

The transformers and switching equipment are arranged along the rear wall of the plant on the main floor and in a gallery supported on steel columns. The low-tension switches and busses are in a subway parallel to the rear wall running the full length of the power house. The switchboard is on the main floor parallel to the rear wall, about in the center of the room. The transfer busses are in a long gallery under the main floor. The pressure line to each wheel runs from a header straight across the power house, and the wheel discharges through an arched wasteway opening directly over the river.

Hydraulic equipment.—The three 900 kilovolt-ampere units are operated by Risdon Iron Works 67⅝-inch wheels, with two rotors per unit, both carried in the same housing, each equipped with 24 buckets and operated by a single plain deflecting 3-inch nozzle controlled by a Lombard governor, type F.

The three 2,000 kilovolt-ampere units are operated by wheels of the same type but 79 inches in diameter, and each rotor is equipped with 22 buckets and receives a stream from a single 4½-inch plain deflecting nozzle controlled by a Lombard governor, type D.

The two wheels that operate the single 6,875-kilovolt-ampere unit are of Doble design and manufacture and are of the double-overhung type, one wheel at each end of the shaft. The wheels are 59 inches in diameter and each rotor is equipped with 15 buckets. Each wheel is operated by the stream from a single 7½-inch deflecting needle nozzle controlled by a Lombard governor, type Q. The installed capacity of the plant is 15,575 kilovolt-amperes (20,878 horsepower).

Generators.—The 900 kilovolt-ampere generators are of the Stanley SKC 3-phase 60-cycle 2,300-ampere type, operating at 360 revolutions per minute.

The 2,000-kilovolt-ampere machines are of the same type, phase, and voltage but are rated at 500 amperes and operated at 240 revolutions.

The 5,500-kilovolt-ampere generator is a Westinghouse 3-phase 60-cycle 2,300-volt 1,375-ampere alternator, operating at 300 revolutions per minute.

Exciters.—Two General Electric 4-pole 60-volt 750-ampere 45-kilowatt exciters, one operated by a Risdon wheel, the other by a similar wheel or by a 50-horsepower Westinghouse induction motor, and one Northern Electric Manufacturing Co. 60-volt 500-ampere 30-kilowatt exciter direct-connected to a 40-horsepower Westinghouse induction motor furnish excitation for the entire plant.

Transformers.—The power house normally operates in two sections, one transmitting at 60,000 volts to Sacramento and Oakland and the other at 30,000 volts to the mining district around Nevada City. The station is equipped with three banks of Stanley SKC shell-type 700-kilowatt 2,300/34,675 water-cooled transformers with a spare that can be connected in emergency to any of the three banks; three Stanley SKC shell-type 1,000-kilowatt 2,300/34,675 water-cooled transformers connected Y on the high-tension side to give 60,000 volts; and three 1,500-kilowatt 2,300/34,675 water-cooled transformers also connected Y on the high-tension side to give 60,000 volts.

A. WISE POWER HOUSE.

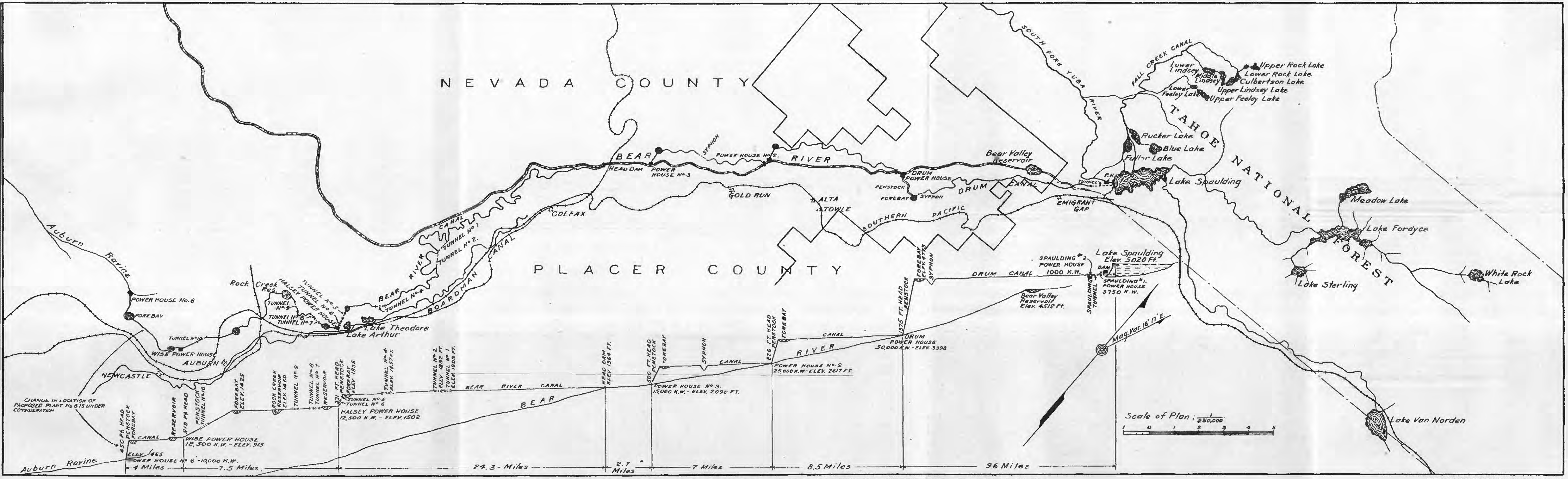
B. HALSEY POWER HOUSE.

C. COLGATE PLANT.

D. GENERATOR ROOM, COLGATE POWER HOUSE.

HYDROELECTRIC SYSTEM OF PACIFIC GAS & ELECTRIC CO.

Photographs *A*, *B*, and *C* by the company.



PLAN AND PROFILE OF SOUTH YUBA POWER SYSTEM, CALIFORNIA

PREPARED BY U. S. FOREST SERVICE

1922

The three banks of 700-kilowatt transformers are so arranged that they may supply either the 30,000 or the 60,000 volt circuits; under normal conditions only one bank (with a total capacity of 2,100 kilowatts) is connected to the 30,000-volt outgoing lines. All outgoing lines will be operated at 60,000 volts upon reconstruction of the 30,000-volt circuits, now under way.

A bank of three 50-kilowatt transformers supplies a local line from the power house to the Mother Lode mines.

The lightning arresters originally installed at the power house have been removed.

Wiring.—The generators, except one, connect through oil switches to a transfer bus which runs the full length of the building through a tunnel under the main floor. The 6,875-kilovolt-ampere generator connects to a bus in the cell structure on the main floor. The high-tension busses are carried in a horizontal plane under the roof trusses. They are sectionized between the taps to the transmission lines. The transformers connect to busses through air-disconnecting switches only. The transmission lines connect to busses through oil switches and air-disconnecting switches (the latter between the oil switch and bus) and to air switches and grounding switches on the bus side of the oil switches. The transfer bus is sectionized by an oil switch between each pair of generator connections and by a disconnecting switch on each side of unit No. 4.

SOUTH YUBA-BEAR RIVER POWER SYSTEM.

RELATIONS OF CONDUITS AND RESERVOIRS.

Through its acquisition of South Yuba Water Co. the Pacific Gas & Electric Co. came into possession of numerous storage reservoirs and a complicated system of conduits receiving water from an area comprising about 134 square miles on the extreme headwaters of South Fork of Yuba River and smaller areas directly to the south on the headwaters of Bear River and North Fork of American River. Probably none of the areas contributing water for the development of power in California are more familiar to the public than these, which form the source of supply of what is known locally as the South Yuba water system.

The largest reservoir on South Yuba, into which all the others on that stream drained, was Lake Spaulding. The two principal conduits were Main South Yuba canal, diverting from the South Fork a short distance below Lake Spaulding and extending westward into the country above Nevada City, and Boardman canal, diverting from Bear River at Bear Valley reservoir and extending southwesterly along the ridge between Bear River and the North Fork of the American to Alta power house, and continuing to the foothills in what is called the lower Boardman ditch.

Main South Yuba canal delivers water directly to but one power plant—the Deer Creek—below which the water is again diverted and distributed for domestic use and for mining and irrigation in the Nevada water district.

The lower Boardman system was and still is fed from the east by branch conduits heading on North Fork of American River and was interconnected in the vicinity of Clipper Gap with ditch systems diverting at lower points on Bear River.

In 1912 Pacific Gas & Electric Co. began constructing its so-called "South Yuba-Bear River progressive development" (see Pl. XXIV), the first step being enlargement of Lake Spaulding and construction of Drum canal and power house.

Drum conduit crosses the head of the Bear Valley drainage basin to the south side of Bear River canyon and parallels Boardman canal at a higher level. Since its construction only the water required by the Nevada water district plus enough to care for prior rights has been allowed to reach Main South Yuba canal and pass through Deer Creek power house. Boardman ditch system has had to depend on the run-off of Bear River drainage above its intake, on water leaking or wasted from the upper reaches of Drum canal, and on water diverted through branch systems from North Fork of American River.

Auburn power house had been shut down before construction was begun on the South Yuba-Bear River system. After Drum plant was completed, part of the equipment at Alta was put out of commission, and after Halsey and Wise power plants, near the lower end of the new system, began operation Newcastle plant was shut down. The Boardman ditch system is no longer used for power development below Alta power house but still supplies water used for irrigation in the deciduous-fruit belt of Placer County.

It is therefore clear that Lake Spaulding and the other reservoirs above it in South Yuba drainage basin may be utilized to supply Deer Creek or Alta plants but deliver most of their supply to the Drum, Halsey, and Wise plants. Storage in Lake Valley and Canyon Creek reservoirs is available for use only in Alta plant. Drainage from the area above the Boardman canal intake may be used either through Alta or by allowing the water to flow down Bear River and into the Bear River canal with Halsey and Wise developments.

The stored water of the South Yuba system is thus put to two main uses—power development and irrigation. It should be understood, however, that the two uses are not incompatible. Any part of the supply from the South Fork of the Yuba that is not delivered to Drum canal but is discharged through Lake Spaulding dam can be diverted by the Main South Yuba canal half a mile below Spaulding and either spilled into the Bear River basin or carried down to the Deer Creek plant. Water spilled into Bear River can be diverted by either the Boardman or the Bear River canal. Water not spilled from the Main South Yuba canal into Bear Valley is carried down the conduit and through the Chalk Bluff Ridge into the Chalk Bluff canal for use in the Deer Creek power house. Beyond the Deer Creek power house it flows through the mining and irrigation ditches that supply water in the vicinity of Nevada City and Grass Valley. Any water used through the Drum system can not be used in Deer Creek or Alta power houses but can still be passed through the Halsey and Wise plants by rediversion from Bear River through Bear River canal some distance below Drum power house.

SOURCE OF WATER SUPPLY.

The part of the South Yuba basin tributary to the system is that above the new Lake Spaulding dam, which is directly north of Emigrant Gap station on the Overland Line of the Southern Pacific. The area tributary to the lake, including the basin of the Fall Creek lakes, embraces about 134 square miles in the eastern part of Nevada and Placer counties. The tributary part of the American River basin is on the North Fork of the North Fork east of Blue Canyon station and south of the South Fork of the Yuba. Water from this area (39 square miles) is diverted to Alta power house through Towle canal and its feeders and therefore can not be stored in Lake Spaulding. The part of the Bear River basin yielding water for power development is the 4.4 square miles above the head of the Bear River canal, through which water is diverted to the lower plants of the South Yuba-Bear River power system. The supply made available for diversions from the basins of American and Bear rivers is so affected by the size of the diversion canals, by water brought in by the South Yuba, and by other factors that the basins of these streams need not be described in detail.

The South Yuba basin above the head of the Main South Yuba canal extends about 18 miles almost due east from Emigrant Gap to the main divide and about 9 miles (north and south) from the top of the ridge just south of the main line of the Southern Pacific to the divide between Fordyce and Canyon creeks above Bowman and Fauchere lakes. Its extreme east end is in the vicinity of Summit station on the railroad; the South Fork of the Yuba runs parallel to and just below the railroad from Emigrant Gap. An excellent view of a large part of the basin is obtained from the railroad between Emigrant Gap and Summit, and a good view of the Bear River basin from a point in the vicinity of Gold Run.

The northeastern and northern parts of the area are drained by Fordyce Creek, which flows southwestward and joins the main stream about 3 miles northeast of Emigrant Gap. The northwestern part of the area would naturally be drained by streams that enter the South Fork below the Lake Spaulding dam, but it is made tributary above the dam by the Fall Creek canal, which skirts the western borders of the basin and discharges into Lake Spaulding.

The elevations in the part of the basin of the South Fork of the Yuba tributary to the system range from 5,000 feet at the head dam of the Main South Yuba canal up to 9,139 feet at the top of Castle Peak, 4 miles north of Donner. Most of the northern and eastern boundary ranges in elevation from 7,000 to 8,000 feet, the southern boundary between 5,500 and 7,000 feet (with only a few peaks of 7,500 or more), and the western boundary from 5,000 to 5,500 feet. Eight or ten peaks in the basin rise to about 8,000 feet above sea level. The whole area is rough and rugged, for it is traversed by granitic ridges separated by moderately deep, well-forested canyons. In by far the larger part of the area the rocks exposed are granites or granodiorites, although andesite occurs in irregular areas in the eastern part, and moraines are numerous throughout the basin. Many of the small lakes scattered among the ridges have been enlarged by dams that were built by miners in the early days or since then by irrigators and power companies.

In and directly around the basin are many stations at which records of rainfall have been kept for a number of years. Much of the precipitation is in the form of snow. The seasonal means at Bowman's dam, Summit, Cisco, Emigrant Gap, Bear Valley, Blue Canyon, and Towle are shown on Plates III–XII (p. 20).

Records of flow of streams supplying the South Yuba system are not available, but the company's engineers report that during the years for which they have records the run-off from the basin of the South Fork of Yuba River above the Lake Spaulding dam has ranged from 185,000 acre-feet (during the season of 1919–20) to 475,000 acre-feet (during the season of 1906–7). In general the water is drawn from the higher mountain lakes first, the lower lakes being kept full during the early part of the season and drawn upon only after the upper lakes have been thoroughly drained.

RESERVOIRS.

The South Yuba Water system includes 24 reservoirs which are owned or controlled by Pacific Gas & Electric Co. Information in regard to these reservoirs is given in Table 22, which is supplemented by the notes in the following paragraphs.

TABLE 22.—*Storage reservoirs on South Yuba-Bear River power system.*

Reservoir.	Elevation.				Catchment area.	Maximum capacity.	Area at maximum capacity.	Dam.						Spillway.		
	Crest.	Maximum water surface.	Spillway bottom.	Outlet bottom.				Maximum height.	Length of crest.	Width of crest.	Maximum width of base.	Inner slope.	Outer slope.	Width.	Depth.	Length
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Acres.*	*Cubic feet.*	*Acres.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*			*Feet.*	*Feet.*	*Feet.*
Upper Rock Lake	6,984.4	6,982.4	....	6,968.7	40	9,000,000	20	15.5	52	9.5	22	⅔:1	½:1	....	....	....
Lower Rock Lake	6,894.3	6,893.5	....	6,891	10	1,350,000	7.8	3.5	40	6	10.3	2:1	⅓:1	....	....	....
Culbertson	6,702.1	6,699.1	6,669.1	6,689.3	240	35,000,000	70	13.5	121	10.5	30	½:1	⅛:1	6	2.8	15
Upper Lindsey	6,750.5	6,749.8	....	6,744.4	20	850,000	3.8	6.1	40	4	12.5	2:1 ½:1	⅙:1	....	....	....
Middle Lindsey	6,703.9	6,703.0	....	6,696.9	65	6,000,000	21	6.9	317	2.5	13	(a)	½:1	....	....	....
Lower Lindsey	6,501.5	6,497.7	6,498.5	6,490.7	300	7,500,000	24.3	10.8	156	14	16	⅙:1	(b)	10.5	2.8	....
Upper Feeley	6,992.2	6,990.0	6,988.9	6,975.1	450	34,000,000	54	17.1	168	10	27	2:1 ⅔:1	¼:1	3.75	3.33	....
Lower Feeley	6,934	6,930.0	6,930.0	6,919.7	96	5,000,000	17.5	14.3	86	11.5	22	¾:1	⅛:1	15	....	....
Blue Lake	5,962	5,960	5,960	5,940	153.6	48,958,500	68	22	254	15	60	2:1	¼:1	5	2	10
Rucker Lake	5,497	5,494.4	5,491.4	5,480	909	22,620,000	63	19	[c] 200 335	4	59	2½:1	1:1	16	3	12
Fuller Lake	5,377	5,375	5,371	5,355	1,395	40,000,000	67.5	27	300	5	88	2:1	1½:1	(d)	(e)	48
White Rock	7,752	7,750	7,749	7,743	698	[f] 180,000,000	90	[g] 10.5 [k] 10	165 137	[h] 5 3	34 25	[i] 3:1 [i] 3:1	(j) (j)	6	3	14
Meadow	7,249	7,247	7,246	[i] 7,215	6,840	200,000,000	245	34	971	40	120	2½:1	⅛:1	14	2.5	20
Sterling	6,700	6,700	....	6,680	646	120,000,000	104	25	228	14	37	1¼:1	(b)	....	....	....
Fordyce	6,294	6,294	6,288	6,225	19,296.0	875,000,000	510	92	800	5	139	1:1	[l] ½:1 ¼:1	99	5.25	....
Lost River Lake	6,698	6,695	6,695	6,687	....	10,803,000	22	13	46	11	22.5	1:1	(b)	12	....	....
Lake Van Norden	6,770	6,768	6,762	[i] 6,738	7,770	230,000,000	390	30	1,633	6	145	1¾:1	2:1	38.5	8	70
Kidd Lake	6,771	6,769.2	6,767.7	6,742.7	315	65,000,000	90	32.5	391	18	90	3:1	½:1	14.25	3.33	....
Upper Peak Lake	6,750	6,748	6,745	6,717	420	70,000,000	84	37	290	8	88	2:1	½:1	16	5	....
Lower Peak Lake	6,722	6,720	6,718.5	6,700	147	21,500,000	35	....	154.9	12	52	2:1	(m)	15.33	3.5	213
Lake Spaulding	4,875	4,875	4,870	4,679	85,800	3,223,449,000	695	275	800	11	185.6	(n)	100:16 100:3	270	5	....
Lake Valley	5,853	5,848	5,848	5,792	3,040	354,000,000	312	63	1,513	8	285	1¾:1 4¾:1	1½:1 3:1	100	....	....
Bear Valley [o]	4,365	4,362.5	4,362	4,341.5	2,680	14,000,000	60	23.5 41	215.5 187	12	30 45	⅝:1 ⅝:1	¼:1	42	3	....
Canyon Creek	4,295.2	4,293	4,290	4,287.4	1,728	850,000	3	10	300	54	....	(b)	½:1	9.8	5.9	18.33
Lake Arthur	1,493.5	1,490.5	1,488.5	1,454	1,293	4,100,000	7.1	45	300	8	168	2½:1	1½:1 2:1	(p)	....	....
Rock Creek	1,303	1,300	1,300	1,279.6	....	2,400,000	....	[q] 36 [s] 20	1,080 775	[r] 1 10	51 75	1:1 2½:1	(b) 2:1	58.5	3	....

[a] Vertical rock face. [b] Vertical. [c] Two dams; first section, 200 feet; second section, 335 feet. [d] 9 feet at mouth, tapering to 6 feet at center. [e] Flashboards 4 feet. [f] Available storage, 25,178,000 cubic feet. [g] East dam. [h] Or less. [i] Approximate. [j] Approximately vertical. [k] West dam. [l] Two benches. [m] With shelf 4.5 feet wide in middle section of dam face. [n] Variable 100:3.14 to 100:70. [o] Two dams; figures in the upper line refer to the south dam and those in the lower to the north. Outer slope of south dam is irregular. [p] Sloping sides 1½:1. [q] Multiple-arch concrete dam. [r] Arch rings 12 inches thick at top. [s] Earth-fill section.

Upper and Lower Rock lakes, Nevada County.—Lower Rock Lake (in secs. 15 and 16, T. 18 N., R. 12 E.) receives water from Upper Rock Lake (in sec. 15, T. 18 N., R. 12 E.) and discharges through random grade into Fall Creek canal and thence to Lake Spaulding. The dam at each lake is an earth-fill structure with dry rubble wall on both faces. Neither reservoir is provided with spillway. The outlet of the lower dam is a wooden trunk having an opening 18 by 24 inches at the upper toe of the dam, enlarged to 18 by 48½ inches at the lower toe; when the water is not needed the outlet is blocked up. The wooden trunk that forms the outlet of the upper dam is built of 2 by 11 and 2 by 20 inch timbers, the opening being 11 by 16 inches.

The dams were built by Culbertson, who sold the property to the Blue Tent Co., and later it passed into the hands of the South Yuba Water Co.

Culbertson reservoir, Nevada County.—Another dam built by Culbertson in the early fifties and later acquired by the Blue Tent Co. and then by South Yuba Water Co. is that at the Culbertson reservoir. The dam is of earth fill with dry rubble facing on both sides and crest for its entire length. The reservoir (in secs. 15, 16, 21, and 22, T. 18 N., R. 12 E.) discharges into a natural watercourse leading to Fall Creek canal and thence to Lake Spaulding. There is a wooden spillway at the north end of the dam. The outlet is a 15 by 18 inch wooden trunk built of 3 by 15 inch and 3 by 24 inch timbers.

Upper, Middle, and Lower Lindsey lakes, Nevada County.—The dams of these lakes are of the earth-fill type with dry rubble walls on both upstream and downstream faces. The upper and middle lakes are in sec. 21, and the lower lake in secs. 20 and 21, T. 18 N., R. 12 E. The upper and middle lakes are not provided with spillways. The spillway at Lower Lindsey is of wood and is 12 feet south of the north end of the spillway dam, which is 80 feet north of the main dam and is of the same type of construction. The outlets of all three dams are wooden trunks, the opening in that at Upper Lindsey being 9 by 12 inches, at Middle Lindsey 12 by 18 inches, and at Lower Lindsey 18 by 21 inches. The flow at the upper lake is controlled by blocking up the outlet when the water is not needed. The flow from the middle and lower lakes is controlled by hand-operated gates. Water from the upper lake is discharged through middle lake to the lower lake, whence it passes into random grade of Fall Creek canal and thence into Lake Spaulding.

The dams on these lakes were originally built by Lindsey Mining Co., which dynamited them when the properties were claimed by outside parties. The present dams were built by South Yuba Water Co.

Upper and Lower Feeley lakes, Nevada County.—The dams at Upper and Lower Feeley lakes are of the earth-fill type and are faced on both sides with dry rubble; on Lower Feeley Lake the rubble facing covers also the crest of the dam for its entire length. The upper lake is in sec. 28 and the lower lake in secs. 28 and 29, T. 18 N., R. 12 E. Each dam is provided with a spillway at its north end, that in the upper lake being made of wood and that in the lower lake being cut 15 feet in bedrock, 4 feet below the crest of the dam. The outlet in each dam is a wooden trunk, that at the upper dam having an opening 14 by 20 inches and that at the lower dam 16 by 17 inches. The flow from the upper dam is controlled by a hand-operated gate; that from the lower dam is controlled by a wooden gate at the inner toe of the dam operated from a platform extending out into the lake.

The water received by Upper Feeley Lake from its catchment area is passed into Lower Feeley Lake, whence it flows in random grade to Fall Creek canal and thence to Lake Spaulding.

The dams were built in the early seventies, but the upper dam failed, probably from overtopping, and was washed out, taking with it the dam of Lower Feeley. Both dams were repaired and have since been used continuously.

Blue Lake, Nevada County.—The dam at Blue Lake, which is on a small tributary of the South Fork of Yuba River, in sec. 9, T. 17 N., R. 12 E., is constructed of loose rock and earth faced with rock walls. At the south end of the dam is a wooden spillway 5 feet wide. The outlet is a wooden trunk, 2 feet wide by 3 feet deep, in the base of the dam. The flow is controlled by a gate tower 6 feet from the dam. Discharge from the lake passes through a natural channel to Rucker Lake and thence by Fall Creek canal to Lake Spaulding.

This dam, as well as the dams at Rucker and Fuller lakes, was built by Meager Mining Co. sometime before 1871, when all three lakes were purchased by John Spaulding.

Rucker Lake, Nevada County.—The dam at Rucker Lake is on a small branch of the South Fork of Yuba River, is built of earth and loose rock, and is in two sections; the inner slope is worn from the action of water. Between the dams, in natural earth, is a wooden spillway. The outlet of the dam is a wooden trunk 2 feet wide and 10 inches deep in the base of the north section of the dam. A ditch 3 feet wide and 3 feet deep, in the bottom of the lake, leads water to trunk at lower stages. The flow is controlled by a gate mechanism out in the lake 35 feet from the dam. Rucker Lake is in sec. 8, T. 17 N., R. 12 E., and receives water from its catchment area and from Blue Lake, and the discharge passes through a small ditch to Fall Creek canal, where it combines with waters from other reservoirs and flows to Lake Spaulding through canal and natural course. (See Blue Lake.)

Fuller Lake, Nevada County.—One of the three lakes bought by John Spaulding in 1871. The dam is an earth-fill structure on Jordan Creek, a tributary of South Fork of Yuba River, and the east end of the dam is a wooden spillway. About the center of the dam, at the base, is a timber trunk, 1 foot 9 inches wide by 2 feet deep. The flow is operated by a gate mechanism in the lake 42 feet from the crest of the dam. The lake is in secs. 8 and 17, T. 17 N., R. 12 E. Water from Fuller Lake is discharged into Jordan Creek, from which it is picked up by a small canal and carried to another natural water course and delivered to Lake Spaulding. (See Blue Lake.)

White Rock Lake, Nevada County.—At White Rock there are two dams with natural earth between them, the east dam being 10 feet 6 inches and the west dam 10 feet high. The dams are of earth fill backed with rock walls. At the east end of the east dam is a spillway made of 8 by 10 inch logs. The outlet, which is in the base of the west dam, has rock-wall sides and a log covering topped with earth, and is 3 feet wide by 2 feet deep by 64 feet long. Flow is controlled by a slide gate at the upper end, operated by screw from a frame in the lake. The lake is in secs. 14, 15, and 22, T. 18 N., R. 14 E. Water caught in White Rock Lake is discharged into Fordyce Lake through North Creek.

The dam was built in 1850 by predecessors of South Yuba Water Co. at the outlet of a natural lake which was about 135 feet deep. The total depth now is about 140 feet, of which 7 feet is available.

Meadow Lake, Nevada County.—The dam at Meadow Lake is an earth-fill structure backed by dry masonry. At the east end of the dam is a wooden spillway. The outlet opening is 30 by 30 inches and is made of 3 by 7-inch lumber; an iron slide gate, 80 feet from the outer face is operated by screw from a frame in the lake. The lake is in secs. 14, 15, 22, 23, and 27, T. 18 N., R. 13 E. The run-off caught by Meadow Lake is discharged through a natural water course into Lake Fordyce.

The dam was built by predecessors of South Yuba Water Co. to furnish a supply for hydraulic mining. The foundation was laid in 1855, and the dam was finished in 1863 or 1864.

Sterling Lake, Nevada County.—The dam on Sterling Lake is made of log crib with a small quantity of rock fill. As it is not provided with spillway, water flows over the top of the dam filling the log crib with bark and débris. The outlet is a 30 by 30-inch wooden trunk and flow is controlled by a cast-iron slide gate at the upper end operated by screw from a frame in the lake. The lake is in secs. 10 and 11, T. 17 N., R. 13 E. The water caught by Lake Sterling is discharged into Bloody Run arm of Fordyce Lake through

A. LAKE SPAULDING DAM, PACIFIC GAS & ELECTRIC CO.

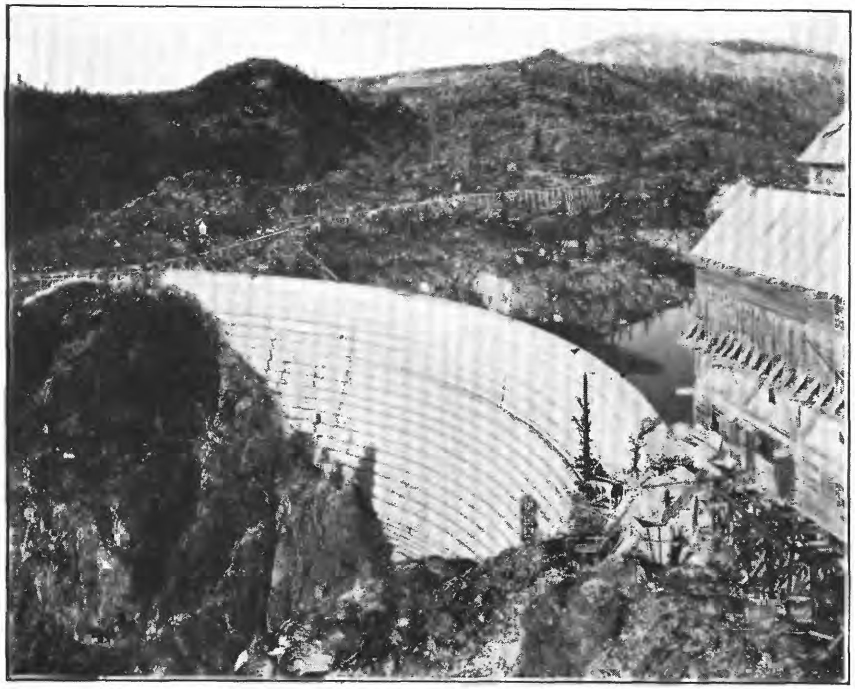
Completed to height of 260 feet.

B. LAKE FORDYCE, PACIFIC GAS & ELECTRIC CO.

Photograph by the company.

C. LAKE ALMANOR DAM, GREAT WESTERN POWER CO. OF CALIFORNIA.

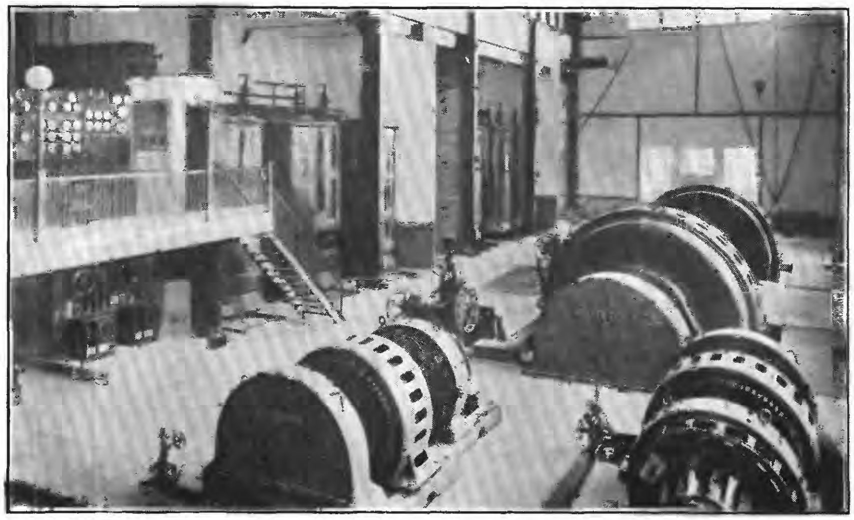
Photograph by P. W. Ham.



A. LAKE SPAULDING DAM.
Completed to a height of 260 feet.

C. DRUM POWER HOUSE.

B. DRUM CANAL.



D. GENERATOR ROOM, DRUM POWER HOUSE.

HYDROELECTRIC SYSTEM OF PACIFIC GAS & ELECTRIC CO.

Photographs by the company.

Bloody Run and Lost River. The dam was built by predecessors of South Yuba Water Co. in 1877 or 1878.

Fordyce Lake, Nevada County.—Lake Fordyce, in sec. 3, T. 17 N., R. 13 E., and secs. 25, 26, 34, 35, and 36, T. 18 N., R. 13 E., impounds run-off from the catchment area above the dam and the discharge from White Rock Lake, Meadow Lake, and Lake Sterling. The water is discharged into Lake Spaulding by Fordyce Creek. The dam is of earth and rock fill, faced with 3 by 7-inch boards on the inner slope. The spillway is of the overflow type at the north end of the dam. (See Pl. XXV, *B*.)

Fordyce dam was begun by South Yuba Canal Co. in 1873 and was built to a height of 55 feet during 1874 and 1875. In 1881 another tier, 16 feet high and 5 feet wide on the crest, was added.

Lost River Lake, Nevada County.—Lost River Lake, in sec. 2, T. 17 N., R. 13 E., impounds water in a small stream above Lake Fordyce and discharges into that lake. The dam is a rock-filled timber crib with inner slope faced with boards. The outlet is a 30 by 30 inch wooden chute through the dam, controlled by a 20 by 22 inch sluice gate at the inner toe.

Lake Spaulding, Nevada County.—The water from all the other reservoirs in the basin of the South Fork of Yuba River above Lake Spaulding, as well as a part of the run-off from the catchment area of the lake below the higher reservoirs, is discharged into Lake Spaulding. At this point the draft on storage water of the South Yuba reservoir to supply the Drum, Main South Yuba, and Upper Boardman canals is regulated.

The original dam at Lake Spaulding (Pl. XXV, *A*) was built by South Yuba Water & Mining Co. in 1892 on South Yuba River in sec. 21, T. 17 N., R. 12 E. In type it was of coarse dry rubble, faced on the inner side by 3 by 6 inch planks. At the south end of the dam was a wooden spillway. At the base of the dam was a masonry tunnel 5 by 6 feet in cross section, the flow through which was controlled at the upper end by a 4 by 5 foot iron slide gate operated by a wooden stem terminating in a 3-inch screw and extending upward along the vertical face of the stone gate tower built out from the main body of the dam.

Work on the new Spaulding dam (Pl. XXVI, *A*), about half a mile below the old one, was begun October 28, 1912, and before the close of the season, the base was put in of sufficient width, up and down stream, to form a foundation for a structure the full height designed—305 feet above bedrock or 325 feet above the lowest part of the base When work was resumed April 28, 1913, the plans were changed to provide for building the dam to a height of 260 instead of 305 feet, and the lower face of the new construction was moved far enough upstream to give a base thickness of 185.5 feet. In July, 1913, when the concrete had been completed to a height of about 50 feet, it was decided to carry the dam only to a height of 225 feet during the year, and the lower face was again moved upstream. The downstream face of the base for the 260-foot section and that of the base of the 225-foot section were carried up in steps 2 feet wide and 3 feet high to insure a more perfect bond when additional work was done on the dam.

Changes in height, together with the fact that elevations on various maps, plans, and sections of the structure which have been published, have been referred to two different datum planes, has probably led to considerable confusion in the minds of those reading the descriptions. Table 23 sets forth clearly the general characteristics of the structure.

The enlarged reservoir floods parts of secs. 9, 10, 15, 16, 20, and 21, T. 17 N., R. 12 E.

TABLE 23.—*Dimensions and storage capacity of new dam at Lake Spaulding.*

Height of dam.[a]	Elevation of crest of dam.		Radius of arch at top.	Crest length.	Elevation of water surface. (U. S. G. S.).	Storage capacity of reservoir.	Estimated contents of dam.
	Local datum.	U. S. Geological Survey datum.					
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Acre-feet.*	*Cubic yards.*
305	4,905	5,055	440	....	5,050	92,586	....
275	4,875	5,025	428	800	5,020	74,488	191,172
260	4,860	5,010	421	745	5,005	64,000	169,312
225	4,825	4,975	400	580	4,970	43,500	153,806

[a] Above river bed; add 20 feet to get height of dam above lowest point in foundation. The bottoms of the expansion joints are at 4,850 feet (U. S. Geological Survey datum).

The outlet of the new dam is a 30-inch steel pipe embedded in the concrete and extending horizontally from the center of the upstream face of the dam a distance of 43 feet downstream. A hand-operated valve is set in a gate chamber at the lower end of the pipe. Beyond the gate valve the pipe discharges into a 6 by 8 foot sluice tunnel which reaches from the chamber to the lower face of the dam. The slope of this tunnel is 15 feet in 1,000, and its invert elevation at the lower portal is 4,781.7 feet above sea level. An inspection tunnel, 7 feet wide by 9 feet high, runs transversely through the lower part of the dam, following down the gradual slope on a line about 10 feet above bedrock on the north side of the canyon to the level of the gate chamber; at this level it starts horizontally through the base of the dam, passing through the gate chamber to the opposite wall of the dam site, whence it follows up through the dam in the same way that it followed down through the north side, until, at an elevation of 4,860.2 feet, it enters bedrock and runs horizontally again, finally entering a vertical shaft that was sunk from ground surface to the base of the dam during construction. From this vertical shaft two horizontal tunnels lead to the gate chambers of the outlet tunnel, which are on different levels.

A double row of 6-inch weep holes, spaced 8 feet apart in each row, extends vertically above the inspection tunnel to the top of the dam and below the tunnel to bedrock. To guard against cracks due to expansion and contraction, four vertical expansion joints, spaced about 80 feet apart, extend radially through the dam from the 4,850-foot level upward to the crest of the dam. The faces of two adjoining blocks at each of these joints are interlocked by casting 8-foot recesses into one block and using this face as the form for the other block of concrete. The joints are filled with asphalt for 2 feet back from the upstream or water face of the dam. Storage began October 3, 1913.

The main dam was raised to a total height of 260 feet in 1916, the addition being 35 feet high, the same thickness at its base as the crest of the 225-foot dam, and 14 feet thick at the top. The new material placed in the main dam amounted to 15,506 cubic yards, but in addition about 10,000 cubic yards of material was placed in four supplementary dams built in depressions on the ridge north of the main canyon. These are designated respectively dams Nos. 2 to 5. The lower section of the dam designated as No. 2 in 1913 is now incorporated in the upstream toe of dam No. 5.

Dam No. 2 was 15 feet in maximum height, 240 feet in crest length, 6 feet in crest width, and contained 560 cubic yards of concrete. It was of overflow gravity section, was arched on a radius of 300 feet, and in its crest was a spillway opening 5 feet deep and 156 feet long, fitted with a walkway and flashboard frame.

Dam No. 3 was 30 feet in maximum height, 4 feet in crest width, 79 feet in crest length, and contained 158 cubic yards of concrete. It was of gravity section and arched on a radius of 200 feet.

Dam No. 4 was 75 feet in maximum height, 196 feet in crest length, 7.25 feet in crest width, and contained 3,723 cubic yards of concrete. It was of gravity section and arched on a radius of 800 feet.

Dam No. 5 was 65 feet in maximum height, 279 feet in crest length, 7.25 feet in crest width, and contained 3,610 cubic yards of concrete, of which 313 cubic yards formed old dam No. 2, built in 1913. The No. 5 dam was of gravity section, arched on a radius of 800 feet. The first concrete was placed in the addition to the main dam on August 29, 1916, and this structure was finished to the 260-foot height November 2. The last concrete was placed in dam No. 5 on November 30, 1916.

During the later part of 1919 Lake Spaulding dam was raised to a height of 275 feet. Studies made by the company since the structure was originally planned show that any increase in height above 275 feet will probably not be justified, as storage may be developed more cheaply elsewhere in the basin. The dam was therefore heightened in a manner which makes it extremely doubtful that it will ever be raised to the 305-foot height originally proposed.

The 1919 work on the main dam consisted in raising its crest 15 feet and reinforcing the back of the structure by pouring additional concrete between elevations 4,888 and 4,995 feet. The top of the finished dam is at elevation 5,025 feet (U. S. Geological Survey datum). The concrete backing is between 2 and 4 feet thick at its bottom (elevation 4,888 feet), is 15 feet thick at elevation 4,952 feet, and decreases in thickness to a knife-edge at 4,995 feet, where it ties into the old concrete in a notch 4 inches deep and 24 inches high. A satisfactory bond between old and new concrete was secured by steps and steel rods left in the face of the original work. At each abutment of the dam the new concrete reinforcement is thickened sufficiently to give the completed structure a gravity section, to assure an even distribution of the thrust from the central arch ring. In pouring the new concrete slots 30 inches wide were left opposite the joints of the old dam, and these slots were to be filled with concrete after the rest of the new work had had sufficient time to thoroughly set and contract. The keys in the slots were held firmly at one side by means of tie rods protruding from the old work, and provision was made for grouting the joint between the key and the other section of the dam. It was anticipated that all contraction would have taken place and the final grouting would be done early in 1921.

Dams 2 to 5 were carried up at the same time as the main structure. As finally completed, dam No. 2 is a gravity-section arch on a 300-foot radius. It is provided with a spillway 270 feet long and 5 feet deep equipped with flashboards that will permit raising water to the extreme crest level of the dams. In carrying up dam No. 3, also an arch structure, the central portion was reinforced between two buttresses spaced 40 feet on centers.

Fifteen feet was added on top of the old gravity sections of dams Nos. 4 and 5, and the structures are now backed by buttresses 6 feet thick spaced 30 feet on centers. The two dams were originally laid out on a common arc of 800 feet radius, but the curve in the west end of dam No. 4 has been flattened to a radius of 2,000 feet in order to connect with dam No. 3.

The storage capacity of the reservoir has been increased by this new construction from slightly less than 64,000 to 74,488 acre-feet.[24]

The outlet into the Drum canal is through two branches of a tunnel driven through a spur of the mountain at the south end of

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[24] See Steele, I. C., Pacific Service Mag., vol. 11, November, 1919.

the dam. The two portals are in the reservoir just upstream from the dam, one at the 4,821-foot level and the other at the 4,920-foot level (U. S. Geological Survey datum). Water is admitted through a screen and a steel taper pipe in each tunnel to a butterfly gate valve. Beyond its gate valve the upper tunnel empties into a concrete-lined inclined shaft 8 feet 8 inches in diameter, which leads down to the main tunnel. About 1,000 feet from the main portal is the Spaulding power-house chamber, excavated in the solid rock, to which access is gained through an adit from the canyon below the dam. Just before the conduit tunnel reaches this chamber there is a needle valve, which controls the flow through a steel-pipe elbow connecting with a 5,000-horsepower turbine installed in the power-house chamber 22 feet above the main tunnel. The turbine discharges through a draft tube into a continuation of the tunnel under the power-house floor, and the water flows away to the head of the open canal through 3,358 feet of unlined tunnel driven through solid granite. This unlined tunnel is 9½ feet in diameter, whereas between the power house and the intake the tunnel is lined with concrete and is 8 feet 8 inches in diameter The total length of the tunnel is 4,456 feet, and its grade 7 feet per mile.

Lake Van Norden, Nevada and Placer counties.—The dam at Lake Van Norden is of earth fill, riprapped on the inner slope, and has a wooden core of 3 by 8 inch planking. The dam is provided with a wooden spillway at its west end. The outlet is a 22-inch pipe of riveted steel through the base of the dam. Flow is controlled by a slide gate on the upper end, operated from a tower or frame in the lake by a screw attached to stem and also by one 22-inch gate valve at the lower end covered by a small wooden gatehouse. The lake is in secs. 23, 24, 25, and 26, T. 17 N., R. 14 E. Water from Lake Van Norden discharges through the South Fork of Yuba River to Lake Spaulding. The dam was built in 1900 by South Yuba Water & Mining Co. The earth fill was placed by wagons and was sprinkled but not rolled.

Kidd Lake, Placer County.—An earth-faced dam, rock walled on the outer slope, impounds water from the catchment area of Kidd Lake. In the base of the dam, at its eastern end, is an outlet formed by logs built in a triangular section, spaces between the logs being covered by rock slabs. The flow is controlled by a wooden slide gate at the upper toe of the dam, and the water is discharged into a natural ravine tributary to the South Fork of Yuba River, and thus to Lake Spaulding. In a separate dam, of similar type, north of the main dam is a wooden spillway. The lake is in sec. 29, T. 17 N., R. 14 E.

The dam was built in the early fifties by a predecessor of South Yuba Water Co., and the water was used for hydraulic mining and for domestic supply in Nevada City during the summer and fall.

Upper and Lower Peak lakes, Placer County.—Upper Peak Lake, in secs. 29 and 32, T. 17 N., R. 14 E., receives water from its catchment area and discharges it into Lower Peak Lake, secs. 29, 30, 31, and 32, T. 17 N., R. 14 E., which is tributary through a natural ravine emptying into the South Fork of Yuba River to Lake Spaulding. The dam at the upper lake is made of earth, is faced with rock wall on its outer slope, and is provided with a wooden spillway at its south end. At the north end of the dam, in its base, is an outlet, 2 by 4 feet in section, constructed of timber and rock slab and very irregular throughout its length. The flow is controlled by a wooden slide gate at upper toe of dam.

The dam at Lower Peak Lake has a rock core and back, the rock not being bonded to the foundation. The face of the dam is earth fill. A spillway is provided in a separate dam north of the main dam. The outlet is composed of logs and timber, with rock slabs for sides and top. The opening is trapezoidal in section, 2 feet 9 inches wide at top, 4 feet 2 inches wide at bottom, and 6 feet high. The flow is controlled by a gate at upstream toe of dam.

The dam at the upper lake was built in the early fifties by a predecessor of South Yuba Water Co., and the water was used for hydraulic mining and for domestic supply in Nevada City in the summer and fall. The dam at the lower lake was built in 1860 by D. Rich.

Lake Valley reservoir, Placer County.—Lake Valley reservoir, in secs. 35 and 36, T. 17 N., R. 12 E., is formed by two earth-fill dams with wood cores, on a branch of North Fork of North Fork of American River, into which it discharges. A concrete spillway is provided at the south end of a small earth-fill secondary dam. The outlet is a tunnel through bedrock at the east end of the main dam. This tunnel is 7.5 by 5.5 feet in section and 420 feet long. The outflow is regulated by two 20-inch gate valves in the tunnel 50 feet from the portal. A steel grizzly is placed across the tunnel entrance. About 8 miles below the reservoir water is taken from the North Fork of American River and conveyed 24.5 miles through Towle canal to the head of Alta pipe line, where it unites with the Boardman canal to furnish water for Alta power house.

The original dam was built in 1887 by Towle Bros. to supply water for operating the pulp mills at Towle. It was extended in 1909–1911 by Pacific Gas & Electric Co.

Lake Arthur, Placer County.—The dam at Lake Arthur is on the South Fork of Dry Creek in sec. 19, T. 13 N., R. 9 E., and is of the earth-fill type riprapped on the inside. A spillway was cut through natural rock east of the dam and lined with concrete. The outlet is a 30-inch riveted steel pipe, $\frac{3}{16}$-inch thick and 168 feet long, incased in 12 inches of concrete with four concrete cut-off walls; it is placed at the base of the dam with a 42-inch to 30-inch tapering section at the upper end and a 30-foot gate valve at the lower end to control the flow. A grizzly is placed in concrete intake at the head of the pipe.

The chief use of the Lake Arthur reservoir is to regulate water flowing in Bear River canal and to insure continuous service of the Fiddler Green canal. The dam was begun in April and completed in September, 1909. Earth was hauled by patented dump wagons and scrapers to the dam, spread in 12-inch layers, sprinkled, and harrowed. All vegetable matter and large rocks were removed, and the earth was thoroughly compacted and rolled with a "Petrolithic" road roller.

SPAULDING PLANT NO. 1.

History.—The gallery in the granite wall of the canyon just below Lake Spaulding, which now forms the Spaulding power house, was excavated by Pacific Gas & Electric Co. in 1912, while the Drum plant was being constructed. The generating equipment was not installed, however, until five years later. The power house was put into commercial operation December 16, 1917.

Spaulding power house is designed to use the water discharged through the tunnels from Lake Spaulding into the conduit leading to Drum power house. The tributary drainage basin and storage reservoirs are described on pages 161–162, and details concerning the outlet tunnels and dam are given on pages 167–171.

Power house.—The Spaulding power house was originally designed for a horizontal generating unit, and the gallery that was to form the generating room was therefore excavated to comparatively moderate height. In the fall of 1917, when it became necessary to install the equipment, conditions due to the war made it impossible to procure a horizontal generator within a reasonable time. The company, therefore, decided to purchase a vertical unit that had been built for a plant in Oregon but had not yet been delivered by the manufacturer.

The generator room is 85 feet deep from the face of the cliff to the back of the tailrace pit; its interior clear width is 30 feet except at the extreme back part over the inlet pipe and tailrace where in a triangular bay it widens to a maximum of about 47 feet. The elevations of various points in the power house and reservoir are as follows:

TABLE 24.—*Elevations in Spaulding power house and reservoir.*

[U. S. Geological Survey datum.]

	Feet.
Water surface (present) with 275-foot dam, maximum	5,025.00
Water surface at lowest intake tunnel, minimum	4,821.00
Center line of turbine	4,836.80

	Feet.
Center line of draft-tube outlet	4,815.25
Bottom of sump	4,811.25
Center line of 8-foot outlet tunnel	4,823.25
Power-house floor	4,841.50
Power-house ceiling	4,867.00
High-tension outlets	4,886.90

The front of the power house is carried up close to the face of the cliff in a tower that serves as an outlet for the outgoing line.

The main axis of the generator room is about north and south, and the main unit is set on the center line of the room and 57 feet back from the front wall of the power house. Behind the unit is the tailrace or sump, which receives the discharge of the draft tube of the turbine and the bypass relief valves. The 2,300-volt switch cells, the transformers, and the 60,000-volt-switch cells occupy, in order named, the space along the east wall of the room, between the generator and the front of the power house. The switchboard and telephone booth are placed along the west wall directly opposite the 2,300-volt switch cells. The exciter is mounted on the top of the main unit. A 20-ton crane is carried on a steel frame runway over the part of the room occupied by the generator. During the rainy season and while there is still snow on the ground, considerable water leaks through the rock above the room, and a galvanized iron ceiling has therefore been installed and suitable provision made for taking care of the drip.

Hydraulic equipment.—At the point where the tunnel from Lake Spaulding reaches the power house a steel pipe has been concreted in. Two bypass valves, either of which can be operated in connection with the turbine governor, are installed at the ends of short stubs on the main pipe where it crosses the tailrace pit; these valves are of the same size and each is large enough to discharge about 400 second-feet of water when operating under a 100-foot head. On the main line between the bypass branches and the turbine there is a 72-inch butterfly valve. The 52-inch turbine was designed to deliver 5,000 horsepower when operating under a 147-foot head. Actual head under operation will never be less than 50 feet, and the maximum will be 196 feet, with the 275-foot dam. The turbine is of the Pelton-Francis type, controlled by a Pelton governor.

Generator.—The generator is a 3-phase 60-cycle vertical machine, manufactured by the General Electric Co., rated at 2,300 volts, 943 amperes, 3,750 kilovolt-amperes, and operated at 300 revolutions per minute.

Exciter.—A 125-volt 248-ampere 31-kilowatt direct-current generator mounted on top of the main unit and operated by its shaft furnishes excitation.

Transformers.—A single bank of three Westinghouse 1,500-kilovolt-ampere single-phase water-cooled 2,300/60,000-volt transformers, connected delta on the low and Y with grounded neutral on the high tension side, steps the voltage up for transmission.

Wiring.—The wiring of the power house is simple and direct. The leads from the generator to the high-tension outlets pass through low-tension switches, transformers, and high-tension switches which are arranged in an almost straight line along the east wall of the generating room. From the high-tension switches outgoing circuits are carried vertically upward in the outlet tower. A stub transmission line connects the power house to a 60,000-volt line that was run from Alta power house to Lake Spaulding when construction was begun on the new Lake Spaulding dam.

The power house is equipped with horn-gap lightning arresters.

SPAULDING PLANT NO. 2.

Location.—In order to use a water supply ranging from a minimum of 40 second-feet to a maximum of 125 second-feet, formerly wasted through a fall of 150 feet from the Drum conduit to supply the South Yuba canal, Pacific Gas & Electric Co. constructed in 1920 Spaulding plant No. 2, which went into operation October 29, 1920. The plant diverts from the afterbay of Spaulding plant No. 1 through a short pressure line to a power house on the edge of the river just above the Main South Yuba canal intake. The entire plant from intake to tailrace is in the NW. ¼ sec. 21, T. 17 N., R. 12 E.

Conduit.—A pressure pipe 239 feet long, ranging in diameter from 48 inches at its head in the afterbay of Spaulding plant No. 1 to 36 inches at Spaulding plant No. 2, is anchored to the granite of the canyon wall by its concrete supporting piers. The maximum elevation of the water surface at the head of the pipe is 4,835.37 feet, and the normal elevation at the tailrace 4,678.89 feet, giving a static head of 156.48 feet; the normal static head is about 150 feet.

Power house.—The power house is a reinforced-concrete structure built on solid granite foundations in the bed of Yuba River. The walls of the building are strengthened by pilasters to support the crane loads and to resist unusually heavy snow loads resulting from heavy drifts. The building is 32 feet long, 23 feet wide, and 20 feet high to the eaves. The roof is peaked to shed snow.

Power house No. 2 is reached from power house No. 1 by a stairway covered for protection against heavy snows.

Hydraulic equipment.—The single unit is operated by a 1,335-horsepower Allis-Chalmers Francis turbine overhung on the generator shaft. A special automatic apparatus has been provided to control the speed of the turbine to prevent overheated bearings and to shut the unit down entirely in case of emergency.

Electric generator.—The 1,000-kilovolt-ampere 2,300-volt Allis-Chalmers horizontal 3-phase 60-cycle alternator transmits through lead-covered cables to Spaulding power house No. 1, where all switching and transformation is provided for, power house No. 2 being operated merely as a semiautomatic plant from the switchboard of power house No. 1.

DRUM PLANT.

Location.—The Drum power plant, named in honor of the former president of Pacific Gas & Electric Co., is the first in a series of seven designed by the company to utilize the water supply of the South Yuba system. The power house is on Bear River in sec. 17, T. 16 N., R. 11 E., about 9 miles southwest of Lake Spaulding. General views of the project are shown in Plate XXVI, *B*, *C*, and *D*. Detailed information in regard to the reservoirs above the plant is given in Table 22 and the descriptive paragraphs on pages 164–173.

Conduit.—Up to the end of 1913 the Main South Yuba canal (p. 191) was the only conduit owned by the company that diverted from the South Fork of Yuba River, but in November of that year Drum canal was finished and is now the principal diversion.

The Drum conduit heads at the Lake Spaulding dam (see p. 167), in the NW. ¼ sec. 21, T. 17 N., R. 12 E., and traverses secs. 21, 20, 29, 30, and 31 of the same township, secs. 36 and 35, T. 17 N., R. 11 E., and secs. 2, 3, 10, 15, 16, T. 16 N., R. 11 E., to a forebay in the SW. ¼ sec. 16. From this point the pipe line runs through secs. 16 and 17 to the power house in the NW. ¼ sec. 17.

From the lower end of the outlet tunnel (pp. 170–171), the total length of the conduit to the forebay is 46,291 feet, nearly all of which is sidehill canal, which was excavated by steam shovel and reinforced with masonry where the material was not of the proper quality to form the canal. (See Pl. XXVI, *B*.) In these reinforced sections the inner banks are held in place by a dry-laid rock wall and the outer bank by a wall of ordinary rock laid in mortar. This reinforcing necessitated placing 8,511 linear feet of masonry wall and 16,313 linear feet of dry rubble wall. The walls are 18 inches thick on bottom, 12 inches thick on top, and have inside slopes of 1:2.

Typical sections of the Drum conduit in earth show a bottom width of 11 feet and a depth to water surface of 7 feet, with side slopes of ½:1, giving a total surface width of 18 feet. In some formations, however, the slopes were varied to 1:1. The water surface is at the same elevation as the original natural ground on the outside of the canal, and the center line is shifted back far enough toward the hillside to leave a berm of 1½ feet of original earth in place between the side slope of the canal and the inner face of the main embankment This main embankment rises a foot above the berm on a 1:1 slope and is 8 feet wide on top; its outer slope is 1½:1 downward. The necessary excavation averaged 6 cubic yards per linear foot of conduit.

There are four short flumes aggregating 2,602 linear feet and two siphons on the line. One of the siphons was necessary from a structural standpoint and the other was put in as a matter of policy. The first siphon, which is just above the forebay reservoir, is constructed of riveted steel plates $\frac{5}{16}$-inch thick, is 102 inches in diameter, and 1,889 feet long. The static head at its lowest point is 128 feet. The other siphon is 1,875 feet long and constructed almost entirely of 8-foot wood-stave pipe, but at its lowest point there is a short stretch of steel pipe under a maximum head of 213 feet; this siphon carries the conduit around one corner of a piece of Government land in the Tahoe National Forest.[25]

The forebay is excavated in a sloping flat on top of a knoll, and the excavated material, when of proper quality, has been thrown up as an earth dam, curving around the lower side of the reservoir. This dam has a maximum height of 54 feet, a maximum base width of 230 feet, and a uniform crest width of 12 feet. Fill in the dam amounted to about 266,000 cubic yards. Its inner side has a slope of 3:1 and is riprapped for 50 feet from the crest; the slopes on its outer side range from 2:1 at the bottom to 1½:1 near the top of the dam. The capacity of the forebay is 19,353,708 cubic feet.

The canal runs into the forebay and follows down the slope to the bed of the reservoir in the same way that the Los Angeles Aqueduct runs down into Fairmont reservoir. (See Pl. LXVII, *A*, p. 746.) On the steep slope the bottom of the canal is paved with rock, but near the foot of the slope the paving is discontinued and the channel is widened to 35 feet, is 3 feet deep, and is unlined across the bottom of the reservoir to the pipe intake.

The intake of the pressure system is a concrete structure provided with inclined trash racks over the bell-mouthed entrance to the pipes. These bells contract from 8 feet in diameter at their mouths to 6 feet in diameter at their lower ends, and from them the pipes continue at a uniform diameter of 6 feet through a lined tunnel 328 feet long. Below the tunnel there is a 6-foot butterfly gate in each line.[26]

The length of the pipe line from the forebay to the power house is 6,271.6 feet, but most of the drop is in the last 2,500 feet down the side of the main canyon. Before it reaches the top of the main drop the pipe at one place forms an inverted siphon. At the forebay the pipe is 72 inches in diameter, one-fourth inch thick, and is of the lap-riveted type. For heads of over 260 feet butt-and-strap

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[25] The directors of the company were unwilling to meet the conditions of the Forest Service permits regulating conduits of this kind, and the company therefore put in this siphon as a temporary expedient.

[26] Only one line has been put in place, as only two of the four proposed units have been installed at the power house.

riveting is used. At the lower end of the 72-inch section—which is 4,121 feet long—the pipe tapers to 66 inches, then to 60 inches, and finally to 52 inches (outside diameter) at the power house. The maximum thickness of plate used is 1¼ inches.

The anchorages along the main pressure drop are of unusual type, being reinforced-concrete rings surrounding the pipe and anchored into the bedrock by a number of inclined tie-rods. The bond between the rings and the pipe is secured by riveting angle irons around the pipe. About 260 feet behind the power house the pipe passes by a sharp incline into a tunnel, in which, on reaching the nozzle level, it bends to a horizontal and runs directly toward the power house. At the retaining wall back of the power house the pipe connects with a Y casting, and immediately inside the building there is a gate valve in each branch of the Y. A short cast section follows each gate valve and connects it to another Y. One branch of each of these secondary Ys runs straight on toward the nearest wheel of its unit, and the other runs outward at an angle of 45° to connect with a nozzle feeding the wheel on the opposite end of the shaft. The branch pipes leading to the nozzles are 26 inches in diameter and are steel castings; they connect directly to the nozzle castings. The present main pipe line supplies the two units at the west end of the building. Two future units at the east end and the second pipe will complete the installation. When the second pipe is put in the inner branches of the first Ys inside the power-house wall, on each line, will be connected just inside the gate valves by a 36-inch cross connection.

The maximum elevation of water surface at the forebay is 4,773 feet and the elevation of nozzle centers at the power house is 3,398 feet, giving a static head of 1,375 feet.

Power house.—The Drum power house (Pl. XXVI, *C*) is a steel structure with reinforced-concrete roof and walls,[27] extending along the south bank of Bear River, the bench for its foundation having been excavated to bedrock in the hillside. The building is 208 feet 8 inches long, and its breadth—or depth at right angles to the stream—is 77 feet 6 inches. It is divided by a longitudinal row of columns into a generator room (Pl. XXVI, *D*), occupying the full front and height of the house to a depth of 42 feet and a transformer and switching space occupying the back of the building. This transformer and switching space also extends the full length of the building, but is divided by transverse walls and by floors that form two or three stories. The peak of the roof is over the major axis of the switch room, the roof having equal pitches of very slight

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[27] The building as originally completed is large enough to house the full equipment of four units, having total capacity of 50,000 kilovolt-amperes with all auxiliary apparatus. The initial installation includes only two units and their auxiliaries, in the west end of the building.

slope, both toward the back and the front of the plant. The slope toward the front is very much longer, as it extends over the full width of the generator room.

The main generating units are set with shafts on line, parallel to the front wall and slightly nearer to it than the back wall. The floor of the generator room is commanded by two 50-ton electric cranes. The ultimate installation will be four 12,500-kilovolt-ampere units, only two of which are now installed. In arrangement of generators, transformers, and switching equipment the two ends of the building are in general symmetrical with respect to the transverse axis of the power house.

The transformers are accommodated in four bays in the back of the generator room. Each bay is about 34 feet wide and contains a bank of three single-phase transformers. The three transformers in each bank are not separated by barriers or screens.

Hydraulic equipment.—Each of the two units now in place is provided with 85-inch double-overhung Pelton-Doble impulse wheels, made by the Pelton Water Wheel Co., one wheel fitted to each end of the shaft. Each wheel is rated at 9,000 horsepower (18,000 for the pair) and carries 17 ellipsoidal buckets. The casting to which the buckets are bolted is a spider and not the ordinary steel disk. Each wheel is served by a single deflecting needle nozzle of 6⅞-inch bore. Each unit is controlled by a Lombard governor.

The original design contemplated a free discharge from the wheels through tunnel wasteways, but when the plant was nearly completed it was decided to add jet deflectors to prevent the stream impinging on the opposite hillside and throwing earth and rocks back against the power house at times of short circuit. Heavy reinforced-concrete extensions sloping down at an angle of about 30° were therefore added to the ends of the straight discharge culverts. In the roof of this inclined section of each culvert a longitudinal deflector was constructed of rails set in the concrete with their flanges parallel and overlapping in such manner as to present a smooth inclined surface to deflect the stream. In cross section this deflector is of the "vortex" form.

Generators.—The generators are Westinghouse 12,500-kilovolt-ampere 6,600-volt 1,094-ampere 3-phase 60-cycle machines, operated at 360 revolutions per minute, supported between pedestal bearings which are water cooled but are not provided with forced lubrication. The installed capacity of the plant (1921) is 25,000 kilovolt-amperes, or 33,500 horsepower.

Exciters.—The two exciter sets are placed side by side in the center of the house between the second and third generator areas. The sets are identical motor generators, with impulse wheel attached to the shaft of each. The wheel is used except when an accident occurs; the motor then comes into play. The generators in these sets are Westinghouse 400-kilowatt 125-volt 3,200-ampere machines, operated at 514 revolutions per minute. Each impulse wheel and induction motor is rated at 600 horsepower.

Transformers.—The power house is provided with Allis-Chalmers 4,250-kilovolt-ampere oil-insulated water-cooled transformers, with a ratio of 6,000 to 110,000 volts. The secondary voltage can be raised to 125,000 by changing the connection on the primary side to different taps. There are two full banks in use and a spare transformer is held in reserve for emergencies.

Wiring.—The generator leads are carried through ducts under the power-house floor to the low-tension switching equipment directly beyond the wall that forms the back of the transformer bays. Low-tension connections from these switches to the transformers pass forward through the wall at about the level of the top of the transformers. The high-tension leads from the transformers pass up through an opening in the second floor directly above the transformers, and are carried over the tops of the high-tension switch cells by insulators mounted on top of the cell walls. From the high-tension switches the leads are carried up to the high-tension busses, which are suspended from the steel frame of the building. The outgoing lines leave the building through apertures glazed with two panes of plate glass; the inner pane is pierced by a hole 12 inches and the outer pane by a hole 18 inches in diameter. Each set of high-tension switches consists of three 1-phase 4-break Baum cast-iron tub oil switches, and is in a separate cell inclosed in concrete fire walls.

The main switchboard is in the center of the power house between the second and third transformer bays, on a platform raised 10 feet above the main floor.

HALSEY PLANT.

Location.—The Halsey power house, in sec. 25, T. 13 N., R. 8 E., on Dry Creek, about 5 miles southeast of Auburn, Placer County, was formerly known as plant No. 4 of the South Yuba-Bear River development of Pacific Gas & Electric Co. It was designed by the company's engineers and construction was begun in April, 1913, but was soon suspended and not resumed until December, 1915. The plant began operation December 6, 1916.

Reservoirs.—The reservoirs used in connection with the Halsey plant are listed in Table 22 and briefly described on pages 164–173.

Conduit.—The Halsey plant diverts its entire water supply through Bear River canal, which heads on Bear River just below the bridge of the Nevada County Narrow Gage Railroad. The old Bear River canal [28] was constructed during the early fifties to furnish water for

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[28] Records of water passing over the intake dam and through the canal are published in U. S. Geol. Survey Water-Supply Papers as follows: 298, pp. 287–289; 331, pp. 309–313; 361, pp. 350–353; 391, pp. 254–256, 411, pp. 264–268; 441, pp. 238–244; 461, pp. 237–238; 481 (canal only), pp. 228–229.

hydraulic mining, and for many years delivered water to Fiddler Green canal at a point a short distance below the present Lake Arthur. (See p. 172.) The water was then used through lower ditch systems, first for mining and later for irrigation and the development of power at the Auburn and Newcastle power houses. The intake is in sec. 22, T. 15 N., R. 9 E. The conduit traverses secs. 22, 27, 28, 33, and 32 of the same township; secs. 4, 9, 8, 17, 20, 19, 29, and 32 of T. 14 N., R. 9 E.; secs. 5, 6, 7, 8, and 18 of T. 13 N., R. 9 E., to the forebay, in sec. 13, T. 13 N., R. 8 E.

The original capacity of the Bear River canal was about 43 second-feet, but with the completion of the enlarged storage at Lake Spaulding and as a link in the extensive development of the South Yuba-Bear River power and irrigation system the conduit was increased to a capacity of 350 second-feet.

The following details of the conduit are abstracted from a paper by Mr. R. W. Van Norden.[29] The old canal had a maximum depth ranging from 4½ to about 5½ feet. The new canal was so designed that its water surface will come to the top of the old berm, the bank being raised above the original surface by piling up the excavated material, great care being used not to disturb the old berm. In many places the outer bank of the new canal is lined with dry rock from bottom to top; the typical design calls for a dry-rock edging at the top of the outer bank the full length of the ditch.

Two canal sections are used: The first, used on the lower end of the conduit where the grade is 0.52 foot per thousand, is 10 feet wide at bottom, 18.3 feet wide on the surface, and 8.2 feet deep, with side slopes of 1 : 2. The area of water way of this section is 117.5 square feet, and estimated discharge 348 second-feet with $n=0.030$ or 414 second-feet with $n=0.025$. The second type of section, used on the upper 5½ miles of conduit on grades of 1.10 feet per thousand, is 10 feet wide at the bottom, 16.6 feet wide at the water surface, and 6.7 feet deep from bottom to water surface, with side slopes 1: 2. The area of waterway is 89 square feet; carrying capacity, 337 second-feet with $n=0.030$ or 404 second-feet with $n=0.025$.

Two sizes of flume section also are used. The smaller flume, used on a grade of 1.10, has mud sills 6 by 8 inches in section, 10 feet long, supporting three stringers 6 by 8 inches in section and 18 feet long, overlapping a foot on each and spaced 3 feet in the clear. These stringers support sills 6 by 8 inches in section and 14 feet long, into which 1½-inch daps are cut to receive side posts 4 by 8 inches in section and 7 feet 5 inches long. The caps spiked to the upper end of the side posts are 2 by 8 inches in section and 12 feet long. Side posts are braced to the ends of the stringers by struts 2 by 8 inches in section, 3 by 9 inches long, making an angle of about 60° with the

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[29] Jour. Electricity, Mar. 15-22, 1913.

horizontal. The bottom of the flume box is composed of six boards 1½ inches thick by 18 inches wide and 16 feet long. Each side of the flume is composed of 4 boards, 1½ by 18 inches, 16 feet long, and one board 1½ inches thick, 6 inches wide, and 16 feet long. All cracks are covered by battens five-eighths inch thick by 4 inches wide. The interior width of box is 9 feet, its depth to water surface 6 feet, and the clearance between the water surface and the lower side of the caps 6 inches. The larger flumes are 11 feet wide and water depth is 6½ feet. There are seven concrete sand-box wasteways along the canal. These are fitted with sliding timber gates which are raised and lowered by rack-and-pinion gears.

The diversion dam is of the overflow type and is constructed of cyclopean rubble masonry. It was built in 1909, and replaced the last of three earlier crib dams that had occupied the same site. The dam has a gravity section, straight crest, and nearly vertical downstream face. When the canal was enlarged a concrete gate structure, fitted with double sluice gates operated by screws, was built in the south end of the dam. Directly below the gates there is an emergency spillway over a wall on the outer side of the canal, back into the stream.

A reinforced-concrete gravel settler was built immediately below headworks in 1920. This is simply an enlarged ditch section ranging from 16 to 34 feet in width. Its lower side contains a weir 56 feet long and 2½ feet deep, over which the cleared water flows into the main channel. The outlets or sand gates are at the lower end of the structure and are 14 feet below the spillway crest. The outlets are 5½ by 5½ feet and are closed by radial gates.

About half a mile below on the ditch the original settler is also in use. This trap is concrete lined and has a spillway 163 feet long. Water is diverted from the canal by a simple gate across the flume. The outlet is a 36-inch steel pipe flaring to 60 inches by a single radial gate at its outlet.

The original length of the conduit was 32.7 miles, but by the construction of tunnels across loops in the old line the total length was reduced to 23.31 miles from the intake to the Halsey forebay, when the ditch was enlarged.

Between the intake and Halsey forebay there is 114,084 feet of open canal, 2,620 feet of timber flume, and three tunnels, with a combined length of 6,356 feet of which tunnel No. 1 is 2,112 feet and tunnel No. 2, 1,971 feet, both with 8 by 8 feet rectangular section; tunnel No. 4[30] is 2,273 feet long, partly 8 by 8 feet 6 inches rectangular, and partly 7 feet 3 inches by 6 feet 2 inches horseshoe section, giving a total length of conduit from intake to forebay of 123,060 feet.

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[30] Tunnel No. 3, which was 409.7 feet long and 8 by 8 feet in section, was abandoned Jan. 18, 1913, on account of change in plans.

Forebay.—Halsey forebay is formed by two small earth dams and has a net capacity of 185 acre-feet above the bottom of the outlet and below the lip of the spillway.

Water from the forebay is discharged directly into tunnel No. 5, which is 1,439 feet long, 8 feet in diameter, circular in section, and is lined with reinforced concrete. The lower portal of tunnel No. 5 is connected to the upper portal of tunnel No. 6 by a 96-inch wood-stave pipe, 259 feet long (not including 31 feet which projects into the two tunnels). Tunnel No. 6 is 1,175 feet long and of the same type and diameter as tunnel No. 5. Below tunnel No. 6 a section of 96-inch wood-stave pipe, 1,481 feet long, extends to the upper end of the steel pressure line, which is 72 inches in uniform diameter and 1,240 feet long (including a Y branch), terminating at the power house. The total length of the pressure system, from forebay to power house, as given above, is 5,420.5 feet.

The static head at the power house, depending upon the elevation of water surface in the forebay and afterbay reservoirs, will vary between 328 and 314 feet.

Power house.—The Halsey power house (Pl. XXIII, *B*, p. 158) is an attractive single-story structure of Spanish architecture, finished in buff plaster and roofed with red tile, with flat central deck. A series of windows, each 7 feet square, completely encircles the building, just below the heavy ornamental cornice. The concrete work of the two-arch tailrace extends beyond one end of the plant so that when water in the afterbay is low the building gives the appearance of being partly supported on a graceful arched bridge.

The structure has a steel frame, outside of which are self-supporting reinforced concrete walls, the steel frame serving chiefly as a support for the heavy loads necessarily handled by the crane. The building is 97 feet 1 inch long and 44 feet 5 inches wide; the height of the structure, from floor level to the lower chord of the roof trusses, is 35 feet 2 inches, and the height from floor to crane railway is 27 feet 11 inches.

The large generator room occupies the entire interior of the building except for a switching space which is partitioned off from one end of the generator room by a reinforced-concrete fire curtain that extends from the floor nearly to the height of the crane runway.

The single main unit is installed near the front wall of the station, with its shaft parallel to the main axis of the building. The three single-phase transformers are set in a pit 7 feet deep, which is just in front of the curtain wall of the switching compartment. The switchboard is against the back wall of the generator room immediately opposite the main unit. A crane runway, supported on the steel frame of the building, extends the entire length of the generator room and also over the transformer pit but not over the switch compartment.

Hydraulic equipment.—The main unit consists of two 9,000-horsepower 60-inch double-overhung Allis-Chalmers Francis turbines, one at each end of the shaft. The great size and weight of the generator and wheel casings called for extremely stable foundations. Not only was the excavation carried down to bedrock, but a heavily reinforced concrete block 3 feet 8 inches thick was constructed underneath the part of the building occupied by the unit. Upon this supplemental foundation the piers for the generator bearings, the turbines, and the generator sole plate were built. The main shaft of the generator is supported on two bearings—one on each side of the generator between it and the turbine casing. The governors operate in connection with dash-pot relief valves, which can be set to close in any desired time. Experiments made by the company show that with a closing time of 1½ minutes dropping a load of 9,200 kilowatts caused a rise in pressure of only 11 per cent above static pressure. The draft tubes discharge beneath the surface of the small reservoir at the head of the conduit leading to the Wise power house.

Generator.—The main generator is a Westinghouse 12,500-kilovolt-ampere (16,750 horsepower) 6,600-volt 1,094-ampere 3-phase 60-cycle alternator, operated at 360 revolutions per minute, and is one of the four generators originally purchased for the Drum plant, two having been installed at that power house, one at this, and the other in the Wise power house.

Exciter.—The exciter is a Crocker-Wheeler 100-kilowatt 125-volt direct-current generator, placed against the front wall of the plant opposite one of the turbines and operated by a 150-horsepower Pelton water wheel that makes 514 revolutions per minute.

Transformers.—Three 1-phase 60-cycle 4,250-kilovolt ampere water-cooled transformers step the potential up from 6,600 to 60,000 or 110,000 to 125,000 volts. They can be connected to the Drum-Cordelia tower line, operated at 110,000 volts, and also to the Wise tower line running south to Stockton and thence to Newark, near the south end of San Francisco Bay, operated at 110,000 volts.

Wiring.—The generator leads are carried in ducts to the transformers, and the high-tension conductors from the transformers are made of tubing supported by bushing insulators fastened to the sides and top of the curtain wall of the switch compartment, bending over the wall and down to the high-tension oil switches. These switches are of the type used at Drum power house. Tubing conductors are carried from the switches up to outlets through the square, glazed windows in the end wall of the power house.

WISE PLANT.

Location.—The Wise power house is in sec. 16, T. 12 N., R. 8 E., about 2 miles west of Auburn. The plant was formerly known as plant No. 5 of the South Yuba-Bear River development of the Pacific Gas &

Electric Co. and was not completed until 1917, although some work was done on the system in 1913, and active construction began in the fall of 1915. The plant was put into commission March 4, 1917, its entire design and construction having been carried on by the forces of the company. The Wise power house diverts its supply directly from the Christian Valley reservoir, the afterbay of the Halsey power plant.

Reservoirs and conduit.—Except for the small afterbay reservoir, immediately below the Halsey power house, and the Rock Creek reservoir, which is on the course of the Wise conduit, the storage reservoirs used in connection with the Wise plant are described on pages 164–173 and listed in Table 22.

The Halsey afterbay is formed by a rock-fill dam and has a capacity of 110 acre-feet to the spillway lip.

Beginning at the Halsey afterbay in sec. 25, T. 13 N., R. 8 E., Wise canal runs southwestward through secs. 26, 27, and 22 of T. 13 N., R. 8 E., entering Rock Creek reservoir in sec. 28 and leaving it in sec. 33, T. 13, N., R. 8 E., and running through secs. 4, 9, and 16, T. 12 N., R. 8 E., to Wise power house, in secs. 16 and 17, T. 12 N., R. 8 E.

The Rock Creek reservoir is formed by a multiple-arch reinforced-concrete dam, 1,080 feet long, composed of 36 arches of 30-foot span on centers. The maximum height of the dam is only 36 feet, but it is so designed that it can be raised to a maximum height of 53 feet. At one end of the dam, making an angle of 30° with the main dam and connecting it to the hillside, is a wing embankment 775 feet long, 8 feet wide on crest, with an upstream slope of 2½ :1 and a downstream slope of 2 :1; it contains about 11,700 cubic yards of earth. The net capacity of the reservoir formed by the present dam is 550 acre-feet; that of the reservoir to be formed by the ultimate dam will be 2,500 acre-feet. The outlet from the present dam is through two 4 by 6 feet sluice gates, which are operated by motors. Near the center of the dam there is a spillway 3 feet deep and 925 second-feet in maximum capacity, with ogee apron to divert the discharge from the foundations.

The lengths and types of conduit from Halsey afterbay to Wise forebay are as follows:

TABLE 25.—*Conduit line from Halsey afterbay to Wise forebay.*

	Feet.
Open ditch	27, 227. 8
Semicircular steel flume	296. 0
Tunnel No. 7	606. 9
Tunnel No. 8	639. 4
Tunnel No. 9	2, 762. 0
Rock Creek reservoir (width)	882. 0
	32, 414. 1

The capacity of Wise forebay up to the spillway lip is 41.25 acre-feet. Water is admitted from the forebay to the pressure system through two motor-operated headgates, protected by inclined trash racks. The headgate structure and an emergency wasteway are constructed of concrete. The pressure system connecting the forebay with the power house, like that at the Halsey plant, is of composite design; the forebay being connected to a pressure tunnel—tunnel No. 10—by a 96-inch wood-stave pipe, and the lower end of the pressure tunnel being connected to the power house by a riveted steel pipe ranging in diameter from 84 to 66 inches and in thickness from one-fourth to three-fourths inch. The several lengths of the various sections of this pressure line are as follows:

TABLE 26.—*Pressure line of Wise plant.*

	Feet.
Wood-stave pipe from forebay to tunnel No. 10	1,335
Tunnel No. 10, portal to portal	445
Steel pipe from tunnel No. 10 to power house (including a Venturi meter 54 feet long)	6,640
	8,420

The elevation of the forebay is 1,425 feet and the elevation of the tailrace at the power house 906 feet above sea level, giving a static head of 519 feet.

Power house.—The Wise power house (Pl. XXIII, *A*, p. 158), except for its turbine, is a duplicate of the Halsey power house, being of the same size and same pleasing design. As at the Halsey station, the entire generating equipment is contained in a single room and is arranged in the same way. The only important difference between the two stations is that the unit of the Wise power house is operated by one turbine instead of two. The transformers are in a pit at the end of the generator room along the curtain wall separating the main part of the room from the high-tension switching compartment. The station is equipped with 50-ton crane similar to that at Halsey power house.

Hydraulic equipment.—The 74-inch turbine is of the Pelton-Francis type and was designed to develop 20,000 horsepower when operating at 360 revolutions per minute under a head of 518.75 feet, with a maximum discharge of 400 second-feet. Water is admitted through a 66-inch butterfly gate at the turbine, operated either by a 10-horsepower motor or by hand. The turbine is controlled by a Pelton-Doble oil-pressure governor, acting in connection with a relief valve that opens as the turbine gates close and is so regulated that it then closes normally in about 1½ minutes. Some idea of the size of the turbine may be derived from the fact that the turbine unit weighs over 163,000 pounds.

Water is discharged from the turbine through a steel draft tube embedded in the concrete of the foundation. The draft tube discharges into a short ditch leading into the canyon, from which the water will be rediverted at a lower point into the conduit system of plant 6. Until plant 6 is completed the water will be used below Wise power house only for irrigation.

Generator.—The generator of the main unit at Wise power house is a Westinghouse 12,500-kilovolt-ampere (16,750 horsepower) 6,600-volt 1,094-ampere 3-phase 60-cycle alternator, operating at 360 revolutions per minute, and like that at the Halsey power house is one of the four generators originally purchased for installation at the Drum power house.

Exciter.—The exciter is a Crocker-Wheeler 100-kilowatt 125-volt direct-current generator, operated by a Pelton-Doble 150-horsepower impulse wheel, at 514 revolutions per minute, and is placed between the main unit and the back wall of the power house. The needle valve of the exciter wheel is operated by a motor controlled from the switchboard.

Transformers.—A bank of three single-phase 4,250-kilovolt-ampere 60-cycle 6,600/110,000–125,000-volt water-cooled transformers is installed in the pit in the end of the generator room.

Wiring.—The station wiring and high-tension switching equipment duplicates that at the Halsey power house, oil switches being tested for 125,000 volts and operated by remote control from the switchboard. The station connects to the steel-tower transmission line from Halsey power house to Stockton and Newark, now called the Wise tower line.

ALTA PLANT.

Location.—Alta power house is on Little Bear River in sec. 25, T. 16 N., R. 10 E., 3,439.5 feet above sea level. The plant was built by Central California Electric Co. and put into commission November 7, 1902.

Reservoirs. The storage works above Alta plant include all the reservoirs given in Table 22 except Lake Arthur and Rock Creek reservoir, which are below the Alta power house.

Conduits.—Alta power house is operated with water delivered to it through upper Boardman canal, which heads on Bear River, and through Towle canal and its branches, which head on tributaries of North Fork of American River.

Upper Boardman canal receives water from the lakes and reservoirs in the drainage basins of Bear River and South Fork of Yuba River above and including Spaulding reservoir. From its head at Bear Valley reservoir, in sec. 36, T. 17 N., R. 11 E., the course of upper Boardman canal is southwesterly to the Alta forebay in sec.

30, T. 16 N., R. 11 E. The canal is 69,670 feet long from Bear Valley reservoir to the power-house forebay, 58,288 feet being in ditch, 11,057 feet in numerous short flumes, and 325 feet in tunnel. Its capacity is 80 second-feet. Before Drum canal was constructed about 40 per cent of the water from the lakes and reservoirs in the drainage basins of Bear River and the South Fork of the Yuba above Lake Spaulding was spilled into Bear River below Lake Spaulding, diverted at Boardman head dam, and carried to Alta power house. Most of the water passing Lake Spaulding is now carried in through Drum canal, only surplus water and the minimum required by established rights being diverted through South Yuba and upper Boardman canals. Water was formerly carried from Alta power house by lower Boardman canal through Auburn and Newcastle power houses, which have been abandoned.

Towle canal receives water from Lake Valley reservoir through a branch of North Fork of American River. Feeders also pick up water for this canal at North Fork of North Fork, at Canyon Creek, and at a branch of Canyon Creek. The canal delivers water to Alta power-house forebay.

The head dam, which is in sec. 5, T. 16 N., R. 12 E., is built of logs faced with plank and is 15 feet high and 40 feet long on the crest. The total length of the canal is 109,163 feet; 101,772 feet is ditch, 5,195 feet flume, 1,089 feet tunnel, 967 feet in stream beds, and 140 feet of steel pipe. The ditch section is 8 feet wide on top, 6 feet on bottom, and 4.5 feet deep. The flume is 5 feet wide and 3.5 feet deep. The tunnels have trapezoidal sections varying from a minimum of 3.5 feet wide at top, 4 feet wide at bottom, and 4.5 feet high to a maximum of 6 feet wide at top, 6.5 feet wide at bottom, and 6 feet high. The average grade for the conduit is 1.89 feet per thousand or 9.98 feet per mile, but there are two rapid drops of 125 feet each. The elevation at the head of the canal is 4,947.4 feet, and at the end (where it joins Boardman ditch) 4,397.2 feet. The capacity of the canal is 30 second-feet.

The canal was built as far as Canyon Creek by Bradley & Gardner about 1853. It was extended to Alta power-house forebay in 1904.

Forebay.—For several years the forebay reservoir at Alta was abandoned on account of the porous nature of the ground in which it was constructed, and the Boardman and Towle canals discharged into a timber-box penstock (instead of the forebay) from which the water entered a single pressure pipe through sliding wooden gates. About 1918 the bottom of the forebay was puddled and the reservoir again made serviceable. The wooden intake was left in place and is in use at present.

Pressure pipe.—The pressure pipe,[31] which is 5,380 feet long from the forebay to the Y at the upper end of the power house, is made of riveted steel throughout, and ranges in plate thickness from one-fourth to three-eighths of an inch. The sections forming the upper 3,480 feet of the pressure pipe are 38 inches and the lower 1,900 feet, 36 inches in diameter. Just before reaching the power house the pipe line crosses Little Bear River on a concrete bridge; just above the bridge there is a bend in the line and a concrete anchorage; between the anchorage and the stream there is a 36-inch hand-operated gate valve. After crossing the bridge the line runs into one of the branches of a specially designed reversed Y; the other branch of this Y is capped and was intended to receive a second pipe line; both branches are 36 inches in diameter. Both the gate valve and the Y were tested to 600 pounds pressure per square inch. The body of the Y is 48 inches in diameter and connects with a receiver which is 110 feet long and 48 inches in diameter at the junction.

The receiver curves 33° from the line of the pipe to a line parallel to and 6 feet above the floor of the power house and runs along outside the back wall of the plant. Throughout its length it is set in a concrete block support. The 22-inch supply branches to the units are taken off from the pipe at right angles to its axis and 45° below the horizontal. Each branch bends through an easy curve to the back wall of the power house, where it passes through a hydraulically operated gate valve and thence on horizontally to the wheel. The total static head developed is 660 feet.[32]

Power house.—The single building housing the entire generating equipment is constructed of masonry and roofed with corrugated iron supported on steel trusses. The side walls are 2 feet and the end walls 20 inches thick; the interior dimensions of the house are 112 by 30 feet. At the back of the building there is an addition, 22 feet long by 12 feet deep, which houses the switching equipment. A crane runway is laid on a shoulder in each side wall, and a hand-operated traveling crane of 10 tons capacity moving on these rails has command of the entire floor of the generator room.

The two 1,000-kilovolt-ampere units are arranged with their shafts parallel to the main axis of the room. The switchboard is placed along and slightly out from the back wall, near its center, and the transformers along the back wall at each end of the switchboard.

Hydraulic equipment.—The branch pipes, after leaving the hydraulic gates at the back wall, run horizontally at a level 1½ feet below the

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[31] The writer is indebted to Mr. R. W. Van Norden, designer of the plant, for the information concerning the pipe line.

[32] The plant was designed for four units, but only three were installed. Since the completion of Drum plant, only two units at Alta have been operated.

floor of the building to the units, and terminate in a casting giving a quarter-turn to the wheels, which are Pelton-Doble impulse wheels, rated at 1,700 horsepower each.

Each wheel is direct-connected to its generator shaft, and its supply pipe is fitted with a bypass so that when the wheel is shut down the full flow of the canal will continue uninterruptedly. This arrangement is necessary, as the power plant is operated in connection with irrigation lower down on the drainage basin.

The two wheels are governed by Lombard governors, type Q. The water passing through the wheels is discharged directly into the canyon bed, from which it is almost immediately picked up by the head of the lower section of the Boardman canal.

Generators.—The two generators are Westinghouse revolving-field 1,000-kilovolt-ampere 500-volt 1,155-ampere 3-phase 60-cycle alternators, with bearings of the ordinary ring type. Their speed is 400 revolutions per minute. Only two of these generators are in use, the present capacity of the plant being 2,000 kilovolt-amperes or 2,680 horsepower.

Exciters.—The exciter equipment is a double set of 45-kilowatt 360-ampere 125-volt direct-current Westinghouse generators, with a speed of 850 revolutions per minute, driven by Pelton wheels. A 50-horsepower Westinghouse 500-volt 56-ampere type C induction motor is arranged between the sets, so that it can be connected to either one by a system of clutches.

Transformers.—The power house contains a single bank of three Stanley shell-type 1-phase 60-cycle 500-kilowatt transformers, with a ratio of 500 to 60,000, which steps up the potential for the Sacramento transmission. Four Westinghouse water-cooled 500 to 39,300-volt 375-kilowatt transformers, with secondaries connected in series, step the generator potential up to that in use on the circuit to Grass Valley, 60,000 volts. Both outgoing lines are operated with grounded neutral.

Wiring.—Generator leads are carried to the switchboard, which is provided with double busses, through tile ducts leading under the floor. From the switchboard to the transformers the leads are carried in a subway, and from the transformers, the high-tension leads run up to a bracket on the back wall and are then carried along on insulators to the bay back of the switchboard, where they pass out of the building through circular openings. One circuit runs from the plant to Grass Valley and the other to Sacramento. The lines from the Deer Creek and Spaulding plants tie in on the latter circuit very close to the power house.

The lightning arresters originally installed at the power house have been dismantled.

DEER CREEK PLANT.

Location.—Deer Creek power house, which was put in operation by the company May 6, 1908, is on the south bank of South Fork of Deer Creek in sec. 34, T. 17 N., R. 10 E.

Reservoirs.—Aside from the main reservoirs of the South Yuba system, described in Table 22 and on pages 164–173, Deer Creek power house is served only by the small emergency peak-load supply of Deer Creek forebay.

Conduit.—The water for the plant is diverted from the South Fork of Yuba River at a point 2 miles northeast of Emigrant Gap through the Main South Yuba canal. The head dam of the Main South Yuba canal is a masonry overflow structure in the gorge of the South Fork of Yuba River about half a mile below Lake Spaulding in sec. 20, T. 17 N., R. 12 E. A short distance below its head the canal crosses through a sag in the hill just north of Emigrant Gap into the Bear River basin, continues in a southwesterly course for 6 miles, then turns north toward Deer Creek, passing through Big Tunnel and running into the Chalk Bluff canal, which runs to Deer Creek power house. In this course it traverses secs 20, 29, and 30 of T. 17 N., R. 12 E.; secs. 25, 26, 35, 34, 33, 32, 29, 30, and 31 of T. 17 N., R. 11 E.; and secs. 3 and 4 of T. 16 N., R. 11 E. The Chalk Bluff canal begins at this point and runs through secs. 30 and 31, T. 17 N., R. 11 E., and secs. 36 and 35, T. 17 N., R. 10 E., to the Deer Creek forebay in sec. 35. The pressure pipe extends through secs. 35 and 34 to the power house.

Of the total length of the conduit (Main South Yuba only)—84,280 feet—44,860 feet is ditch 11½ feet wide on top, 8½ feet wide on the bottom, and 5 feet deep, 35,734 feet is flume 6 feet wide and 5 feet deep, and 3,686 feet is tunnel 6 feet wide at the top, 8 feet on the bottom, and 6 feet high. The capacity of the conduit is 185 second-feet. The elevation at the head dam is 4,694.47 feet at the end of the canal, in sec. 30, T. 17 N., R. 11 E.; at the headgate of Chalk Bluff canal the elevation is 4,540.87 feet. The canal may be used to deliver water to Bear River basin, above the head of Boardman canal, the supply for Alta power house, and to the Deer Creek power house through Chalk Bluff canal.

The canal was built about 1850 to supply water for hydraulic mining. The present concrete head dam was put in about 1900 by South Yuba Water & Mining Co. to replace the old log head dam.

Chalk Bluff canal receives water from the Main South Yuba canal at the lower end of Big Tunnel, in sec. 30, T. 17 N., R. 11 E., at an altitude of 4,540.87 feet above sea level, and delivers it to Deer Creek forebay at an altitude of 4,496.08 feet. Of the total length of the canal—17,060 feet—15,251 feet is ditch and 1,809 feet flume. The average grade for the line is 2.5 feet per thousand. The canal was built about 1860 to supply water for hydraulic mining. In 1907 California Gas & Electric Corporation enlarged it as far as Deer Creek forebay.

Forebay.—The forebay has a maximum capacity of 880,000 cubic feet (20.2 acre-feet), an area at maximum capacity of 4.4 acres, and a water-surface elevation of 4,498 feet above sea level. The reservoir is formed by an earth-fill dam, riprapped on its inner slope, with a maximum height of about 13 feet and total length of 1,175 feet. The lake is almost circular and the dam incloses about two-thirds of the circumference, the other third being formed by the hillside. The outlet is through a reinforced-concrete heading, fitted with trash racks and with wooden slide gates 4 feet 6 inches wide by 9 feet 9 inches high, which admit water to the single pipe line leading to the power house.

Pressure pipe.—From the forebay to the power house the total length of the pressure line is 5,589 feet, of which 4,144 feet is 48-inch and 1,445 feet is 42-inch riveted steel pipe. The total static head is 837 feet. The upper part of the line lies along the gentle slope of the flat-topped hill above the plant and is perfectly straight. Where the edge of the hill breaks away more steeply toward the power house there is an easy bend of about 25°, after which the line runs directly to the back of the station at a steeper grade. Just back of the building a sharp bend carries the pipe down to a Y casting at the back wall of the power house. The pipe is covered throughout its length.

Power house.—The power house is a steel-frame concrete building with corrugated iron roof carried on steel trusses. In plan it measures 53 by 41 feet and contains but one room; the transformers are in a bay at its upstream end, and the high-tension oil switches are in an open gallery above them.

The single 5,500-kilovolt-ampere unit is placed parallel to the long axis of the building on the side toward the stream. The steel Y branches under the floor at the back wall of the building and each branch runs to a single overhung wheel at each end of the generator shaft. A motor-driven gate valve is placed in each branch about the center of the room.

Near the back wall there is a small switchboard, on one side of which is the oil-supply equipment for the governor and on the other side the exciter set. In the back corner, near the transformer cell, there is a small machine-shop equipment. A hand-operated traveling crane, commanding the main floor, is supported on runways on each side of the room.

Hydraulic equipment.—Each branch of the Y after passing through the 24-inch motor-driven gate valves connects to a single 7½-inch needle nozzle which supplies the overhung Pelton wheel at that end of the shaft.[33] The position of the needle is controlled by hand, and nozzles are deflected by a Lombard governor, type Q, supplied with oil under pressure from a tank at the back of the generator room. Pressure in the oil tank is maintained by an automatic electric cut-out operated by a pressure gage which is mounted on a bracket at the side of the switchboard and is so set that when the pressure falls below a certain point the motor that operates the oil pump is put in service and runs until the desired pressure is again attained.

Each wheel has a 58½-inch forged-steel disk with 17 buckets bolted to its rim. The operating speed is 300 revolutions per minute. The wheels are rated at 5,225 horsepower each.

Generator.—The single generator is a 5,500-kilovolt-ampere (7,370 horsepower) Westinghouse alternator, giving 1,375 amperes per terminal at 2,300 volts. It is a 3-phase 60-cycle machine of the two-bearing type, operating at 300 revolutions per minute. The bearings are water-jacketed but have ordinary ring lubrication.

Exciter.—The exciter is a motor generator connected to a Risdon impulse wheel with 30-inch disk and 28 buckets. This wheel is rated at 90 horsepower. The direct-current generator of the set is a 60-kilowatt Stanley 1,000-ampere 60-volt machine, type MP, operating at 720 revolutions per minute. The motor is a Stanley SKC 85-horsepower 3-phase 60-cycle 22.8-ampere machine, type A, fitted with a 2,080 primary volt, 832 to 1,772 secondary volt starting compensator, type M. The exciter impulse wheel is regulated by a hood jet deflector controlled by a handwheel mounted on the side of the switchboard.

Transformers.—The single bank of transformers consists of three Stanley SKC 2,000-kilowatt single-phase shell-type water-cooled transformers, with a ratio of 2,300 to 60,000, connected delta on the low-tension and Y with grounded neutral on the high-tension side.

Wiring.—The switchboard is equipped with one Thompson voltmeter, three Thompson ammeters, two Thompson indicating wattmeters, two Thompson high-torque induction meters, one Thompson astatic ammeter, one Thompson astatic voltmeter, one frequency indicator, and one Bristol recording meter. Below the recording instruments on the base of the board are the field rheostat controls and the levers to the low-tension oil switches, which are below the board in the basement of the power house. From the generator switch the leads run under the main floor of the plant to the transformer cell and pass up through the floor to the transformer. The high-tension

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[33] For results of tests see Eckart, W. R., The application of the Pitot tube to the testing of impulse water wheels: Inst. Mech. Eng. [London] Proc., January, 1910.

wiring from the transformers runs directly up through the floor of the gallery above to three Baum oil-tub switches, which are operated by levers from the main floor. From these high-tension switches the wires pass out through square glazed windows in the end of the building to insulators fixed to a bracket just outside the wall. Thence the lines are carried to pole-top disconnecting switches a few feet away, which are operated by a lever from the ground. The single 60,000-volt outgoing circuit runs almost due southeast 6.4 miles to Alta power house.

The power house is not equipped with lightning arresters.

ELECTRA PLANT.

LOCATION.

The Electra plant (Pl. XXIX, *D*, p. 199), which was constructed by The Standard Electric Co., of California, began transmitting power to the neighboring mining district May 6, 1902, but delivered none in San Francisco until early in November. The power house is on the north bank of Mokelumne River in sec. 32, T. 6 N., R. 12 E.

SOURCE OF WATER SUPPLY.

The part of the drainage basin of the North Fork of Mokelumne River that supplies the Electra plant comprises 356 square miles (see Pl. XXVII, in pocket) in Amador, Alpine, and Calaveras counties, 120 miles east of San Francisco. The basin is long and narrow and extends nearly due west from the crest of the Sierra to the eastern edge of the foothills. Most of it is directly in the main canyon, which is rather wide and is shut in by broad-topped ridges. The maximum width of the basin (north and south) is about 12 miles and average width 9 miles. Bear River, which joins the main stream from the north in the central part of the basin, and Blue Creek, which enters from the south a few miles lower down, are the main tributaries. Their courses are nearly parallel to the course of the Mokelumne.

Elevations within the basin range from 2,500 feet above sea level at the intakes to 8,000 feet on the ridges that shut in the canyon on the north and south and to 10,000 feet along the main divide, on the eastern boundary. Round Top, 10,430 feet, is the highest peak. Mokelumne Peak north of the river but in the central part of the basin is 9,311 feet high and is, on account of its isolated position, the most conspicuous landmark.

Except in the higher regions the country presents a spacious and rolling rather than rugged appearance. The canyon is from 1,500 to 3,000 feet deep and is flanked by round-topped ridges whose sides are steep but not precipitous. A few miles east of the mouth of

Bear River on both sides of the Mokelumne are very high granitic domes that form a narrow gateway for the stream. Above these the canyon opens out again and then gradually narrows and gets rougher as the headwaters are approached. Bare granitic domes and peaks are the characteristic features of the eastern end of the basin.

The geology of the greater part of the drainage basin is covered by the Pyramid Peak folio,[34] which shows that from the main divide to the ridge west of Bear River the rocks are granite and granodiorite. Along the ridge between Bear and Consumnes rivers there is much andesite and the red soil weathered from it. In the upper parts of the basin are several moraines. The geology of the rest of the area—a relatively small strip in the southwest—has not yet been worked out.

The basin is well forested except on the sides of the canyon, where trees are sparse and mingled with brush, and in the east end of the basin, which is for the most part of bare granite or is above timber line. On the tops of the ridges north and south of the river and in the basins of a number of the smaller tributaries the timber is very fine.

Comparatively short records at several rainfall stations shown on the map indicate a mean seasonal rainfall on the basin ranging from 40 to slightly more than 60 inches. Over much of the basin the precipitation in winter is entirely in the form of snow, but elevations, even in the highest parts of the catchment area, are not sufficient to support perpetual snowfields. The stream flow is therefore well maintained during the early summer but in the last part of the summer (especially after mild winters) there is a very marked drop in the flow and the low season has to be tided over by draft on storage. The only published records of the discharge of the Mokelumne in the immediate vicinity of Electra cover the years 1901 to 1904.[35]

RESERVOIRS.

Sites available.—To provide water during the period of low flow several reservoirs have been constructed at the best sites in the upper basin. Other sites farther downstream could be used to regulate the flow to a still greater extent, but the unit cost of their storage would probably be greater than that already provided. The reservoirs now in use in the Electra system are Twin, Blue, and Meadow lakes, Bear River reservoir, and Tabeaud and Petty forebay reservoirs.

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[34] U. S. Geol. Survey Geol. Atlas, Folio 31, 1896.

[35] U. S. Geol. Survey Water-Supply Paper 299, pp. 369-372, 1912.

The engineering features of these reservoirs are presented in Table 27 and in the paragraphs that follow.

TABLE 27.—*Reservoirs controlled for the generation of power at Electra.*

Reservoir.	Elevation.				Catchment area.	Maximum capacity.	Area at maximum capacity.
	Crest.	Maximum water surface.	Spillway bottom.	Outlet bottom.			
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Acres.*	*Cu. ft.*	*Acres.*
Twin Lakes	8,172	8,170	8,168	8,150	506	62,063,850	118.3
Upper Blue Lake	8,131	8,127.5	8,126	8,100	1,728	293,859,766	343.5
Lower Blue Lake	8,040	8,035	8,037	8,000	2,963	163,000,000	145
Meadow Lake	7,773.5	7,770.5	7,768.5	7,719.3	3,514	244,500,000	141.2
Bear River	5,680	5,677.5	5,675.0	5,620	17,920	267,054,300	161.5
Tabeaud	1,965	1,961	1,958	1,890	1,280	50,425,000	39.7
Petty	2,163	2,161	2,160	2,152.4	2	540,000	1.9

Reservoir.	Dam.						Spillway.		
	Maximum height.	Length of crest.	Width of crest.	Maximum width of base.	Inner slope.	Outer slope.	Width.	Depth.	Length.
	Feet.	*Feet.*	*Feet.*	*Feet.*			*Feet.*	*Feet.*	*Feet.*
Twin Lakes	22	1,552	a 33 b 14	a 43 b 71	a ½:1 b 3:1	a ½:1 b 2:1	6	4	....
Upper Blue Lake	31	790	25	74	2:1	a ½:1 b 2:1	26	5	....
Lower Blue Lake	48	1,050	25	97	2:1 ½:1	½:1	49	3	....
Meadow Lake	73.5	775	12	103	½:1 ¾:1	½:1 1:1 ½:1	46	5	....
Bear River	80	748	13	133	½:1 ¾:1	¾:1 ¾:1 1:1	90.7	5	....
Tabeaud	120	636	c 35 d 20	620	2½:1 3:1	2½:1	36	10	300
Petty	10	....	....	....	....	....	....	....	....

a Rock wall. b Earth fill. c Ends. d Crown.

Twin Lakes.—Twin Lakes reservoir on a branch of Mokelumne River, in sec. 25, T. 9 N., R. 18 E., and sec. 30, T. 9 N., R. 19 E., Alpine County, impounds run-off from its small catchment area and from the upper end of Meadow Lake drainage basin by means of a canal at the north end of the dam. The dam is made of earth fill with rock retaining wall on both faces near the south end and inner face riprapped. Outlet is provided by two 16-inch riveted iron pipes, in the lower end of which 16-inch Ludlow gate valves are set to control the flow. The spillway, which is in the upper end of the reservoir, is built of wood.

Overflow from the reservoir is carried by ditch through a saddle to a ravine below Lower Blue Lake. Discharge from the outlet pipes runs down a natural watercourse to Meadow Lake.

Work on the dam was begun in 1885 and completed in 1898; it then had an open box near its middle point and the height of water in the reservoir was controlled by stop planks. The box was removed and outlet pipes were substituted in 1899. The inner face of the dam was riprapped in 1904.

Upper Blue Lake.—Upper Blue Lake is on Blue Creek, Alpine County, in secs. 12 and 13, T. 9 N., R. 18 E., and sec. 18, T. 9 N., R. 19 E. The dam is an earth-fill structure with rock retaining walls in the center of the downstream face and inner slope riprapped to within 2 feet of the crest. A concrete spillway, with rails for stop-plank supports, is provided at the north end of the dam. Flow is controlled by two 18-inch gate valves set at the lower end of two 18-inch pipes through the base of the dam. Water from this reservoir passes through the natural channel to Lower Blue Lake.

The dam was begun in 1872 and completed about 1881. The two outlet pipes were substituted for the original open-box outlet in 1899, and the height of the dam was increased 10 feet. Reconstruction was completed in 1901.

Lower Blue Lake.—The dam at Lower Blue Lake is earth fill with dry rubble on both faces, with a core wall of placed rock on the center line of the dam. The spillway is a cut in rock at the east end of the dam. Two 30-inch steel pipes, incased in 12-inch concrete, with cut-off walls of concrete, form the outlet. Flow is controlled by two 30-inch gate valves at lower end.

The lake is in secs. 19 and 30, T. 9 N., R. 19 E. It receives water from Upper Blue Lake and discharges through Deer Creek into Mokelumne River, from which water is picked up by Upper and Lower Standard ditches and conveyed to Electra.

The original dam was built in 1874 of logs and earth. In 1881 a dam 28 feet high was constructed having a retaining wall of logs and filled earth. In 1899 the dam was raised 12 feet, and the retaining wall of logs was removed. A part of the dam was washed downstream July 3, 1901, as the result of a leak. The work of repair was completed in November, 1903.

Meadow Lake.—Meadow Lake, in secs. 26 and 27, T. 9 N., R. 18 E., receives run-off from its catchment area above and discharge from Twin Lakes, and discharges by natural course into Mokelumne River. (See Bear River reservoir, below.) The dam is of loose rock fill with uncoursed dry-rubble faces, and the inner slope is faced with timber. The spillway is of concrete in solid rock and is 8 feet from the south end of the dam. The outlet is through two 30-inch pipes, and the flow is controlled by two 30-inch Ludlow gate valves at the lower end. The old dam, which was 400 feet above the present dam, was built in 1885. The present dam (see Pl. XXIX, *C*) was begun in 1899 and completed July 4, 1903.

Bear River reservoir.—The Bear River reservoir, on Bear River, Amador County, in secs. 4 and 9, T. 8 N., R. 16 E., is formed by a rock-fill dam faced with timber on the inner slope and provided with a spillway cut in solid rock (concrete lip) 20 feet from the end of the dam. Outlet consists of three 16-inch cast-iron pipes through the concrete bulkhead at upper end of a 7 by 7 foot tunnel in solid rock under dam. Flow is controlled by a 16-inch Ludlow gate valve at lower end of each pipe in the tunnel. From this reservoir water flows into Bear River and down natural channels to Mokelumne River, where it unites with natural run-off and stored water drawn from Blue, Twin, or Meadow Lake and is conveyed to Electra power house by Upper and Lower Standard canals. The dam was begun in 1899 and finished in 1900. In years of excessive run-off the dam has been overtopped without damage, but there has been no overflow since 1906, when the spillway was enlarged to 92 feet.

Tabeaud forebay.—The Tabeaud forebay reservoir is on a small tributary of the South Fork of Jackson Creek, in Amador County, in sec. 28, T. 6 N., R. 12 E. The inner slope of the earth-fill dam is riprapped. The spillway, which is in the saddle north of the dam, is a 48-foot cut in the rim of the reservoir, with concrete floor and walls at the inner end of the cut. The outlet is provided by a tunnel, 40 square feet in cross-section and 2,903 feet long, cut through a ridge of slate and terminating at the south end in a 60-inch riveted steel pipe 175 feet long to a receiver. The steel pipe is connected to the tunnel by a water-tight brick and concrete masonry wall.

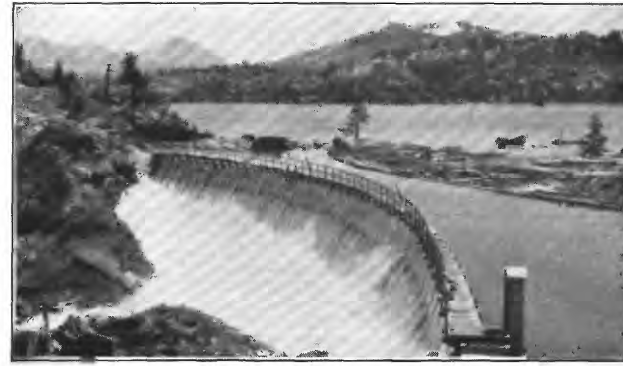
Tabeaud reservoir (Pl. XXVIII, *C*) impounds water brought from Mokelumne River by Upper and Lower Standard canals and discharges into a manifold at the head of the pipe lines to Electra power house. It is used as a regulator for peak loads when the canal service is interrupted. The dam was begun in March, 1900, was finished December 14, 1901, and contains 370,350 cubic yards of material.

Petty forebay.—The Petty forebay reservoir (Pl. XXVIII, *C, D*) is in sec. 28, T. 6 N., R. 12 E., and is formed by an earth embankment that extends almost around the reservoir. The spillway is on the north side. Flow is controlled by two main gates and by four auxiliary wood-slide gates about 14 feet above the main gates. Water flows through the main gates into the penstock intake and thence through a wood-stave pipe and steel pipe to a manifold at the head of the pressure pipes leading to the power house. The reservoir is used as a regulator for Electra power house during peak loads or when the canal service is interrupted. The Upper Standard canal flume runs the entire length of the forebay and is anchored to its bottom, which is covered with 4 inches of concrete to prevent loss of water by seepage.

CONDUITS.

Upper and Lower Standard canals.—Electra receives its supply through two ditches which are known officially as the Upper and

A. HAT CREEK POWER HOUSE NO. 1.



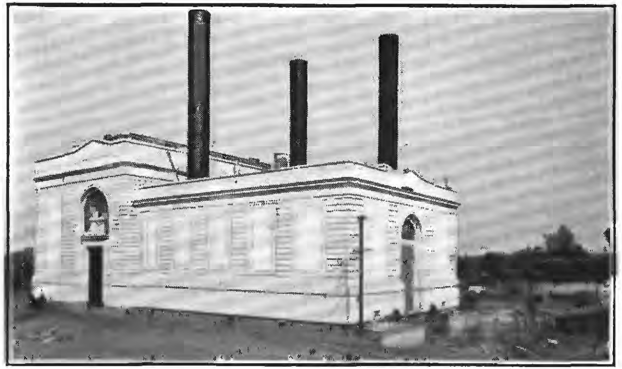
B. SPILLWAY CREST OF AUXILIARY DAM, LAKE SPAULDING.

C. TABEAUD AND PETTY RESERVOIRS.

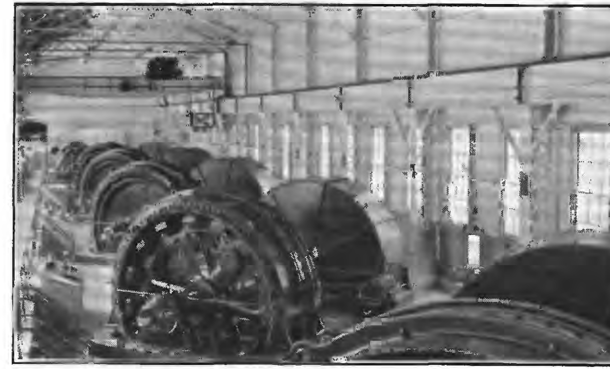
D. LOWER END OF CONDUIT LINES, ELECTRA PLANT.

HYDROELECTRIC SYSTEM OF PACIFIC GAS & ELECTRIC CO.

Photographs *A* and *B* by the company.



A. STEAM STATION B, SACRAMENTO.



B. GENERATOR ROOM, ELECTRA POWER HOUSE.

C. MEADOW LAKE DAM, ELECTRA SYSTEM.

D. ELECTRA POWER HOUSE.

ELECTRIC SYSTEM OF PACIFIC GAS & ELECTRIC CO.

Photographs *A*, *C*, and *D* by the company.

Lower Standard canals, though locally the lower canal is often referred to as the Amador ditch. The ditches follow a parallel course along the northwest side of Mokelumne River canyon, one about 160 feet above the other.

The Upper Standard canal takes water from Mokelumne River in Amador County, at a concrete dam 10 feet high and 134 feet along the crest, half a mile above the mouth of Tiger Creek and 2 miles above the head dam of Lower Standard canal, and carries it to Petty forebay reservoir, traversing secs. 23, 24, 26, 27, 28, 32, 33, and 34 of T. 7 N., R. 13 E.; secs. 5 and 6, T. 6 N., R. 13 E.; and secs. 1, 2, 11, 12, 14, 22, 23, 27, and 28, T. 6 N., R. 12 E. The canal is 19.28 miles (101,817 feet) long, of which 76,624 feet is ditch, 13 feet wide on top, 7 feet wide on bottom, and 4 feet deep; 24,159 feet is flume 7 feet wide by 4½ feet deep; and 1,034 feet is tunnel. The average grade is 1.5 feet per thousand, or 8 feet per mile, in the ditch, and 2.5 feet per thousand, or 13 feet per mile, in the flume. Petty reservoir, into which the waters of the upper ditch are discharged, serves as a forebay for the high-head pressure pipe at Electra.[36]

Lower Standard canal diverts water from Mokelumne River 1 mile below the mouth of Mill Creek and 2 miles below Upper Standard head dam in sec. 26, T. 7 N., R. 13 E., traverses the same sections (except secs. 23 and 24 of T. 7 N., R. 13 E.) as the Upper Standard and ends in sec. 28, T. 6 N., R. 12 E. This canal is 93,840 feet long; 69,193 feet is ditch, 13 feet wide on top, 7 feet on bottom, and 4 feet deep; 23,989 feet is flume either 7 feet wide by 4 feet deep or 6 feet wide by 3 feet deep; and 658 feet is tunnel. Its grade is 1.5 feet per thousand, or 8 feet per mile, in the ditch, and 2.5 feet per thousand, or 13 feet per mile, in the flume. Its capacity is 75 second-feet.

The lower ditch follows around the hill (Pl. XXVIII, *D*) below Petty reservoir, passes through a tunnel west of it, and is continued toward the town of Jackson by what is properly known as Amador ditch. After emerging from the tunnel the conduit passes around the upper end of Tabeaud reservoir (Pl. XXVIII, *C*), which furnishes the storage and forebay capacity for the low-head pipe line to Electra. A turnout is provided in the ditch at this point so that any part or all of its flow can be emptied into Tabeaud. Surplus waters from Petty forebay may also be discharged down a gully into Tabeaud reservoir and thus saved.

Pressure system.—From the Petty reservoir a single line, consisting of 2,766 feet of 48-inch wood-stave pipe and 521 feet of 48-inch riveted steel pipe, leads to a manifold at the head of the main pressure drop. The manifold is a horizontal header cut into two divisions (one

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[36] It is interesting to note that if the flow in a ditch system of this length is made to follow the natural daily fluctuations in power, the large supply needed at the power house about 6.30 p. m. must be turned in to the head of the ditch at 10.30 a. m.

long and one short) by a large horizontal gate valve. Water is brought to the same point from Tabeaud reservoir through a tunnel, 2,903 feet long, to which it is admitted through an open cut about 350 feet long. Back from the lower portal of the tunnel 153 feet is a bulkhead through which a lap-riveted 60-inch steel pipe is run to the main pressure system. There is no pipe in the tunnel above this point, the waters of the reservoir having free access. The section of the tunnel is 6 feet wide by 6 feet high to the spring line of the semicircular arched roof. Silt passing from the tunnel into the pipe is caught in a trap, and may be discharged through a sluice pipe leading into a small canyon.

Near the manifold at the head of the main drop there is a Y in the 60-inch line from Tabeaud tunnel. Each of the branches of the Y is 35 feet long, one is 30 inches and the other is 42 inches in diameter, and both are provided with gate valves. The 30-inch branch runs to the long division of the manifold receiver. The other runs through the short division of the receiver and connects with the No. 3 pressure main, consisting of 1,852 feet of 40-inch and 1,719 feet of 36-inch riveted pipe leading to the power house.

As a rule this line from Tabeaud is used to pass the water directly through the small division of the manifold, the connection with the main section of the manifold being usually shut off, as is the gate valve dividing the manifold. There is a gate valve on the line leading from Petty forebay reservoir to the manifold and one in each of the two lines leading from the main part of the manifold to the plant. Each of these two lines consists of 764 feet of 30-inch cast-iron pipe and 2,514 feet of riveted steel pipe. The power house is therefore served from the manifold by two lines 3,278 feet long under 1,466 feet head and by a single separate line 3,571 feet long under 1,266 feet head. The difference in length is caused by the lines diverging at a point part way to the power house and taking separate routes. The pressure pipes are buried throughout their length except where Nos. 1 and 2 cross a slip in the hillside and No. 3 crosses a gulch on a trestle. (See Pl. XXIX, *D*.) Where the first pipe lines pass the shifting ground they are covered by a long shed roof, in order to prevent rain water from loosening the unstable soil.

At the power house lines Nos. 1 and 2, operating on the high head, bend along the back wall; the No. 1 line extends as far as the No. 6 unit; the No. 2 parallels the No. 1 line and joins it between the third and fourth units.

All the branches are taken from the No. 1 line either before or after it is joined by No. 2. A single branch from the end of No. 1 line serves the wheel at one end of the No. 6 unit; the wheel at the other end can be served from the No. 3 pipe line under the head of 1,266 instead of 1,466 feet. The No. 3 line runs directly to a point behind the back wall of the power house and then branches through a Y. One branch runs to the No. 6 and the other to the No. 7 unit. In each of these branches there is a gate valve within the power-house wall.

The normal elevation of the water surface in Tabeaud reservoir is 1,961 feet; that in Petty reservoir 2,161 feet, and that of the nozzles at the power house 695 feet, giving a fall of 1,466 feet from the Petty and 1,266 feet from Tabeaud reservoir.

GENERATING STATION.

Power house.—Electra power house (see Pl. XXIX, *D*) is noticeable at first view for its extreme length. The site was such that a very long power house could be built cheaply, whereas a deeper one would have necessitated considerable heavy excavation. The transformer room, therefore, instead of being back of the generator room is simply a longitudinal extension of it. The building measures, in floor plan, 40 feet wide by 275 feet long. The frame is steel, the covering and roof are corrugated galvanized iron, and the building is set on concrete foundations. There is a Louvre ventilator along the full length of the crest of the roof. An electric crane is carried on a plate girder runway, supported on latticed columns.

Each of the first five units (Pl. XXIX, *B*) was of 2,000-kilovolt-ampere capacity and was set with its shaft at an angle of 45° to the main axis of the generator room. Later an addition was made at the lower end of the building and two 5,000-kilovolt-ampere units were put in, with their shafts parallel to the long axis of the room.

Along the river side of the room is a low balcony runway from which the generator floor may be reached by a short flight of steps opposite each of the old machines. Opposite each of the 2,000-kilovolt-ampere generators is an oil switch set in a marble casing, and on the runway, at the center of the room, is the switchboard, with the rheostats above it. The switches and transformers for the two 5,000-kilovolt-ampere units are in an open pit back of the machines. The other transformers are in the main transformer room, which is a continuation of the generator room but has a floor level half a story higher. The exciter equipment is in a bay on the river side of the building at the point where the steps lead from the generator up into the transformer room.

Hydraulic equipment.—The five 2,000-kilovolt-ampere machines are identical in design. Each is run by a double rotor Pelton wheel, rated at 3,000 horsepower, with both rotors in the same housing. Each rotor is 11 feet 6½ inches in diameter on the pitch line, 12 feet 4 inches on the tip line, carries 30 buckets, and receives its supply from a single plain deflecting nozzle of 2½-inch bore. The deflecting mechanism is regulated by a Lombard governor, type F.

The sixth generator (the first 5,000-kilovolt-ampere unit) is run by two 70-inch 7,500-horsepower overhung Doble wheels, one equipped with a single deflecting needle nozzle with needle regulated by hand, the other provided with a similar nozzle with needle controlled by motor. One of the wheels is under a 1,466-foot head with a 7½-inch nozzle and the other under a 1,266-foot head with an 8⅝-inch nozzle.

The seventh unit is operated by a single 68-inch 7,500-horsepower overhung wheel, which carries 18 buckets 26½ inches wide by 19 inches long, constructed after design drawn up by the late W. R. Eckart, consulting engineer for the company. The wheel is served through a single deflecting needle nozzle connected to the 1,266-foot head. The position of the needle is regulated by hand.

Both of these 5,000-kilovolt-ampere units are governed by Lombard governors, type Q, acting on their nozzle-deflecting mechanisms. Oil under pressure for the governors is supplied from two small triplex pumps placed between the fifth and sixth generators. The pumps can be driven either by a small impulse wheel or by a General Electric 10-horsepower induction motor.

Generators.—Each of the 2,000-kilovolt-ampere machines is a Stanley SKC inductor generator, giving 3-phase 60-cycle alternating current at 2,200 volts when operating at 240 revolutions per minute; both of the 5,000-kilovolt-ampere generators are Stanley revolving field 3-phase 60-cycle machines, giving 2,400 volts and operating at 400 revolutions per minute. Ordinary ring lubrication is used on the first five, and ring lubrication with water-cooled bearings on the sixth and seventh machines. The installed capacity of the plant is 20,000 kilovolt-amperes (26,800 horsepower).

Exciters.—The five 2,000-kilovolt-ampere units are served by two exciter sets, each containing a Crocker-Wheeler 50-kilowatt 70-volt 715-ampere continuous-current generator, operated at 600 revolutions per minute by a Doble impulse wheel. One of these sets is converted into a motor generator by the addition of a General Electric 100 horsepower 2,060-volt 27-ampere induction motor on the same shaft. The two 5,000-kilovolt-ampere units are excited by a motor generator consisting of a Stanley continuous-current 105-kilowatt 1,500-ampere 70-volt generator, type CL, driven at 720 revolutions per minute, either by a Doble wheel or by a Stanley alternating-current 150-horsepower 3-phase 60-cycle 2,080-volt 40-ampere induction motor, type I.

Near the exciters is a Crocker-Wheeler 65-kilowatt 250-volt 260-ampere continuous-current generator, type CCD, which is operated at 625 revolutions per minute and furnishes power for the crane motor.

Transformers.—The station is equipped with five main banks of transformers. Three of these consist of Stanley shell-type 1,100-kilowatt single-phase transformers, two connected delta on the low and Y on the high tension side and one connected delta on both high and low tension sides; the fourth and fifth banks are Stanley shell-type single-phase transformers, having a capacity of 1,250 kilowatts each. These also are connected delta on the low and Y on the high tension side. One bank of the 1,100-kilowatt transformers is connected to the three circuits running to the mines along the Mother Lode. The rest of the equipment is connected to the 60,000-volt line running to the San Francisco Bay district. All the equipment is water cooled.

Wiring.—Double low-tension busses extend in a tunnel under the main floor of the plant from unit 1 to unit 5, and a single bus from there on to connect with units 6 and 7. Opposite each of the first five units there is a double-throw 3-pole Stanley SKC switch, in a marble case, to connect the generator with either of the double busses. No. 1 bus is continuous and No. 2 is sectionized at three places, so that the first five, the sixth, and the sixth and seventh generators may be isolated.

The low-tension busses connect to transformers through oil switches, and the transformers to the high-tension busses through disconnecting and oil-tub switches, except on the 17,000-volt lines, where the connection to the high-tension bus is direct.

All lightning arresters have been removed from this plant.

DE SABLA PLANT.

LOCATION.

De Sabla power house is on a bench blasted out of the west side of Butte Creek canyon in sec. 10, T. 23 N., R. 3 E. The installation at De Sabla was made in three steps. The first pipe line and two 2,000-kilovolt-ampere units were put in by the Valley Counties Power Co., when the plant began operation on October 10, 1903; the second pipe and the 4,000-kilovolt-ampere generator were installed by California Gas & Electric Corporation August 5, 1904; and the 5,000-kilovolt-ampere unit was put in by Pacific Gas & Electric Co. June 26, 1906.

SOURCE OF WATER SUPPLY.

The De Sabla and Centerville plants are operated with water derived from the branches of Butte Creek and from the West Branch of Feather River. The parts of the basins utilized embrace about 230 square miles lying entirely in Butte County, about 16 miles northeast of Chico and 150 miles northeast of San Francisco, above the intake of Butte Creek canal on Butte Creek and Hendricks canal on West Branch, and include the broad ridge between the two streams, the run-off from which is intercepted by the two canals in their course to the De Sabla forebay. The intake of the lower Centerville canal is just below De Sabla power house, and that of the upper Centerville canal is just below De Sabla forebay (see p. 205). In width, east and west, the combined basins of Butte Creek and West Branch of Feather River measure 12 miles; and the distance from the De Sabla forebay to the upper end of the basin is 23 miles.

The shape and size of the basin are shown on Plate XXX (in pocket). The general course of the two streams is almost due south.

Elevations within the basins range from 1,000 feet at the Lower Centerville intake, 3,209 feet at the intake at the Hendricks canal, and 2,857 feet at the intake of Butte canal, to 7,000 feet on isolated points of the northwest boundary of the West Branch basin. In these upper regions ridges that rise to 6,650 feet are common, but on the west boundary of the Butte Creek basin altitudes decrease rapidly to 3,000 or 4,000 feet. The ridges on the east and west sides of Butte Creek canyon, opposite the Centerville intake, do not greatly exceed 2,500 feet in elevation.

The upper parts of the basins consist of rolling mountain ridges between stream courses which in general parallel each other. The canyons are deep and their walls are precipitous. Farther south the ridges flatten, and in the sections between De Sabla reservoir and the Centerville power house they form the tablelands and flat-topped buttes that give the name to the county as well as to the stream on which the plant is established.[37]

The rocks over much of the region are volcanic, and the characteristic topography of the country is due to the work of the streams in cutting through the cap of lava that extends over wide areas. In these volcanic formations is stored the water for the many springs in the upper basin that regulate the stream flow of the region. Shales and andesites, more or less decomposed, are also abundant in large areas in the drainage basin.

North of De Sabla the country is heavily wooded and lumbering is carried on as extensively as in any other part of California—especially along the canyon of the West Branch of Feather River near the intake of Hendricks ditch. South of De Sabla the trees are more scattering or the region has been cut over.

The records of precipitation obtained at several stations in the basins of Butte Creek and the West Branch of Feather River are rather short, but all show a very high mean rainfall, the lowest slightly exceeding 60 inches, and the highest (near Inskip) nearly

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[37] The view from a point near De Sabla forebay down Butte Creek canyon, including the long sweep of the canyon with its steep sides rising in successive wooded terraces to the basaltic cliffs that rim the flat-topped ridges, forms a picture long to be remembered as among the most beautiful seen by the writer in the course of a trip that was made to collect data for this report and that extended over many of the river basins of California.

reaching 90 inches. With better storage facilities these basins, although relatively small, would furnish a very high regulated flow.

No stream-flow measurements for Butte Creek and West Branch of Feather River have been published,[38] although Pacific Gas & Electric Co. has made systematic measurements at its intakes.

RESERVOIRS.

The only storage for the De Sabla plant (and for the Centerville plant below it) is provided in the De Sabla and Round Valley reservoirs. When there is surplus water at De Sabla reservoir, it can be turned directly into the head of the Upper Centerville canal.

Round Valley reservoir is on the West Branch of Feather River, in Butte County in sec. 30, T. 26 N., R. 5 E., and impounds water from the catchment area above. Below the reservoir the water is taken by the Miners, Dewey, or Hendricks ditches and carried through a series of ditches to De Sabla power house. The Round Valley dam, which was built in 1877 by the Cherokee Mining Co., is made of earth fill, riprapped on the inner slope, and is 27 feet high, 490 feet long, about 6 feet wide on the crest and 125 feet wide at the base, and has an inner slope of 2½ : 1 and an outer slope of 2:1. The crest of the dam is 5,497 feet above sea level and the maximum elevation of the water surface 5,490 feet. Two hundred feet north of the dam is a wooden spillway in earth channel 26 feet wide, 2 feet deep, 25 feet long, and 5,490 feet above sea level at the bottom. The outlet, which is 5,471.5 feet above sea level, is an 18-inch riveted steel pipe provided at its lower end with a gate valve. The catchment area of the Round Valley reservoir is 2.25 square miles. The maximum capacity of the reservoir is 38,290,000 cubic feet, and the area at maximum capacity is 90 acres.

De Sabla reservoir, which is the forebay for De Sabla power house, is at the lower end of Butte Creek canal in the southwest quarter of sec. 2, T. 23 N., R. 3 E. An earth-fill dam, 53 feet high, 1,035 feet long, 30 feet wide on the crest, and 256 feet wide at the base, with inner slope 3½:1 and outer slope 2:1, impounds water fed by Miners, Dewey, Inskip, Hendricks, Toadtown, and Butte Creek ditches through Lower Butte Creek ditch. A wooden spillway 7 feet wide, 5 feet 4 inches deep, and 64 feet long, is provided at the east end of the dam. The outlet consists of two 43-inch riveted steel pipes incased in masonry; one branches into two 30-inch pipe lines supplying the De Sabla power house; the other terminates in a 30-inch and 16-inch Y. The 16-inch branch is used to discharge water into the upper Centerville canal, and the 30-inch pipe is dead-ended for a future line to the power house. The crest of the dam is 2,736.5

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[38] Except three miscellaneous measurements of West Branch in U. S. Geol. Survey Water-Supply Paper 298, p. 389.

feet above sea level, and the maximum elevation of the water surface 2,731.5 feet. The elevation at the bottom of the outlet is 2,695 feet and at the bottom of the spillway 2,728 feet. The maximum capacity of the reservoir is 11,500,000 cubic feet and its area at this capacity is 16.5 acres.

CONDUITS.

General relations.—The De Sabla forebay reservoir is served by an intricate system of ditches traversing the country between Butte Creek and West Branch of Feather River. The main conduits of this system are the Butte Creek and the Hendricks canals, the latter heading on the West Branch of Feather River. The Butte Creek canal runs nearly due south, and the Hendricks canal, after running south for about half its length, turns westward and zigzags across the intervening country to discharge finally into the Butte Creek canal about a mile above De Sabla reservoir. The lower 2 miles of the Hendricks ditch is sometimes known as the Toadtown canal.

The other ditches of the De Sabla system empty into the Butte or Hendricks canals either through artificial or natural watercourses. All the smaller canals head either on the West Branch of Feather River or are fed by canals that come from that stream. The location of these different conduit lines can be traced by referring to the accompanying map (Pl. XXX).

Butte Creek canal.—Butte Creek canal diverts water by a concrete-arch dam on Butte Creek in Butte County, in the NE. ¼ sec. 36, T. 25 N., R. 3 E., and traverses sec. 36, T. 25 N., R. 3 E.; secs. 1, 12, 13, 24, 23, 26, and 35, T. 24 N., R. 3 E.; and secs. 2 and 10, T. 23 N., R. 3 E. It also receives water from the Dewey, Miners, Inskip, Hendricks, and Toadtown canals below the 10½-mile post. The elevation at the head of the canal is 2,857 feet and at its end in De Sabla reservoir 2,732 feet. The Butte Creek dam is 45 feet high, 110 feet long, 4 feet thick at the crest, and 13 feet thick at the base and has a radius of 60 feet. The conduit is 61,492 feet long, of which 53,361 feet is ditch, 7,646 feet flume, and 485 feet tunnel. The flume is 6 feet wide and 4 feet deep and is supported on trestle bents spaced 8 feet on centers. The tunnel is 5.5 feet wide on top, 6.5 feet on bottom, and 5 feet high. Part of the ditch is 15 feet wide on top, 7 feet on bottom, and 5 feet deep; and the extreme lower end is 21 feet on top, 15 feet on bottom, and 7 feet deep. The average grade for the conduit is 2.67 feet per thousand to station 69, 1.85 feet from station 69 to 575, and 2.76 feet per thousand from station 575 to 611.

The canal was built in 1871 by the Cherokee Mining Co., and at that time extended down the ridge past Nimshew to Helltown Ravine, where the water was used for mining. In 1873 it was extended from Middle Butte Creek to Concow Creek, where the old

Spring Valley Mining Co. had a ditch that carried water to the mines at Cherokee. In 1902 it was purchased by Valley Counties Power Co., and in 1903 and 1904 it was enlarged to its present capacity.

The most noticeable features of the Butte ditch are the numerous dry-laid retaining walls on the outer bank. At several places the bank supported by these walls, though only 4 feet wide on top, carries water to within 6 inches of its crest without damage. As the back wall is not more than a foot thick, topping of the bank is prevented by waste over the sides of the flumes.

Hendricks canal.—Hendricks canal diverts water at a log-crib rock-filled dam on the West Branch of Feather River below Dewey and Miners canals, at an altitude of 3,209 feet above sea level. The dam is 100 feet long on the crest, is faced with plank, and has concrete piers and wing walls. The intake of the canal is in sec. 16, T. 24 N., R. 4 E., and the canal traverses secs. 16, 21, 22, 27, 34, 32, 33, 28, 29, 30, and 31, T. 24 N., R. 4 E.; secs. 3, 4, and 5, T. 23 N., R. 4 E.; and sec. 36, T. 24 N., R. 3 E. It joins Toadtown canal near the head dam of the latter through a rapid flume in sec. 36, T. 24 N., R. 3 E., at an altitude of 2,793 feet. Four miles from its head it receives water from a ravine through a 160-foot flume; 13.5 miles from the head it is fed through 96 feet of flume and 400 feet of ditch with a capacity of 30 second-feet. At Cunningham Gulch, 15½ miles from its head, it receives 20 second-feet of water through 312 feet of flume; at Little West Branch, it is fed 30 second-feet of water through 32 feet of flume and 750 feet of ditch. The canal is 103,473 feet long, and its course is irregular but in general westerly. It comprises 93,563 feet of ditch, 12 feet wide on top, 6 feet on bottom, and 4.5 feet deep, 7,806 feet of flume, and 2,104 feet of tunnel 2.7 feet wide on top, 3.75 feet on the bottom, and 5.1 feet high. The flume has a clear inside width of 6 feet, a depth of 4 feet 4½ inches, and is built of 1½ by 18-inch by 16-foot planking. The flume is supported on trestles. The average grade for the line is 2 feet per thousand, or 10.56 feet per mile. A view of the canal with plank lining on outside of the curve is given in Plate XXXI, *A* (p. 222).

The original stretch of the canal, 12.3 miles long, was built about 1871 to a ravine a mile southwest of Stirling City, where it was used for hydraulic mining. When hydraulic mining was stopped the canal was abandoned for a few years, but in the summer of 1905 it was cleaned out and extended to its present length, the extension being finished during the winter of 1905–6.

Toadtown canal.—The Toadtown canal takes out of Little Butte Creek, in Butte County, in sec. 36, T. 24 N., R. 3 E., about 3 miles southwest of Powellton and half a mile west of Lovelock at an altitude of 2,793 feet above sea level, and carries the water into

Butte Creek canal half a mile above De Sabla reservoir in sec. 2, T. 23 N., R. 3 E., at an altitude of 2,743 feet above sea level. The head dam is a wooden box 6 feet 6 inches high, 16 feet long on the crest, and 16 feet wide at the base. The lower end of the box is closed to a height of 3 feet above the bottom to back water into the ditch. The conduit is 12,822 feet long, 12,602 feet being ditch 10 feet wide on top, 5 feet wide on bottom, and 5 feet deep, and 220 feet flume 8 feet wide by 3 feet deep. The grade from the head of the conduit to station 67 is 4.048 feet per thousand, and thence to the lower end 2.931 feet per thousand.

Dewey canal.—Dewey canal diverts water at a log-crib dam 1½ miles below Round Valley reservoir, on West Branch of Feather River in Butte County, in the SW. ¼ sec. 36, T. 26 N., R. 4 E., and the conduit traverses secs. 35 and 36 of this township and secs. 2, 3, 10, 9, 16, and 21 of T. 25 N., R. 4 E. The dam is faced with 2-inch planks, is 6 feet high, and is 68 feet long on the crest. The conduit is 41,072 feet long, 41,022 feet being ditch 8.5 feet wide on top, 4 feet wide on bottom, 2.3 feet deep, and 50 feet being flume. The average grade is 3 feet per thousand, or 16 feet per mile, where there are not rapid drops. Elevation at the head of the conduit is 5,183.1 feet, and at the end 4,813.7 feet. The capacity of the canal is 20 second-feet. Its water, united with that of Miners canal, flows through Inskip canal and Long Gulch to Hendricks canal, the combined water being taken by the Toadtown canal.

The canal was built in 1858 to supply placer mines around Inskip and was bought in 1873 by the Cherokee Mining Co., which later sold it to the Valley Counties Power Co. Below its junction with Miners canal, in sec. 21, T. 25 N., R. 4 E., about a mile above Inskip, it is known as the Inskip canal.

Miners canal.—Miners canal takes out on the west side of the West Branch of Feather River, in Butte County, at the quarter corner between secs. 2 and 11, T. 25 N., R. 4 E., about a mile below the head dam of Dewey canal and 214.8 feet lower, and traverses secs. 11, 10, 15, 16 and 21 of the same township. Its general direction is southwesterly to its confluence with Dewey canal in sec. 21, T. 25 N., R. 4 E., below which it is known as the Inskip canal. The intake is merely a flume heading. The canal is 6.19 miles (32,700 feet) long, 32,099 feet being ditch 8 feet wide on top, 3 feet on the bottom, and 1.7 feet deep, and 601 feet flume 3 feet wide and 1½ feet deep. The average grade of the canal is 4.033 feet per thousand, or 21.29 feet per mile. The head of the canal is 4,948.4 feet above sea level, its end is 4,813.3 feet, and its capacity is 10 second-feet.

The canal was built in 1859 and 1860 by a league of miners who opposed the excessive rates charged by the owners of the Dewey canal. It was bought in 1873 by the Cherokee Mining Co., and sold to the Valley Counties Power Co. The old Miners canal, which extended to a point about 3 miles below Inskip, passed under a flume of the Dewey canal at the present junction. The water collected at the junction of the Dewey and Miners canals is carried on through Inskip canal and Long Gulch to Hendricks canal.

Inskip canal.—Inskip canal starts in sec. 21, T. 25 N., R. 4 E., and passes in a general southerly direction across secs. 21, 20, 28, 29, 33, and 32 of that township and secs. 5, 8, and 17 of T. 24 N., R. 4 E., to the head of Long Gulch. The water flows down Long Gulch 3.55 miles and is diverted into the Hendricks canal. The stretch of canal called the Inskip is 6.64 miles (35,044 feet) long; 30,865 feet is ditch 10 feet wide on top, 3.5 feet wide on bottom, and 3.5 feet deep; 2,759 feet is in a natural watercourse; and 1,420 feet is flume 3 feet wide, 2.5 feet deep. The elevation at the head of the canal is 4,813.3 feet and at the end it is 4,156.9 feet, but the grade is irregular. Between stations 322 and 410 the grade is 3.455 feet per thousand; from station 410 to station 425 there is a steep drop; between 425 and 528 the grade is about 6 feet per thousand; the stretch between 528 and 544 is in a ravine; the grade between 544 and 651 is 6.103 feet per thousand; from 651 to the end the grade is steep and irregular. The capacity of the canal is 30 second-feet.

When the canal was built by a league of miners in 1859 and 1860 it flowed under the Dewey canal but later, when both canals were bought by the Cherokee Mining Co., their waters were allowed to flow together.

Pipe lines.—De Sabla power house is fed from De Sabla reservoir by two 30-inch riveted steel pipes, 6,045 feet long, (6,299 feet long including pipe under the dam). At the lower side of the dam each line is fitted with a standpipe. After leaving the dam the pipes bend through a gentle curve and then run straight to the power house. Each line branches through a Y casting at the power house. The pipes are buried or carried in tunnels throughout their entire length, except at a few points where they are exposed at anchorages or on trestles. About 850 feet (in elevation) above the power house, the No. 2 line enters a tunnel inclined downward at an angle of about 35° from the horizontal.[39] The length of this inclined shaft is 1,555 feet, and from its lower end a horizontal tunnel, 250 feet long, continues to the back of the power house. The section of the tunnel is 6 feet high by 8 feet wide, and it is of ample size to give room for another pipe line if it should become desirable to install one. The pipe is of three types; the upper part is of lap-riveted steel, below which follow, in order, lap-welded steel pipe 30 inches in inside diameter with bell ends riveted, and (at the bottom) lap-welded pipe 30 inches

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[1] See Galloway, J. D., Eng., News, vol. 54, p. 131, Aug. 10, 1905.

in outside diameter, with flanged ends. The riveted pipe varies in thickness from No. 10 to nine-sixteenths inch, and the lap-welded from one-half to three-fourths inch. The bend at the junction of the horizontal and inclined tunnels is a steel casting. In the tunnels the pipe is carried on concrete supports and anchored at frequent intervals with heavy concrete blocks. Pipe line No. 2 runs directly to and serves only unit No. 3. The No. 1 line is of the same general type as No. 2 and follows a nearly parallel route to the power house. The line enters a separate tunnel at a lower point than the No. 2 line. The line runs straight to the Nos. 1 and 2 units, branching to their adjacent wheels through a Y casting within the power house. Back of the plant the line runs through a single Y casting from which a 20-inch line is run to the No. 4 wheel, and crosses the No. 2 pipe line en route. The static head obtained is 1,531 feet.

GENERATING STATION.

Power house.—De Sabla power house (Pl. XXXII, *D*, p. 222), rests upon foundations of concrete and rock and has a steel frame and galvanized corrugated-iron covering. A Louvre ventilator runs along the peak of the roof. The power house is 109 feet long along the stream, by 50 to 57 feet deep. The generator room (see Pl. XXXI, *C*) is 109 feet long by 36 feet wide between the columns supporting the crane runways. The height from the floor to the bottom of the crane is 18 feet 6 inches and to the lower chord of the roof truss 28 feet. The exciter bay, over the stream, is 6 feet 8 inches in clear width and covers the central third of the front of the power house. The transformer bay and switching gallery, at the back of the building, measures 109 feet by 10 feet 6 inches. The total width of the power house at the exciter bay is 57 feet. An addition to the power house, 36 by 50 feet, is used for a machine shop.

The generators are arranged along the main axis of the building, parallel to the creek; the exciters are in the bay that extends out from the discharge or stream side of the power house. On the opposite side of the generators, along the back wall of the building, are the sets of transformers, and above them, in a gallery extending the full length of the station, are the busses and oil-switching apparatus. The switchboard is on the main floor, just in front of the center of the transformer space, facing out into the generator room. Above it, in the central part of the switch gallery are the rheostats. There is a concrete retaining wall back of the building and above this are the pole-top disconnecting switches and horn-gap lightning arresters.

Hydraulic equipment.—The No. 1 pipe line enters the back of the station, passes through a gate valve, and then branches to the water wheels of units Nos. 1 and 2. By a 20-inch branch from outside the wall it also supplies unit No. 4. No. 2 pipe supplies unit No. 3 only. The branches to units Nos. 1 and 2 contain hydraulically operated 14-inch gates, and those to units Nos. 3 and 4, motor-driven gates. Each branch serves a single wheel through a deflecting needle-nozzle. The diameter of wheel for units Nos. 1 and 2 is 12 feet 5 inches, the rating 3,000 horsepower, and the bore of nozzle 5¾ inches; the diameter of wheel for unit No. 3 is 8 feet 5½ inches, the rating 7,500 horsepower, the number of buckets 18, and the bore of nozzle 7¾ inches; the diameter of wheel for unit No. 4 is 8 feet 4 inches, the rating 7,500 horsepower, the number of buckets 18, and the bore of nozzle 7¾ inches. A 6-inch branch from the main pipe line runs the exciters. The first, second, and fourth units are operated by Doble wheels, and the third by a wheel designed by the late W. R. Eckart, consulting engineer for the company. This special wheel operates the 4,000-kilovolt-ampere machine (Pl. XXXI, *C*). The two 2,000-kilovolt-ampere units are governed by Lombard type B and the 4,000 and 5,000 kilovolt-ampere units by Lombard type Q hydraulic governors, which act on the deflecting mechanism; the needles are regulated by hand.

Generators.—Generators Nos. 1 and 2 are Stanley inductor machines, of 2,000-kilovolt-ampere capacity,[40] each giving 3-phase 60-cycle alternating current at 2,400 volts potential and operating at 240 revolutions per minute. The 4,000-kilovolt-ampere [41] and 5,000-kilovolt-ampere [42] units are of the Stanley revolving-field type, giving the same frequency phase and voltage but operating at 400 revolutions per minute. All the units are run by single overhung wheels. The installed capacity of the plant is 13,000 kilovolt-amperes (17,420 horsepower). The bearings are water-cooled and are lubricated by oil under pressure. When running on peak load the two 2,000-kilovolt-ampere units together are reported to have turned out as high as 6,900 kilowatts, and the 4,000-kilovolt-ampere unit 5,800 kilowatts.

Exciters.—The two exciters are General Electric 4-pole 45-kilowatt direct-current generators, giving 60 volts, 750 amperes, at 720 revolutions per minute. They are driven by impulse wheels.

Transformers.—There are 12 transformers of the Stanley shell type, with a ratio of 2,400 to 60,000 volts, arranged in four banks of three. Each unit has its own bank of transformers. The banks for units Nos. 1, 2, and 3 contain three 840-kilowatt and those for unit No. 4 three 1,500-kilowatt single-phase transformers.

Wiring.—The wiring system of the De Sabla power house differs from that of the Electra and Colgate plants in that there is no low-

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[40] Put in operation Oct. 10, 1903. [41] Put in operation Aug. 5, 1904. [42] Put in operation June 26, 1906.

tension bus. Each generator is connected to its own bank of transformers, and a single-panel generator switchboard is placed on this circuit. The leads run from the generator directly toward the back wall of the building, and to the transformer, through two oil-switches,[43] and the high-tension lead thence passes directly up through the floor in the front part of the switch gallery to a high-tension disconnecting switch, thence back to a four-break oil switch, of the Baum tub type, and thence to the high-tension bus. The three-phase high-tension bus bar extends the full length of the station. The phases are carried in three tile compartments, each 2 feet square, placed one above the other against the back wall of the switching and bus gallery. Each conductor from the high-tension busses passes through a 6-inch aperture in the center of a 36-inch square, double-glazed outlet. The oil switches are operated by a system of levers placed just in front of the switchboard on the main floor, below the center of the switch gallery. The disconnecting switches are operated by wooden handles which are carried down through the floor of the switch gallery to the main floor just in front of the transformers. The disconnecting switches for the three phases of each circuit are so connected that they are operated by a single handle. Outside the building the outgoing lines run to the pole frame above the retaining wall and thence to the main line.

Protection against lightning is furnished solely by horn gaps mounted upon the pole-top frame back of the power house.

CENTERVILLE PLANT.

LOCATION.

The site of the present Centerville plant has been used since 1898 when a small plant was constructed by the Butte County Electric Power & Lighting Co. When the plant was acquired by the Valley Counties Power Co. it contained two 400-kilovolt-ampere units, to which there was immediately added a 900-kilovolt-ampere unit. In 1906 and 1907 the two small units were replaced by a single 5,300-kilovolt-ampere generator. The power house is on the west side of Butte Creek, in sec. 5, T. 22 N., R. 3 E., below the De Sabla plant.

SOURCE OF WATER SUPPLY.

The Centerville plant is operated with water derived from the same drainage basin that supplies the De Sabla plant and receives benefit of the same storage. (See pp. 205–206.) The additional drainage area that is tributary to the Centerville plant and not to De Sabla is very small. It consists chiefly of the basin of Butte Creek and its

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[43] A tap is taken off between these two switches and runs to a paralleling oil switch connecting in a similar way to the leads from the next unit. There are, therefore, three low-tension paralleling switches.

branches below De Sabla power house. The run-off intercepted by Upper Centerville ditch in its course along the ridge on the west side of Butte Creek is negligible.

CONDUITS.

General relations.—The main supply for the Centerville plant is diverted from Butte Creek, a quarter of a mile below De Sabla power house. The diversion dam is a cyclopean concrete-arch structure. At the head of the canal are two heavy wooden gates, operated by hand winches. Just below the dam is a short section of concrete flume, and in this, 100 feet from the head, there is a sand trap. The trap is formed by dropping the flume floor very rapidly from the head of the canal to the side gate at the lower end of the trap, where the bottom of the canal is 4 feet below grade, and then raising the bottom grade almost vertically to the normal bottom level of the conduit. The back wall of the sand trap, or pocket, thus formed below normal conduit depth is curved to meet the outer wall of the flume at the downstream edge of the gate. This curve causes the velocity of the water to scour out collected sediment when the gates are opened.

Below the sand trap the water flows through the main Centerville canal, which follows the west side of Butte Creek canyon. An additional supply may be delivered to the system through the upper Centerville canal which extends along the crest of the mesa from De Sabla forebay to a point about a mile above Centerville forebay. Here its contents may be emptied into a natural watercourse and find their way into the main Centerville canal below. Water may also be wasted out of De Sabla reservoir, through Middle Butte Creek, into the head of Hupp canal, which lies above the lower part of upper Centerville canal, and thence flow through natural courses in turn to upper Centerville and main Centerville canals. The ditch systems below De Sabla and above Centerville power houses are shown on the map forming Plate XXX (in pocket).

Upper Centerville canal.—Upper Centerville canal receives water from De Sabla reservoir by two pipes and by a spillway flume. The intake is in secs. 2 and 11, T. 23 N., R. 3 E., and the general course of the canal is southward across secs. 11, 14, 23, 22, 27, and 34 about 4.9 miles (25,700 feet, not including natural watercourses) to Helltown Ravine in sec. 34, by which its water is carried westward to the Centerville canal in sec. 33. The altitude of the intake is 2,687 feet; where it spills into Helltown Ravine it is 2,246.80 feet. The length of the natural course in Slaughterhouse Ravine is 2,200 feet; 25,582 feet is ditch and 118 feet is flume. One section of the ditch is 9 feet wide on top, 5.3 feet on the bottom, and 4 feet deep. The second section is 8.5 feet on top, 4 feet on the bottom, and 4 feet deep, and the third (in channel) is 18.5 feet on the top, 10 feet on the bottom, and 6 feet deep. For the first 9,100 feet from the intake the grade is 3.846 feet per thousand or 21.31 feet per mile; at Slaughterhouse Ravine about 60 feet per mile. The capacity of the canal is 55 second-feet. In Helltown Ravine the water carried by this canal and that in Hupp canal is dropped into Centerville canal proper.

The Upper Centerville canal is a part of the old Cherokee ditch from De Sabla reservoir to Helltown Ravine, which was built in 1871, bought by the Valley Counties Power Co. in 1902, and enlarged to its present capacity in 1903–4.

Centerville canal.—The head dam for the Centerville canal is on Butte Creek just below De Sabla power house, in Butte County, in sec. 10, T. 23 N., R. 3 E. The course of the canal is almost due south across secs. 10, 15, 16, 21, 28, and 33 of the same township to the Centerville forebay in sec. 4, T. 22 N., R. 3 E. The dam is cyclopean, concrete, and is of the ogee type, 90 feet long, 12 feet high, 3 feet wide on the crest, and 11½ feet thick through the base. The total length of the conduit is 43,886 feet (8.3 miles), of which 35,105 feet is ditch 4 feet 8 inches deep and 9 to 11 feet wide on the bottom and 12 to 13.5 feet wide on the top, 8,652 feet is flume, 7 feet 6 inches wide by 5 feet deep, and 129 feet is tunnel 11.3 feet wide and 7 feet high to crown of arch. The flume is in 53 sections. The elevation at the head dam is 1,115 feet and at the forebay is 1,056 feet. The average grade from station 0 to 19 is 2.63 feet per 1,000; from station 19 to end the grade is 1.28 feet per 1,000. The canal has two small feeders, and about 1½ miles above Centerville it receives the water of Hupp and Upper Centerville canals through Helltown Ravine.

The water right was taken up and a small piece of ditch dug by Yokum in 1875. In 1876 it was sold to Moss, Sheppard, Ballard, and Bothin, and in 1876 and 1877 3 miles of ditch was dug. In 1880 it was extended to Helltown Ravine, and in 1885 to the present forebay, where the water was used for hydraulic mining. The lower end of the canal was enlarged in 1900 by Butte County Electric Power & Lighting Co. and the canal was enlarged to its present size in 1905–1907 by California Gas & Electric Co.

The original Centerville canal was an old mining ditch with a grade of 1.28 feet per thousand (except for 2,000 feet at head in which the grade was 2.6 feet per thousand) and a capacity of 45 second-feet. When reconstructed the capacity was increased to 175 second-feet above and 192 second-feet below Helltown Ravine, with same grades. The most noteworthy points of the reconstructed canal are the excellent dry-laid rock retaining walls (Pl. XXXI, *B*) and the dry-laid warped approaches to the numerous flumes along its course. The material for the flumes was floated down from a supply camp at the head of the ditch before the reconstruction was begun, so that it was possible to carry on construction of both ditch and flume at the same time and still retain the advantage of the easy mode of transporting the timbers.

The material used in the flume box is 1½-inch sugar pine planking. All the timbering and trestle bents are spruce, and the footing blocks for the trestle are cedar. The box is built in sections 16 feet long, is 7 feet 8 inches wide, and water is carried to a depth of 4 feet 8 inches. Timber sand traps are placed along the line at intervals of about three-quarters of a mile.

Hupp canal.—Water from Middle Butte Creek is taken by Hupp canal in sec. 23, T. 23 N., R. 3 E., crosses secs. 23, 26, 27, and 34 of the same township, and discharges into Helltown Ravine in sec. 34, whence it is taken up with the water of Upper Centerville by Centerville canal. The ditch has a small feeder at Slaughterhouse Ravine, about 1¼ miles below the head dam. No water flows in Middle Butte Creek or Slaughterhouse Ravine during the summer, and the canal is used only in the winter. The total length of the conduit is 21,000 feet (4 miles), of which 20,574 feet is ditch 6½ feet wide on top, 2½ to 3½ feet wide at the bottom, and 2½ feet deep, and 426 feet is flume, 2 feet wide and 2 feet deep. The elevation at the head is 2,304.23 feet, and at the spill 2,234.83 feet. The grade is irregular, being 1.913 feet per thousand from stations 0 to 69, a very rapid drop from 69 to 72, 1.627 feet per thousand from 72 to 190, 3.66 feet per thousand from 190 to 205, and very rapid from 205 to the end. The canal was built about 1859 by a Capt. Haines for use in hydraulic mining along Helltown Ravine. Between 1864 and 1871, when it was sold to John Hupp and used for the Hupp mine, it passed through several hands. After various exchanges, it was sold in 1899 to Butte County Electric Power & Lighting Co.

Forebay.—The Centerville forebay is merely an enlargement of the end of the canal. The hillside at this point offered no chance for the construction of a pond or lake, and it was therefore necessary to blast and excavate a site for and construct a reinforced concrete forebay. This forebay is 25 feet by 18 feet in plan, and from 20 to 23 feet deep. Its walls are 6 inches thick, reinforced with round rods, and supported at frequent intervals by counterforts. In the bay two vertical longitudinal walls separate the heads of the three pressure pipes, and the gates are so arranged that any of the pipes may be cut out while the others are still in commission.

About 300 feet up the canal from the forebay there is a settling basin 50 feet long, 18 feet broad, and 9 feet deep. Water enters this basin through a screen of flat steel bars, which is inclined at 30° from the horizonal, and rests at its lower end on a beam placed a foot above the bottom of the canal. This arrangement permits gravel that washes along the bottom of the canal to pass on into the basin, but removes all floating wood, leaves, and such material. Along the lower bank of the basin, there are two automatic flashboards, each 10 feet long by 2 feet high, so arranged that they trip and discharge when the water rises above ordinary level, and provided with counterweights so that after discharging they are returned automatically to their upright position.

Pressure pipes.—Three pressure pipes lead from the forebay to the power house; two of them are of 24-inch diameter throughout; the third is made up of 1,891 feet of 42-inch and 675 feet of 36-inch pipe. The length of each line is 2,566 feet. Expansion joints are provided in all the lines at the forebay. All three lines are of lap-riveted and butt-riveted steel plates. The last pipe laid is supported on concrete piers and anchored by 1½-inch rods. Except at the very steep section near the upper end the lines are covered. The pressure lines are straight in horizontal alignment; the profile is slightly concave. Elevation of water surface at the forebay is 1,062 feet above sea level. The static head developed is 577 feet on the impulse wheel, and 591 feet to tail-water surface for the turbine, giving the turbine 565 feet effective head when operating under full load.

GENERATING STATION.

Power house.—Centerville power house, like De Sabla, is on the west bank of Butte Creek, but here the canyon is wide and its walls and sides are far less rugged than at the upper station. The slopes just above the power house are very gentle, and there is ample room for the building on the rather flat bank of the creek, where a site has been blasted out on top of a sandstone ledge.

The building is constructed of concrete with an iron roof on steel trusses. Its height from the floor to the 60,000-pound hand-operated traveling crane is 19 feet 3 inches, and to the lower member of the roof truss 23 feet 5 inches. In plan it is 110 feet long by 32 feet broad, with an addition 25 by 32 feet used for a machine shop. It houses two units, which are arranged along its main axis parallel to the stream. The transformers are in the downstream end of the building, separated from the generators by a half partition, and the switchboard is along the center of the back wall. Back of the generating station and slightly above it, on a small rise, there is a reinforced-concrete house, containing the 60,000-volt oil switches. Outside of this switch house are the pole-top disconnecting switches.

Hydraulic equipment.—The No. 3 (42–36-inch) pipe runs directly to the turbine of the main unit. The No. 2 (24-inch) pipe runs directly to the impulse wheel of the smaller unit, passing through a gate valve just outside of the power-house wall. The No. 1 line runs between the other two for the greater part of its length and then bends in a long curve across No. 3 line, and then back to it. It enters one branch of the 3-way casting which is placed in the large line just back of the power-house wall. A straight branch from the No. 2 line connects to the other outlet of this 3-way casting. There is a gate valve in this branch and another in the No. 1 line just before reaching the casting. There is no valve in the 36-inch (No. 3) line above the casting, but in the power house between the line and the turbine there is a 38-inch motor-operated gate valve.

A 1,200-horsepower Doble impulse wheel, 48½ inches in diameter, provided with 18 Pelton Water Wheel Co.'s buckets, supplied through a single deflecting needle nozzle of 6⅔½-inch bore, controlled by a Lombard governor, type F, operates the 900-kilovolt-ampere generator, which is a part of the original installation.

A 9,700-horsepower Allis-Chalmers turbine of the Francis type, equipped with 24 guide vanes giving a maximum opening of 2⅞ inches and a width of 3⅜ inches, and 63-inch runner with 20 vanes with an opening of 2$\frac{11}{16}$ inches and width of 7 inches, operates the 5,300-kilovolt-ampere unit. This turbine is one of the first of its type designed for and operated under a high head. It is controlled by a Lombard governor, type N. Although the rated capacity of the wheel is 9,700 horsepower, it has never developed more than 8,200 horsepower, as the generator to which it is coupled is limited to this capacity. The unit is provided with a relief valve that may be connected with a dash pot so as to close slowly when the load is thrown off, or connected to act as a by-pass, to open as the turbine vanes close, and vice versa. Tests of this apparatus have shown that when the unit was running with 155 second-feet at its full load and the vanes were suddenly closed the relief valve opened and then closed after a period of 30 seconds, the total rise of pressure being 15 pounds above the static and 28 pounds above the normal working pressure. With a load of 1,000 kilowatts on the units, the relief valve closed in 5 seconds and the rise in pressure was 42 pounds above the working and 41 pounds above the static pressure. The turbine discharges through a draft tube and tunnel into a weir pool on the bank of Butte Creek, where the quantity discharged can be measured when tests are made. In order to measure all the water passing through the plant, the spill from the tailrace of the 900-kilovolt-ampere unit had to be brought along the bank of the stream and run into this pool instead of discharging directly into the creek.

Generator.—The 900-kilovolt-ampere generator is of the Stanley inductor type, giving 225 amperes 3-phase 60-cycle alternating current at 2,300 volts potential when operated at 360 revolutions per minute. The 5,500-kilovolt-ampere General Electric revolving-field generator gives 1,322 amperes at the same voltage, phase, and frequency, when operating at 400 revolutions per minute; this machine is supported on a 16-inch shaft between two oil-ring bearings.

When the unit was designed the high-head turbine was in its experimental stages, and on this account the bearings were so arranged that if the turbine proved a failure it could be removed and an overhung impulse wheel fastened to the end of the generator shaft. The installed capacity of the plant is 6,200 kilovolt-amperes (8,308 horsepower).

Exciters.—Two exciters are installed—one a Stanley 60-kilowatt 60-volt 1,000-ampere machine, the other a Northern Electric Manufacturing Co. 60-volt 167-ampere direct-current generator. The former can be driven either by motor or impulse wheel.

Transformers.—All the transformer equipment is of the Stanley shell type. There are six 840-kilowatt single-phase transformers, with a ratio of 2,300 to 60,000 volts, arranged in two banks, and three 350-kilowatt single-phase transformers of the same ratio in a third bank. The supply of circulating water is furnished from a concrete tank back of and 50 feet above the power house. All three banks are connected delta on the low-tension side and Y grounded on the high-tension side.

Wiring.—The generator leads run through ducts laid in the floor to a low-tension switch cell structure on the main floor. The General Electric oil switches in the pit are operated by toggles connecting with the levers at the switchboard. The rods of this system are carried through a covered trench in the floor. There are two General Electric switches (type F) per unit. From the switch cells 12 low-tension ducts lead to the transformers. The two high-tension lines from the transformers pass out the back of the plant at one end of the building to Baum oil switches in the reinforced-concrete switch house behind the main building. The disconnecting switches are placed on pole tops outside the building. The high-tension oil switches are operated by levers from the switchboard in the generator room.

No lightning arresters are in use at the station.

LIME SADDLE PLANT.

LOCATION.

The Lime Saddle plant was constructed by Oro Water, Light & Power Co. in 1905–6 and put into operation August 1, 1906. The power house is on a small tributary of West Branch of Feather River, in the SW. ¼ sec. 6, T. 21 N., R. 4 E., about 14 miles north of Oroville.

SOURCE OF WATER SUPPLY.

The forebay reservoir of the Lime Saddle plant receives its main supply through Miocene ditch, which heads on the West Branch of Feather River at a point nearly opposite Magalia. An auxiliary supply comes through Nickerson ditch, which heads on Little Butte

Creek. The general location and characteristics of the drainage basins that yield the water have already been described in connection with the De Sabla and Centerville plants, pages 203–205.

The various ditch systems heading above the Miocene and Nickerson intakes are so complicated that it is almost useless to try to form any idea of the disposition of the waters diverted at various points. Only a small part of the flood flow is stored, and practically none of the low flow goes to waste. The fragmentary records [44] seem to show that about 55 second-feet is usually available at the Miocene heading, but occasionally, in seasons of very low flow, the quantity is considerably less.

RESERVOIRS.

No storage is operated in connection with the Lime Saddle plant except for the very small amount available in the Kunkle reservoir that serves as a forebay. Kunkle forebay reservoir, which was constructed at a little meadow through which Kunkle Creek passed just before it dropped into the West Branch Canyon, is formed by an earth-fill dam, 980 feet long, 24 feet wide on the crest, and 42 feet in maximum height, with 2 : 1 slope on the lower side and 2½ : 1 on the upper side. The upper face of the dam is riprapped with lava to a point above high-water line. The capacity of the reservoir is 11,000,000 cubic feet.

CONDUITS.

Miocene ditch.—The Miocene heading on the West Branch of Feather River is a timber-crib dam 12 feet high and 160 feet long on the crest. Water is admitted to the canal through two timber headgates. The total length of conduit from the head dam to Kunkle reservoir is 53,688 feet. Of this 9,181 feet is in timber flume 6 and 7 feet wide by 3 and 4 feet deep, 312 feet is in tunnel 6 feet wide and 5.5 feet high, and the rest in earth ditch 6.5 feet wide on the bottom, 12.5 feet at water surface, and 4 feet deep. The head of the ditch is 1,580 feet above sea level, the elevation of the water surface in Kunkle reservoir is 1,495.5 feet, giving a total drop of 84.5 for the line. The capacity of the ditch is 60 second-feet. The ditch traverses the SW. ¼ secs. 30 and 31, T. 23 N., R. 4 E., secs. 6, 7, 8, 18, 19, 30, 31, and 32 of T. 22 N., R. 4 E., and sec. 6, T. 21 N., R. 4 E. The line follows the west side of the West Branch Canyon, nearly due south for its full length, bending to the west at its lower end to enter the reservoir.

Nickerson ditch.—The Nickerson ditch heads at a timber-crib dam on Little Butte Creek about a quarter of a mile nearly due east of Magalia. The dam is 52 feet long on its crest and 10 feet high.

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[44] For records up to June 30, 1912, see U. S. Geol. Survey Water-Supply Paper 298, p. 389. No later records have been published.

Water is diverted into the canal at the east end of the dam. The ditch traverses sec. 36, T. 23 N., R. 3 E.; secs. 1 and 12, T. 22 N., R. 3 E.; and secs. 18, 19, 30, and 31, T. 22 N., R. 4 E., following down the east side of the canyon for about 2½ miles, then bending around the point and dropping into Kunkle Creek which flows into the upper part of the forebay reservoir. The entire length of the conduit is 5.9 miles, and all of it is ditch save for two short flumes. The ditch is 4 to 7 feet wide on bottom, its surface width varies with the material encountered, and it is 2 to 4 feet deep; the grade is 15 feet per mile. The total distance traveled by the water, both in natural courses and artificial conduits, is 8.8 miles from the heading to the intake. The capacity of the Nickerson ditch is slightly over 40 second-feet.

Both the Miocene and Nickerson ditches were built for use in the early mining days; their use for power development is a relatively recent phase of their history.

Pressure pipes.—Water is admitted to the single-pressure pipe through a gate valve set well out in Kunkle reservoir above the dam. The valve is operated by a screw and hand wheel from the head of a frame tower extending well above maximum water surface. At the toe of the dam there is an 8-inch standpipe in the line, which is of lap riveted steel throughout. Its total length is 5,940 feet, and its diameter ranges from 44 to 30 inches.

The pressure line runs due south from the reservoir, descending on a very gentle slope along the west side of the canyon until it reaches a point almost above the power house, where it bends sharply toward the east and drops abruptly down the hill. At the point of descent the wall of the canyon above the power house is very steep, falling away regularly eastward from a lava cap at the crest of the ridge on the west side of the stream. On the gentle slopes in the upper part the pressure line is laid on the surface of the ground, but it is protected by dry-laid rock wall on each side and the top is covered with earth; on the steep slopes it is laid in trench and buried. The static head developed is 478 feet; on account of the length of the pipe line the working head is, however, considerably less. At the powerhouse the pressure line connects to a 30-inch steel header.

GENERATING STATION.

Power house.—Lime Saddle power house consists of two main buildings—a generator house, 36 feet 8 inches by 66 feet, built of concrete with iron roof on a steel frame, and a brick transformer house, 20 by 30 feet. The main buildings are separated by about 50 feet, the transformer house being on the hill above the generating station. Just down the canyon from the transformer house a pole frame supports the disconnecting switches and horn gaps.

The generating station houses two units, each operated by two impulse wheels, one overhung on each end of the shaft. The units are placed in line along one side of the generator room. In each corner on the opposite side of the room are offices and store rooms, an arrangement which leaves a bay in that side of the room between the two partitioned spaces. Just in front of the bay is the switchboard, and in the bay is the switching apparatus. The two exciter sets are in the space between the two main units in the center of the room.

Hydraulic equipment.—The two water wheels of each unit are of Pelton manufacture, are rated at 750 horsepower each, are 5 feet in diameter, and are provided with 18 buckets to each rotor. Water is supplied to each rotor through double stationary needle nozzles controlled by Sturgess K-1 governors. The discharge from the wheels strikes against baffle plates which deflect it into a sluiceway running along the side of the building.

Generators.—The two generators are General Electric ATB 1,000-kilovolt-ampere 18-pole revolving-field 2,300-volt 250-ampere 3-phase 60-cycle alternators, operating at 400 revolutions per minute. The installed capacity is therefore 2,680 horsepower.

Exciters.—The exciters are 6-pole General Electric 280-ampere 125-volt 35-kilowatt continuous-current generators, type CL, operated at 900 revolutions per minute, either by a 40-horsepower motor or by small impluse wheel, all three—generator, motor and impulse wheel—being mounted on the same shaft.

Transformers.—There are three General Electric 1-phase 60-cycle 2,300/33,000-volt 1,000-kilowatt water-cooled transformers connected delta on the low-tension side and Y with grounded neutral on the high-tension side.

Wiring.—A 6-panel marble switchboard contains the usual meters, a Tirrill regulator, and 3-pole double-throw low-tension oil-switch controls. There is a double bus for the 2,300-volt and an oil switch on the transformer bank low-tension side. On the high-tension side of the transformers there is a Pacific Electric Manufacturing Co.'s 60-kilovolt oil-switch in a separate fireproof compartment, with pole-top disconnecting switches outside.

The protective equipment consists of one set of Pacific Gas & Electric Co. sphere-gap lightning arresters.

COAL CANYON PLANT.

LOCATION.

Coal Canyon plant was built by the Oro Water, Light & Power Co. during 1907 and went into operation December 24 of that year. The power house is on the south side of Coal Canyon in sec. 11, T. 20 N., R. 3 E.

SOURCE OF WATER SUPPLY.

The plant is operated with water from the tailrace of the Lime Saddle power house and the region furnishing the supply is described on pages 203–205, 218–219.

The Kunkle forebay reservoir, the only storage reservoir on the system, is described on page 219.

CONDUITS.

The water supply for Coal Canyon plant comes through an extension of the old Miocene ditch that diverts from the canyon at the tailrace of the Lime Saddle power house and flows southerly past the town of Cherokee and around the edge of the mesa to Coal Canyon, 6 miles northwest of Oroville. A pipe line is run down the point of the hill to the Coal Canyon power house, so that the water flowing in the ditch system may be used for the generation of power. At the tailrace of the Coal Canyon power house the discharge from this pipe is received into the Powers ditch. The Powers ditch is 10.4 miles long and terminates in a small reservoir 1½ miles north of Oroville.

The total length of the section of the Miocene ditch from Lime Saddle power house to the head of the Coal Canyon pressure pipe is 12.4 miles, of which about 10.5 miles is in open-ditch line, about 1.7 miles (9,009 feet) in flume, and 0.2 mile (978 feet) in two tunnels. The ditch is 6 to 7 feet wide at the bottom, and the water is 3 to 4 feet deep. The grade is 10 feet per mile. The elevation of the line at its head—Lime Saddle power house—is 1,010 feet above sea level, and the elevation at the head of Coal Canyon pressure pipe is 870 feet, the total drop along the ditch being 140 feet. A small reservoir takes up 10 feet of head in the first mile of ditch below Lime Saddle power house. The capacity of the ditch is 60 second-feet.

There is no forebay at the head of the pressure line, but water is diverted from the ditch into a small timber box and flows thence through a timber head gate into the head of the single lap-riveted steel-pressure pipe, which runs in a straight line to the power house, at a very light grade. The total length of the pressure line is 3,042 feet and its diameter decreases from 36 inches to 28 inches. The pipe is laid in a trench and covered. The total static head developed is 350 feet.

GENERATING STATION.

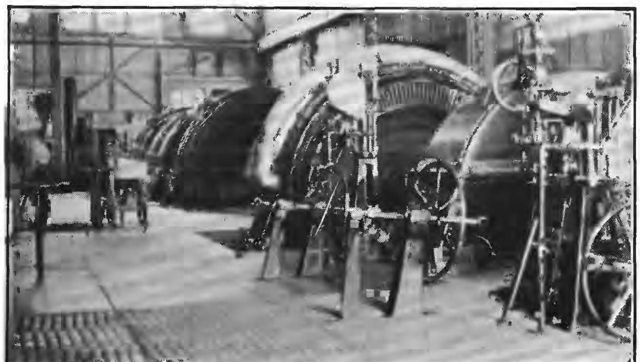
Power house.—Coal Canyon power house is a masonry building with iron roof and steel roof frame, divided by a transverse wall into a generator room, 24 feet wide by 34 feet 3 inches long, at the lower end of the plant, and a transformer room, 24 feet by 22 feet 3 inches long, at the upper end. The transformer room opens at the end of the power house through two large swinging doors so that a free circulation of air may be maintained. The single generating unit

A. HENDRICKS CANAL, DE SABLA SYSTEM.

Showing plank lining used at some points on outer banks.

B. MAIN CENTERVILLE CANAL.

Showing junction of rock retaining wall and section of flume.



C. GENERATOR ROOM, DE SABLA POWER HOUSE.

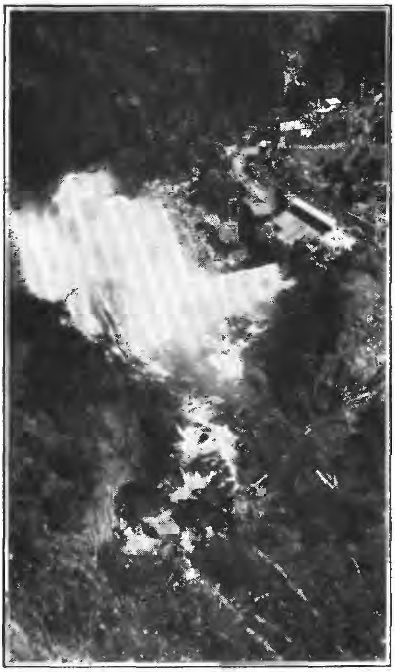
D. VOLTA POWER HOUSE.

HYDROELECTRIC SYSTEM OF PACIFIC GAS & ELECTRIC CO.

A. SPECIAL LONG-SPAN SUPPORT ON DE SABLA TRANSMISSION LINE.

B. NEW TOWER OF CARQUINEZ SPAN.
Photograph by the company.

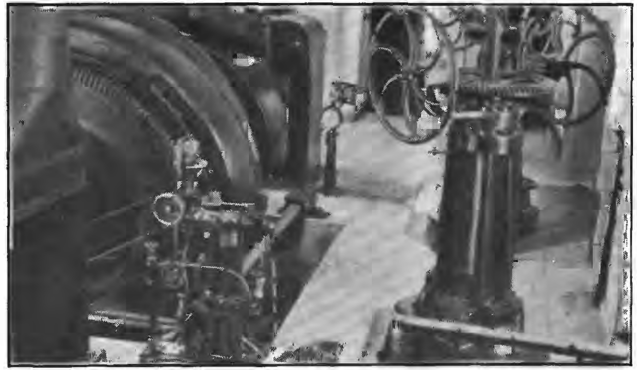
C. ALVISO SUBSTATION AND FIRST TOWER ON TRANSMISSION LINE TO SAN JOSE.



D. DE SABLA POWER HOUSE.
Just after a short circuit had deflected the streams.

HYDROELECTRIC SYSTEM OF PACIFIC GAS & ELECTRIC CO.

A. LASSEN PEAK FROM HILL ABOVE BATTLE CREEK MEADOWS.



B. GENERATOR ROOM, SOUTH POWER HOUSE.
Generator is piped for ventilation by tailrace suction.

C. COLEMAN POWER HOUSE.

D. HEAD DAM OF COLEMAN PLANT.

HYDROELECTRIC SYSTEM OF PACIFIC GAS & ELECTRIC CO.

Photographs *A* and *C* by R. W. Van Norden.

A. HEAD OF PRESSURE LINES, STANISLAUS PLANT, SIERRA & SAN FRANCISCO POWER CO.

B. KILARC DITCH, PACIFIC GAS & ELECTRIC CO.

C. GENERATOR ROOM, STEAM STATION A, SAN FRANCISCO, PACIFIC GAS & ELECTRIC CO.

Photograph by the company.

is placed parallel to the side wall of the building in a depression in the floor of the generator room. On the main floor beside it there is a governor, and at the end of the room, just far enough out from the transverse wall so that the low-tension switching apparatus can go behind it, is the switchboard.

Hydraulic equipment.—The pressure pipe connects under the power-house floor with a short header, from which branches run to the Pelton impulse wheels. The single unit is of the four-bearing type, but instead of carrying a single wheel, it carries two wheels under the same hood at each end of the shaft. Their combined rated capacity is 1,400 horsepower. The wheels are 36 inches in diameter on pitch line, mount 12 buckets each, and are controlled by a Lombard governor, type R, acting on one of the two pairs. The nozzles are of the stationary needle type, and the units are governed by jet deflectors. Baffles in the tailraces turn the discharge down into a weir pool at the side of the power house.

Generator.—The generator is a General Electric 2,300-volt 250-ampere 1,000-kilovolt-ampere (1,340 horsepower) 3-phase 60-cycle alternator, operated at 400 revolutions per minute.

Exciters.—Excitation is furnished either by a motor generator set coupled to an impulse wheel or by a direct-current machine belted to the generator shaft. The direct-current machine on the first set is General Electric 40-kilowatt 125-volt 320-ampere dynamo, class 50, form 8; the motor is a General Electric 3-phase 60-cycle 2,080-volt 16-ampere 60 horsepower induction motor, form K, placed between the end of the main generator unit and the central wall. The belted exciter is a General Electric compound-wound 128-ampere 125-volt machine, operated at 950 revolutions per minute.

Transformers.—The generator potential is stepped up from 2,300 to 60,000 volts on the line by three General Electric 1-phase 60-cycle B-1 transformers of 400 kilowatts capacity each.

Wiring.—The generator leads run through low-tension oil switches to the transformers. The high-tension leads from the transformers are carried out through tiled outlets above the doors in the end of the station to horn-gap disconnecting switches mounted on a pole framework about 30 feet from the end of the building. Thence the lines run to Pacific Gas & Electric Co. sphere-gap lightning arresters and on up the hill to connect with the main line from the Lime Saddle power house to Oroville.

BATTLE CREEK SYSTEM.

SOURCE OF WATER SUPPLY.

Battle Creek and its tributaries furnish water to operate four plants—Volta, South, Inskip, and Coleman. The developments follow each other closely and utilize a static head of 2,630 feet. There is very little difference in elevation between the discharge of one plant and the intake of the next below, except between the discharge of Volta and the North Battle intake of South, where the drop is 129 feet. Volta plant is on the North Fork of Battle Creek and receives its water supply only from that stream,[45] but the other three plants of the series are on South Fork, or on the main stream, and use the flow of South Fork in addition to that of the North Fork.

The drainage area above the Coleman plant (the lowest of the four) embraces 332 square miles, lying entirely above the junction of the North and South forks of Battle Creek on the volcanic slopes to the northwest, west, and southwest of Lassen Peak in Shasta, Lassen, and Tehama counties. Its eastern side is from 40 to 50 miles east of the city of Redding. The general relations of the Battle Creek plants and their tributary drainage basins are shown on the map forming Plate XXXIII (in pocket) and in the following table:

TABLE 28.—*Drainage areas of streams used in operating Battle Creek plants.*

	Square miles.
North Fork of Battle Creek above Macomber reservoir	23
Manzanita Creek above crossing of Deer Creek ditch flume	53
Bailey Creek above intake of feeder flume to Upper Mill Creek ditch	5
North Fork of Battle Creek below Lake Macumber reservoir and Manzanita Creek crossing of Deer Creek flume and above intake of Keswick ditch	10
North side of Battle Creek Canyon below Macumber reservoir and above ditch lines	8
Digger, Rock, Bailey, and North Fork of Battle Creek drainages below Volta and above South power house ditch systems	81
South Fork of Battle Creek above intake of South ditch to South power house	71
North side of South Fork Canyon below South ditch intake and above South ditch to South power house	20
South Fork of Battle Creek below South power house ditch system and above intake of South Inskip ditch of Inskip plant	7
North Fork of Battle Creek below South power house ditch system and above intake of Eagle Canyon ditch of Inskip plant	14
South Fork of Battle Creek below Inskip ditch system and above Coleman ditch intake of Coleman plant	30
North Fork of Battle Creek below Inskip ditch system and above Baldwin and Darrah Creek intakes of Coleman plant	10
	332
Total drainage area above Volta plant	99
Total drainage area above South power house	271
Total drainage area above Inskip plant	292
Total drainage area above Coleman plant	332

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[45] On purchasing the properties of the Sacramento Valley Power Co., Northern California Power Co. Consolidated acquired a ditch system of 23 second-feet capacity, leading from Lost and Hat creeks across North Fork of Battle Creek and Bear Creek drainage basins to the Snow Creek plant. The Snow Creek plant was then shut down and such water as was diverted from Lost and Hat creeks was utilized through the four Battle Creek plants. In 1914 the upper part of the Hat Creek ditch was destroyed by an eruption of Mount Lassen, and has not been reconstructed.

The ditch system above Volta is complicated. Two ditches, of which the Keswick, with 93 square miles of tributary drainage area, is the lower, divert from the North Fork of Battle Creek or from large springs along its course within a few miles above the power house, and a longer main ditch heads at the Lake Macumber storage reservoir on the North Fork above the mouth of Manzanita Creek, and runs down the flat-topped ridge north of Battle Creek. On the ridge and above this ditch there is an additional tributary drainage area of 8 square miles. The flow from Manzanita Creek is diverted into Deer Creek above the intake of the Deer Creek ditch. Another ditch line diverts from Bailey Creek and also empties into Deer Creek above the intake of the Deer Creek ditch. The Deer Creek ditch diverts water from Deer Creek, crosses Manzanita Creek and the North Fork of Battle Creek in flumes, and discharges into the main ditch below Lake Macumber or may be discharged into the North Fork of Battle Creek.

The part of the drainage basin (99 square miles) on North Fork of Battle Creek, Manzanita Creek, and Bailey Creek above the head and line of Keswick ditch is entirely in Shasta County, about 48 miles east of Redding and directly on the northwest slope of Lassen Peak. (See Pl. XXXIV, *A*.) This section of the basin is 14 miles in maximum length from Cow Creek divide southeast to Lassen Peak and 13 miles wide from Noble Pass west to the intake of Keswick ditch. The North Fork of Battle Creek heads in the northeastern part of the basin, flows southwestward, and is joined just below Lake Macomber by Manzanita Creek, which flows northwest from Lassen Peak. Elevations within this area range from 3,500 feet above sea level at the Keswick intake to 10,437 at the crest of Lassen Peak, but in by far the greater part are between 4,000 and 7,000 feet above sea level. Topographically the basin is characterized by long and comparatively regular volcanic slopes that extend southwesterly from Latur Butte at the head of the North Fork and northwesterly from the cone near the crest of Lassen Peak.

The area above Volta is in general well forested, except in certain rough brush-covered areas and the barren country above timber line on Lassen Peak.

There are no rainfall stations on the basin above the plants, but the precipitation is undoubtedly heavy—probably about the same as in the Butte Creek basin, not far to the south, from which De Sabla and Centerville plants receive their water supply. Large snow fields on Lassen Peak tend to maintain stream flow until late in the season. Uniformity of stream flow is also favored by the volcanic rocks of the basin, which absorb water rapidly in the wet season and return it to the streams in the form of spring-flow during the following dry season. The first large springs below the headwaters appear on Manzanita Creek in Deer Flat and from that point to below the Keswick intake springs are numerous.

South power house, in addition to receiving nearly the entire discharge from Volta, catches the flow from the part of the basin of the North Fork of Battle Creek lying below Keswick ditch, the flows from the basins of Bailey and Rock creeks, which lie directly between the North and South forks of Battle Creek, and the flow from the 73 square miles lying directly on the South Fork above the South power house diversion dam. All these streams drain areas that resemble the basin of North Battle Creek but are in general lower and not so well supplied with springs. The combined basins, exclusive of those tributary also to Volta plant, cover an area 17 miles long east and west by 11 miles north and south in Shasta and Tehama counties, 55 miles east of Redding, 10 miles southwest of Lassen Peak, and immediately south of that tributary to the Volta plant. All the streams flow westerly and join each other or the North Fork of Battle Creek. The maximum elevation in these lower drainage basins is slightly over 9,000 feet (at the top of an isolated butte 4 miles southwest of Lassen Peak). The topographic and geologic features are similar to those of the area above Volta. The forest cover on the lower parts of the area is very poor, but it improves on the higher country, and above 3,000 feet it is, in general, excellent.

The elevations of the intakes of the various South power house ditches above sea level are as follows:

	Feet.
North Battle Creek	2,072
Rock Creek	2,400
South Battle Creek	1,975

West of the area supplying water for the South plant ditches an area of low country (1,000 to 2,000 feet in elevation) extends 9 miles north and south by 5 east and west. This area, which is sparsely wooded and more poorly watered than the area above it, is made tributary to the Inskip and Coleman plants by canals leading from the North and South forks of Battle Creek. The rocks of this area are rough lavas.

The areas described are the only parts of the Battle Creek basin that are likely to be developed, for there is hardly fall enough between the Coleman tailrace and Sacramento River for another plant.

RESERVOIRS.

The Battle Creek plants receive water from two main storage reservoirs—Lake Macumber and North Battle Creek reservoir. The storage afforded by Manzanita Lake is small.

Lake Macumber was formed by an earth and rock fill dam 27 feet high and 2,420 feet long on the crest, thrown across North Fork of Battle Creek a short distance above the mouth of Manzanita Creek. Its area is 140 acres and its capacity 52,272,000 cubic feet. A rubble-masonry spillway 32 feet wide in two 16-foot sections and about 12 feet deep is provided in the rock section of the dam. The elevation at the dam is (roughly) 4,000 feet, and the drainage area tributary to the reservoir is 24 square miles, about half of which lies on the North Fork of Battle Creek and the rest on Bridge Creek, a tributary from the east. The stored waters are controlled entirely by the power company and are used solely for the development of power.

The North Battle Creek reservoir is 6 miles upstream from Lake Macumber, at an elevation 5,250 feet above sea level. The original plans called for a dry rubble and rock-fill dam with concrete facing, 100 feet in maximum height, 658 feet long on the crest, and 75 feet thick at the base. The reservoir formed by a dam of this height will have a capacity of 640,000,000 cubic feet and an area of 542 acres. The rock section of the dam has been carried only to a height of 46 feet, and above this a temporary wooden dam, 475 feet long on the crest, has been built of sufficient height to bring the total up to 54 feet; the area of the reservoir formed by this structure is 105 acres and its capacity 79,580,000 cubic feet. The spillway is of timber construction, 20 feet in crest length and 3 feet deep. The outlet is a masonry arch opening through the center of the dam. The discharge is controlled by a gate valve at the lower end of the outlet arch. The drainage area above the dam is 5 square miles, and the storage is entirely controlled by the company for use in the generation of power.

A plan to utilize Manzanita Lake for a storage site, proposes to tap it at a point 20 feet below its normal surface by a 275-foot tunnel. The normal water surface of Manzanita Lake was raised 5 feet in 1911 by the construction of an earth dam 10 feet high at the center, 8 feet wide on top, and 500 feet long; and in the summer of 1912 the inner face of this dam was covered by timber sheeting. In connection with the original plan of drawing 20 feet from the normal water level, this additional 5 feet would create an ultimate storage capacity of 39,200,000 cubic feet.

VOLTA PLANT.

Location.—Volta power house (Pl. XXXI, *D*, p. 222) is on a bench 129 feet above the North Fork of Battle Creek, in sec. 16, T. 30 N., R. 1 E., 2,200 feet above sea level. The plant was constructed by the Keswick Electric Power Co., and the first two 750-kilovolt-ampere units went into operation in October, 1901. A third unit of the same capacity was soon added, and in 1906 the building was enlarged, a second pipe line was installed, and a 2,000-kilovolt-ampere unit added to serve the west end of the station. In 1908 the equipment was further increased by adding a 2,000-kilovolt-ampere unit extending the transformer compartments, and building the switch house back of the main station.

Ditch system.—The complexity of the ditch system supplying Volta is due to the fact that the present system is a combination of several smaller ones that have been purchased from time to time. These systems diverted not only the flow of Battle Creek but also that of smaller streams and numerous springs which discharge into it from the plateau on the north. In addition to the several ditches purchased, a ditch from Lake Macumber on the North Fork of Battle Creek down the plateau to the forebay (through several randoms) and a 3-mile ditch and flume from Bailey Creek across Battle Creek to the main ditch from Lake Macumber were built by the Northern California Power Co. Consolidated.

The Upper Mill Creek ditch heads in sec. 15, T. 31 N., R. 2 E., traverses secs. 15, 16, 20, and 19 of the same township and secs. 25 and 26 of T. 31 N., R. 1 E., and discharges into Millseat Creek. The Al Smith ditch heads in the North Fork of Battle Creek in sec. 30, T. 31 N., R. 2 E., traverses secs. 25, 35, and 26, T. 31 N., R. 1 E., and discharges into Millseat Creek. The Baldwin-Millseat Creek ditch heads in Millseat Creek below the points of discharge of the Upper Mill Creek and Al Smith ditches and empties into Baldwin reservoir. The Keswick ditch heads in the North Fork of Battle Creek in sec. 30, T. 31 N., R. 2 E., and flows through secs. 36 and 35, T. 31 N., R. 1 E., and secs. 2, 3, and 4, T. 30 N., R. 1 E., to Lake Nora. The Lower Mill Creek ditch heads in Millseat Creek and flows into Lake Grace. Baldwin reservoir, Lake Grace, and Lake Nora are connected by ditches. The headings of most of the ditches are small dams built of earth and rock.

The physical characteristics of the ditch systems are shown by Table 29.

TABLE 29.—*Ditch systems of Volta plant.*

Ditch.	Length.	Elevation.		Grade.	Width.		Depth to water surface.	Capacity.
		Head.	End.		Surface.	Bottom.		
	Miles.	*Feet.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*	*Sec.-ft.*
Millseat or No. 1 ditch (Lake Grace supply), from Millseat Creek to Lake Grace	0.78	3,469	3,454	0.0038	7	5	3	45
Keswick ditch, from Battle Creek to Lake Nora	4.17	3,500	3,404	.0025	7	5	3	35
Ditches from Bailey Creek to Upper Mill Creek	3.01	4,250	4,000	.0016	5	3	2	12.5
Upper Mill Creek ditch, from Lake Macumber to Millseat Creek	6.86	4,000	3,505	.0038	8	6	3	30
Al Smith ditch, from Battle Creek to Millseat Creek	3.41	3,560	3,485	.0038	8	6	3	45

Forebays and pressure pipes.—The power house is served directly from two forebay reservoirs—Lake Nora and Lake Grace—and also receives an additional supply from the Baldwin auxiliary forebay reservoir. Lake Nora forebay reservoir (elevation 3,404 feet), on the plateau above Volta, was constructed with the original plant. The capacity of the lake is 217,000 cubic feet. The gates that admit water into the pressure line are in a timber crib out in the lake; before reaching the gates the water passes through trash screens. The entire pressure main from the reservoir to the power house is a lap-riveted and lap-welded steel pipe[47] having a total length of 6,658 feet, as shown by Table 30.

TABLE 30.—*Dimensions of Lake Nora pressure pipe.*

Thickness.	Diameter.	Length.
Inch.	*Inches.*	*Feet.*
$\frac{1}{4}$	40	671
$\frac{3}{16}$	35	39
$\frac{3}{16}$	30	1,091
$\frac{7}{32}$	30	781
$\frac{5}{16}$	30	798
$\frac{3}{8}$	30	1,132
$\frac{7}{16}$	30	314
$\frac{1}{2}$	30	1,832
		6,658

At its lower end the pipe from Lake Nora connects with the center of a 30-inch header 45 feet long just back of and parallel to the original part of the power house. The three supply pipes running directly to the three 750-kilovolt-ampere units are taken off at right angles from this header. Inside the generator room each branch passes through a gate valve operated by a hand-driven worm gear. Some distance back of the power house this old pipe line has been tapped and a branch from it run diagonally to connect with the new line at a point under the floor at the west end of the building to operate generator No. 5. The static head on this line, from normal water surface in Lake Nora to center of nozzles at the power house is 1,204 feet.

Lake Grace forebay reservoir (elevation 3,454 feet), on the ridge about half a mile northwest of Lake Nora, was constructed when the plant was enlarged in 1906. Lake Grace has an area of 8.43 acres and capacity of 1,001,880 cubic feet. Like Lake Nora, it was formed by throwing a long embankment dam around the lower margin of a mountain meadow. The earth dam that forms the lake slopes $\frac{1}{2}:1$ on both inner and outer faces and is sufficiently high to give the lake a maximum depth of 18 feet. The pipe line, as at Lake Nora, runs through the embankment from an intake crib out in the lake. The crib is fitted with trash racks and screens over

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[47] An old wood-stave section was replaced by a steel pipe in 1912.

the pipe mouth. Water is admitted to the pipe through timber headgates. As Lake Grace is farther from the edge of the plateau than Lake Nora, the pipe leading from it to the power house is much longer, comprising 8,896 feet, of which the first 3,108 feet to the edge of the mesa as originally constructed was wood-stave pipe 36 inches in inside diameter; the steel section of the line, reaching from the edge of the mesa to the power house, is 5,788 feet long and 36 inches in diameter at its upper end, but its diameter is gradually reduced until at the power house it is only 24 inches. The thickness of the steel plates in the pipe varies from one-fourth to one-half inch. In the spring of 1920, 3,070 feet of 36-inch wood-stave pipe in the upper part of this line was replaced with 672.5 feet of 36-inch and 1,000 feet of 34-inch riveted steel pipe and 1,397.5 feet of wood-stave pipe 36 inches in inside diameter. The static head from normal water surface in the lake to the center of the nozzles at the power house is 1,254 feet.

The two pressure pipes converge toward the power house, being well separated at the top of the main drop. At its lower end the line from Lake Grace runs directly toward unit No. 4, which is in the west end of the power house. Back of the building a branch is taken off to the right, passing to a special multiple casting under the power-house floor; this casting also receives the branch from the Lake Nora pipe line and has a dead end to receive a third main pipe if one should become necessary. The shank of this three-branch Y feeds unit No. 5. All the branch lines running to this casting are fitted with gate valves.

Although forebays for the old and new pipes differ by 50 feet in elevation, the two lines are cross-connected and can be operated together, as the new line is longer and the surplus head is lost by friction. An auxiliary supply received (from Springs in Millseat Creek) through a small ditch and an 8-inch pipe line drives two of the exciters. The static head on this line is 500 feet. The other exciters receive their supply from the main pressure line. The water supply for operating the governors is taken from Brush Creek, led to a tank on the hillside, and then served to the power house through a separate piping system; the head on this line is 250 feet.

Construction of the Baldwin (or Phelps) reservoir was started in 1911 and completed in 1912. It is three-quarters of a mile above Lake Grace, in secs. 33 and 34, T. 31 N., R. 1 E. It receives the run-off from a drainage area of 5 square miles and discharges into Lake Grace. The surface area of the reservoir is 38 acres, and its capacity is 1,525,000 cubic feet, or 350 acre-feet. The crest length of the dam is 1,176 feet, its maximum height 25 feet, its base thickness 84 feet, and its crest width 7 feet. Its upper and lower faces both slope 1½ to 1. It is of the earth-fill type and is not provided with a spillway. The elevation of the dam is approximately 3,520 feet above sea level.

Power house.—Volta power house (Pl. XXXI, *D*, p. 222) consists of two buildings—a combined generator and transformer house in front, toward Battle Creek, and a switch and transformer house back of it, toward the hill. Both houses are constructed of rubble masonry, with corrugated-iron roofs supported by timber trusses, and the generator room has an iron ceiling. The older part of the building, built in 1901, measures 84 feet 6 inches long by 47 feet wide; the newer part, built in 1906, is 59 feet 6 inches long by 58 feet 4 inches wide. The total length of the building is 144 feet. The back wall of the power house is straight, but owing to the greater width of the addition the front wall of the newer (west) end of the power house extends forward beyond the front wall of the older (east) end. A longitudinal wall running the full length of the building divides it into a generator room and a transformer space. The generator room is 144 feet long, 28 feet wide in the old part of the building, and 34 feet wide in the new part. The space in the back of the power house, which is occupied by transformers and auxiliaries, is 144 feet long by 15 feet wide and is divided by transverse partitions into four rooms.

The three original units are arranged in line, with their shafts parallel to the main axis of the building; the two newer units are in the west end of the building, in line parallel to but slightly in front of the others. Two 10-ton hand-operated traveling cranes are supported on rails set on shoulders in the side walls of the generator room.

The discharge from the impulse wheels is free and is carried out through tunnel tailrace openings under the front of the building. The switch house back of the generating system is 78 feet 6 inches long by 43 feet wide.

Hydraulic equipment.—Each of the three original units is operated by a 1,500-horsepower, 64-inch, Pelton wheel, connected to the generator by flexible, rawhide couplings. The wheels carry 20 buckets and are mounted on their own bedplates, between bearings. Water is delivered to each rotor through a single 2.8-inch deflecting nozzle regulated by a Lombard governor, type F.

The fourth unit is of the 2-bearing type and is operated by a single overhung Doble 4,200-horsepower 86-inch impulse wheel which carries 18 buckets and is fitted to the end of the generator shaft. The needle of the 5-inch stationary nozzle that supplies this wheel is regulated by a Lombard governor, type Q.

The fifth unit is of the two-bearing type and is operated by a single overhung Pelton 4,000-horsepower, 76-inch impulse wheel, carrying 18 buckets supplied through a 6-inch deflecting needle nozzle; the needle is regulated by hand and the nozzle deflected by a Lombard governor, type M. The wheel housings and bearings of the machines operating the fourth and fifth units are not carried on bedplates but bolted down separately to the foundations.

Generators.—The three 750-kilovolt-ampere generators are Westinghouse revolving-armature 500-volt 868-ampere 3-phase 60-cycle units, operating at 400 revolutions per minute, with ring-oiling bearings. The fourth unit is a Westinghouse 2,000-kilovolt-ampere revolving-field 2,200-volt 521.3-ampere 3-phase 60-cycle unit, operating at 300 revolutions per minute; its bearings are water cooled. The fifth unit is a General Electric ATB 2,000-kilovolt-ampere 2,200-volt 3-phase 60-cycle revolving-field machine, operating at 300 revolutions per minute; its bearings also are water cooled. The installed capacity of the plant is 6,250 kilovolt-amperes, or 8,375 horsepower.

Exciters.—The old section of the power house, containing the three 750-kilovolt-ampere units, is equipped with two exciter sets, each run by an 18-inch Pelton impulse wheel. The direct-current generator of each set is a Westinghouse 4-pole 45-kilowatt 125-volt 360-ampere machine, operating at 850 revolutions per minute; one set is converted into a motor generator by the addition of a 50-horsepower induction motor, the other set depends for motive power on the impulse wheel alone.

The exciter for the 2,000-kilovolt-ampere generator is of the same type and speed as those already described; it is driven by a Doble wheel regulated by a Lombard governor, type J.

The 2,400-kilovolt-ampere generator is excited by a General Electric class 35 form B 45-kilowatt direct-current machine operated at 975 revolutions per minute by a Pelton wheel with needle nozzle.

All exciters are normally operated in parallel.

Transformers.—In the rooms directly back of units Nos. 4 and 5 there are six General Electric type B–1 oil-insulated water-cooled single-phase 60-cycle 875-kilowatt transformers, with a ratio of 2,200 to 66,000 volts. In the rooms [48] of the back of the old part of the station there are seven Westinghouse oil-insulated air-cooled single-phase 300-kilowatt transformers, with a ratio of 500 to 22,000 volts.

In the switch house there was originally an additional bank of three Westinghouse single-phase 60-cycle oil-insulated water-cooled 1,250-kilowatt transformers having a ratio of 22,000 to 66,000 volts, with one spare in a separate compartment. These have been removed.

Wiring.—The power house is operated in two sections with separate switchboards, the three original 750-kilovolt-ampere units being controlled from one, and the two 2,000-kilovolt-ampere units from the other.[49] The three original units are connected to the air-cooled

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[48] One of these is a small offset on the back of the main building, not included in the general outlines given on page 231.

[49] Wiring diagrams for the original installations at most of the Northern California Power Co.'s generating stations were published by Van Norden, R. W., Jour. Electricity, vol. 25, p. 5, Aug. 6, 1910.

banks of transformers by means of knife-blade switches, and on the high-tension side these transformers connect to oil switches in the switch house. The 66,000-volt transformer equipment in turn connects to the Chico and South power house lines through 66,000-volt Kellman oil switches.

The two 2,000 and 2,400 kilovolt-ampere machines are operated from the second switchboard and are connected with the two banks of 875-kilowatt 2,200/66,000-volt transformers through 2,200-volt oil switches operating on double bus bars. Each of these banks of transformers may be connected to the outgoing 66,000-volt circuits through a bank of Kellman oil switches. Pole-top disconnecting switches, with horn arc breaks, serve to connect these two circuits with the single circuits to Chico and to South power house or to the double circuit to Palo Cedro.

The lightning arresters are of the Westinghouse low equivalent type and are mounted on the wall in one end of the switch house; there are also horn-type arresters on the 60,000 volt lines.

SOUTH PLANT.

Location.—The South plant was built by Northern California Power Co. Consolidated as the third station in its system and was put into operation in January, 1910. The power house is on the north bank of the South Fork of Battle Creek, in the SE. ¼ sec. 5 (near the east line), T. 29 N., R. 1 E., 1,399 feet above sea level.

Conduit.—The South plant is operated by water diverted through two ditches which unite some three-fourths of a mile from the forebay. The first comes from Volta and the North Fork of Battle Creek, the second from the South Fork of Battle Creek.

The intake from the North Fork of Battle Creek is in sec. 16, T. 30 N., R. 1 E., at the lower end of a short ditch leading to the stream from Volta power house. The conduit from this intake to the South plant traverses secs. 16, 21, 28, and 33 of the same township, taking up supplies from Bailey and Rock creeks en route, and through sec. 4, T. 29 N., R. 1 E., to a junction with the South Battle Creek ditch above the South plant forebay. The South Battle Creek intake is on that stream in sec. 18, T. 29 N., R. 2 E., and the conduit traverses sec. 18 of that township and secs. 13, 12, 11, 2, 3, and 4, T. 29 N., R. 1 E., to the forebay. The pipe line from the forebay to the power house traverses secs. 4 and 5, T. 29 N., R. 1 E.

The water discharged from the tailraces at Volta, after leaving the power house, is carried to the edge of Battle Creek Canyon and dropped through a timber chute into a flume carried across the canyon on a trestle close above the stream. The water of the stream is picked up a short distance above the crossing by a branch flume. The elevation at Volta power house is 2,200 feet, and that at the junction of the Battle Creek branch flume 2,071 feet above sea-level. Below the junction with the North Battle Creek feeder the ditch follows the south side of the canyon, reaches the top of the plateau southwest of Volta, joins the South Battle Creek ditch and continues to the South plant forebay.

The length of the North Fork conduit from Volta to the junction with South Battle Creek ditch is about 5.5 miles and its capacity is 90 second-feet. The conduit is all in ditch except about 0.8 mile of 5 by 4 foot flume. The ditch is 11 feet wide on the surface, 6 feet on the bottom, and 3.5 feet deep; its capacity is 90 second-feet.

Water is diverted from the stream into the South Battle Creek branch of the conduit by means of a masonry dam in the NW. ¼ sec. 18, T. 29 N., R. 2 E. The length of the conduit is about 5.7 miles, and the length from its junction with the North Fork or Volta ditch to the forebay is 0.6 mile, making a total of 6.3 miles from the South Fork diversion dam to the forebay. Along the South Battle Creek ditch there are ten tunnels, all of which are unlined. The three longest are 4,258, 1,280, and 727 feet, respectively—6,265 feet in all; the total length of the ten is 7,731 feet, leaving 1,466 feet for the aggregate length of the seven shortest. The grade of tunnels and ditch is 0.002, or 10.56 feet per mile. The tunnels have a clear width of 7 feet height to spring line 4.5 feet, and maximum height to crown of arch 6.5 feet.[50] The cross-section area of the ditch is 45 square feet, bottom width 7 feet, surface width 11 feet, and depth 5 feet. Its maximum capacity from diversion dam to the junction is 100 second-feet, which added to the 90 second-feet of the North Battle Creek ditch gives the plant a maximum possible supply of 190 second-feet.

The elevations of the various intakes of the South plant ditches above sea level are

	Feet.
North Battle Creek	2,072
Rock Creek	2,400
South Battle Creek	1,975

The maximum elevation of water surface in the forebay is 1,915 feet, giving 60 feet total fall in the South Battle and 157 feet in the North Battle Creek ditch line (not counting the 129 drop just below Volta).

Forebay.—The forebay above South power house is a masonry box at the head of the pressure pipe, fitted with trash racks to prevent débris from entering the pipes. The upper end of this box at its junction with the conduit is provided with a set of timber gates which are operated by rack and pinion. When these gates are

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[50] The entire cost of 6,598 feet in the tunnels, not including the compressor plant, was $59,514.29, or $9.02 per running foot. The cost of 4,260 feet of tunnel alone was $32,772.26, or $7.68 per foot. The material penetrated was self-supporting lava. (See Van Norden, R. W., op. cit.)

closed to cut off water from the pressure pipe the overflow from the conduit passes over a masonry apron a short distance above the gates and wastes down the side of the mountain. The outer bank of the canal for some distance above the wasteway and between it and the forebay box is reinforced by a heavy stone wall. The capacity of the forebay is 9,000 cubic feet.

Pressure line.—The upper end of the pressure line has a bell mouth 72 inches in diameter; a single 54-inch pipe, about 1,334 feet long, tapering to a 48-inch section about 450 feet long, extends to the power house; the total length of the line is 1,805 and the static head 516 feet. The entire pipe is lap riveted and the plates range in thickness from one-fourth to one-half inch. The pipe line is anchored by heavy masonry blocks at two points and just before it enters the power house it is embedded in a large masonry block. The pipe, like that at Coleman, was rolled into shape and built on the ground. Its weight is 366,000 pounds. The alignment of the pressure main is straight; the profile shows a long convex curve at the head of the line connected by a long section of gentle slope and very slight curvature to another curve just above the power house. The pipe is not covered but has a loose rock bracing laid up against its lower surface at each side.

Power house.—The entire installation is housed in a single rectangular building, 37.5 feet wide and 69 feet long, placed broadside toward the stream, constructed of rubble masonry, and roofed with corrugated iron supported on steel trusses; its walls are 2 feet thick.

The single unit is placed on the long axis of the building, so that the discharge from the wheels passes under the floor through tailrace tunnels that open directly over the creek. In the downstream end of the generator room (Pl. XXXIV, *B*, p. 222) is a three-compartment bay containing the transformers. A gallery room above them reached by a steel ladder from the main floor contains the high-tension switching apparatus, which is operated from switchboard on the generator floor. A small room at the side of the transformer bay houses the remote-control generator switch.

The switchboard is placed along the back wall in the opposite end of the building from the transformers and the exciter is in the corner opposite the switchboard but in the same end of the room.

Hydraulic equipment.—The single generator is driven by two 66-inch overhung Doble wheels, one mounted on each end of the shaft; the two bearings are water cooled. Each wheel carries 16 buckets and is supplied through a Doble stationary needle nozzle of 9-inch bore. The needle of each nozzle is adjusted by hand, and automatic regulation of the unit is obtained through a jet deflector connected to a Lombard governor, type Q. The pressure pipe branches to the nozzles at the rear wall of the building, and in each branch, just before it reaches the nozzle, is a hand-operated gate valve.

Generators.—The single generator is a Westinghouse 4,000-kilovolt-ampere (5,360 horsepower) 6,600-volt 350-ampere 3-phase 60-cycle revolving-field machine, operating at 225 revolutions per minute; a hollow steel shaft permits the use of a water-cooling system.

A very successful attempt has been made to cool the machine by utilizing tailrace suction. The openings around one side of the generator frame have been plugged and a hollow sheet-iron shield applied over those on the other side, entirely around the circumference of the armature frame. In the shield two sheet-iron pipes (Pl. XXXIV, *B*) have been run from points diametrically opposite, one pipe connecting with each tailrace back of the impulse-wheel housing. By this arrangement suction in the tailrace draws air from the room through the generator.

Exciter.—A single 55-kilowatt multipolar 125-volt 440-ampere Westinghouse continuous-current generator, operated at 350 revolutions per minute by a Doble impulse wheel, furnished excitation for the main unit.

Transformers.—A bank of three single-phase water-cooled 1,500-kilowatt transformers, in separate cells at the end of the building, steps the generator potential of 6,600 volts up to 66,000 volts for transmission.

Wiring.—The switchboard contains but two panels, one for the exciter and one for the switch control and meters of the main units. The cables from the main generator run through ducts in the floor to a Westinghouse 3-phase 6,600-volt remote-control oil switch, placed in a cell near the transformers. One set of 66,000-volt Kellman oil switches is placed in the gallery and receives its high-tension leads through the floor from 66,000-volt wire busses above the transformers. The outgoing line passes through square, glazed windows to pole-top disconnecting switches and horn-gap lightning arresters at the west end of the power house. One line runs from South power house to Volta and the other to Inskip.

INSKIP PLANT.

Location.—The Inskip plant, the fourth installed on the system of the Northern California Power Co. Consolidated and the third on the Battle Creek system, began operation July 10, 1910. The power house is on the South Fork of Battle Creek in the northeast corner NW. ¼ sec. 3, T. 29 N., R. 1 W., 969 feet above sea level.

Conduit.—The Inskip power plant receives water from both the North and South forks of Battle Creek. South Battle Creek feeder heads at an ogee masonry dam just below the South power house in sec. 5, T. 29 N., R. 1 E.; the conduit traverses secs. 5 and 6 of the same township and secs. 1, 2, and 3, T. 29 N., R. 1 W., to the forebay. The pipe line from the forebay to power house is entirely in the N. ½ sec. 3, T. 29 N., R. 1 W. The ditch follows the north side of South Fork Canyon to a junction with the ditch from North Battle Creek just above Inskip forebay. The crest of the diversion dam on South Fork is 44 feet above the lowest point in its foundations and 32 feet above the bed of the stream; the crest length from the south end to the intake wall at the north end is 95 feet. The maximum flood that has passed over the dam is 1,850 second-feet, the water being 3.5 feet deep on the crest. The intake of the canal is at the north end of the dam. The outer bank of the intake is a heavy masonry wall, the top of which at the upper end is 6 feet above the crest of the dam. Immediately downstream from the dam the wall begins to bend toward the north bank of the stream and in a very short distance the conduit turns into the mouth of the first tunnel. The wall does not extend upstream above the dam, as at the head of the main conduit of the Coleman plant, but ends at a point even with the upstream face of the dam. The inlet is on line with the axis of the dam. A few feet below the entrance of the canal there are two timber head gates that slide vertically in a wooden frame bolted to the masonry. Each gate is 4 feet 6 inches wide by 8 feet high, and is lifted from above by pinions acting on double upright racks bolted to the two heavy timbers of the gates. No sand gates are provided at the heading.

The ditch is 4.52 miles long, and its capacity is 200 second-feet. The elevation of water surface at the head of the conduit is 1,390, and at the forebay 1,345 feet. The grade is 0.002 (2 feet per thousand). The open-ditch section is 8 feet wide at the bottom, 13.5 feet at the top, and 5.5 feet deep. A single short flume, 8 feet wide and 5 feet deep, carries the line over Ripley Creek; the flume contains three waste gates. There are eight tunnels along the conduit, ranging in length from 96 feet to 1,787 feet, the aggregate being 5,013 feet. The tunnel cross section is 8 feet wide by 5.5 feet to spring line, and 8 feet to crown of arch.[51]

The excavated area of the tunnels is 63 square feet. The cost was $9.20 to $9.60 per linear foot, except in one section where the maximum cost was $16.[52]

The North Battle Creek intake collects the water reaching that stream below the diversion from Volta to South power house. The conduit heads in sec. 25, T. 30 N., R. 1 W., and traverses secs. 25, 26, and 35 of the same township, and joins the South Battle Creek feeder at the forebay in the extreme northeast corner of sec. 3, T. 29 N., R. 1 W. The intake dam is a rubble overflow structure, similar to that at the head of the South Fork ditch; it is 72 feet long, about 12

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[51] The overall cost of open sections of South Battle Creek ditch to Inskip, excavated by pick and shovel, was $4 per linear foot. Sections excavated by a 1½ yard steam shovel cost $1.83 per foot, which was distributed as follows: Blasting 60 cents, shovel excavating 43 cents, cleaning and trimming 80 cents. The material was cemented gravel and lava, and the average excavation 3 cubic yards per linear foot of conduit.

[52] Van Norden, R. W., op. cit.

feet in maximum height, and 8 feet thick through the base. The canal gates are at the south end of the dam. The ditch is 2.61 miles long and has a capacity of 70 second-feet. The approximate dimensions of this ditch are: Surface width 8 feet, bottom width 6 feet, depth 4 feet; its grade is 0.0025. The two branches join at the forebay.

The Inskip forebay is similar to that at South power house, already described. Each gate, however, opens into a sand trap, which is formed by a low division wall down the center of the box and a slope in the floor toward sand gates in the side walls. The total capacity of the forebay is 22,500 cubic feet.

Pressure pipe.—A single pressure pipe, 3,147 feet long, consisting of 2,145 feet of 72-inch (inside diameter) wood-stave pipe and 1,006 feet of 72-inch steel pipe develops a static head of 378 feet.[53] The maximum thickness of plate in the steel section of the lap-riveted pressure pipe is one-half inch. The head at the lower end of the wood-stave section is 80 feet; at a point farther up the line a 24-inch standpipe, 40 feet high is fitted to the pipe. The alinement of the Inskip pipe down the point of a ridge necessitated a curve. The profile of the hill, also, is much less favorable than that at the upper plants. The line in not covered and not trenched but it is prevented from moving laterally by low, dry-laid walls of lava fragments.

At its lower end the pipe is continued by a header lying along the back wall of the power house. Branches to the wheels are made at right angles to this header through individual pipes. After the three branches leading to the wheels of the first unit are taken off, the diameter of the header is decreased to 42 inches; this 42-inch section extends to a point just past the second unit, where it is reduced to a 12-inch pipe running to the exciters.

The supply for the governor is not taken from the main pressure pipe at the power house but is diverted from it near its head. After passing through a system of screens in a wooden tank it is served to the governors through a pipe line tapering from 3.5 to 2.5 inches.

Power house.—The power house is 125 feet long by 37.5 feet wide, with 2-foot rubble walls and iron roof on steel frame.

The two units are set on the side of the room toward the stream, their shafts parallel to the long axis of the building, the larger unit being in the upstream end and the smaller in the center of the building. The wheel housings of the two units are close together, on the adjoining ends of the machines.

The separate service pipes from the receiver just outside the back wall of the room cross directly to their respective nozzles. The discharge from the wheels is in the same straight line, through tunnel

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[53] The wood-stave pipe on this line cost $1.56 per foot, exclusive of the ⅝-inch round mild-steel bands, which vary in spacing from a maximum of 10 inches down to a minimum of 2 inches. The company cut the 3-inch fir staves at its own mill. (See Van Norden, R. W., op. cit.)

escapes that open directly above the stream. The supply for the exciters is brought through the back wall above the floor by a right-angled bend in the 12-inch feeder.

The main entrance to the building is at the center of the downstream end. On each side of the entry, between the door and the main generator room, are three transformer cells. The high-tension switch room is above the cells, an arrangement similar to that at south power house, except that, as the banks of the transformers are along the side walls of the first floor of the building, the switch room is much longer—32 feet 8 inches. Like that at South power house, it is reached by a vertical steel ladder fastened to the wall and running up to a steel balcony in the end of the generator room. In the corner of the generator room, on the side of the building toward the stream and next to the transformer cells, there is a generator switch room, and in a similar position on the opposite side of the generator room are the two exciter units. The switchboard is against the back wall of the building, opposite the two wheel housings of the main units.

Hydraulic equipment.—The units are both of the three-bearing type, and in both the wheels are on the same shaft with the generator rotor instead of being coupled to the generator shaft by a flexible link (as in units 1 to 3 at Volta and both units at Kilarc). The wheels and generators of each unit are on spearate bases, which, with the bearings, are bolted to the masonry. The wheel housings are in two parts—a heavy cast-iron base surmounted by a sheet-steel hood.

The 4,000-kilovolt-ampere unit is operated by a Pelton wheel with three rotors in the same housing. The combined rated capacity of the three rotors is 6,000 horsepower. Each rotor receives its supply from one plain and one needle nozzle, both of which are stationary. The needles are operated by hand, but all the streams of each unit are automatically governed by a set of deflectors controlled by a Lombard governor, type Q. The rotors are 44 inches in diameter and are fitted with 16 buckets each.

The 2,000-kilovolt-ampere unit has a similar three-rotor 44-inch Pelton impulse wheel, each rotor carrying 16 buckets and each being supplied through a single 6-inch needle nozzle. The combined rated capacity of the three rotors is 3,500 horsepower. The jet deflectors on this machine are controlled by a governor of the same type.

The service pipe to each rotor of the larger unit runs through a 27-inch hydraulically operated gate valve. On the lines to the smaller machine the gates are of the same type but only of 21-inch aperture.

Generators.—The power house is equipped with Westinghouse revolving-field 6,600-volt 3-phase 60-cycle generators, operating at

225 revolutions per minute and mounted on the same shaft with the impulse wheels. The 2,000-kilovolt-ampere unit is rated at 173 amperes and the 4,000-kilovolt-ampere unit at 350 amperes. The installed capacity of the station is therefore 6,000 kilovolt-amperes, or 8,040 horsepower.

Exciters.—The two exciter units of the installation are General Electric form B 60-kilowatt 120-volt 480 ampere, continuous-current generators. Motive power is furnished to each by a Pelton wheel supplied through a needle nozzle; the speed of the units is 625 revolutions per minute.

Transformers.—The transformer equipment consists of two banks of three General Electric 1,500-kilowatt single-phase water-cooled transformers, form B 1, raising the generator voltage of 6,600 to 66,000 volts for transmission.

Wiring.—The switchboard consists of an exciter and two generator panels equipped for double bus bars. There are four electrically operated 6,600-volt General Electric remote-control oil switches and two 66,000-volt Kellman oil switches. The former are mounted in a compartment in the corner of the generator room; the latter are in the room above the transformer cells. The high-tension outlets pass through square glazed windows in the back wall of the high-tension switch room. Just back of the power house is a double wiring system (carried on poles), by which either of the two circuits from the plant can be connected to any of the four outgoing lines to Chico, Coleman, South, or Volta. Including the switches in the high-tension leads just back of the building there are ten 3-phase pole-top disconnecting switches in the wiring system. The lines are operated with Y connection and grounded neutral.

The power house was originally provided only with horn-gap lightning arresters but is now equipped with aluminum-cell arresters. Horn-gap switches have been installed, and in 1921 the remote-control oil switches were being replaced by hand-operated oil switches.

COLEMAN PLANT.

Location.—The Coleman plant is the latest and largest generating station built by Northern California Power Co. Consolidated. The power house (see Pl. XXXIV, *C*, p. 222) is in the SW. ¼ sec. 32, T. 30 N., R. 2 W., on the north side of Battle Creek about 300 feet from the main stream, a location made feasible without in any way sacrificing head by the use of turbines with draft tubes. The main intake is in sec. 3, T. 29 N., R. 1 W.; the conduit traverses secs. 3 and 4 of the same township; secs. 33, 32, 29, and 30, T. 30 N., R. 1 W.; and secs. 25, 26, 27, 28, 33, and 32 of T. 30 N., R. 2 W.

The station is an excellent example of modern construction and its very pleasing appearance shows that architectural grace may be united to high-grade engineering designing at very small additional expense.[54]

Its construction was begun during the year 1910, and the plant began operation on November 27, 1911.

Main conduit.—The Coleman plant is operated with water received chiefly through a main conduit line that heads immediately below the Inskip power house on the South Fork of Battle Creek. The line follows down the north side of this stream until it reaches the North Fork, which it crosses through siphon No. 1. A short distance farther down it crosses Baldwin Creek, a tributary entering Battle Creek from the north through siphon No. 2. From siphon No. 2 to the Coleman forebay the entire line of the main canal is in open conduit. A short distance above siphon No. 2 the canal is joined by the Pacific ditch, which conveys water from Darrah Creek.

A branch conduit from Baldwin and Darrah creeks was constructed in 1912 and 1913. The separate branches from the two streams unite in a single flume, which discharges into the main conduit. The flume from Baldwin Creek is 5 feet wide by 4 feet deep, and that from Darrah Creek is 6 feet wide by 4 feet deep; from their junction to the main conduit the flume is 7 feet wide by 4 feet deep. The discharge of a series of springs below the Darrah Creek intake is pumped into the feeder below the junction of the Baldwin and Darrah Creek branches by a Byron Jackson single-stage centrifugal pump with 26-inch suction and 24-inch discharge pipe. The pump is motor driven and operates under a 46-foot head. About 21 second-feet is available at the pump.

The intake dam (Pl. XXXIV, *D*) at the head of the main canal is a rubble structure, ogee in section about 15 feet high, crossing the stream immediately below a sharp point and at right angles to its course. The total length of the crest of the dam is 115 feet, but the central section, 35 feet long is depressed 3 feet below the rest to form a spillway that will carry the entire waste except in flood.

The entrance to the canal is on the north side of the stream and is above the dam. A wing wall at right angles to the axis of the dam extends upstream for about 50 feet, then turns toward the shore and joins the inner wall of the canal, forming an intake bay that widens out from its narrow upper end to the full width of the canal at the dam. Two large openings in the wing wall just above the dam admit water to the bay, but there is no gate mechanism at that point for its control. Below the dam the wing wall is continued in a gentle curve along the bank of the stream to form the outer wall of the con-

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[54] The power house was designed by Mr. Rudolph W. Van Norden and was constructed under the supervision of Mr. Perry O. Crawford. The conduit and pipe line were designed and laid out by Mr. J. H. Stutt and were constructed by the company under the superintendence of Mr. Edward Whaley. The Long Beach steam plant and the Drum, Halsey, Wise, and Big Creek hydroelectric plants may also be cited as examples of the combination of architectural beauty with high-grade engineering design.

duit. Some 300 feet from the intake there is a masonry heading for the canal proper, and immediately above are three sluice gates that are used to turn water back into the stream bed.

The flow in the canal is regulated by two timber gates in the masonry canal heading. The gates are 6 feet wide by 8 feet deep and are supported on each side by the headgate abutments and at the center by a pier. Each gate is provided with two upright beams and is raised and lowered by a double pinion on the gate frame which engages with a rack on each of the upright timbers. The back of each gate is bound on both sides with iron strips that rest against rollers in the abutment. Discharge through the waste gates just above the canal headgates is controlled by a similar set of gates.

Below the headgates the entire canal was excavated by steam shovels, except at the single tunnel, 379 feet long, 12 feet wide, and 9 feet deep above the first siphon.

Above the entrance of the Baldwin Creek feeder, at the lower end of siphon No. 2, the canal has nearly vertical sides, a bottom width of 11 feet, depth of water 5 feet, grade of 0.001, and a capacity of 275 second-feet. Below siphon No. 2 the section is sufficiently increased to accommodate the extra supply received from the feeder.

From this junction to the power house the bottom width is 16 feet, the depth of water 5.5 feet, the sides, as before, nearly vertical, the grade 0.001, and the carrying capacity 300 second-feet.

The water surface at the head dam is 933.63 feet and that in the forebay is 870.28 feet above sea level, a difference of 63.35 feet; of this, 10.52 feet lies between the head of siphon No. 1 and the lower end of siphon No. 2. The total length of the canal from head dam to forebay is 53,594 feet.

The first siphon is about 2 miles from the head of the conduit. It is 892 feet long and is constructed throughout of 81-inch steel pipe which is built of plates one-fourth inch thick and sustains a maximum head of 80 feet. In crossing Battle Creek proper it is supported on a Howe truss bridge of 50-feet span; in approaching the bridge it is carried on masonry piers. At the head of the siphon there is a gate in the canal and a waste gate in the outer embankment. The distance from the lower end of siphon No. 1 to the upper end of siphon No. 2 is about 1,000 feet.

Siphon No. 2 is of composite construction. Its total length is 3,755 feet, of which the first 1,764 feet is of reinforced concrete and the last 1,991 feet steel. In the concrete section the inside diameter of the pipe is 90 inches and the thickness of the pipe shell is 7 inches at the bottom and 5 inches at the top. The reinforcement consists of triangle-mesh fabric, and the reinforcing is proportioned to give a factor safety of two when the strength of the concrete is entirely disregarded. At the junction of the concrete and steel sections of the line there is an expansion joint inclosed in a block of concrete 10 feet square and 12 feet deep. The pipe in the steel section of No. 2 siphon has an inside diameter of 86 inches and a plate thickness of one-fourth inch. The maximum head on the steel pipe is 115 feet and the maximum on the concrete pipe 46 feet. On the approaches to Baldwin Creek the line is supported on masonry piers and over the creek itself on two 24-inch I beams.

In the outer bank of the canal there are, in all, 9 rubble spillways of ogee section. Six of these are at the mouths of canyons in which the water forms small ponds that act as settling basins. The crest of each spillway is 140 feet long and 8 feet above the bottom of the ditch, and there is at each, in the bottom of the canal, a masonry sand box that can be cleared through two 30-inch square openings by raising cast-iron sluice gates operated by screws from the top of the wall.

Forebay.—At the lower end of the conduit a forebay reservoir, with capacity of 3,500,000 cubic feet, was constructed on the plateau. The dam is of the earth-fill type, the material being obtained from the reservoir site by steam shovels. At the lower end of the forebay there is a masonry heading or penstock for the two pressure mains. The side walls of the heading are 17 feet apart and are parallel for a short distance; below this contracted passage they diverge slightly to join the ends of a cross wall that connects them; above the contracted passage, or toward the forebay, they diverge until they are 50 feet apart where they join the embankments of the forebay. The frame that supports the headgates is placed in the short stretch where the walls are parallel. This frame supports two submerged sluice gates, each 6 feet high by 8 feet wide. As the water at the gates is 18 feet deep, the flow of water into the pipes can not be shut off until the reservoir is more than half empty. In the cross wall that forms the lower end of the pool below the gates are bell-mouth openings (flattened down to an elliptical instead of circular shape) through which the water enters the heads of the pressure pipes. Screens are placed over the heads of the pipes. There is also a set of trash racks where the canal discharges into the upper end of the forebay.

Pressure pipes.—The two lap-riveted steel pressure pipes were bent from plates and constructed on the ground instead of being hauled from the railroad in sections. The pipes are 7 feet in diameter and one-fourth inch thick at the upper end of the lines but decreased in diameter and increased in thickness of plate until at the power house the diameter is 5 feet and the thickness one-half inch. For a long distance the pipes lie on a very gentle slope along the plateau, then bend slightly to the left, pass at a sharp angle downward over the edge of the mesa, and run straight toward the power house. In order to pass a small hump on the side hill near the power house without changing the alinement, it was necessary to carry one pipe through an 86-foot and the other through a 195-foot tunnel. Except for these tunnels the pipes are uncovered, but they are supported on both sides by dry-laid lava wall. At the top of the main drop the pipes are embedded in large concrete anchor blocks. The pipes are 3,600 feet long.

The maximum elevation of water in the forebay is 870.28 feet, and the elevation of tail water at the power house 382.75 feet, giving a total head of 487.53 feet.

As there are three units in the power house and only two pipe lines, it was necessary to supply the third unit through branch connections. A pipe was therefore led off from the inside of each main line and these two branches were united by a Y, the shank of which serves the third unit. The supply for the two exciters is obtained by tapping each branch of the Y with a 12-inch pipe, uniting these taps by a T, and leading a 12-inch main from the T to the exciter wheels. The station water supply is taken from the exciter main through a pressure regulator.

In each main line just below the branch to the Y there is a hydraulically operated 48-inch gate valve, and a similar valve is set in each of the Y branches, above their junction. Flow through each of the 12-inch exciter supply pipes is controlled by a hand-operated gate valve.

In front of the station there is a concrete discharge pool about 40 feet wide, and from the lower corner of this pool a concrete-lined channel runs diagonally toward Battle Creek, joining the stream below the power house. This wasteway is protected on its upper side by a gravel bar along the bank of the stream.

Power house.—The power house is set on massive concrete foundations that extend down to a sandstone ledge just below the level of the draft tube. In plan it is 115 feet 6 inches long by 58 feet wide. The generator room is 34 feet wide and runs the full length of the front of the building. The three main generator units are placed in line parallel to the main axis of the building, and the two exciters are placed between the second and third main units.

The 24-foot space between the generator room and the back wall of the building houses the transformer, switching, and other electrical equipment, with the following arrangement:

The transformer cells, each 12 feet deep by 16 feet wide, face out into each end of the generator room, leaving a space 48 feet long by 12 feet deep between the pairs of cells. On the main floor this space is used for all auxiliaries except the exciters. On the second floor, 10 feet above the main floor, the corresponding space is occupied by the switchboard. The third floor, 20 feet above the main floor, roofs the transformer cells and extends the full length of the building but covers only the area occupied by the cells and switchboard. A clear view down behind the cells into the open top of the high-tension gallery and down in front into the generator room is thus obtainable; this third floor carries all the low-tension switching apparatus.

The high-tension switching apparatus is installed back of the transformer cells and switchboard on the second floor in a space 12 feet wide extending the full length of the building. The corresponding room on the first floor is used for storeroom and workshop.

Hydraulic equipment.—The pipes of the three main units and exciters are carried from the connections at the lower end of the pressure mains directly through the walls and underneath the main floor of the building to their respective wheels. The three main units are operated by Allis-Chalmers horizontal Francis turbines rated at 7,000 horsepower,[55] each carrying a 34-inch runner with single discharge. The thrust of the runner is received by a collar bearing at the turbine end of the main shaft, which is very short, so that turbine and generator are side by side and the machine has but two bearings. The speed of the machines is 450 revolutions per minute. The governors, of the Escher-Wyss type, are set slightly back of but very close to the turbine end of the units and receive their oil supply at 250 pounds pressure from motor-driven oil pumps. Allis-Chalmers relief valves are operated directly on the shaft from the governors.

Generators.—The three main generators are Allis-Chalmers 3-phase 60-cycle 438-ampere 6,600-volt 5,000-kilovolt-ampere machines, with revolving fields mounted on the shaft with the turbine runner. The installed capacity of the station is therefore 15,000 kilovolt-amperes, or 20,100 horsepower.

Exciters.—The two exciter sets are side by side in the central part of the generator room. Each set is an Allis-Chalmers 1,876-ampere 120-volt continuous-current generator, driven at 525 revolutions per minute by an Allis-Chalmers impulse wheel supplied through a stationary needle nozzle. The governors used on these wheels are of the same type as those on the main units but are much smaller.

Transformers.—The transformers at the Coleman power house, contrary to the usual practice in California, are of the 3-phase pattern; they are General Electric water-cooled units and step the generator voltage of 6,600 up to a line potential of 66,000. Four transformers, one for each machine and a spare to be used in emergency, are installed. Each transformer has a capacity of 4,000 kilowatts and is connected delta on the low and Y on the high tension side.

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[55] Manufacturer guaranteed 78 per cent efficiency at half load, 80 per cent at three-quarters load, 82 per cent at full load.

Wiring.—The leads from the generators are carried in 3-inch fibre ducts through the main floor and up through the walls between the transformer cells to the low-tension switch gallery on the third floor. All the ducts are laid in the concrete of the building. From the switches in this gallery the leads pass directly down through the floor to the transformers and thence through the back wall of the transformer cells to the high-tension switch gallery. In running from the generator to the transformer each lead passes in order through a "K–4" oil switch and a disconnecting switch to the equalizing bus connection, thence through another disconnecting switch and a "K–4" transformer switch to the transformers. From the transformers to the 66,000-volt busses each lead passes through a "K–10" oil switch and two sets of disconnecting switches. All the oil-switching apparatus is of solenoid-operated remote-control type.

The high-tension outlets are, through 18-inch wall bushings. The poles in the immediate vicinity of the building are of reinforced concrete and range in height from 30 to 50 feet; the tallest are 14 inches square at the butt and 8 inches at the top. One line runs westward from the power house to the main transmission system at Cottonwood; the second runs southward and connects with the Sacramento Valley main line at Hamilton City; the third runs eastward to the Inskip power house. All these lines operate at a potential of 66,000 volts.

General Electric aluminum lightning arresters, originally housed in a separate steel and concrete building about 100 feet from the generating station, have been moved outdoors.

KILARC PLANT.

LOCATION.

Kilarc, the first plant built by Northern California Power Co. after Volta, was begun in 1903 and put into commission in May, 1904.

The power house is on North Fork of Cow Creek in the NW. ¼ sec. 33, T. 33 N., R. 1 E. The main conduit heads in sec. 25, T. 33 N., R. 1 E., and traverses secs. 25, 26, 27, 34, and 33 of the same township to the forebay, which is in the SW. ¼ sec. 33. A small auxiliary conduit heads in the NW. ¼ sec. 24, T. 33 N., R. 1 E., and traverses secs. 24 and 25 of the same township.

SOURCE OF WATER SUPPLY.

Kilarc utilizes the headwaters of the North Fork of Cow Creek, supplementing the flow of that stream by diverting the discharge from a part of the headwaters of Canyon Creek, which lies directly to the west. The tributary drainage area (Pl. XXXIII, in pocket) is about 35 miles east of Redding and is entirely in Shasta County.

The North Fork of Cow Creek rises on the south slopes of Crater Peak, at an elevation of about 6,000 feet above sea level, and flows westerly. The Kilarc intake is about 10 miles due west from the head of the stream, and the part of the drainage basin contributing water to the plant has an average width of about 3 miles, north and south. No large tributaries enter the stream above the intake. The Canyon Creek drainage basin, which lies northwest of the Cow Creek headwaters, is about 4 miles long (east and west) by 2 miles wide. The Canyon Creek intake is about 1½ miles northwest of the main intake on Cow Creek. Cow Creek canyon in this part of its course is cut rather deeply into the lava slopes southwest of Crater Peak.

Elevations in the basin range from 3,900 feet at the North Fork of Cow Creek intake to 8,724 feet at the crest of Crater Peak, but most of the area is between 4,000 and 6,000 feet above sea level. The basin above Kilarc lies on a steep highland above the long volcanic slopes that are characteristic of the region and is heavily timbered. The stream flow is in general much scantier in summer and early in fall than in the Battle Creek basin, owing to the fact that most of the large springs in the basin are somewhat below Kilarc. No long-time records are available to show the relative discharge of the two streams.[56]

Precipitation on the basins contributing water to the plant is probably fully as high as that over the basins farther south, but no rainfall records are available. The seasonal mean doubtless ranges from 65 to 80 inches.

RESERVOIRS.

The only storage used in connection with the Kilarc plant is at Buckhorn Lake, in sec. 19, T. 33 N., R. 2 E. (elevation 5,000 feet), where an earth dam 12 feet high and 60 feet long on the crest forms a reservoir with an area of 21 acres and available capacity of 17,424,000 cubic feet.[57]

CONDUIT.

The Kilarc system diverts its water supply from the North Fork of Cow Creek at an elevation of approximately 3,884 feet above sea level. A small auxiliary supply is diverted from Canyon Creek through a feeder 1⅜ miles long, with 10 second-feet capacity, discharging into North Fork of Cow Creek just above the main intake dam, which is merely a small rubble masonry dam with concrete face and crest

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[56] For records of flow of Clover Creek and Cow Creek (to which Canyon Creek is tributary) see U. S. Geol. Survey Water-Supply Papers as follows: 298, pp. 140-144 and 386; 361, pp. 296-299 (1912-13); 391, pp. 219-221 (1913-14). These measurements were made downstream from the power diversions. No records were published for 1915 and 1916.

[57] A diversion from Pit River basin through the ridge into Cow Creek has been projected. This would lead water from a storage reservoir of 1,285,020,000 cubic feet capacity at Tamarack Flat. As yet only preliminary work has been done.

placed on a ledge among the boulders in the bottom of the canyon. At the south end of the dam a sliding timber gate admits the combined flow of the two streams into the head of the first flume on the main line.

The conduit includes 10,374 feet of ditch, 7,794 feet of flume, and 1,429 feet of tunnel. The total of these figures is 19,597, but as the flume runs through 617 feet of tunnel, the full length of the line is 18,980 feet. The conduit follows along the precipitous side of the south wall of Cow Creek canyon to a point a short distance above the forebay, where it reaches the gentler slopes on top of the plateau south of that stream. In the lower section of the line, along the canyon, about one-half of the conduit is ditch and one-half is flume. In this part of the conduit there are five tunnels. The two upper ones are of moderate length and are timbered; the two lower ones are very short and water is carried through them in flume. The flume box is 5 feet wide by 3 feet deep, and most of it is laid as bench flume. The ditch section is about 12 feet wide, 4 feet deep to flow line where measured (Pl. XXXV, *B*, p. 223), and the bottom width as designed is 8 feet. The grade is 0.0013 in all types of conduit except in the 550 feet of tunnel No. 2, where it is 0.0010. The capacity of the ditch is about 52 second-feet. The elevation at the head is 3,884 feet and at the forebay 3,840 feet above sea level. The original flume is being replaced from time to time by tunnels. The two longer tunnels cut off sections of old ditch and flume.

TABLE 31.—*Tunnels on Kilarc conduit.*

Number.	Length.	Section.	Lining.
	Feet.	*Feet.*	
1	262	4 by 5	Timbered.
2	550	6 by 7	Do.
3	564	5 by 5	Flume.
4	10	5 by 5	Do.
5	43	5 by 5	Do.

The forebay is about 6 acres in area and is on the edge of the plateau south of the stream. The outlet to the single-pressure pipe is through trash racks placed in a log crib built out in the lake some distance from the shore. The total length of the presssure pipe is 4,801 feet, and there is but one horizontal bend in the line. The pipe is in most places laid in trench cut to bedrock, but at some points it is carried over small depressions on dry-laid rock walls. The first 850 feet of the penstock was originally 54-inch wood-stave pipe, but this section was replaced by 48-inch riveted steel pipe in 1914. The details of the steel section as published in the Electrical World September 17, 1904, are given in Table 32.

TABLE 32.—*Dimensions of Kilarc steel pipe line.*

Section.	Length.	Diameter.	Thickness.	Static head on lower end of section.
	Feet.	*Inches.*	*Inches.*	*Feet.*
1	224.23	42	$\frac{3}{16}$	191
2	150.34	42	$\frac{1}{4}$	275
3	200.00	42	$\frac{5}{16}$	347
4	199.87	42	$\frac{3}{8}$	450
5	186.00	42	$\frac{7}{16}$	510
6	217.53	40	$\frac{7}{16}$	584
7	193.70	40	$\frac{1}{2}$	603
8	644.44	40	$\frac{9}{16}$	700
9	322.28	36	$\frac{9}{16}$	772.1
10	333.60	36	$\frac{5}{8}$	820
11	686.26	36	$\frac{11}{16}$	988.8
12	376.10	36	$\frac{3}{4}$	1,074.7
13	248.80	36	$\frac{13}{16}$	1,200
	3,983.25			

Three manholes and a number of air valves are installed along the line.

At its lower end the pipe runs into a 36-inch header lying along the upstream side of the generator room, and from this header the branches are taken off to the generators and exciters. The static head developed is 1,200 feet, and the net head, with a velocity of 10 feet per second, 1,170 feet. The line was designed to provide for a 3,000-kilovolt-ampere unit in addition to the present equipment.

GENERATING STATION.

Power house.—The power house consists of two buildings, set side by side, one of which contains the generating equipment and the other the transformers and high-tension switching apparatus. Both are built of rubble masonry and have corrugated-iron roofs supported on steel trusses. The generator house is 63 feet 4 inches long by 40 feet wide; the transformer and switch house is of the same length, but is only 31 feet wide. The north end, instead of the front of the station, is toward the bank of Cow Creek. The nozzles discharge through masonry tunnels into a sharp southward bend of the stream below the building. At the power house the pressure main enters a header, 70 feet long and 36 inches in diameter, which lies between the foundations of the two buildings. From the header a separate branch leads through a 14-inch gate to each of the four rotors of the main units. A 6-inch gate admits water to a 4-inch T, the branches of which still further reduce to 3 inches and supply each exciter. The power house contains two units placed end to end along the downstream side of the building. The four gate valves on the service lines to the wheels are along the center line of the room. A 16-ton hand-operated crane spans the room and is supported on rails laid on ledges in either wall. On the upstream side of the room, toward the transformer house, the switchboard occupies the center of the wall, with the exciter units on either side.

The transformer house is divided by a longitudinal wall into two rooms. The one nearest the generator building houses the high-tension switches, lightning arresters, and static interrupters; the room on the farther side is divided by transverse walls into three transformer compartments. At each end there is a compartment large enough to contain a bank and between the two there is a small cell containing a spare transformer.

Hydraulic equipment.—Each unit is driven by two 90-inch Pelton impulse wheels which are mounted 3 feet apart on the same shaft and covered by a single hood. The combined rated capacity of the two rotors is 2,000 horsepower. Each rotor carries 20 cast-steel buckets. Each wheel has its own bearings and its shaft is connected to that of the generator by rawhide link couplings. A plain deflecting nozzle of 2.8-inch bore serves one rotor, and a hand-operated deflecting needle nozzle of 4-inch bore the other rotor of each unit. The position of the needle is regulated by hand; a Lombard governor, type Q, on each unit deflects both nozzles. Water is supplied to the governors from a spring under a head of about 275 feet.

Generators.—Two Westinghouse 1,500-kilovolt-ampere 2,200-volt 393-ampere revolving-field generators, operated at 300 revolutions per minute, give 3-phase 60-cycle alternating current. The generator shaft is 10.5 inches in diameter at the rotor and tapers to 9 inches at the bearings, which are water-cooled. The installed capacity of the station is 3,000 kilovolt-amperes or 4,020 horsepower.

Exciters.—The two exciter sets were originally motor generators, each fitted with a 34-inch overhung impulse wheel. The motor from one of these sets was removed, so that the exciter can be operated only by the impulse wheel; the other set still retains a 60-horsepower Westinghouse induction motor. Each exciter is a 45-kilowatt 125-volt 360-ampere multipolar direct-current generator, operated at 850 revolutions per minute.

Transformers.—The transformer house originally contained two banks of three 650-kilowatt single-phase air-cooled transformers, and a spare to be used in emergency. Each bank was set in a separate compartment in one side of the transformer house, the spare being in a small cell between the two compartments. One of the original banks of 650-kilowatt transformers has since been removed, and the other moved out of doors; a new bank of three Westinghouse water-cooled 1,500-kilowatt single-phase 2,200/66,000-volt transformers and a set of outdoor aluminum-cell lightning arresters have been installed.

Wiring.—The switchboard is fitted with double 2,200-volt busses which connect with the transformers by cable leads carried underground through 30-inch by 3-inch ducts, the circuits passing through Westinghouse 3-pole 400-ampere oil switches. There is a set of

22,000-volt tub oil switches on each of the two outgoing circuits, one of which runs to Volta and the other to Delamar. The high-tension lines from the transformer house are carried through circular glass windows from which the wires run directly to horn gaps and pole-top disconnecting switches.

The station was originally equipped with a set of Westinghouse low-equivalent lightning arresters and a set of Westinghouse 20,000-volt 57-ampere static interrupters and two horn-gap arresters on each line. Two 22,000-volt lines originally left the power house, one running to Volta and the other to Delamar. In 1917, however, the line to Volta was abandoned, and the Kilarc and Cow Creek power houses were connected by a 66,000-volt line. The 22,000-volt transformers connect to their outgoing line through a set of tub oil switches, and the 66,000-volt transformers through Kellman oil switches; disconnecting switches are installed between the oil switches and the main line.

SOUTH COW CREEK PLANT.

LOCATION.

South Cow Creek plant was constructed by the Northern Light & Power Co. in 1907 and put into commission in 1908. The power house is in sec. 6, T. 31 N., R. 1 W., on the north bank of a small tributary of South Cow Creek, just above the junction with the main creek, about 990 feet above sea level. The conduit heads in sec. 33, T. 32 N., R. 1 W., and traverses secs. 33, 32 and 31 of the same township and sec. 6, T. 31 N., R. 1 W.

SOURCE OF WATER SUPPLY.

The part of the basin of South Cow Creek from which the plant derives its supply is directly south of that contributing to Kilarc and southwest of Crater Peak. The entire area (Pl. XXXIII, in pocket) is in Shasta County, 35 miles east of Redding. The basin extends nearly east and west about 16 miles and its average width north and south is about 4 miles. The stream receives no tributary of any great length. The topography, like that of the basins furnishing water for the other plants, is characterized by a long and comparatively regular westward slope through which the stream has cut a canyon nearly 800 feet deep. The rocks, as in the neighboring basins, are volcanic. The forest cover is thick in the upper parts of the drainage area but thins out in the western half. Elevations range from 1,740 feet at the intake to about 7,000 feet near the head of the stream. The stream receives a large part of its low flow from springs.[58]

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[58] The only gaging stations in the Cow Creek basin are below the junction of the North and South forks. For records of flow see U. S. Geol. Survey Water-Supply Papers, as follows: 298, pp. 140-147, 386 (up to June 30, 1912); 361, pp. 296-299 (1912-13); 399, pp. 219-221 (up to Mar. 31, 1914); no records were published for 1915 and 1916.

CONDUIT.

A ditch 895 feet long conveys the flow from Mill Creek to a point above the diversion from the South Fork of Cow Creek.

The entire flow of the South Fork of Cow Creek is diverted through a conduit line which passes along the south side of the canyon. The diversion dam is constructed of rock and its elevation is about 1,740 feet above sea level. The intake is a concrete structure with wooden gates operated by a rack and pinion. Of the total length of 10,969 feet 176 feet is tunnel and 10,793 feet ditch. The maximum capacity of the conduit is 50 second-feet; its average grade is 0.002 (2 feet per 1,000). At its lower end the conduit terminates in a small forebay lake (260,000 cubic feet capacity) which was formed by throwing an earth dam across a hollow at the top of the power drop.

From the forebay water is admitted into a single pressure line through a timber headgate, set in a crib out in the reservoir. The total length of the pressure line is 4,487 feet, of which the first 781 feet is 42-inch wood-stave pipe and the remaining 3,706 feet 30-inch lap-riveted steel pipe. The static head obtained is 715 feet.

GENERATING STATION.

Power house.—The power house is a masonry building 53 feet 6 inches long and 34 feet 8 inches wide, roofed with corrugated iron supported on steel roof trusses. The station contains two units placed wheel to wheel along one side of the generator room, with their shafts parallel to its long axis. The pressure pipe enters at the center of the back of the building and branches underneath the floor to the adjacent impulse wheels of the two units.

The back corners of the generator room are partitioned into office and storeroom, leaving a bay opening out into the main room between them. In front of this bay is the switchboard, with the rheostats and low-tension wiring behind it and in the bay. The low-tension circuits to the transformers are carried directly through tile outlets in the wall back of the switchboard to pole-top disconnecting switches, from which the conductors pass to the low-tension sides of the transformers. The transformers are housed in a separate corrugated iron building, back of the main power house, and all the low-tension wiring between the switchboard and the transformers is lead-sheathed cable.

Hydraulic equipment.—Each unit is operated by a single overhung 48-inch Pelton impulse wheel which carries 20 buckets and is rated at 1,500 horsepower. Each rotor is supplied through a single deflecting needle nozzle controlled by a Pelton oil-pressure governor; the discharge is free, through arched tailraces.

Generators.—The generators are General Electric ATB 750-kilovolt-ampere 189-ampere 3-phase 60-cycle 2,300-volt 18-pole revolving-field alternating-current machines, designed for a speed of 400 revolutions per minute. Installed capacity of the plant is 1,500 kilovolt-amperes, or 2,010 horsepower.

Exciters.—A General Electric 280-ampere 125-volt 35-kilowatt continuous-current exciter, class C–25, form B, operated at 1,050 revolutions per minute, is belted to each main generator shaft.

Transformers.—The generator potential of 2,300 volts was originally stepped up to 34,000 volts for transmission by three Westinghouse 500-kilowatt 1-phase 60-cycle water-cooled transformers, connected delta on both low and high tension sides. These have been replaced by General Electric 500-kilowatt transformers which now step the 2,300 volts up to 66,000 volts for transmission. The transformers are connected delta on the low and Y on the high tension side.

Wiring.—The 4-panel switchboard is equipped with General Electric 500-ampere generator and transformer oil switches. The high-tension conductors pass out of the transformer house through circular openings in the centers of square sheet-glass windows directly to pole-top disconnecting switches beside the building. The transmission line runs directly from the power house west to Redding.

In the end of the transformer house there is a set of General Electric multigap lightning arresters.

PIT RIVER SYSTEM.

GENERAL PLAN.

In 1919 Pacific Gas & Electric Co., through its subsidiary Mount Shasta Power Corporation, began the construction of a series of seven plants comprising its so-called Pit River progressive development. The first two permanent plants completed are not on the main stream, however, but on Hat Creek, a tributary from the south.

The first plant on the main river (Pit River No. 1 plant) was under construction at the end of 1921 and should be completed before the fall of 1922. It receives its water supply from Fall River, a tributary from the north, although the power house is on the Pit. Upon its completion two small temporary plants diverting from Fall River at its junction with the Pit will be put out of commission. One of these contains a 750-kilovolt-ampere unit operating under 32 feet head, and the other a 200-kilovolt-ampere unit operating under 56 feet head. On account of their temporary nature, neither of these plants is described in this report. The total head to be developed by Pit River plants Nos. 1 to 5 will be about 2,090 feet, and their total installed capacity as now proposed will be 425,000 kilovolt-amperes, divided as follows:

Plant.	Head (feet).	Capacity (kilovolt-amperes).
No. 1	454	70,000
No. 2	118	17,500
No. 3	313	67,500
No. 4	233	50,000
No. 5	985	220,000
	2,103	425,000

Power generated at Hat Creek Nos. 1 and 2 power houses will be transmitted to Pit River No. 1 plant upon its completion, and there stepped up for transmission at 220,000 volts to the main network of the company.

HAT CREEK PLANTS.

SOURCE OF WATER SUPPLY.

Hat Creek rises on the north slope of the ridge running eastward from Lassen Peak to Hat Mountain. Its headwaters are at an elevation of about 8,000 feet above sea level. From its source the stream flows in a sinuous course generally due north and joins Pit River about 8 miles due west of the town of Fall River Mills, Lassen County. The length of the Hat Creek basin from its source to its mouth is 36 miles in an air line.

The drainage area of Hat Creek is uncertain, owing to the topography of the eastern part of its basin, where flat lava beds make the location of the watershed very indefinite. If it is assumed that the run-off from streams draining northward from Lake Bidwell finally reaches Hat Creek, after sinking, the drainage area at the mouth of the stream is approximately 500 square miles, and the area at Cassel 450 square miles. If the true eastern boundary of the basin runs directly north from Prospect Peak, however, the total drainage area is only about 70 per cent of these figures.

Hat Creek has no long tributaries except Lost Creek, in the upper basin, which forms practically a western and equal branch of the stream. It receives a large part of its supply from Big Spring, a short distance from the mouth of Lost Creek, and from the spring-fed Rising River Lake, which empties into it through a short tributary near Cassel, about 6 miles above its mouth.

The highest point in the Hat Creek basin is Lassen Peak, at its extreme southern tip, 10,437 feet. The elevation at its junction with Pit River, at the extreme north end of the basin, is 2,750 feet above sea level. The elevation of Hat Creek No. 1 or upper intake is 3,200 feet, and that of Hat Creek No. 2 power house is 2,790 feet. The upper part of the basin above Big Spring ranges from 4,500 to 8,000 feet in general elevation, but below that point the gradient of the stream is much flatter, and the more rapid drop starts only north of Cassel.

The rocks of the entire basin are volcanic, principally lavas, with certain areas of pumice. The upper basin is in general well forested. The mean seasonal precipitation is probably about 28 to 42 inches. The heavy snowfall in the upper basin finds its way into the stream on melting chiefly through springs, because, owing to the geologic structure, there is comparatively little surface run-off.

On the basis of gagings of Hat Creek during the years 1911, 1912, 1913, and 1921 the corporation's engineers estimate that the minimum discharge above Cassel is about 310 second-feet, the maximum 500 second-feet, and the mean 403 second-feet. They also estimate that with an average flow of 400 second-feet through Hat Creek No. 1 plant the mean output will be 5,680 kilowatts.

Crystal Lake below Cassel furnishes about 150 second-feet from the flow of springs, and Rock Creek about 25 second-feet; a similar estimate for Hat Creek No. 2 intake gives a probable maximum discharge of 675 second-feet, minimum 465 second-feet, and mean 585 second-feet. With a discharge of 600 second-feet through the conduit, the plant output is estimated to be 8,200 kilowatts.[58a]

HAT CREEK PLANT NO. 1.

Hat Creek plant No. 1 was constructed by engineers of the company and was put into commercial operation August 22, 1921.

LOCATION.

Hat Creek No. 1 intake is in the SW. ¼ sec. 5, T. 35 N., R. 4 E. The conduit runs northeastward through sec. 5, T. 35 N., R. 4 E., and sec. 32, T. 36 N., R. 4 E. The power house is in the SE. ¼ sec. 32 of the same township, about 0.6 mile north of Cassel.

CONDUIT.

A timber and rock-fill crib dam 180 feet long, connecting a concrete abutment on the east with a concrete headworks structure on the west side of the stream, was completed to its initial height of 3,206 feet July 25, 1921, and has since been raised to an elevation of 3,208.5 feet, to provide additional forebay capacity. The elevation of the original water surface at the dam was 3,203.5 feet. The elevation of the top of the abutments is 3,210.5 feet.

Water is admitted to the canal through two motor-operated radial gates 8 feet wide by 11 feet deep, in a reinforced-concrete gate structure on the west bank of the stream. Two 5-horsepower 220-volt 13.5-ampere General Electric induction motors operated at 1,200 revolutions per minute furnish power for the operating mechan-

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[58a] For records of flow in the Hat Creek basin see U. S. Geol. Survey Water-Supply Papers as follows: 298, pp. 112-113, 386-387 (1911-12); 311, p. 147 (1911); 331, pp. 241-244 (1912); 361, pp. 277-281 (1913); 391, pp. 214-215 (1914); 411, pp. 227-228, 335 (1915); 441, pp. 206-207, 331 (1916); 461, pp. 203-204 (1917).

ism. A trash rack 38 feet long by 20 feet deep constructed of ¼-inch by 3-inch flat bars is installed above the gates. Above the headworks an earth embankment containing 4,553 cubic yards was built to prevent flooding of private property.

The first 2,750 feet of the conduit is open canal, bottom width 17 feet, side slopes 1½ horizontal to 1 vertical, normal depth of 8 feet to water surface. The grade is 0.25 foot per thousand.

The total excavation for the canal was 25,553 cubic yards, and in order to provide for a maximum flow of 600 second-feet 3,177 cubic yards of earth was placed in embankments on the berms. The canal was excavated by steam shovel. About 1,512 cubic yards of rock-wall lining was placed along the sides of the canal where necessary, and part of this lining was faced with cement mortar. The transition section at the headworks was all lined with rock. The normal capacity of the canal is estimated to be 450 second-feet, and its maximum capacity 600 second-feet.

The canal empties into a forebay of 12½ acre-feet capacity formed by an earth embankment with core wall; 1,161 cubic yards of riprap and 100 cubic yards of wall were placed in constructing the forebay. Water is discharged from the forebay into the pressure pipe through two motor-operated radial gates measuring 8 by 14 feet, set in an outlet structure containing 320 cubic yards of concrete. The gates are protected by a screen measuring 24 by 16 feet constructed of flat steel bars. Water was first admitted to the forebay on July 16, 1921, and first raised to high-water elevation, 3,206 feet, on July 19; the elevation at the top of the bank is 3,213 feet.

The single riveted steel pressure pipe, 1,605.66 feet long, ranges from 10 feet in diameter and $\frac{5}{16}$ inch in plate thickness at the forebay to 8 feet in diameter and ⅜ inch in plate thickness at the power house. Three anchors containing a total of 171 cubic yards of concrete are installed along the line, and one expansion joint was provided at anchor No. 2. It was necessary to excavate 2,345 cubic yards of earth and rock in placing the pressure pipe, which is, however, laid above ground. The pressure pipe is carried across Hat Creek on a 96-foot hewn-timber bridge supported on concrete piers and wing walls (Pl. XXXVI, *A*.)

The lower end of the pressure pipe connects to the unit inside the power house through a 90-inch butterfly valve operated by an electric motor.

The maximum water surface in the forebay is 3,210 feet, and the tail-water level at the power house is 2,991.7 feet, giving a static head of 218.3 feet.

GENERATING STATION.

Power house.—Hat Creek No. 1 power house (Pl. XXVIII, *A*) is 43 feet wide by 56 feet 6 inches long and 48 feet 2 inches high from the

A. HAT CREEK POWER HOUSE NO. 1, PACIFIC GAS & ELECTRIC CO., FROM THE FOREBAY.

Photograph by the company.

B. SINGLE-CIRCUIT TOWER, STANISLAUS LINE, SIERRA & SAN FRANCISCO POWER CO.

C. HIGH-TENSION SWITCHES, BAY SHORE SUBSTATION, SIERRA & SAN FRANCISCO POWER CO.

main (or turbine) floor level to the top of the parapet; the bottom of the tailrace is 33 feet 9 inches and the water surface in the tailrace 23 feet 9 inches below the main floor level. The building is constructed of reinforced concrete with steel frames (weighing 46.6 tons) and has concrete foundations.

A single room with main floor level at the top of the turbine scroll case occupies the entire interior of the building. The generator is raised 9 feet above the main floor on a hexagonal reinforced-concrete base, and about two-thirds of the length of the room is decked at generator level by a reinforced-concrete floor. This arrangement leaves the third of the room near the main entrance clear for the full height of the building, so that the 50-ton hand-operated traveling crane may be used in lifting not only from the generator deck but from the turbine floor.

The exciter unit is on the main (or turbine) floor near the front wall of the building in the end near the main entrance. The motor-driven mechanism operating the butterfly valve is on the same floor in the opposite end of the room, under the deck. The switchboard is on the generator deck.

The elevation of the generator floor is 3,024.5 feet above sea level; of the turbine floor, 3,015.4 feet; center line of turbine, 3,010.7 feet; tail-water surface, 2,991.7 feet.

Hydraulic equipment.—The butterfly valve connects the lower end of the pressure pipe to the cast-iron spiral casing of the 15,000-horsepower Wellman-Seaver-Morgan vertical Francis type turbine with 89-inch runner. The valve is provided with a motor-driven opening and closing mechanism. A 48-inch pressure regulator operates in conjunction with the turbine governor.

Generator.—The generator of the single vertical unit is a General Electric ATB form V 12,500-kilovolt-ampere 6,600-volt 1,093-ampere 3-phase 60-cycle alternator direct-connected to the turbine and operated at 225 revolutions per minute.

Exciter.—The General Electric MPC 150-kilowatt 250-volt 600-ampere continuous-current exciter is operated at 450 revolutions per minute by a 175-horsepower single overhung impulse wheel supplied through a double nozzle.

Wiring.—Energy generated at 6,600 volts at Hat Creek No. 1 power house is not stepped up at that station but is transmitted to Hat Creek No. 2 power house, where the transformers for both stations are installed. It is proposed to transmit from both Hat Creek power houses to Pit River No. 1 upon its completion for transformation to high-line voltage.

HAT CREEK PLANT NO. 2.

LOCATION.

Hat Creek No. 2 intake is at the center of sec. 29, T. 36 N., R. 4 E. The conduit runs northward through secs. 29 and 20, T. 36 N., R. 4 E. The power house is in sec. 20, just south of the town of Carbon. The plant was constructed by engineers of the company and was first put into commercial operation September 24, 1921.

CONDUIT.

The intake dam is a timber-crib and sheet-piling structure 456 feet long. The elevation of the original water surface at the dam was 2,986.2 feet above sea level, and that of the present spillway is 2,992.7 feet. A reinforced-concrete gate structure provided with two radial gates and trash racks of the same type as at Hat Creek No. 1 intake admits water to the canal heading on the west side of the stream. Like those at Hat Creek No. 1 intake, the gates are motor operated.

The entire conduit from intake to forebay is timber flume 4,400 feet long, 8 feet 2½ inches deep from floor to cap, 7 feet deep to water surface, and 16 feet 3½ inches wide. Its grade is 0.7 foot in 1,000 feet, and its estimated maximum capacity is 800 second-feet. The flume is laid on a bench which necessitated the excavation of 60,527 cubic yards and the placing of 793 cubic yards of wall to prevent slides. About 64 per cent of the 833 mud sills are concrete and the rest cedar. The 8 by 12 inch by 18 foot stringers are sugar pine; the caps, composed of two 4 by 8 inch by 20 foot pieces, are fir; the 6 by 10 inch by 10 foot posts are fir; and the sills, formed by two 6 by 8 inch by 24 foot pieces, are also fir. The flume box is 2 by 12 inch surfaced tongue and groove sugar pine.

A reinforced-concrete transition section 225 feet long connects the flume with the concrete gate structure at the head of the pressure pipe. The transition section is so designed that water spilled from both sides may run through a spillway chute to Hat Creek. The spillway contains 730 cubic yards of concrete, heavily reinforced, and necessitated the excavation of 3,824 cubic yards of earth and rock.

Two motor-operated radial gates protected by trash racks admit water from the forebay transition section to the head of the single riveted steel pressure pipe 419.82 feet long, which ranges from 10 feet in diameter and $\frac{5}{16}$-inch plate thickness at the top to 8 feet in diameter and $\frac{3}{8}$-inch plate thickness at the power house. In placing the pressure pipe 1,105 cubic yards of excavation was necessary. Two reinforced-concrete anchors containing a total of 161 cubic yards of concrete were provided along the line, but no expansion joints were installed. No butterfly valve or pressure regulator was installed at the power house. The pipe is laid above ground.

The maximum water-surface elevation in the forebay is 3,208.5 feet, and tail-water level at the power house is 2,991.7 feet, giving a static head of 216.8 feet.

GENERATING STATION.

Power house.—Hat Creek No. 2 power house is a reinforced-concrete building, with structural steel frame, measuring 43 feet wide, 56 feet 6 inches long, and 48 feet 2 inches high from the main floor level to the parapet. In size and general arrangement it is a duplicate of Hat Creek power house No. 1, save that transformers are installed outside the main entrance, and no butterfly valve is installed.

The elevation of the generator floor is 2,823.33 feet above sea level; turbine floor, 2,814.15 feet; center line of turbine, 2,809.40 feet; and tail-water 2,790.40 feet.

Hydraulic equipment.—The lower end of the pressure pipe connects directly to the cast-iron spiral casing of the 15,000-horsepower Wellman-Seaver-Morgan single vertical Francis type turbine with 80-inch runner. The exciter is operated at 450 revolutions per minute by a 175-horsepower Pelton water wheel similar in every respect to that at Hat Creek No. 1 power house.

Generator.—The electric generator of the single vertical unit is a General Electric ATB form V 12,500-kilovolt-ampere 6,600-volt 1,093-ampere 3-phase 60-cycle alternator, direct-connected to the turbine and operated at 225 revolutions per minute.

Exciter.—The exciter, similar to that at Hat Creek No. 1 power house, is a General Electric 150-kilowatt 250-volt 600-ampere compound-wound horizontal direct-connected generator operated at 450 revolutions per minute by a 175-horsepower Pelton impulse wheel.

Transformers.—The four transformers (a bank of three with one spare) installed at Hat Creek power house No. 2 receive the energy from that station and that from Hat Creek No. 1 and step it up to transmission voltage. The transformers are of the General Electric 8,000-kilovolt-ampere single-phase 60-cycle water-cooled outdoor type, with a ratio of 6,600 volts on the low-tension side to 63,500 volts or 110,000 volts Y on the high-tension side. The outgoing line running directly to Cottonwood, south of Redding, was in December, 1921, operated at 60,000 volts.

STEAM-ELECTRIC STATIONS.

STEAM STATION A, SAN FRANCISCO.

History.—The first section of station A, which now extends from 23d Street to Humboldt Street between Georgia and Louisiana streets, was constructed and put into operation by the Independent Electric Light & Power Co. in 1901 and was designed for one 500-

kilovolt-ampere and three 1,500-kilovolt-ampere units. Before the first section was completed, however, a fourth 1,500-kilovolt-ampere unit had been ordered, and later a fifth of the same size was put in place.

Immediately after the plant was purchased by San Francisco Gas & Electric Co., in the summer of 1903, two 1,500-kilovolt-ampere units were removed to it from the Townsend Street station and two 3,500-kilovolt-ampere machines were ordered, making 10 units in all.

Replacement of old reciprocating engines by large turbo-generators was begun in 1910 and has continued progressively to date. Since the completion of the bay cable across Golden Gate in 1915, the station has usually carried only part of Pacific Gas & Electric Co.'s San Francisco load, but in emergencies has carried the full city load, and at times of low water has transmitted power back through the general transmission system of the company to other districts.

Building.—The power house is a brick structure, 433 feet 7 inches long by 133 feet 7 inches wide, outside, not including a low cable terminal, switch and bus house on the Georgia Street (west) side. The building may be considered to consist of two long buildings placed side by side but separated by a common longitudinal wall. The boiler house (on the east side), is 63 feet 8 inches wide, and the generator building is 57 feet wide. The boiler house is divided into two rooms by a transverse wall, the north boiler room being 247 feet 3 inches and the south 173 feet 6 inches long. The generator room extends the full length of the plant—426 feet 9 inches. Both boiler and generator rooms are 62 feet 8 inches high to the lower chords of the steel roof trusses. A 50-ton electric traveling crane runs on tracks supported on shoulders in the generator-room walls and has a maximum lift of 50 feet.

The general arrangement of the generator room is well shown in Plate XXXV, *C* (p. 223), which was taken after the second turbo-generator was installed. The wall at the right in this picture is the longitudinal wall separating generator and boiler rooms.

In the south end of the south boiler room 12 boilers are arranged in two rows of 6 each, backing against the side walls of the room and facing on a central aisle 17 feet 9 inches wide. In the north end of the south boiler room, and on the other side of the transverse wall in the south end of the north boiler room, there are 10 boilers in a single row facing toward the east wall, with auxiliaries such as feed pumps, oil pumps, economizers between their backs and the generator-room wall. In the north end of the north boiler room are eight boilers in two rows, facing each other with an aisle between, on the main axis of the room, and one separate boiler.

Mechanical equipment.—Original units 1 to 6 were supplied with steam by fifteen Babcock & Wilcox 524-horsepower boilers designed for operation at 200 pounds pressure, arranged in general in batteries of two, the first 12 boilers being in the north boiler room. The station was equipped with Green fuel economizers, Wheeler Admiralty condensers, and Snow Duplex feed pumps.

When units 7 to 10 were put in, six 686-horsepower Babcock & Wilcox boilers with superheaters and six 541-horsepower Heine boilers, also provided with superheaters, were added, giving a total capacity of 15,222 boiler-horsepower for 18,000 kilovolt-amperes in reciprocating units.

After the installation of turbines was begun, the Heine boilers were replaced by six 822-horsepower Stirling boilers, and ten of the original Babcock & Wilcox were equipped with Foster superheaters for 100° superheat. In 1919 three of the old 524-horsepower Babcock & Wilcox boilers were removed to make room for eight Stirling 822-horsepower boilers, giving a total boiler capacity of 21,388 horsepower.

Two Wheeler condensers were installed with the first turbo-generator (now designated unit No. 6), one in its base and the second or auxiliary just in front of the unit. These condensers are of the 2-stage type, and have a cooling surface of 25,000 square feet. The Worthington 2-stage condenser serving the second turbo-generator (unit No. 5) is contained entirely within its base and has a cooling surface of 19,150 square feet. The Wheeler 2-stage condenser for the third turbo-generator (unit No. 7) is also contained within the turbine base and has a cooling surface of 29,000 square feet. The Wheeler surface condenser for the last turbo-generator (unit No. 4) is in a basement excavated under the unit and has a total cooling surface of 25,000 square feet.

The circulating pumps draw the cooling water from a sump to which it is admitted from the bay through a 60-inch pipe and system of screens. Four pumps are now in operation. All four were manufactured by the Byron Jackson Co. and are of centrifugal type. No. 1, operated by two 400-horsepower motors, has a capacity of 35,000 to 40,000 gallons per minute; No. 2, operated by a 400-horsepower motor, has a capacity of 30,000 gallons; No. 3, operated by a 700-horsepower motor, has a capacity of 30,000 gallons; and No. 4, operated by a 600-horsepower motor, has a capacity of 28,000 to 30,000 gallons. The pumps are arranged tandem above the axis of the discharge pipe, with their double suction pipes extending down on either side of the 60-inch circulating main, and each pump connecting to it through a downturn casting. The circulating main from the pumps to the condensers is 60 inches in diameter.

Dry vacuum is maintained by a Laidlaw-Dunn-Gordon 14 by 39 by 30 inch pump, a C. & G. Cooper Co. 15 by 36 by 34 inch and a Wheeler 16 by 42 by 24 inch rotative dry vacuum pump, and four Wheeler Radgett air pumps.

The four feed-water pumps have a combined capacity of 1,890 gallons per minute. Fuel oil is delivered by two Snow pumps having a combined capacity of 320 gallons per minute.

Eight hot-well pumps, driven by motors or by steam turbines, have a combined capacity of 4,880 gallons per minute.

A 75-gallon R. D. Wood & Co. accumulator maintains a pressure of 1,000 pounds per square inch, step-bearing oil being provided by a Dean 5½ by 3¾ by 5 inch and a Worthington 10 by 6 by 10 inch duplex pump.

Electrical equipment.—Old units Nos. 1 to 8, inclusive, have been removed from the plant from time to time as the installation of turbo-generators has proceeded. Old unit No. 1 was a Westinghouse 2-phase 60-cycle 500-ampere 500-volt 500-kilovolt-ampere alternator, operated at 157 revolutions per minute by a McIntosh & Seymour compound vertical engine rated at 760 indicated horsepower.

Old units Nos. 2, 3, 4, 5, and 6 were Westinghouse 62-pole 500-volt 1,500-ampere 1,500-kilovolt-ampere 2-phase alternators, operated at 157 revolutions per minute, direct-connected to McIntosh & Seymour compound vertical engines, rated at 2,400 indicated horsepower.

Units Nos. 7 and 8 were the 1,500-kilowatt units moved from the Townsend station.

Units Nos. 9 and 10, the only part of the old equipment remaining in place, are General Electric ATB form F class 68–3 500 B–106 11,000-volt 184-ampere 3-phase alternators, installed at the same time. All four units 7, 8, 9, and 10 were driven by triple-expansion engines manufactured by the Union Iron Works.

In 1910 it became apparent that additional steam-generating capacity would be needed on the system, and unit No. 6 was removed to provide room for a 5-stage General Electric-Curtis 11,000-volt 12,000-kilovolt-ampere vertical turbo-generator, operated at 720 revolutions per minute. This is now designated unit No. 6.

Early in 1912 a 6-stage General Electric-Curtis 11,000-volt turbo-generator, of 15,000-kilovolt-amperes capacity and operating at 720 revolutions per minute, was installed in the space occupied by old unit No. 5, which was removed in the fall of 1911 to make room. This unit is now designated No. 5.

In the fall of 1913 the company began the installation of a 15,000-kilovolt-ampere 7-stage General Electric-Curtis 11,000-volt turbo-generator, designed to operate at 175-pounds pressure with 100° superheat and 28½ inches vacuum. This unit occupied the place of the two 1,500-kilovolt-ampere generators which were operated by triple-expansion engines—units 7 and 8, and is now designated No. 7.

In installing the fourth turbo-generator, during 1918-19, all the old units numbered 1 to 4 were removed, although the new machine occupies only part of the space vacated. The unit (No. 4) is a General Electric-Curtis 11,000-volt 15,000-kilovolt-ampere turbo-generator of the horizontal type, operated at 1,800 revolutions per minute. The condenser for the unit is beneath it in a basement.

Six exciters supplying the entire plant are on the main floor between units 4 and 5. Two exciters of 100 and one of 200 kilowatts capacity are driven by turbines, one of 100 kilowatts by an engine, and one of 200 kilowatts and one of 250 kilowatts by motors.

The station is connected to station H—the old Martin station near Visitacion Valley, which steps up such power as is transmitted to the hydroelectric lines to 60,000 volts. Station A is also connected to several of the other San Francisco substations through 11,000-volt feeder cables. By these various connections it can feed either the city distribution or the hydroelectric section.

STEAM STATION C, OAKLAND.

History.—As a large steam auxiliary, station C dates back only to 1908, when the first turbo-generator in the plant was put into operation by Pacific Gas & Electric Co. The company had, however, for some time previously operated an old reciprocating engine equipment on the same premises. Early in the spring of 1912 the 9,000-kilowatt turbo-generator of 1908 was reinforced by the addition of a 12,000-kilowatt unit of the same type.

Building.—Station C is near the corner of First and Jefferson Streets, on the water front of Oakland. The building has a structural-steel frame and reinforced-concrete front; the covering of the rest of the plant is galvanized corrugated iron. The layout provides for extension and is of the same form as the Long Beach plant of Southern California Edison Co. (see p. 677), although the building is not so permanent in type of construction. The building was originally T-shaped, with the generator room in the cross and the boiler rooms in the shank of the letter, a plan that lent itself readily to extensions by simply lengthening the generator room and adding boiler rooms to these extensions parallel to the old room. It has been extended to 184 feet 4 inches by 155 feet 8 inches in plan, with an addition for the latest installation of boilers extending along Jefferson Street to Water Street.

The Oakland plant normally operates 19 hours per day, with one turbine floating on the line and generating not more than 100 or 200 kilowatts, except during the peak in the evening, when a load of about 6,000 kilowatts is carried. When minor troubles occur on the transmission system the station instantly picks up a load of about

6,500 kilowatts, and if the difficulty continues, this load may, within two minutes, be increased to 12,000 kilowatts.[59]

Mechanical equipment.—The station is equipped with eight 750-horsepower McNaul water-tube boilers, four 773-horsepower Parker water-tube boilers, eight 822-horsepower Stirling water-tube boilers, two 600-horsepower Stirling water-tube boilers, and four 524-horsepower Babcock & Wilcox water-tube boilers. The total boiler capacity is 18,964 horsepower. All boilers are fired by fuel oil and supplied with feed water from a well on the property. Each of the Parker boilers contains 366 4-inch tubes, 20 feet long, presenting a heating surface of 7,734 square feet; the grate surface is 48 square feet.

The eight McNaul boilers are arranged in two opposite rows, with their fronts toward the main aisle down the center of one of the boiler rooms and their backs toward the side walls. The eight are arranged in four batteries of two each, two batteries on each side of the room. The equipment on each side of the room is served by a single self-supporting steel stack 125 feet high and 10 feet in diameter. Four Stirling boilers are arranged in a row opposite the four Parker boilers in the east boiler room. The Babcock & Wilcox boilers are set singly, each at the south end of the four rows of boilers. The six Stirling boilers latest installed are set in two rows in the new addition.

The Worthington condenser of the 9,000-kilowatt turbine is separate from the unit, and is raised above the floor between the unit and the back wall of the generator room; that of the 12,000-kilowatt unit is of the turbine-base type, and that of the new 12,500-kilowatt turbine is a Wheeler surface condenser of 25,000 square feet cooling surface. The Worthington 2-stage condenser of the 12,000-kilowatt unit contains 5,600 tubes, each 17 feet 2 inches long, giving a total surface of 25,000 square feet. The cooling water for all condensers is drawn from the bay through a concrete tunnel 4 feet by 6 feet 3 inches.

The circulating pump for the 9,000-kilowatt unit is a Byron Jackson centrifugal pump with a capacity of 30,000 gallons per minute. It is direct-connected to a 400-horsepower 4,000-volt 3-phase induction motor, which is controlled from a switchboard at the north end of the pump room. A Wheeler vertical feed-water heater with 1,000 square feet of heating surface is provided with the 9,000-kilowatt unit. Both Worthington hot-well pumps for this unit are motor driven—one by a 20-horsepower direct-current motor, the other by a 20-horsepower alternating-current motor. The hot well is of steel, 10 by 5 by 6 feet. Vacuum is maintained by a Worthington horizontal 12 by 12 by 18 inch dry vacuum pump. Two Dow vertical duplex 14 by 10½ by 24 inch feed pumps are used

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[59] Delaney, C. H., Oil-burning standby plants: National Electric Light Assoc. Proc., 1915.

on the boiler feed system. The step bearings are supplied with oil by two Dean pumps at a pressure of about 1,200 pounds, and the guide bearings by two pumps of the same make but of low pressure. A Turner filter is used on the lubricating system. The accumulator, of the cast-iron weight type, has 10-inch diameter and a stroke of 12 feet 4 inches and was manufactured by R. D. Wood & Co.

The Byron Jackson centrifugal circulating pump installed with the 12,000-kilowatt unit has a capacity of 40,000 gallons per minute and is operated by a 16-inch and a 27 by 35 inch American Engine Co.'s engine. The 12,000-kilowatt unit is provided with a Wheeler vertical closed feed-water heater, with 2,000 square feet of heating surface. One of the Worthington 2-stage hot-well pumps is driven by a motor and the other by a steam turbine. The hot-well tank is of steel, 10 feet by 6 feet in plan and 5 feet high. The rotating dry-vacuum pump, manufactured by Laidlaw-Dunn-Gordon Co., has 14 by 39 by 30 inch cylinders. The feed pumps are an Alberger 4-stage turbo-driven centrifugal and a Platt 6-stage motor-driven centrifugal. The step bearings are supplied with oil by two Dean 12 by 2⅞ by 12 inch pumps, and the guide bearings by two 5½ by 3¾ by 5 inch pumps of the same manufacture. The oil-return pumps are two Snow 5¼ by 4¾ by 5 inch pumps. The Turner oil tank filter is 12 feet 3 inches by 4 feet by 5 feet high. An R. D. Wood 11½ inches by 14 feet stroke accumulator of the tank-ballast type can maintain 1,150 pounds pressure.

The 12,500-kilowatt horizontal turbine is provided with a Byron Jackson centrifugal circulating pump, which is driven through a reduction gear by a Westinghouse steam turbine. Two feed-water heaters of the open type are installed. Turbo-driven centrifugal feed pumps built by the A. S. Cameron Steam Pump Works are used; they are driven by Sturtevant steam turbines. As in the 12,000-kilowatt vertical unit, there are two hot-well pumps, one turbo-driven and one motor-driven. Four Wheeler rado-jets are used on the vacuum system. The lubricating oil is filtered by a Richardson Phoenix filter. The generator is filled with an air washer, insuring clean cooling air. Air washers have recently been installed on the two older generators. A combination hot-well tank and grease extractor is located in a small steel and corrugated-iron building at the rear of the main building. Feed water from all three units goes through this tank. The 12,500-kilowatt unit was put into operation March 15, 1921.

Electrical equipment.—Unit No. 1 is a 9,000-kilowatt General Electric-Curtis vertical 3-phase 60-cycle turbo-generator; the No. 2 or 12,000-kilowatt unit is of the same type but has a condenser base; and the No. 3 unit is a horizontal General Electric 12,500-kilowatt

3-phase 60-cycle turbo-generator. No. 3 operates at 720 revolutions per minute and generates 3-phase 60-cycle alternating current at 4,150 volts potential. The exciter is a 125-volt direct-current generator driven by a Curtis turbine.

STEAM STATION B, SACRAMENTO.

History.—The Sacramento steam plant[60] was completed by Pacific Gas & Electric Co. in the fall of 1912. It is on a 4-acre tract a short distance north of the city limits of Sacramento, and on the east bank of Sacramento River, from which it draws its condenser-cooling water supply.

Building.—The entire station is housed in a single L-shaped building, which consists of a generator room with its main axis at right angles to the course of the river, and a boiler room with its main axis parallel to the river extending back from the river end of the generating station. The total length of the building on its west side (Pl. XXIX, *A*) which is parallel to the river and includes the depth of the generator room and the length of the boiler room is 156 feet 5 inches. The length of the generator room at right angles to the river is 100 feet 6 inches, and the width of the boiler room in the same direction is 71 feet 4 inches. The entire station is on a terrace 10 feet above the general ground level and rests on a pile foundation which contains about 500 piles 35 feet long, cut off below the elevation of ground water. Each pile was driven until it would support a load of 35 tons with $\frac{3}{16}$-inch settlement. The frame of the building is of structural steel, and the curtain walls, floors, and roof are of reinforced concrete. The boiler room is 40 feet and the part of the building containing the generator is 70 feet high.

The boiler room has only one floor and extends the full height of 40 feet. The boilers are set in batteries, backing on the side wall and facing the main central aisle which leads from the generator room. A glazed monitor ventilator admits light. Room is provided for four batteries of boilers, each supporting its own stack, but only three batteries are in place, the southwest corner of the room being vacant.

The generator room is divided into two parts. The first of these—the generator bay—is on the south side of the room toward the boiler room; it measures 38 feet wide and runs the full length of the room—100 feet. This space is divided into two floors, with the auxiliary equipment on the main floor and the single turbine on the second floor. Above the generator floor there is a 40-ton traveling crane. The second part of the generator room may be called a switch bay; it extends the full length—100 feet—of the north face of the

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[60] Information concerning this station drawn from an article by Paul E. Magerstadt, superintendent of construction, which appeared in the Pacific Gas & Electric Mag., p. 155, October, 1912.

building, is divided into three floors, and is given over to the electrical machinery, comprising transformers, bus-bar cells, and switching equipment. The station may be extended at the east end, which now has but a temporary wall; there is room in the west end of the present generator room for the future installation of a 7,500-kilowatt vertical turbo-generator.

Mechanical equipment.—The single unit now in place is served by four Sterling water-tube boilers, each containing six hundred $3\frac{1}{4}$-inch tubes, three 42-inch steam drums, and one 18-inch mud drum. The boilers are arranged in two batteries of two each, one battery being on the east and one on the west side of the boiler room. Each of the boilers is rated at 822 boiler horsepower, giving a total of 3,288 boiler horsepower. The steam equipment is designed to operate at 200 pounds pressure with 125° superheat. All fittings and castings larger than 2 inches in diameter are steel, and all pipes are protected by magnesia asbestos covering 2 inches thick. The steam piping is so arranged that any part of the equipment may be cut out for repairs without shutting down the plant. Each battery of boilers is provided with a self-supporting steel smokestack 100 feet high and 7.6 inches in diameter. The furnaces are supplied with fuel oil from two 200-barrel service tanks which are just behind the boiler room and sunk below the floor level, and are filled from two 10,000-barrel steel tanks at the east end of the property about 450 feet from the main station. These storage tanks can be filled from oil barges brought up the river and moored at the company's wharf. The oil is brought from the main supply to the building through an 8-inch pipe line incased in sawdust, with a 2-inch steam line to heat the oil. From the service tanks it is handled to the burners by Worthington duplex pumps. Each boiler is provided with three Peabody back-shot burners.

The condenser is on the main floor of the generator bay immediately below the generator, which is in the extreme east end of the bay and is raised to the second floor level on a foundation of six concrete columns. The condenser contains about three thousand 1-inch brass tubes 14 feet long, which give a cooling surface of 10,000 square feet. It is set up above the floor level on a steel column support. Two 4-inch hot-well pumps are under the condenser. One is driven at 1,500 revolutions per minute by a Kerr steam turbine, and the other by a 20-horsepower 110-volt direct-current interpole motor. Directly toward the south wall from these is one Stillwell feed-water heater and the hot-well tank. West of the turbine foundation and the condenser there is a Wheeler Rotex 20 by 40 inch vacuum pump driven by a 7 by 7 inch Simplex vertical engine.

The circulating pump for the condenser is placed in a pit in the center of the ground floor of the generator bay and 10 feet below the floor level. The pump is a Byron Jackson 30-inch double-feed centrifugal, connected to an American Ball compound engine. The supply is drawn from the river through a 36-inch cast-iron pipe, and after passing through the condenser it is returned to the river through a similar main. At its outer end the intake main is about 10 feet above the low-water mark. As the river has a range in stage of more than 25 feet between the extreme low and extreme high water, a special tee joint, which revolves in cast bearings, was designed to fit onto the end of the main. At the end of this revolving pipe, which may be raised or lowered by a winch on the pile intake frame, there is a foot valve and a strainer. There are two angles at the end of the discharge pipe so that it discharges horizontally at a point below the lowest water and downstream from the intake.

The boiler feed water can be drawn from the river or from a well on the premises, the source depending on the stage of the river water. It is served to the boilers by a 4-inch 4-stage Alberger rotary pump, direct-connected to an Alberger-Curtis steam turbine, and by a Dow horizontal compound duplex 9 by 16 by 7 by 12 inch pump. The equipment is on the main floor under the generator. The feed-water heaters are next to the boiler-room wall, west of the circulating-pump pit.

Electrical equipment.—The single main generator in place is a horizontal General Electric-Curtis 5-stage 5,000-kilowatt 3-phase alternator and is in the extreme eastern end of the generator bay. It is raised to the second-floor level and is surrounded by a steel operating platform, provided with pipe guards around the well holes. The duplicate exciter equipment is carried on the north side of this platform. No. 1 exciter is a steam-driven 6-pole interpole 75-kilowatt 120-volt direct-current generator, direct-connected to a Curtis noncondensing steam turbine, designed for 175 pounds pressure. No. 2 exciter is a 100-kilowatt 125-volt direct-current generator, driven through a rigid coupling by a Fort Wayne 150-horsepower 3-phase 220-volt induction motor, at a speed of 870 revolutions per minute.

In the switch bay there are, on the first floor, seven 1,500-kilowatt General Electric oil-insulated water-cooled transformers, with a ratio of 31,215/54,000 Y on the high-tension and 11,250/19,500 Y on the low-tension side. In front of these transformers there is a row of concrete 11,000-volt bus cells for the duplicate busses. At the east end of the transformer space there is a 5,000-kilowatt oil-insulated water-cooled transformer which acts as a reactance in the generator circuit and also transforms from 4,000-volt generator current to the 11,000-volt potential of the low-tension busses.

The second floor of the switch bay contains offices and locker room, store room, and laboratory, a switchboard space, and a double row of 12 cells containing an H–3 General Electric motor-operated 11,000-volt circuit breaker. The nine-panel switchboard is set on the arc of a circle just south of these cells and facing out onto the part of the generator operating floor west of the present unit. At the extreme east end of the gallery is a switch cell containing two 4,000-volt 3-pole H–3 circuit breakers on the main generator leads, and near it are the concrete cells containing the disconnector and series and shunt transformers for supplying the generator switchboard instruments.

The third floor in the switch bay is entirely inclosed and forms a 60,000-volt bus and switch gallery, in which there are seven sets of switches—3 phases each—arranged in two parallel rows, each having its own cell. The three high-tension circuits from the transformers on the first floor are brought up to these switches through the line cells having an inside clearance of 36 inches. The high-tension bus is carried by suspension insulators from the roof trusses and is provided with sectionizer at its center. The 60,000-volt lines pass into a closed monitor from the circuit breakers and then run horizontally through double-glazed windows to Baum horizontal 2-break rotary disconnecting switches, mounted on the steel frame of the roof and operated from a platform on top of the monitor. From the insulators along the north parapet of the roof the lines run down to the steel switch tower along the north side of the plant. This tower is connected to the main transmission line at Sacramento by a branch line 1½ miles long carried on 78-foot double circuit steel towers.

TRANSMISSION AND DISTRIBUTION SYSTEM.

LINES INHERITED.

Up to 1913 the dominating features of the Pacific Gas & Electric transmission system were those inherited from the two constituent companies which were the first to bring power from the Sierras to San Francisco—Bay Counties Power Co. and The Standard Electric Co. of California. In 1913, however, on completion of the Drum plant—the first of the series of seven plants which is to form a progressive development of the Bear and Yuba River drainage basins—important changes in the transmission system were begun.

Bay Counties Power Co.'s lines were run from Colgate power house on Yuba River southwesterly through Wheatland, Davis, and Suisun to Carquinez Straits where, in a record-breaking span, they crossed to Port Costa, on the south side of the straits, and continued over the rolling country of Contra Costa County to Oakland. A branch line was constructed from the twin lines at Fairfield, north of Carquinez, toward the west, through Napa, to join a main line between Sausalito and Santa Rosa at Petaluma. At the north side of Carquinez Straits small branches supplied Vallejo and Benicia. There were also branches running from Colgate power house directly to Oroville, Marysville, Nevada City, and Sacramento.

The two circuits of the Colgate-Oakland transmission as originally constructed were carried by twin pole lines 25 feet apart, each line carrying a single 3-phase circuit. One circuit was of No. 00 hard-drawn copper and the other of 4/0 seven-stranded aluminum cable of equal conductivity. Round cedar poles, which averaged 35 feet but ranged from 25 to 60 feet in length, were used. In ordinary ground the post holes were from 5 to 8 feet deep, the depth depending on the length of pole. Poles at angles were set a foot deeper. The normal span was 152 feet. The transmission line was designed for an ultimate potential of 60,000 volts, at which it is now operated. The total length of the lines from Colgate to Oakland is 142 miles.

Shortly after beginning operation, the Bay Counties Power Co. began to serve power to The Standard Electric Co. at Oakland for transmission over its line to San Jose (pending the completion of the Electra-San Francisco line), thus giving a total length of transmission of 184 miles.

TABLE 33.—*Details of poles of double line, Colgate to Oakland.*

Height.	Top.	Butt.	Depth in ground.
Feet.	*Inches.*	*Inches.*	*Feet.*
25	8	12	5
40	9	14	6
45	10	15	6.5
50	11	16	7.5
60	12	18	8

The pole tops were painted with hot tar paint and the butts treated with hot carbolineum. The wires have equilateral spacing of 36 inches ordinarily, and 42 inches at transpositions, which occur every mile. The transpositions are to the right on one line and to the left on the other. A great deal of the line crossed over hardpan, which had to be blasted.[61]

The spanning of Carquinez Straits was the boldest feature of the Bay Counties lines, and even now, after the completion of several tower lines and the Golden Gate submarine cable, remains one of the most noteworthy features of the transmission system.

Power is transmitted across this very long span through suspended 19-strand plough-steel cables, each seven-eighths of an inch in diameter. Although the hills rise to a considerable height on both shores of the straits, it was necessary to erect a tower at each end of the span (Pl. XXXII, *B*, p. 222), in order to secure the clearance required by shipping.

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[61] Low, G. P., Jour. Electricity, vol. 11, p. 145, 1901.

When the crossing was first constructed there were four cables in the span—three for the regular 3-phase circuit and the fourth for emergency use. The cables were suspended from insulated brackets, supported at each tower on four cantilever beams which projected alternately from each side of the structure. Each of these beams was on the opposite side of the tower and separated 10 feet (vertically) from the beam next above or below it, so that the cables would not interfere by swinging against each other. Each beam consisted of two wooden timbers, 17 feet 8 inches long, 7¾ inches thick, and 15¾ inches deep. Near the outer end of the beam there were three cross timbers 7¾ by 9¾ inches in section and 6 feet long, and on each of these cross timbers were mounted two steel insulator pins, which in turn carried porcelain insulators. The insulators weighed about 50 pounds and were tested up to 120,000 volts. The pins were $14\frac{11}{16}$ inches high above the cross arms. The head of each insulator was countersunk into the timbers of a framed "raft," or upper platform, built of wood, covered with painted canvas, and supported wholly by the insulators. This platform carried a cable saddle of galvanized iron which measured 3 feet long by 2 feet 2 inches wide with an extreme height of 9 inches. A channel in the top of this saddle carried five cast-iron sheaves whose centers were on an arc of 8 feet radius in the plane of the cable. The sheaves had a diameter of 5⅞ inches and a width of 3 inches. A variation of 60° Fahrenheit in temperature was calculated to cause a variation of 5 feet in the sag and a travel of 2 inches where the cables passed over the sheaves.

The cables were carried back to strain insulator anchorages at each end of the span, after passing over the sheaves on the tower cross arms. The normal strain in each cable is 22,500 pounds. The concrete-block anchorages had bases 9 by 10 feet in plan, were 5 feet high, and were set in bedrock. Each cable extended down from the tower to a 24-inch sheave, around which it was turned and secured with clamps. The sheave was held by the outer end of a heavy, especially designed insulator, which in turn connected to eyebolts fastened to cross channels embedded in the concrete anchor block.

The following table gives the main dimensions of the span as it was with only four cables in place:

TABLE 34.—*Principal dimensions of Carquinez span.*

	Feet.
Length between anchorages	6,292
Length of main span from north tower to south tower	4,427
Length of suspended line	4,448
Distance from north tower to subtower	1,385
Subtower to extreme anchorage	325
Height of north tower above foundations	224
Height of foundations above water surface	162

	Feet.
Distance from north tower to lowest point in span of cable	1,972
Distance of lowest point in span of cable below point of support at north tower	147
Distance from south tower to extreme point of anchorage	125
Height of south tower above foundations	64
Height of foundations above water surface	400
Distance from south tower to lowest point in span of cable	2,455
Distance of lowest point in span of cable below point of support at south tower	227
Height of lowest point of lower cable above extreme high water lines	206
Width of strait at crossing	2,769

The four cables originally installed at the Carquinez crossing were increased in 1914 to six, which now form two 3-phase circuits across the straits. In thus increasing the capacity of the crossing it was necessary to replace the four wooden cantilever cross arms on each tower by three steel beams which extend clear through the tower framework and overhang at either side, so that each beam supports two conductors. These beams are in the same vertical plane and are 10 feet apart; the horizontal distance between the circuits on either side of the tower is 20 feet. The anchorages and insulating arrangements were remodeled to conform with modern practice at the time that the new cables were added.

The line of The Standard Electric Co. of California ran from Electra power house, on Mokelumne River, southwesterly through Stockton and Hurdlyn to Mission San Jose and thence around the south end of San Francisco Bay to San Francisco. Branch lines from the power house transmitted power to the mines in the Mother Lode district from Amador south to Sonora, and a line from Mission San Jose northward tied in to the Bay Counties system at Oakland.

All poles on this line were of sawed redwood, taken from the heart of the tree, and had the following dimensions:

TABLE 35.—*Dimensions of poles on lines from Electra plant.*

Height.	Top.	Butt.	Depth in ground.	
Feet.	*Inches.*	*Inches.*	*Ft.*	*in.*
30	7 by 7	12 by 12	5	
35	7 by 7	13½ by 13½	5	6
40	8 by 8	13½ by 13½	6	
45	9 by 9	15 by 15	6	6
50	10 by 11	16 by 16	7	
60	11 by 11	17 by 17	8	

In soft ground the poles were set 6 inches to a foot deeper than ordinarily. In marsh land a Maltese cross of 2 by 8 inch timbers was spiked on to the bottom of the pole, and sod piled on the cross. On all angles greater than 2½° the poles were strutted from the inside of the angle. On extreme angles a strut was used as an anchor. In crossing water each pole was supported on top of a pile. In crossing navigable water, where clearance of 115 feet was required, steel towers were used 150 feet high, designed to carry two circuits of 3 wires each, one above the other. The longest span was 618 feet with a sag of 19 feet, and 12 feet was allowed for a second line on the same tower, giving a total height of 146 feet to the upper line.

Three aluminum conductors, each seven-eighths inch in outside diameter, made up of 37 strands having a total cross section of 471,034 circular mils were used on this line. The weight of each conductor was 2,404 pounds per mile, and tensile strength 28,000 pounds per square inch. Deflections were calculated for maximum strength 4,000 pounds per square inch, giving a factor of safety of 7 at 20° F.

Eucalyptus insulator pins were used. Their largest diameter was 2¾ inches, tapering to 2½ inches at the upper shoulder. The diameter at the base of the thread was 1½ inches and that at the top 1⅜ inches; they had four threads per inch. The length of the pin over all was 16⅞ inches. The insulators had two petticoats and a sleeve around the base of the pin. The diameter of the upper petticoat was 11 inches, and the height from bottom of the sleeve, which rests against the cross arm, to the groove, for the cable at the top of the insulator, was 15 inches. The upper petticoat of the insulator and the sleeve around the pin were of porcelain, and the lower petticoat of glass.[62]

The following tabulated data [63] give the chief characteristics of the Bay Counties and Standard systems as they were in 1902:

TABLE 36.—*Principal features of Bay Counties and Standard companies' transmission systems in 1902.*

From—	To—	Circuits.	Phase.	Material.	Size.	Length.
					Circular mils.	*Miles.*
Electra [a]	Stockton	1	3	Aluminum cable	471,034	46
Stockton	Mission San Jose	1	3	Special aluminum cable	471,034	49.6
Mission San Jose.	Oakland	1	3	do	188,230	26.3
Alviso	San Jose	1	3	Aluminum wire	No. 1	8.5
Mission San Jose.	Alviso	1	3	Aluminum cable	352,300	9.5
Do	Redwood	1	3	do	352,300	16.3
Redwood	San Francisco	1	3	do	352,300	32.5
Electra	Oakland	1	3	do	352,300	122
Do	San Jose	1	3	do	352,300	113.6
Do	San Francisco			do		153.9
Angels [b]	Amador City	1	3	Copper wire	No. 3	46
Colgate	Oroville	1	3	Aluminum cable	No. 4	28
Do	Nevada County power house.	2	3			7
Do	Old Yuba power house.	2	3	Aluminum cable	No. 4	8
Old Yuba power house.	Marysville	2	3	Copper wire	No. 6	18.75

[a] Not yet in service when table was prepared.
[b] Operated from old Blue Lakes power house.

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[62] Poole, C. O., Jour. Electricity, vol. 11, p. 185, 1901.
[63] Jour. Electricity, vol. 12, p. 54, 1902.

TABLE 36.—*Principal features of Bay Counties and Standard companies' transmission systems in 1902*—Continued.

From—	To—	Circuits.	Phase.	Material.	Size.	Length.
					Circular mils.	*Miles.*
Colgate	Sacramento	2	3	Aluminum cable	No 4.	61
Do	Oakland	2	3	North circuit No. 00 Brown & Sharpe gage copper; south circuit No. 0000 Brown & Sharpe aluminum cable, Colgate to Suisun, and No. 00 Brown & Sharpe gage copper Suisun to Oakland.		132
Cordelia	Penn Grove	1	3	No. 4 Brown & Sharpe gage 3-strand aluminum cable.		26
Penn Grove	Sausalito	1	3	do		32
Do	Santa Rosa	1	3	do		13
Colgate	Sausalito					165
Do	Cordelia					107
Do	San Francisco					211.75

When these lines and the smaller systems now belonging to Pacific Gas & Electric Co., were brought under one management they were interconnected, and in 1907 a transmission map of the combined systems would have shown, in addition to the lines noted above, a loop from Oroville substation northward to Centerville power house and then southwest through Durham to Gridley, Yuba City, Marysville, and the Nicolaus station on the Twin Lines. From this loop a branch ran to Chico, where connection could be made with the Northern California Power Co.'s lines, and branches were run from Gridley westward to Colusa and northwestward to Biggs. The line from Folsom power house to Sacramento, the line from Alta power house southwest to Sacramento, and a line through Grass Valley and Nevada power house to Colgate power house had also been added to the northern system. From Hurdlyn, on the Electra line at the west side of the Sacramento Valley, a line had been run northwestward to connect with the Bay Counties' lines at Martinez. Small extensions from the system had been made along the Mother Lode, lines had been run southwest from Mountain View, and from various substations short branches had been put out to connect with towns along the main lines.

When the various companies were consolidated in 1903, California Gas & Electric Corporation found itself in possession of lines which were designed for and operated at voltages ranging from 5,500 at the Nevada plant, Grass Valley, up to 60,000. In the succeeding years steps were taken to secure a uniform potential throughout the system and bring all main lines to a potential of 60,000 volts. The company still operates certain parts of its mountain lines at 18,000 and 30,000 volts, but all of its main transmission has now been raised to 60,000 volts except the Drum-Cordelia tower line, which is operated at 110,000 volts. The main tower line of Sierra & San Francisco Power

Co. (described on pp. 328–329), forming part of the system leased January 1, 1920, is operated at 104,000 volts.

REORGANIZATION OF TRANSMISSION SYSTEM.

The first great step in reorganizing the transmission system was the construction of the steel tower line from Drum power house to a large receiving station at Cordelia, north of Carquinez Straits and near the company's load center. Radiating pole lines were constructed to connect from this station with several of the older transmission lines, and later, in 1915, a tower line was constructed from Cordelia running southwesterly to the north shore of the Golden Gate and two submarine cables were laid across the Gate to San Francisco, thus giving the city and peninsula south of it the benefit of double service around both the north and south ends of San Francisco Bay. The service around the south end of the bay, however, depended chiefly on the Electra pole line, which had been in operation for many years, and therefore on completion of Halsey and Wise plants a steel tower line was run southward from those power houses to a point a short distance east of Stockton and thence southwesterly to Mission San Jose, near the southern end of San Francisco Bay. This line is to be extended around the end of the Bay and northward to San Francisco, thus completing the steel-tower loop which will inclose a large part of the company's territory. San Jose is connected by a branch tower line from the main transmission system at the southern end of the bay.

DRUM-CORDELIA TOWER LINE.

The steel-tower transmission line from Drum plant to Cordelia substation, operated at 110,000 volts, is typical of the standards now used by the company. Although eventually this line will carry two circuits, only one has been installed. This line is of a composite construction, both in regard to conductors and steel tower supports. For 12.6 miles from the power house, the single 3-phase circuit is carried on 4,200-pound 50-foot A-frame towers which support the three conductors in a horizontal plane 46 feet above the ground. From the lower end of this section the standard double-circuit line of 82-foot towers extends the remaining 96.9 miles to Cordelia, giving a total length for the line of 109.5 miles. The A-frame towers in the first part of the line (nearly 13 miles) are used because at times the district is subject to heavy snowfall. The double towers begin at the point where the line reaches the country below the region of very heavy snowfall. On account of the snow and the unequal spans at certain places, 3/0 7-strand copper cable conductor is used on the first 31 miles of the line, in the mountains and foothills. Across the valley there are 58 miles of 5/0 19-strand aluminum cable, and at the end of this section there is another stretch of 21 miles of 3/0 7-strand copper conductor, which is used here on account of unequal spans and on account of sea fogs which drift through the Straits of Carquinez.

Excavation for foundations on the Drum-Cordelia tower line amounted to 17,000 cubic yards, and in the tower foundations 7,600 cubic yards of concrete was used. The total weight of the towers on the line was 5,000,000 pounds and the average haul 8 miles. The weight of the conductors amounted to 664,000 pounds. A truncated four-sided pyramid of concrete supported each of the four legs of each tower. These pyramids were 6 to 7½ feet deep, 4 to 5½ feet square at the bottom, and 15 inches square at the top. They were of three standard classes, depending on the size of the tower which they were to support. These three classes took 32, 42, and 72 cubic feet of concrete per leg, respectively. Angle-iron foot stubs were spaced by templets, and embedded firmly in the concrete.

Standard two-circuit towers had a total height of 82 feet, and height to lower wire of 54 feet. Three weights were used—(*a*) 4,600 pounds on standard 800-foot spans; (*b*) 5,200 pounds on spans up to 1,200 feet or on angles up to 15°; (*c*) 7,200 pounds on spans over 1,200 feet or angles over 15° and on dead ends. Sixteen special towers for channel crossings were used, which range in height from 123 to 200 feet, and in weight from 12 to 25 tons. Two mountain spans of 4,056 and 3,620 feet, respectively, were carried, between 7-ton 25-foot A-frame towers; on each span 19-strand copper-clad cable three-fourths of an inch in diameter was used and the three circuits were supported in a horizontal plane. With 70° as a standard temperature tension in the copper circuit of the part of the line subject to snowfall was figured at 8,000 pounds per square inch and on other sections 15,000 pounds per square inch. The aluminum lines were designed for 4,000 pounds per square inch. Seven 11-inch disk suspension insulators were used at each point of support for each conductor. The total cost of the line was one-sixth of the total cost of the development.[64]

The Cordelia substation is a concrete and steel building, built in the Mission style. Ultimately it will be 256 feet long, 82 feet wide, and 47 feet high, but up to the end of 1921 it had been constructed only to the length of 155 feet, which gives ample capacity for the full development of the Drum plant. The station is equipped with two banks of three Westinghouse single-phase 4,000-kilovolt-ampere transformers, with a ratio of 100,000/60,000, which step the power received from the Drum plant down to a voltage in use on the rest of the Pacific Gas & Electric Co. system; and as the Cordelia station is not only at the intersection of several of the 60,000-volt lines but is also near the load center of the system, the operating conditions attained are very satisfactory.

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[64] Steele, E. H., Pacific Service Mag., January, 1914.

GOLDEN GATE SUBMARINE CABLES.

Owing to the importance of the load in the San Francisco district and in the region southward to San Jose, it became necessary in 1915 for Pacific Gas & Electric Co. either to increase the transmitting capacity of its hydroelectric lines or to operate its steam plants, even though hydroelectric power was available for transmission.

During the fall of 1915 the company began constructing the first link in a new transmission system to supply the territory. The 60,000-volt double-circuit steel tower transmission line which had been constructed from Cordelia substation to San Rafael in 1913 was extended from the latter point to Sausalito, a pole line was constructed from Sausalito to the north shore of Golden Gate, and two submarine cables were laid across the Gate to the San Francisco shore. The transmission line from Cordelia to San Rafael and thence to Sausalito is now operated at 60,000 volts, but is so constructed that the voltage may be raised to 100,000. At Sausalito the potential is stepped down to 11,000 volts, which is that in use on the San Francisco distribution system.

On account of the strong tides, the liability of damage from the anchors of vessels, and a maximum depth of nearly 200 feet in the Gate, the company's engineers deemed it advisable to lay each electric cable with a steel messenger cable to take the mechanical strains. Each messenger cable was delivered in a 14,000-foot continuous length, on a single reel, the cable and reel weighing together about 30 tons. The cable is $1\frac{3}{8}$ inches in diameter, weighs approximately $4\frac{1}{2}$ pounds per foot, and is composed of 37 galvanized-steel wires.

Each submarine power cable is 4 inches in diameter and contains three conductors, each composed of 37 strands of tinned copper with a total area of 250,000 circular mils. In manufacturing the cable each conductor was surrounded first by an insulation of $\frac{6}{32}$-inch 30 per cent Para rubber, outside of which was applied a layer of $\frac{2}{32}$-inch varnished cambric. After receiving this insulation the three conductors were laid together and the cable built up to a circular section by the application of a jute filler, through which is carried a telephone pair of two No. 13 seven-strand conductors, each surrounded by an insulation of $\frac{2}{32}$ inch of varnished cloth, cotton braid, and paraffine. A layer of $\frac{5}{32}$-inch varnished cambric was applied around the outside of the jute filler and outside of this cambric a casing of $\frac{5}{32}$-inch lead, surrounded by a protecting layer of $\frac{4}{32}$-inch tarred jute, to protect it from an armor coating of 42 No. 4 galvanized armor wires. The outer surface of this wire armor was covered by a layer of $\frac{4}{32}$-inch tarred jute with sanded asphaltum finish, which forms the outside of the cable. At each end of the crossing, after the power cables leave the water, each terminates in a short section provided with 350,000-circular-mil instead of 250,000-circular-mil conductors, as these sections of cable exposed above the water will be working at higher temperatures than those which are submerged. The submarine sections of both lines were laid in lengths of 1,275 feet, and the total length of each power cable is 13,250 feet. The diameter of the 250,000-circular-mil cable is 4 inches and its weight per foot 19 pounds; the diameter of the 350,000-circular-mil cable is 4¼ inches and its weight per foot 22 pounds.

Laying of the first messenger cable was begun on the morning of September 18, 1915; laying of the first power cable on September 26, 1915, and the first cable completed on October 7, 1915. Work on the second cable was begun on October 16 and the cable completed October 30.

Although operating at 11,000 volts the cable was tested after completion for three and one-half minutes at a voltage of 22,000. Shop tests of the short section of the finished cable showed no breakdown until the potential had reached 100,000 volts. Each cable is designed to deliver 6,000 kilowatts in San Francisco.

TABLES.

Condensed information concerning the transmission system and distribution is given in Tables 37 to 43. Data for the system operated by Northern California Power Co. Consolidated, which was acquired in 1919, are shown separately. The substations on the Pacific Gas & Electric system are listed in Tables 39 and 40.

TABLE 37.—*Transmission lines operated by Pacific Gas & Electric Co., Dec. 31, 1911–1920.*

Year.	Miles.	Year.	Miles.
1911	1,319	1916	1,620
1911	1,371	1917	1,640
1913	1,531	1918	1,743
1914	1,534	1919	2,255
1915	1,544	1920	[a] 2,649

[a] Includes 422 miles leased from Sierra & San Francisco Power Co.

TABLE 38.—*Length (in miles) of transmission lines operated by Pacific Gas & Electric Co. Dec. 31, 1920.*

Lines owned.

Division.	Supports.	110-kilovolt.		60-kilovolt.		20, 22, 30 kilovolt.[a]	
		Line.	Circuit.	Line.	Circuit.	Line.	Circuit.
Colgate	Tower	26.66	26.66				
	Pole			386.1	386.9	4.5	9.0
De Sabla	Pole			73.2	73.2		
Drum	Tower	69.88	108.39				
	Pole			92.4	92.4	21.7	32.3
East Bay	Tower	23.96	47.92	31.7	34.4		
	Pole			145.85	152.9	.6	1.2
North Bay	Tower	12.89	12.89	43.6	43.8		
	Pole			125.5	133.4		
Sacramento	Tower	69.51	94.81	1.4	2.8		
	Pole			194.7	196.5		

[a] 17-kilovolt lines not included. See distribution statistics, Table 42.

TABLE 38.—*Length (in miles) of transmission lines operated by Pacific Gas & Electric Co. Dec. 31, 1920*—Continued.

Lines owned—Continued.

Division.	Supports.	110-kilovolts.		60-kilovolts.		20, 22, 30 kilovolts.	
		Line.	Circuit.	Line.	Circuit.	Line.	Circuit.
San Joaquin	Tower	61.20	122.40	7.6	7.6		
	Pole			175.7	175.7		
San Jose	Pole			127.4	140.1	30.4	30.4
Shasta	Pole			216.5	216.5	89.7	112.7
West Side	Pole			194.8	194.8		
Total	Tower	264.10	413.07	84.3	88.6		
	Pole			1,731.7	1,762.4	146.9	185.6
		264.10	413.07	1,816.0	1,851.0	146.9	185.6

Total line, tower, 348.4; pole, 1,878.6; total, 2,227.0. Total circuit, tower, 501.67; pole, 1,948; total, 2,449.67.

Leased properties of Sierra & San Francisco Power Co.

Division.	Supports.	104-kilovolt lines.		60-kilovolt lines.		33-kilovolt lines.	
		Line.	Circuit.	Line.	Circuit.	Line.	Circuit.
East Bay	Tower	54.35	62.06				
San Joaquin	Tower	149.00	149.00		8.5		
	Pole			65.2	68.7	43.4	43.4
San Jose	Tower	32.05	64.10	21.6	43.2		
	Pole			56.5	112.5		
Total	Tower	235.40	275.16	21.6	51.7		
	Pole			121.7	181.2	43.4	43.4
		235.40	275.16	143.3	232.9	43.4	43.4

Total leased line, tower, 257.0; pole, 165.1; total, 422.1. Total leased circuit, tower, 326.86; pole, 224.6; total, 551.46.

Grand total line, tower, 605.4; pole, 2,043.7; total, 2,649.1. Grand total circuit, tower, 828.53; pole, 2,172.60; total, 3,001.13.

The number of the substations and the length of the overhead and underground distribution lines of the company December 31, 1906–1920, are shown by Table 39.

TABLE 39.—*Growth of substation distribution system of Pacific Gas & Electric Co.*

Year.	Number of substations.	Overhead lines.	Underground cable.	Year.	Number of substations.	Overhead lines.	Underground cable.
		Miles.	*Miles.*			*Miles.*	*Miles.*
1911	105	2,233		1916	150	4,030	494
1912	139	2,815		1917	165	4,500	509
1913	146	3,484	420	1918	156	4,593	510
1914	140	3,685	463	1919	191	5,331	517
1915	146	3,836	478	1920	207	6,146	518

Note.—Table includes lines of Oro Electric Corporation after 1916 and those of Northern California Power Co. Consolidated after 1918.

TABLE 40.—*Substations and length of distribution lines operated by Northern California Power Co. Consolidated Sept. 30, 1919.*

Station.	Rated capacity of transformers.	Overhead lines.
	Kilowatts.	*Miles.*
Chico	1,500	235.156
Pacific Gas & Electric Co, Red Bluff	900	157.149
Willows	1,800	318.610
Hamilton	2,250	87.142
Jacinto	300	46.633
Germantown	(a)	36.133
Williams, including Arbuckle and College City	300	78.272
Maxwell	900	64.447
Orland	450	74.916
Butte City	300	47.706
Rice	900	43.210
Princeton	300	30.931
Sacramento Valley Irrigation	1,200	....
Redding	1,500	99.327
Redding River	225	....
Manton	(b)	15.271
Heroult	4,500	2.677
Ingot	2,250	2.416
Palo Cedro	100	31.906
Old Diggings	225	2.192
Keswick	150	17.234
Delamar	900	8.013
Balaklala	900	....
Coram	346	3.604
Mammoth	2,250	....
Kennett	3,000	28.970
Corning	750	254.687
Gas Point	225	....
Gerber	1,500	90.997
Anderson	450	53.534
Cottonwood	173	9.684
Washington	300	13.356
Iron Mountain	1,125	....
Minnesota	750	....
Gardella	450	....
Lewiston	450	1.354
Arbuckle	494	18.081
Baker Gulch	900	....
Vina	75	....
Mallon and Blevin	450	4.320
Capay Rancho	1,350	107.000
Western States	(c)	....
Total	36,888	1,984.928

(a) Off Willows. (b) Off power house. (c) Off transmission line.

TABLE 41.—*Circuit voltage and station capacity of primary substations operated by Pacific Gas & Electric Co. Dec. 31, 1920.*

District and substation.	Voltage.		Station capacity (kilowatts).
	Incoming circuits.	Outgoing circuits.	
Alameda County:			
Antioch	60,000	4,000 11,000	1,500
Avon	60,000	2,300	750
Best Steel Casting Co	60,000	11,000	2,250
Calaveras	60,000	2,300	450
Columbia Steel	60,000	2,300	2,250
Diamond (Pittsburg)	60,000	2,300 4,000	1,200
Livermore	60,000	11,000	1,500
Mountain Copper	60,000	2,300 11,000	375
Newark	60,000 110,000	60,000 11,000	36,000
Nichols	60,000	22,000 2,200	2,250
Oakland	60,000	11,000 4,000 2,300	(a) 39,750

(a) Includes 21,000 kilowatt steam-plant capacity.

TABLE 41.—*Circuit voltage and station capacity of primary substations operated by Pacific Gas & Electric Co. Dec. 31, 1920*—Continued.

District and substation.	Voltage.		Station capacity (kilowatts).
	Incoming circuits.	Outgoing circuits.	
Alameda County—Continued.			
Richmond	60,000	11,000	3,750
Roberts Landing	60,000	4,000	1,450
South Tower	60,000	11,000	2,520
Chico:			
Chico	60,000	6,600	600
Do	60,000	2,300	1,200
Clinch and Peters	60,000	6,600	200
Diamond Match Co	60,000	440	1,200
Sacramento Northern No. 2	60,000	2,300	450
De Sabla:			
Butte Creek	60,000	4,000	225
Marin-Sonoma:			
Alto-Pacific Gas & Electric	60,000	11,000 4,000	1,500
Alto-Northwestern Pacific Railroad Co	60,000	4,000	1,200
Marin	60,000	11,000 4,000	12,750
Novato	60,000	2,300	150
Petaluma	60,000	2,300	1,500
San Rafael	60,000	11,000 4,000	2,700
San Anselmo	60,000	4,000	1,500
Marysville:			
Arbuckle	60,000	6,600	300
Butte City	60,000	6,600	450
Colusa	60,000	2,300 11,000	3,750
Cadora No. 2	60,000	440	450
Gridley	60,000	4,000	900
Hammonton	60,000	4,000	7,500
Lincoln	60,000	2,300	750
Mallon & Bleven	60,000	440	900
Marysville	60,000	2,300 11,000	3,000
Maxwell	60,000	11,000	1,500
Meridian		4,000	750
Oroville	60,000 60,000	11,000 4,000	3,100
Plumas	60,000	2,300	375
Princeton	60,000	6,600	300
Rice	60,000	6,600 2,200	1,350
Sacramento Northern at Stohlman	60,000	2,300	375
Sacramento Northern No. 3	60,000	2,300 11,000	940
Sacramento Northern No. 4	60,000	2,300	450
Sacramento Northern No. 5	60,000	2,300	450
Sacramento Northern No. 8	60,000	2,300 11,000	900
Sacramento Northern No. 9	60,000	2,300	300
Sankey	60,000	11,000	537
Smartsville	60,000	2,300	50
Sutter Butte Canal Co	60,000	6,600	300
Vernon	60,000	2,300	1,800
Wheatland	60,000	11,000 2,300	300
Williams	60,000	11,000 6,600	900
Williams irrigation district	60,000	11,000	1,500
Napa:			
Cordelia	60,000 110,000	11,000 2,000 60,000	1,125 36,000
Napa	60,000	2,300	750
North Tower	60,000	11,000	5,250
Sonoma	60,000	2,300	150
Nevada:			
Grass Valley	30,000 60,000	4,000	6,000
Middle Yuba-Hydroelectric Co	30,000	6,600	1,200
Nevada County Traction Co	30,000	4,000	1,050
Northern:			
Artois	60,000	11,000	1,500
Capay	60,000	6,600	450
Corning	60,000	6,600	600
Gerber	60,000	6,600	1,500

TABLE 41.—*Circuit voltage and station capacity of primary substations operated by Pacific Gas & Electric Co. Dec. 31, 1920*—Continued.

District and substation.	Voltage.		Station capacity (kilowatts).
	Incoming circuits.	Outgoing circuits.	
Northern—Continued.			
Hamilton Nos. 2 and 3	60,000	2,200 6,600	900
Headgate	60,000	2,300	2,700
Jacinto	60,000	6,600	300
Orland	60,000	2,200	450
Princeton-Cadora (Glenn Irrigation)	60,000	440	450
Provident	60,000	2,200	2,000
Red Bluff	60,000	2,200 6,600	900
Vina	60,000	6,600	300
Willows	60,000	6,600 11,000	5,250
Placer County:			
Colfax	60,000	2,300	75
Long Point	60,000	2,300	300
Mountain quarries	60,000	2,300	375
Rising Sun mine	60,000	4,000	375
Roseville	60,000	2,300	750
Weimar	60,000	2,300	150
Redwood:			
Crystal Springs	60,000	2,300	300
Ravenswood	60,000	4,000	750
Redwood	60,000	4,000 11,000	3,000
San Mateo No. 2	60,000	11,000	1,500
South San Francisco	60,000	2,200 4,000	7,500
Sacramento:			
Del Paso	60,000	2,300	300
Natomas	60,000	60,000	....
Sacramento	60,000	11,000 4,000	[b] 14,000
San Francisco:			
Bay shore	104,000	11,000	22,500
Martin Station	60,000	4,000 11,000	13,500
San Joaquin:			
West Side	60,000	17,000 2,300	3,750
Banta	60,000	11,000	600
Comanche No. 2	60,000	440	300
Jenny Lind, Isabelle dredge	60,000	440	225
Middle River	60,000	11,000	3,000
New Hope	60,000	11,000	750
Penn Mine	60,000	4,000	900
Stockton	60,000	11,000 2,300	6,750
Stockton Waterworks	60,000	440	555
Vernalis	60,000	11,000	750
San Jose:			
Old Mission Cement Co.	60,000	575	1,500
Salinas	60,000	60,000	....
San Juan	60,000	4,000 22,000	3,000
Soledad	60,000	60,000	....
Port Marion	100,000	60,000	3,000
Davenport	60,000	2,300 22,000	8,850
Mountain View	60,000	11,000 4,000	4,770
San Jose	60,000	22,000 2,300 4,000	13,500
Santa Rosa:			
Santa Rosa	60,000	2,300	750
Sebastopol	60,000	2,300	675
Shasta:			
America Gold Dredging Co.	60,000	4,000	900
Anderson	60,000	6,600	450
Baker Gulch	60,000	2,300	900
Balaklala	20,000	6,600	6,900
Bully Hill	20,000	2,300	900
Coram	20,000	2,300	225
Cottonwood	60,000	2,300	300
Garadella dredge	20,000	4,000	450
Gas Point	20,000	2,300	225

[b] Includes 5,000 kilowatt steam-plant capacity.

TABLE 41.—*Circuit voltage and station capacity of primary substations operated by Pacific Gas & Electric Co. Dec. 31, 1920*—Continued.

District and substation.	Voltage.		Station capacity (kilowatts).
	Incoming circuits.	Outgoing circuits.	
Shasta—Continued.			
Ingot	20,000	2,300	1,800
Iron Mountain	20,000	2,300	1,225
Jenny Creek	20,000	2,300	900
Junction City	60,000	60,000	....
Kennet	60,000	2,000 20,000	2,250
Keswick	60,000	2,300	150
Mammoth mine	20,000	2,300	2,250
Messalback dam, camp No. 1	20,000	440	750
Messalback dam, east portal	20,000	440	75
Messalback dam, west portal	20,000	440	75
Minnesota mine	20,000	2,300	900
Old Diggings	20,000	2,300	225
Palo Cedro No. 1	20,000	2,300	100
Palo Cedro No. 2	60,000	11,000	300
Redding River substation	60,000	6,600	225
Washington	60,000	2,200	300
Solano:			
Cement	60,000	2,300	4,500
Dixon	60,000	11,000 2,300	1,500
Rio Vista	60,000	2,300	50
Vacaville	60,000	2,300	200
Stanislaus:			
Empire	30,000	2,300	125
Hickman	30,000	6,600	300
Hughson	30,000	6,600	300
Manteca	104,000 60,000	17,000 30,000 60,000	6,750
Modesto	30,000 60,000	17,000 30,000	3,000
Turlock	30,000	2,300	600
Patterson	60,000	2,300 11,000	1,950
Yolo:			
Davis	60,000	11,000 4,000	450
Knights Landing	60,000 100,000	11,000 60,000	12,000
Rough and Ready	60,000	2,300	3,000
Sutter Basin (reclamation district No. 1500)	60,000	2,300	4,500
Wilkins Slough	60,000	11,000	900
Woodland	60,000	11,000 2,300	3,000

Recapitulation, all substations, as of December 31, 1920.

Voltage (kilovolts).	Number of stations.	Transformer data.					
		Main.		Secondary.		Total.	
		Number.	Total capacity.	Number.	Total capacity.	Number.	Total capacity.
100	7	30	116,250	......	....	30	116,250
60	129	463	269,232	......	....	463	269,232
24	32	110	23,315	......	....	110	23,315
17	17	42	7,937.5	12	1,875	54	9,812
11	41	156	84,355	43	10,950	199	5,305
4	1	3	150	6	675	9	825
	227	804	501,239.5	61	13,500	865	514,739.5

TABLE 42.—*Overhead and underground distribution lines operated by Pacific Gas & Electric Co. Dec. 31, 1920.*

District.	Overhead lines (miles).	Underground cables [a] (miles).	Underground duct (miles).	Line transformers.		Number of meters.
				Number.	Capacity (kilowatts).	
Alameda County	1,168.54	57.11	136.36	4,611	68,757.21	71,146
Chico	217.27	2.95	1.97	942	8,104.5	3,952
Colgate	3.75			14	39.5	9
De Sabla	20.9			88	965.0	117
Electra	44.04			107	8,095.5	195
Marin-Sonoma	300.86			1,225	13,039.25	8,653
Marysville	811.55			4,282	46,845.20	8,934
Napa	141.55			391	7,427.86	2,337
Nevada	54.66			366	8,797.49	1,762
Northern	451.00			2,189	16,125.0	4,209
Placer County	63.68			274	1,894.5	943
Redwood	321.6	2.61	2.28	1,887	17,697.70	10,221
Sacramento	301.75	28.70	52.07	1,788	20,091.10	13,063
San Francisco	523.54	407.55	572.52	1,951	55,864.10	102,352
San Joaquin	533.19			1,908	19,340.5	1,626
San Jose	505.06	6.41	8.31	4,127	35,714.0	16,688
Santa Rosa	68.65			367	2,601.4	2,628
Shasta	132.1			423	3,120.0	1,725
Solano	181.12			1,180	5,935.0	2,043
Stanislaus	49.17			168	1,869.1	949
Tuolumne	39.27			3	150.0	7
Yolo	213.37			970	16,188.25	2,459
	6,146.62	505.33	773.51	29,261	358,262.16	256,018

[a] Does not include street lighting underground system.

Sierra & San Francisco Power System (leased).

District.	Overhead lines (miles).	Underground cables (miles).	Underground duct (miles).	Number.	Capacity (kilowatts).	Number of meters.
Redwood	9.11					2
San Francisco	29.2	12.79	18.00	8	1,433.5	8
San Joaquin	73.21			169	2,497.5	955
Stanislaus	462.96			1,954	13,826.5	8,320
Tuolumne	120.67			1,070	7,004.0	77
	695.15	12.79	18.00	2,238	24,761.5	9,362

TABLE 43.—*Length and voltage of single-circuit transmission lines operated by Northern California Power Co. Consolidated Sept. 30, 1919.*

District.	Length (miles).	Voltage.
Iron Mountain-Minnesota	2. 282	20, 000
Bully Hill-Kilarc	21. 712	20, 000
Kennett-Keswick	10. 842	20, 000
Kennett-Mammoth	2. 625	20, 000
Kennett-Washington	14. 826	20, 000
Keswick-Old Diggings	3. 672	20, 000
Keswick-Palo Cedro	13. 597	20, 000
Minnesota-Iron Mountain	1. 977	20, 000
Minnesota-Tap	1. 560	20, 000
Orland-Hamilton	12. 000	20, 000
Redding-Horsetown	9. 121	20, 000
Willows-Tap	. 626	20, 000
Bee Hive at Heroult	. 095	20, 000
Bully Hill Junction-Bully Hill	. 453	20, 000
Bully Hill-Heroult	4. 464	20, 000
Hamilton-Chico	13. 375	60, 000
Hamilton-Willows Junction	11. 114	60, 000
Hamilton-Arbuckle	63. 989	60, 000
Palo Cedro-Kennett	23. 690	60, 000
Palo Cedro-Volta	20. 760	60, 000
Redding-Cow Creek	19. 290	60, 000
Redding-Heroult	23. 986	60, 000
Redding-Willows Junction	65. 903	60, 000
Volta-Chico	64. 886	60, 000
Volta-Coleman	17. 650	60, 000
Willows-Willows Junction	20. 970	60, 000
Butte City Tap	1. 640	60, 000
Palo Cedro Tap	. 650	60, 000
Hamilton Emergency Crossing	. 170	60, 000
Washington-Lewiston-Minersville	18. 000	60, 000
College City-Dunnigan	10. 000	60, 000
Palo Cedro-Palo Cedro substation	. 739	20, 000
Kilarc-South	11. 500	60, 000
Kilarc-Weaversville	10. 500	60, 000
Coleman-Cottonwood	9. 730	60, 000
Coleman-Capay	50. 000	60, 000
Redding to South Volta junction	5. 522	60, 000
Keswick-Washington	17. 456	60, 000
Willows-Maxwell-Loop	. 034	60, 000
Kennett-Redding extension across Sacramento River to ranch	3. 084	60, 000
	584. 490	....

SIERRA & SAN FRANCISCO POWER CO. AND COAST VALLEYS GAS & ELECTRIC CO.

HISTORY.

SIERRA & SAN FRANCISCO SYSTEM.

EARLY ORGANIZATION.

Sierra & San Francisco Power Co., which is primarily a hydroelectric generating company, and Coast Valleys Gas & Electric Co., which is primarily a distributor of power generated on the Sierra & San Francisco system, were formerly controlled by the same interests that own the United Railroads of San Francisco. Both companies were under the same manager and both owned and operated systems acquired from earlier companies.[64a]

Sierra & San Francisco Power Co. is the successor of Stanislaus Water Power Co., which began extensive water-power developments on Stanislaus River in 1905. That company in turn was the outgrowth of an attempt to supply water to the Santo Domingo mine, in Calaveras County, dating back to 1893, when Mr. Beach Thompson acquired an interest in the mine and began to construct a ditch system through which he proposed to supply water to the property from the North Fork of the Stanislaus. The work was continued in the years between 1893 and 1899, when it was found that the North Fork would not furnish sufficient water, and search for an additional supply was begun. In 1896 a claim for 10,000 miner's inches of water on the Middle Fork near Bakers Crossing had been filed by Mr. George Batten, and a survey for a conduit line had been run by F. E. Ames from Sand Bar Flat to what is now Stanislaus forebay. In July, 1899, Beach Thompson secured an option on the Batten water rights, and on May 2, 1900, a survey was begun from Donnell's Flat down the north side of the canyon under the supervision of C. D. Marx, who in July also resurveyed the Ames line. In July, 1901, Marx and the late C. E. Moore ran another line, and on November 30, 1901, submitted the first estimate of the cost of the project. The general plan was later enlarged and a detailed estimate from new surveys was made by D. C. Henny and Franklin Riffle in 1902.

When it was first decided to generate power, the promoters proposed to transmit energy to the Electra plant, some 35 miles to the north, and thence over the Electra line to San Francisco; later however, a direct-transmission tower line was run the entire distance to the bay.

In April, 1905, the promoters obtained sufficient cash to begin construction, and in September 1905, the securities of the new concern

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[64a] On Jan. 1, 1920, the Sierra & San Francisco system was leased to Pacific Gas & Electric Co., but Coast Valleys Gas & Electric Co. was not leased and remained under its original management.

were underwritten under an agreement made with C. C. Cuyler, Frederick Eldridge, and Tucker, Anthony & Co. The financing agreement was completed November 25, 1905. The corporation organized under this agreement was Stanislaus Water Power Co., incorporated December 4, 1905, under the laws of Maine. Construction was carried on by Union Construction Co., a Maine corporation which was organized by Messrs. Sanderson and Porter, civil engineers, of New York City, for that sole purpose. Union Construction Co. signed a contract with Stanislaus Water Power Co. September 18, 1905, to construct the Stanislaus plant, which was later transferred from Stanislaus Water Power Co. to The Stanislaus Electric Power Co.

In February, 1906, Union Construction Co. purchased the properties but not the stock of Tuolumne County Water & Electric Power Co. (incorporated Dec. 7, 1898), which had maintained a local transmission service in and around Sonora from the Phoenix plant; the capital stock of the company was $550,000, all of which had been issued. Tuolumne County Water & Electric Power Co. was, in turn, a reincorporation of Tuolumne County Water Co., formed in the fifties, which owned a system of dams and well-established water rights on the South Fork that had been used since the early mining days. On December 30, 1907, Union Construction Co. transferred these properties to Tuolumne Water Power Co., incorporated on that date.

The Stanislaus Electric Power Co. was incorporated for $10,000,000, capital or common stock, par $100, of which $8,000,000 was issued, and had an authorized issue of $10,000,000 bonds, of which $6,000,000 were issued. Knickerbocker Trust Co. was registrar of the stock, all of which but the directors' qualifying shares was owned by Stanislaus Water Power Co. The latter was incorporated in Maine, as a holding company, December 19, 1905, with an authorized capitalization of $3,000,000 in 6 per cent preferred stock (cumulative from Jan. 1, 1910, and subject to call after Jan. 1, 1913, at $130) and $10,000,000 in common stock. The transfer agents were Tucker, Anthony & Co., of Boston, and the registrar Knickerbocker Trust Co. of New York. No bonds were issued by this holding company, but at the beginning of 1909 (when its affairs were wound up) it had issued all its preferred and $8,250,000 of its common stock.

The financial troubles that temporarily closed Knickerbocker Trust Co. put The Stanislaus Electric Power Co. and Tuolumne Water Power Co. in the hands of a receiver—the late Mr. G. H. Whipple—appointed by Judge DeHaven, of the United States Circuit Court, February 16, 1909. In May, 1908, however, a majority of the bondholders of The Stanislaus Electric Power Co. entered into an agreement to deposit their bonds for the use of a protective committee, and in January, 1909, prior to the appointment of a receiver, the protective committee and United Railways Investment Co.—a corporation interested in the street railways of San Francisco—formulated a plan for the refinancing of The Stanislaus Electric Power Co. and its holding company, Stanislaus Water Power Co. In order to carry out their program United Railways Investment Co., as a holding company, formed Sierra & San Francisco Power Co., a California corporation (May 28, 1909), the entire capital stock of which was to be held by United Railways Investment Co.

PURPOSE OF INCORPORATION.

Sierra & San Francisco Power Co. had for its purpose of incorporation (*a*) the acquisition of the stocks of Stanislaus Water Power Co. and The Stanislaus Electric Power Co., (*b*) the acquisition through foreclosure of the properties of The Stanislaus Electric Power Co., Tuolumne Water Power Co., and Stanislaus Railway Co., (*c*) the purchase of the North Beach plant and the lease of the Bryant Street steam station of United Railways in San Francisco, (*d*) the construction of twin tower lines from the Stanislaus power house to San Francisco.

Sierra & San Francisco Power Co. was to receive as a basis for its operations a 44-year contract[65] from the United Railways Co. for 122,120,000 kilowatt-hours per year at $0.0075 per kilowatt-hour and a maximum delivery of 23,234 kilowatts.

In January, 1909, in pursuance of the plan of reorganization, the holders of the common and preferred stock of Stanislaus Water Power Co. and The Stanislaus Electric Power Co. were requested to deposit their shares with Knickerbocker Trust Co. Since the Water Power Co. held all the stock of the Electric Power Co., control of the former carried control of the latter. The first mortgage of the latter was to be foreclosed and the first mortgage-bonds exchanged at par plus $25 per bond, for $6,000,000 worth of new second-mortgage bonds of Sierra & San Francisco Power Co. A new first-mortgage bond issue was then to be executed, of which $5,000,000 was to be immediately available to complete construction and take care of current needs of the company, and the rest to be reserved to finance future growth.

While Sierra & San Francisco Power Co.'s stock was to be turned over as a whole to United Railways Investment Co. the latter was to turn over to a protective committee $900,000 of its own common stock and $900,000 of its own preferred stock. The preliminaries having been carried out, Knickerbocker Trust Co., trustee for The

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[65] Contract was signed August 31, 1909.

Stanislaus Electric Power Co.'s bonds, brought suit to foreclose the issue. Suit was also brought to foreclose the $350,000 outstanding bond issue of Tuolumne Water Power Co., which was, as noted, controlled through stock ownership by the Stanislaus company. The properties of both companies were disposed of at receiver's sale in August, 1909, and Sierra & San Francisco Power Co. succeeded to the control of the properties of the companies September 1, 1909.

The Stanislaus plant had been completed before the company went into the hands of the receiver and began transmitting power October 18, 1908, to Mission San Jose, where the line was temporarily connected with the system of Pacific Gas & Electric Co. Power was not delivered through the Bay Shore substation in San Francisco to the system of United Railroads until April 13, 1910. April 30, 1910, delivery to Pacific Gas & Electric Co. at Mission San Jose was discontinued except for standby service.

On July 15, 1910, the company purchased the small transmission system belonging to Consolidated Stanislaus Water Power Co. and connected it with the main line, so that the Knights Ferry plant of the old system could be shut down except for regulative and emergency service.

PROPERTIES PURCHASED.

Yosemite Power Co.—The electric generating, transmission, and distribution system belonging to Yosemite Power Co. was purchased by Sierra & San Francisco Power Co. in 1917.

Yosemite Power Co. was organized December 30, 1910, for the purpose of acquiring the operating properties then belonging to La Grange Water & Power Co. and lands and undeveloped water rights higher up on the Tuolumne River basin which were owned by Tuolumne Power & Light Co., Tuolumne River Power Co., and National Park Electric Power Co. Yosemite Power Co. entered into possession of all the above properties June 1, 1911, except those of National Park Electric Co., which it acquired in 1915.

The system of La Grange Water & Power Co. consisted of a small hydroelectric plant a short distance above the town of La Grange and a transmission line extending from the power house to Hughson and Merced. The La Grange company had sold the distribution system in the town of Modesto to Sierra & San Francisco Power Co. September 29, 1911.

Yosemite Power Co. has undertaken no construction on the upper Tuolumne projects, although surveys and plans for extensive developments had been completed. These undeveloped sites were retained by the Yosemite company and not transferred to Sierra & San Francisco Power Co.

Minor properties.—On January 2, 1912, the Sierra & San Francisco company purchased the distribution lines of the Mount Diablo Light & Power Co. in and about Tracy and north to Brentwood in Contra Costa County, and December 14, 1912, it purchased and consolidated with the Tuolumne division the water storage and distributing system of the Gold Mountain Water Co. in and about Sonora.

COAST VALLEYS GAS & ELECTRIC SYSTEM.

Coast Valleys Gas & Electric Co. was formed March 18, 1912, by the same financial interests that controlled Sierra & San Francisco Power Co. for the purpose of consolidating the electric systems then operating in Monterey, Salinas, and King City. On the date of its formation it purchased the electric and gas systems which California Consolidated Light & Power Co. was then operating in Monterey and Salinas. It took over the water properties of the Salinas Valley Water Co. March 19, 1912, and on May 18, 1912, the electric and water properties of the King City Water, Light & Power Co. A part of Coast Valleys Gas & Electric Co.'s first-mortgage bonds were used to retire the bonds of Salinas Water, Light & Power Co., Monterey Gas & Electric Co., and Monterey County Gas & Electric Co.; additional bonds were issued to pay part of the floating debt of California Consolidated Light & Power Co.

California Consolidated Light & Power Co. had been incorporated in July, 1911, by F. G. Baum and associates, for the purpose of taking over the separate steam-electric systems then operating in Salinas and in Monterey and combining the two in order to effect more economical operation of the properties. The company actually issued $2,000,000 preferred and $3,000,000 common stock and authorized $5,000,000 in bonds of which it issued $309,000. In addition, it assumed the $350,000 bonds of Monterey Gas & Electric Co. and Monterey County Gas & Electric Co., and on November 29, 1911, took over the electric and gas properties of both of these systems. On the same date the water properties in Salinas were transferred to Salinas Valley Water Co., which was incorporated November 29, 1911, with an authorized capital of $1,000,000. When this transfer was made Salinas Valley Water Co. assumed the bonds of Salinas Water, Light & Power Co., which amounted to $150,000. The King City properties were not controlled by California Consolidated Light & Power Co., but formed a separate system; in tracing the history of the various companies back further, it is therefore necessary to consider the Monterey, Salinas, and King City divisions separately.

The immediate predecessor of California Consolidated Light & Power Co. in Monterey and Salinas was Monterey County Gas & Electric Co., which had been incorporated July 1, 1903, and which, on October 10, 1903, acquired the gas and electric properties in Monterey and the gas, electric, and water properties in Salinas. The earliest developments in Monterey were made by Monterey Electric Light & Development Co., which was incorporated January 12, 1891, to conduct a real estate and electric business. On September 1, 1902, this company dismantled and removed its plant from Monterey and sold its franchise and distributing systems to Monterey Gas & Electric Co., which was incorporated on May 5, 1902. Monetrey Gas & Electric Co. built a new station, extended its distribution system, and constructed a gas plant. On June 25, 1902, Monterey Gas & Electric Co. acquired all the stock of Monterey & Pacific Grove Railway Co., and on October 10, 1903, disposed of all its properties, as noted, to Monterey County Gas & Electric Co.

The earliest developments in Salinas were made by Salinas City Gas & Water Co. incorporated May 4, 1875, to supply the town gas and water. The authorized capital stock of this company was $60,000; it issued no bonds. About October, 1888, this company constructed an electric plant, and October 12, 1896, its properties were taken over by Salinas City Light & Water Co.; incorporated on September 29, 1896, with an authorized capital stock of $200,000, and no bonds. This company operated this system until February 20, 1902, when it was transferred to Salinas Water, Light & Power Co., incorporated November 25, 1901. The latter was succeeded by Monterey County Gas & Electric Co., which took over its properties October 10, 1903.

King City Water, Light & Power Co. was incorporated July 17, 1908. Its properties and stock were sold to Coast Valleys Gas & Electric Co. May 18, 1912.

At the time of the purchase of the Monterey County systems by Coast Valleys Gas & Electric Co. the territory was supplied with energy from steam-electric sources. One of the first moves made by Coast Valleys Gas & Electric Co. was to contract for the delivery of hydroelectric power, to replace that generated by steam stations. This change necessitated the construction of a transmission line from Guadalupe (Port Marion) substation on the tower line of Sierra & San Francisco Power Co. at the lower end of San Francisco Bay, southward through Gilroy to Salinas. Through the Salinas substation hydroelectric power could be delivered to the entire system of the Coast Valleys company which at the same time was consolidated by the construction of a main transmission line southward from Salinas to King City. The Guadalupe-Salinas line was completed and service begun on December 14, 1912. Since that date the Salinas and Monterey steam plants have served chiefly as stand-bys when trouble occurs on the transmission line.

MARKET.

TERRITORY AND POPULATION.

The transmission lines of Sierra & San Francisco Power Co. distribute power in Calaveras, Contra Costa, Monterey,[66] San Francisco, San Joaquin, Stanislaus, and Tuolumne counties and traverse Alameda, Santa Clara, San Mateo, and San Benito counties, in which they do not distribute power except to Old Mission Portland Cement Co., in San Benito County. The lines of Coast Valleys Gas & Electric Co. serve Monterey and San Benito counties. The area and population of the counties supplied by the distribution systems shown in Table 9 (p. 64) and the general features of the counties are briefly characterized in the notes on pages 66–72.

The population of the incorporated places served by the systems are shown in Table 44.

TABLE 44.—*Incorporated communities served by Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co.*

Sierra & San Francisco lines.

City or town.	County.	Population.			
		1890	1900	1910	1920
Angels	Calaveras				941
Ceres	Stanislaus				637
Manteca	San Joaquin				1,286
Modesto	Stanislaus	2,402	2,024	4,034	9,241
Oakdale	do			1,035	1,745
San Francisco	San Francisco	298,997	342,782	416,912	506,676
Sonora	Tuolumne	1,441	1,922	2,029	1,684
Tracy	San Joaquin				2,450
Turlock	Stanislaus			1,573	3,394
		302,840	346,728	425,583	528,054

Coast Valleys Gas & Electric lines.

City or town.	County.	1890	1900	1910	1920
Carmel by the Sea	Monterey				638
King City	do				1,048
Monterey	do	1,662	1,748	4,923	5,479
Pacific Grove	do	1,336	1,411	2,384	2,974
Salinas	do	2,339	3,304	3,736	4,308
		5,337	6,463	11,043	14,447

The following unincorporated places are also served: Altaville (one mine), Banta, Beards, Bethany, Brentwood, Byron, Copperopolis, Denair, Escalon, Hickman, Hughson, Hurdlyn, Jacksonville, Jamestown, Knights Ferry, La Grange, Lathrop, Mallery, Ripon, Salida, and Waterford by Sierra & San Francisco Power Co.; Chualar, Gonzales, Hilltown, Lagunita, Los Coches, Santa Rita, and Soledad by Coast Valleys Gas & Electric Co.

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[66] Wholesale delivery to Coast Valleys Gas & Electric Co.

LOAD.

Nearly all commercial lighting and all municipal power supplied by Sierra & San Francisco Power Co. and all that used in municipal street and miscellaneous lighting is confined to the San Joaquin district.

During 1918, 10,117,842 kilowatt-hours sold in the Tuolumne district were classified as industrial power. Most of this was, however, used in mines. In the San Joaquin district sales of industrial power totaled 9,653,836 and in the Santa Clara district 2,150,000 kilowatt-hours.

Railways in the San Francisco district consumed 132,661,310 kilowatt-hours and in the San Joaquin district 892,475.

Other electrical corporations in Tuolumne district received 825,000, in Santa Clara district 12,531,606, and in San Francisco district 8,582,624 kilowatt-hours. The deliveries in the Santa Clara district were made to Coast Valleys Gas & Electric Co.

The heaviest municipal street-lighting load on the Coast Valleys system is in Salinas (with 57.6 kilowatts connected and sales of 144,805 kilowatt-hours), and Salinas is followed by Monterey with 17.06 kilowatts connected and sales of 50,578 kilowatt-hours, and Pacific Grove with 19.5 kilowatts connected and sales of 36,420 kilowatt-hours. The heaviest miscellaneous municipal lighting load is in Salinas, with 32.6 kilowatts connected and 11,565 kilowatt-hours sold, followed by Monterey, with 9.2 kilowatts connected and 5,227 kilowatt-hours sold.

Commercial lighting loads are heavy in Monterey (with 978.56 kilowatts connected and 502,614 kilowatt-hours sold), Salinas (809.33 kilowatts connected and 413,016 kilowatt-hours sold), and Pacific Grove (532 kilowatts connected and 180,156 kilowatt-hours sold).

Municipal power is furnished only in Monterey (where the connected load amounts to 15.3 kilowatts and sales to 3,390 kilowatt hours), and in Pacific Grove.

The demands for commercial power are chiefly in King City (2,607.1 kilowatts connected and 3,935,153 kilowatt-hours sold), Salinas (2,639.1 kilowatts connected and 3,008,835 kilowatt-hours sold), and Monterey (1,096.3 kilowatts connected and 596,559 kilowatt-hours sold). Industrial, agricultural, and other power are grouped under the main heading commercial power and are not segregated. The demands in and around Salinas and King City are chiefly agricultural, but in Monterey the chief uses are industrial.

All railway power is delivered in Monterey to Monterey & Pacific Grove Railway, controlled by Coast Valleys Gas & Electric Co.

TABLE 45.—*Power generated and purchased by Sierra & San Francisco Power Co. and subsidiary companies, 1908–1920.*

Year.	Generated.			Purchased.	Total system.	Mean.	Peak.	Load factor.
	Hydroelectric.	Steam.	Total.					
	Kilowatt-hours.	*Kilowatt-hours.*	*Kilowatt-hours.*	*Kilowatt-hours.*	*Kilowatt-hours.*	*Horsepower.*	*Horsepower.*	*Per cent.*
1908 [a]	9,134,133	....	9,134,133	....	9,134,133	6,370	....	......
1909	43,299,980	....	43,299,980	....	39,394,719	6,026	....	......
1910	56,275,394	13,538,320	68,644,864	[b] 7,457,400	76,122,234	11,645	....	......
1911	96,432,945	1,418,400	98,830,453	32,082,900	129,304,346	19,781	....	......
1912	97,922,636	18,036,400	115,969,036	33,134,864	149,103,900	22,809	....	......
1913	110,481,280	27,714,900	138,196,180	32,300,909	170,497,089	26,054	53,695	48.5
1914	134,908,260	9,984,700	144,892,960	34,552,000	179,444,960	27,451	53,707	51.1
1915	130,987,460	24,920,500	155,887,960	34,259,844	190,147,804	29,091	54,351	53.5
1916	153,579,990	9,189,700	162,769,690	34,358,381	197,128,071	30,156	59,577	50.6
1917	148,760,510	18,308,900	167,069,410	29,000,178	196,069,588	29,994	60,662	49.4
1918	167,398,438	71,090,900	238,489,338	8,270,514	246,759,852	37,748	70,530	53.6
1919	148,802,897	95,328,800	244,131,697	....	28,472,652	41,699	....	......

[a] Oct. 12 to Dec. 31.
[b] Purchased during October, November, and December.

Coast Valleys Gas & Electric Co.

Year.	Hydroelectric.	Steam.	Total.	Purchased.	Total system.	Mean.	Peak.	Load factor.
1913	....	291,050	291,050	6,471,473	6,762,523	1,034	2,278	45.3
1914	....	141,521	141,521	7,820,600	7,962,121	1,218	2,513	48.4
1915	....	136,990	136,990	7,411,800	7,548,790	1,155	3,116	37.0
1916	....	3,369,000	3,369,000	6,072,699	9,441,699	1,444	3,451	41.8
1917	....	3,203,400	3,203,400	7,081,518	10,284,918	1,573	4,556	34.5
1918	....	918,098	918,098	12,531,606	13,449,704	2,055	5,226	39.3
1919	....	763,200	763,200	15,181,600	15,944,800	2,439	7,236	33.7
1920	....	1,726,122	1,726,122	18,728,600	20,454,722	3,129	7,150	43.8

Yosemite Power Co.

Year.	Hydroelectric.	Steam.	Total.	Purchased.	Total system.	Mean.	Peak.	Load factor.
1913	3,646,756	....	3,646,756	....	3,646,756	558	1,232	45.3
1914	4,174,800	....	4,174,800	....	4,174,800	639	1,810	35.3
1915	3,854,700	....	3,854,700	8,730	3,863,430	591	1,276	46.3
1916	3,957,600	....	3,957,600	23,391	3,980,991	609	1,453	41.9

TABLE 46.—*Sales and connected load, Sierra & San Francisco Power Co., 1913–1920.*

Class of load.	1913				1914			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence. Commercial.	1,220,684	1.0	....	....	1,298,811	1.0	1,901	3.8
Municipal miscellaneous.	110,775	.1	....	....	130,294	.1	....	....
All other.	710	.0	....	....	....	....	....	....
Power:								
Industrial. Agricultural.	16,200,183	13.4	....	....	123,601,853	98.9	48,699	96.2
All other.	103,153,488	85.5	....	....	....	....	....	....
	120,685,800	100.0	....	....	125,030,958	100.0	50,600	100.0

TABLE 46.—*Sales and connected load, Sierra & San Francisco Power Co., 1913–1920*—Continued.

Class of load.	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	1,359,741	0.8	2,039	3.9	1,566,024	0.8	4,764	8.5
Commercial								
Municipal miscellaneous	155,197	.1			180,024	.1		
Power:								
All other	162,946,735	99.1	49,884	96.1	167,093,272	99.1	50,879.8	91.5
	164,461,673	100.0	51,923	100.0	168,839,320	100.0	55,643.8	100.0

Class of load.	1917				1918			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	1,863,414	1.1	3,793	7.0	2,225,157	1.1	....	....
Commercial							....	....
Municipal street	160,787	.1			145,669	.1	3,962	6.3
Municipal miscellaneous	18,066	....			18,879	....	....	....
Power:								
Municipal	793,319	.5			1,046,161	.5	....	....
Industrial	16,334,946	10.0	11,086	19.4	22,072,989	10.6	13,339	21.2
Agricultural			1,611	2.8				
Railway	117,704,290	71.5	27,850	48.8	133,571,265	64.4	27,071	43.2
All other	....	....	1,009	1.7	....	....	7,512	12.0
Other electric corporations	27,720,161	16.8	11,656	20.3	48,261,704	23.3	10,840	17.3
	164,594,933	100.0	57,005	100.0	207,341,824	100.0	62,724	100.0

Class of load.	1919				1920[c]			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	2,631,964	1.1	No record.	....	56,580	....	[d] 1,269	2.3
Municipal	189,845	.1	No record.	....	149,884	0.1	80	.1
Commercial	([a])	....	No record.	....	4,015,524	1.6	4,200	7.6
Power:								
Industrial	28,512,804	12.4	No record.	....	11,860,576	4.7	3,298	6.0
Agricultural					11,949,274	4.7	4,545	8.2
Municipal	1,281,871	.6	No record.	....	224,311,476	88.9	41,838	75.8
Railway	140,943,025	61.4	No record.	....				
Other	([b])	....	No record.	....				
Other electric corporations	55,965,164	24.4	No record.	....	....	....	....	....
	229,524,673	100.0	....	....	252,343,314	100.0	55,180	100.0

[a] Included in "Residence."
[b] Included in "Agricultural and Industrial."
[c] See also Table 18, p. 136.
[d] Includes "Cooking and heating," 1,161 kilowatts, 2.1 per cent.

TABLE 47.—*Sales and connected load, Coast Valleys Gas & Electric Co., 1913–1920.*

Class of load.	1913				1914			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	829,706	16.8	2,108	40.6	951,132	15.6	2,480	38.8
Commercial								
Municipal miscellaneous	327,603	6.7	73	1.4	289,205	4.8	135	2.8
All other	653,618	13.5	......	......	634,570	10.4	......	......
Power:								
Municipal	......	......	876	16.9	......	......	......	......
Industrial	3,014,524	61.8	2,134	41.1	4,203,263	69.2	1,320	20.6
Agricultural							2,450	38.4
All other power and lighting used by company	59,116	1.2	......	......	......	......	......	......
	4,884,567	100.0	5,191	100.0	6,078,170	100.0	6,385	100.0

Class of load.	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	996,556	18.2	2,289	36.0	1,164,725	19.4	2,430.3	35.4
Commercial								
Municipal miscellaneous	286,201	5.2	136	2.1	271,510	4.5	136.0	2.0
Power:								
Industrial	3,618,217	65.9	1,262	19.8	3,956,244	65.9	1,600.6	23.3
Agricultural			2,685	42.1			2,699.0	39.3
All other power and lighting used by company	588,547	10.7	......	......	613,297	10.2	......	......
	5,489,521	100.0	6,372	100.0	6,005,776	100.0	6,865.9	100.0

Class of load.	1917				1918			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	1,237,058	16.5	2,728.8	32.3	1,259,666	13.3	2,680,490	27.7
Commercial								
Municipal street	244,251	3.2	83.6	1.0	247,988	2.6	162,510	1.1
Municipal miscellaneous	18,728	.3	54.1	.6	19,145	.2	50,100	.5
Power:								
Municipal	5,255	.1	19.2	.2	4,590	.1	19,030	.2
Industrial	5,722,112	76.1	4,953.3	58.6	7,566,099	79.7	6,417,450	66.4
Agricultural								
Railway	281,970	3.8	335.7	4.0	392,121	4.1	335,700	3.5
All other power and lighting used by company	......	......	283.0	3.3	......	......	56,900	.6
	7,509,374	100.0	8,457.7	100.0	9,489,609	100.0	9,662,180	100.0

TABLE 47.—*Sales and connected load, Coast Valleys Gas & Electric Co., 1913–1920*—Con.

Class of load.	1919				1920			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	(a)	....	(a)	....	(a)	....	(a)	....
Municipal	290,024	2.4	153.0	1.0	295,655	2.0	120.1	0.9
Commercial	1,438,994	12.2	2,999.0	22.3	1,787,712	12.0	3,924.6	28.1
Power:								
Industrial	9,524,005	80.4	9,908.0	73.0	1,245,529	8.4	2,075.3	14.9
Agricultural	....	....			10,955,100	73.6	6,657.5	47.7
Municipal	5,220	....	19.0	.2	4,525	....	20.5	.1
Railway	456,800	3.9	335.7	2.5	426,680	2.9	450.0	3.2
Other	85,437	.7	56.5	.4	161,835	1.1	713.0	5.1
Other electric corporations	47,400	.4	....	....	....	....	....	....
	11,847,880	100.0	13,471.2	100.0	14,877,036	100.0	13,961.0	100.0

[a] Included with "Commercial."

TABLE 48.—*Sales and connected load, Yosemite Power Co., 1913–1916.*

Class of load.	1913				1914			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	....	....	335	19.3	121,481	3.6	343.18	26.6
Commercial	....	....	233	13.5	211,090	6.2	206.29	16.0
Municipal	....	....	36	2.1	Flat rate.	....	37.68	2.9
All other	....	....	40	2.2	8,783	.3	47.00	3.7
Power:								
Industrial	....	....	406	23.5	2,003,748	58.8	442.65	34.3
Agricultural	....	....	15	.9	10,205	.3	33.56	2.6
All other	....	....	666	38.5	[a] 1,051,857	30.8	179.19	13.9
	....	....	1,731	100.0	3,407,164	100.0	1,289.55	100.0

Class of load.	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:	125,085	5.6	454.38	24.2	145,933	5.5	511.27	27.0
Residence	126,547	5.7	217.07	11.6	138,533	5.2	231.81	12.3
Commercial	Flat rate.	....	32.93	1.8	Flat rate.	....	35.89	1.8
Municipal	14,234	.6	71.19	3.8	17,247	.7	75.05	4.0
All other								
Power:	[b] 1,768,469	79.5	718.90	38.3	2,039,921	76.9	599.40	31.7
Industrial	13,200	.6	37.30	1.9	13,820	.5	52.59	2.8
Agricultural	178,182	8.0	343.78	18.4	297,068	11.2	384.79	20.4
All other								
	2,225,717	100.0	1,875.55	100.0	2,652,522	100.0	1,890.80	100.0

[a] This includes 811,935 kilowatt-hours sold to Sierra & San Francisco Power Co., which amounts to 23.8 per cent of total sales in kilowatt-hours.

[b] This includes 232,977 kilowatt-hours sold to Sierra & San Francisco Power Co., which amounts to 10.4 per cent of total sales in kilowatt-hours.

TABLE 49.—*Growth of load on Sierra & San Francisco Power system (including Coast Valleys and Yosemite Power companies), 1913–1918.*

Year.	Number of consumers.			Connected load (in horsepower).		
	Sierra & San Francisco Power Co.	Coast Valleys Gas & Electric Co.	Yosemite Power Co.	Sierra & San Francisco Power Co.	Coast Valleys Gas & Electric Co.	Yosemite Power Co.
1913	3,117	3,113	952	....	6,956	2,319
1914	3,717	3,627	1,028	67,804	8,556	1,727
1915	4,079	3,435	1,150	65,577	8,538	2,512
1916	4,445	3,716	1,306	74,561	9,200	2,533
1917	6,196	3,973	....	76,387	11,333	....
1918	6,730	4,380	....	84,050	12,893	....

Mean monthly load on the system operated by Sierra & San Francisco Power Co. from October, 1908, to December 31, 1919, when the system was leased to Pacific Gas & Electric Co., calculated from the output of its own plants and power purchased from other companies, including power delivered to Coast Valleys Gas & Electric Co., but not the power which that company generated at its own steam-electric stations nor that generated by Yosemite Power Co. prior to October 1, 1917, are shown graphically in figure 8. The heavy dash line on the figure shows the combined installed hydroelectric capacity in all generating stations belonging to the company. The following changes in this combined generating capacity were too complicated to be represented on the figure:

Unit No. 1 of the Stanislaus plant went into operation October 12, 1908; unit No. 2, December 1, 1908; unit No. 3, January 15, 1909; unit No. 4, March, 1910. The original capacity of each of these units was 6,700 kilovolt-amperes, giving an installed plant capacity of 26,800 kilovolt-amperes. Unit No. 4 was rewound in May, 1912, to raise its capacity to 8,500 kilovolt-amperes, and between May and December of 1912 the other three units were treated in the same manner, thus raising the capacity of the plant to 34,000 kilovolt-amperes. The capacity of unit No. 4 was still further increased to 10,000 kilovolt-amperes by installing a forced ventilating system in October, 1912, and the other three units were equipped with the same system in October, 1917. All four units can not be operated at full combined capacity—40,000 kilovolt-amperes—until additional pressure pipes are installed. The Phoenix plant was paralleled with the system about December 1, 1909, and the Knights Ferry plant February 1, 1911.

During the year which followed the organization of Coast Valleys Gas & Electric Co., before power was first delivered to it from the Sierra & San Francisco line in December, 1912, the distribution system in and around Monterey and Salinas was supplied from the Monterey, Salinas, and King City steam plants. After the con-

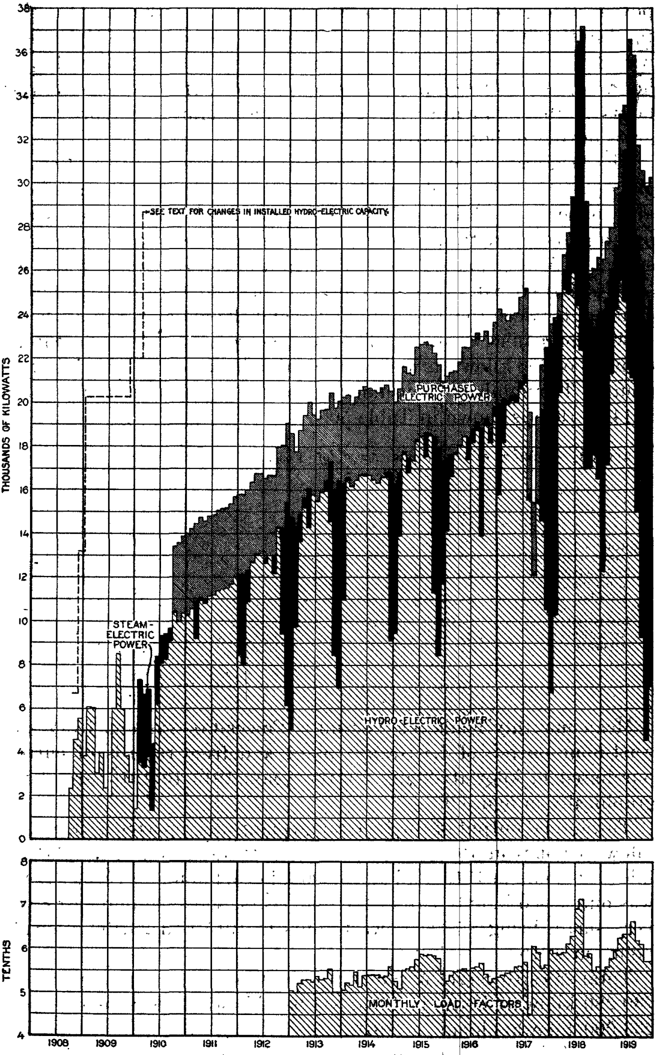

FIGURE 8.—Sierra & San Francisco Power Co., mean monthly loads and load factors, 1908–1919.

nection to the hydroelectric lines was completed practically no power was generated by these small steam-electric plants, their total output being but 291,000 kilowatt-hours in 1913, 141,500 kilowatt-hours in 1914, 136,990 kilowatt-hours in 1915, 289,300 kilowatt-hours in 1916, 336,960 kilowatt-hours in 1917, and 918,098 kilowatt-hours in 1918. Figure 8 can therefore be assumed to represent the gross output of both systems.

The segregation of electric revenues of Yosemite Power Co. as given at the bottom of Table 215 and the sales in kilowatt-hours and connected load in Table 48 show that residence and commercial lighting and industrial power were the most important loads on the system. A large part of the total output of the La Grange plant was sold to Sierra & San Francisco Power Co. prior to April, 1915, when the contract between the Yosemite Power and the Sierra & San Francisco Power companies expired. This contract provided for a maximum demand of 200 kilowatts and an annual delivery of 730,000 kilowatt-hours. The number of consumers served by Yosemite Power Co. from 1914 to 1916 is shown in Table 50.

TABLE 50.—*Number of consumers served by Yosemite Power Co. Dec. 31, 1914–1916.*

	1914	1915	1916
Lighting:			
Residence	643	737	834
Commercial	245	242	286
Municipal		5	5
All other	45	56	46
Power:			
Industrial	56	66	76
Agricultural	14	11	11
All other	25	33	48
	1,028	1,150	1,306

Mean monthly loads for Yosemite Power Co. system, from kilowatt-hour output of La Grange plant and from records of current purchased in kilowatt-hours for the years 1913 to 1916, are shown graphically in figure 9.

The annual output of the La Grange plant was reported as 3,644,700 kilowatt-hours in 1913, 4,174,800 kilowatt-hours in 1914, 3,854,700 kilowatt-hours in 1915, and 4,055,900 kilowatt-hours in 1916. Power was purchased in only two of the four years, and such purchases were very small, being 8,732 kilowatt-hours in 1915 and 23,400 kilowatt-hours in 1916.

Total sales to Sierra & San Francisco Power Co. were reported as 730,280 kilowatt-hours in 1913, 811,935 kilowatt-hours in 1914, and 233,000 kilowatt-hours in 1916.

Typical daily load curves for Sierra & San Francisco Power Co., taken in the years 1913–1919, are shown in figure 12. These curves include all power generated on the system and power purchased, but do not include the small quantity of steam power generated on the system of Coast Valleys Gas & Electric Co. (See fig. 10.) The company takes its readings from the integrating kilowatt meters at the power houses, and the curves therefore show mean output per hour.

Typical daily load curves for Yosemite Power Co. for 1915 and 1916 are given in figure 11.

The curves showing monthly load factors (1913–1919), plotted on the lower part of figure 8, are based on the output of the system plus current purchased. The factors for the years prior to 1913 are not available.

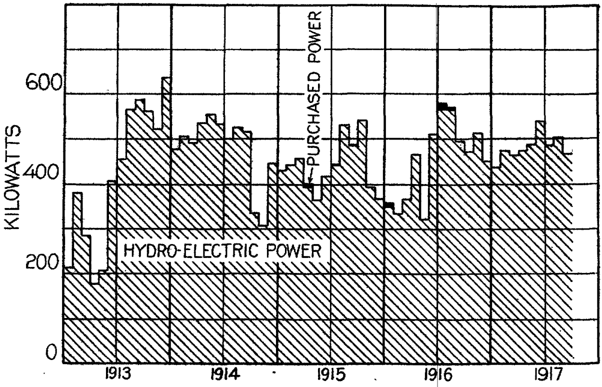

FIGURE 9.—Yosemite Power system, mean monthly loads from 1913 to date of absorption by Sierra & San Francisco Power Co.

ELECTRIC SYSTEM.

GENERAL RELATIONS.

Sierra & San Francisco Power Co. generated most of its output at the Stanislaus plant, from which power is transmitted over two tower lines to the south end of San Francisco Bay, and then by a single tower line northward to San Francisco into the Bay Shore substation. An important pole and tower line extends from the tower line at the south end of the bay southward to Salinas, where power is delivered to Coast Valleys Gas & Electric Co. The principal steam station of the Sierra & San Francisco Power system is the North Beach plant in San Francisco, in addition to which the company leased the Bryant Street steam station from the United Railways. The company has not, however, operated the Bryant Street station for some time, and maintains it solely to comply with the terms of the contract under which the Sierra & San Francisco Co. was financed. In addition to the Stanislaus plant the company operated the Phoenix plant on the South Fork of the Tuolumne, the Knights Ferry plant on the main river in the eastern edge of the San Joaquin Valley (small plants that were purchased for considerations other than their value as generating stations), and the La Grange plant on Tuolumne River.

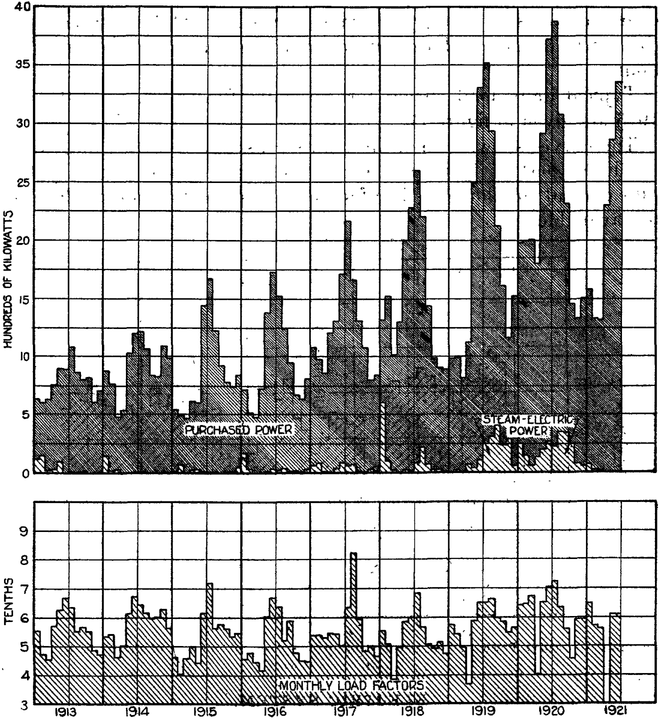

FIGURE 10.—Coast Valleys Gas & Electric Co., mean monthly loads and load factors, 1913-1921.

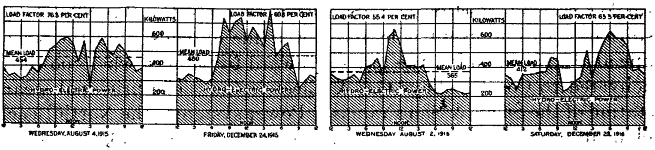

FIGURE 11.—Sierra & San Francisco Power Co. (Yosemite Power Co.), daily load curves, 1915-16.

The system of Sierra & San Francisco Power Co. (with the exception of the Knights Ferry plant, which was shut down) was leased to Pacific Gas & Electric Co. January 1, 1920. The lease did not include the Coast Valleys Gas & Electric system.

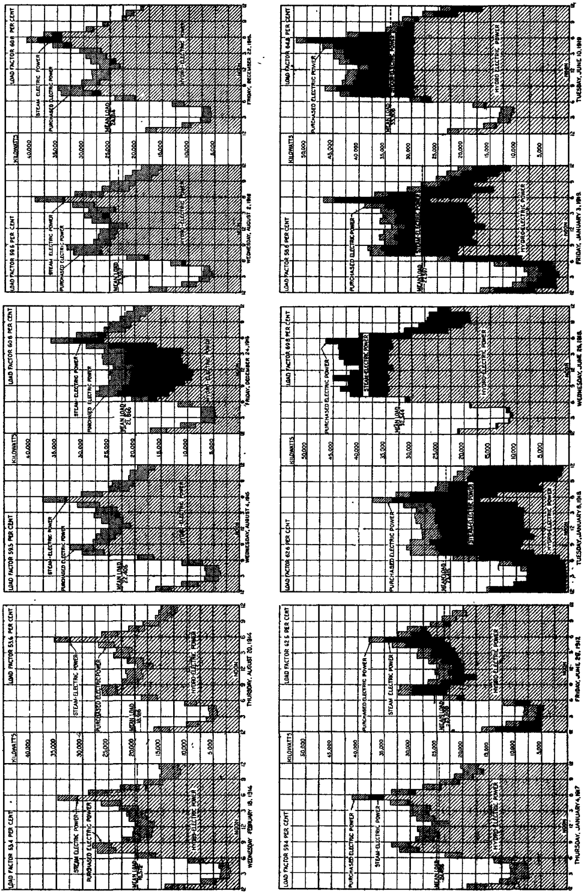

FIGURE 12.—Sierra & San Francisco Power Co., daily load curves, 1914–1919.

Coast Valleys Gas & Electric Co. owns a steam station of 1,000 kilovolt-amperes (1,340 horsepower) capacity at Monterey, and small plants at Salinas (300 kilovolt-amperes, 402 horsepower) and King

City (75 kilovolt-amperes, 100 horsepower). All these plants were taken over from its predecessors; only the Monterey and Salinas plants are further described in this report.

STANISLAUS PLANT.

LOCATION.

The Stanislaus plant is on the Middle Fork of Stanislaus River, 12 miles due north of Sonora, Tuolumne County, the power house being in sec. 6, T. 3 N., R. 15 E. The intake is in sec. 24, T. 4 N., R. 17 E.; the conduit traverses secs. 19, 20, 21, 22, 23, 24, and 30, T. 4 N., R. 16 E.; secs. 25, 26, 27, 28, 32, and 33, T. 4 N., R. 15 E., and secs. 5 and 6, T. 3 N., R. 15 E.

The plant receives most of the water stored in Big Dam reservoir and in Upper and Main Strawberry reservoirs on South Fork, which lie, respectively, in secs. 4, 9, and 10, T. 4 N., R. 19 E., secs. 11 and 14, T. 4 N., R. 18 E., and secs. 14, 15, and 22, T. 4 N., R. 18 E., and all the stored water from Relief reservoir on Relief Creek, a tributary of Middle Fork, which is in secs. 13, 14, 23, and 24, T. 5 N., R. 20 E.

The plant was put into operation October 15, 1908, by The Stanislaus Electric Power Co. and passed into the hands of Sierra & San Francisco Power Co. soon afterward.

SOURCE OF WATER SUPPLY.

The Stanislaus plant is operated by water taken from the Middle and South forks of Stanislaus River, the intake of the plant being on the Middle Fork about 15 miles above the power house and above the mouth of the North Fork. The entire area contributing water to the plant is in Tuolumne, Calaveras, and Alpine counties, at a distance ranging from 110 to 160 miles due east of San Francisco.

The Middle Fork of Stanislaus River is formed by the junction of Relief and Kennedy creeks, which rise along the west slope of the main divide of the Sierra in the vicinity of Kennedy Peak. From its headwaters the river flows northwesterly about 15 miles to the point at which it is joined by Clarks Fork. Below the mouth of Clarks Fork the river flows southwesterly through a deep canyon which extends to the edge of the foothills, some 35 miles in an air line from the mouth of Clarks Fork and 15 miles below the Stanislaus intake. Clarks Fork, which may be considered the chief tributary, rises on the main divide of the Sierra between Sonora and Disaster peaks. The length of the Middle Fork basin from the Stanislaus intake to its northeastern boundary is about 30 miles; its width at its widest point, which is in its headwater basin, is 20 miles. Below the mouth of Clarks Fork, however, where the river flows through a deep canyon, the width of the basin is reduced to about 10 miles; its area is 325 square miles.

Elevations within the part of the basin above the plant range from 2,704 feet at Sand Bar intake to an average of 10,000 and maximum of 11,600 feet along its eastern boundary at the headwaters of the small feeder streams. In general the boundaries of the headwater basin are above 9,500 feet. Elevations along the ridges on the north and south sides of the canyon exceed 5,000 feet, ranging up to 9,400 feet near its head.

The east side of the upper Stanislaus basin is typically alpine, including tremendous domes and peaks of granite and very rugged topography. The west side, though rugged, is slightly lower. Below the mouth of Clarks Fork in the main canyon the stream is shut in by two broad-topped ridges which are covered with heavy timber. The sides of these ridges at first roll away rather gradually toward the stream, and then suddenly break into a deep canyon whose walls are in most places very precipitous, especially in the Donnells Flat region, near the mouth of Niagara Creek, where the domes and cliffs along the canyon form a miniature Hetch Hetchy Valley. Except where cut over by lumber companies the region is covered by a dense forest that extends from the timber line well down along the ridges below the Sand Bar intake.

No records of precipitation for the drainage basin are available, but records obtained at stations at Tamarack and Bear River in the Mokelumne basin, to the north, indicate that the mean seasonal rainfall in the upper sections of the Stanislaus basin should be not less than 55 inches and that of the central section, in the vicinity of the intake, should be about 40 inches. The quantity of snow remaining along the crest of the divide after a dry season is almost negligible, and the stream flow suffers in consequence.[67] The company has found it necessary, therefore, to construct storage works on the headwaters of the river. Of these, the Relief reservoir (Pl. XXXVII, *A*) is completed, some preliminary construction has been done on the foundations of the dam for Kennedy's reservoir, a mile below Relief, and preliminary surveys have been made for a reservoir at Donnells Flat.

The South Fork of Stanislaus River rises on the western slope of the ridge that forms the western boundary of the Relief Creek basin, flows southward, and discharges into the main Stanislaus River not only below Stanislaus intake but several miles below the power house. Water from the South Fork has been diverted to the main Stanislaus at a point about 4 miles below Main Strawberry reservoir and some 15 miles below the extreme headwaters of the South Fork. The average width of the South Fork basin, including Herring Creek, is 3 miles, the widest part being near the headwaters and the narrowest

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[67] For records of flow at Sand Bar intake see U. S. Geol. Survey Water-Supply Papers as follows: 299, pp. 349–353 (1905–1910); 331, pp. 201–203 (1911–12); 361, pp. 232–233 (1912–13); 391, pp. 179–180 (1913–14); 411, pp. 186–187 (1914–15); 441, pp. 163–164 (1915–16); 461, pp. 164–165 (1916–17); 481, pp. 161–162 (1917–18).

near the intake; the part tributary to the head of the South Fork diversion canal comprises 49 square miles. Though the quantity of water that can be diverted to the Stanislaus plant will be limited by the capacity of the diversion canal, it can be closely regulated by storage in the Main Strawberry reservoir, in which a large part of the flood flow of the stream may be impounded. This water can be released in the dry season and the quantity kept well within the capacity of the diversion canal.[68]

The South Fork drainage area that has become tributary to Stanislaus plant is a high, rolling, well-timbered ridge country, like that which shuts in the Middle Fork canyon, but except in its extreme eastern end it is not so rugged as the Middle Fork country. Elevations range between 5,000 feet at the intake of the diversion canal to 9,800 feet on the ridge between the South and Middle forks just southwest of Relief reservoir.

RESERVOIRS.

Relief reservoir.—The reservoir (Pl. XXXVII, *A*) that takes its name from Relief Creek is at the headwaters of Middle Fork at Relief Meadows, in the south-central part of the basin. It is formed by a rock-fill dam (Pl. XXXVII, *B*), 140 feet high, 509 feet long on the crest, at an elevation of 7,340 feet.[69] The area at spillway level (7,330 feet) is 213.6 acres, and the corresponding storage is 601,215,000 cubic feet, but the spillway is fitted with flashboards by which the water surface may be raised to an elevation of 7,337.5 feet; the area of the lake is then increased to 228.7 acres and the storage to 14,965 acre-feet, or 651,900,000 cubic feet.

The dam is faced with concrete on its upper side and contains about 134,200 cubic yards of material. The slope of the upstream face is ½:1, that of the downstream face 2:1, and the crest width is 13 feet. The upstream part is composed of derrick-laid rock with fine material sluiced into the voids between the blocks. The top of this derrick-laid section has the full crest width of the dam and its lower face has a batter of 15 in 100. The drop-fill rock backing was piled in behind (downstream from) the derrick-laid section at the same time that the latter was being carried up. The drop-fill reaches only to a height of 130 feet above the base, so that the upper 10 feet of the more carefully laid section has no loose rock backing. The upstream face of the dam is a very carefully laid rock wall, the front 2 feet of which is laid in mortar. The wall is finished with a facing of concrete which is 9 inches thick at the top and is increased to 18

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[68] For records of stream flow in this part of the basin of the South Fork of Stanislaus River, see U. S. Geol. Survey Water-Supply Papers as follows: 299, pp. 357-359 (up to June 30, 1912); 331, pp. 208-210 (1911-12); 361, pp. 239-241 (1912-13); 391, pp. 185-187 (1913-14); 411, pp. 197-198 (1914-15); 441, pp. 195-196 (1915-16); 461, pp. 173-174 (1916-17).

[69] Approximate datum assumed from the U. S. Geol. Survey topographic maps.

A. RELIEF RESERVOIR, SIERRA & SAN FRANCISCO POWER CO.

B. RELIEF DAM, SIERRA & SAN FRANCISCO POWER CO.

C. CARIBOU POWER HOUSE, GREAT WESTERN POWER CO. OF CALIFORNIA.
Photograph by Stone & Webster, Inc.

D. IMPULSE WHEEL WITH HOUSING LIFTED, CARIBOU POWER HOUSE, GREAT WESTERN POWER CO. OF CALIFORNIA.
Photograph by Stone & Webster, Inc.

A. STANISLAUS POWER HOUSE.

B. SANDBAR INTAKE DAM, STANISLAUS PLANT.

C. CROSS CONNECTION AT JUNCTION OF WOOD AND STEEL PRESSURE PIPES, STANISLAUS PLANT.

D. BAY SHORE SUBSTATION.

HYDROELECTRIC SYSTEM OF SIERRA & SAN FRANCISCO POWER CO.

Photographs *A*, *B*, and *C* by the company.

inches thick at an elevation of 7,227 feet and to 36 inches at an elevation of 7,214 feet; from elevation 7,214 feet down to bedrock the concrete facing continues at a uniform thickness of 36 inches and at the bottom of the dam is sealed in a trench cut in the bedrock foundation.

The outlet of the reservoir is through three 33-inch pipes, each controlled by a 30-inch gate valve. The pipes are laid in a culvert and pass through the bottom of the dam near its center. The upper ends of the pipes head in an intake chamber along the upstream toe of the dam, into which water flows through iron screens supported on I-beam grids. The gates in the pipes are in a chamber in the center of the dam and are reached by crawling through a 33-inch pipe extending out to its lower face.

At the south end of the dam there is a spillway 30 feet wide, with floor 10 feet below crest level, cut through solid granite of a spur that juts out into the canyon.

The original plan was drawn for a dam which was to be arched upstream, but when the foundations were explored a deep hole was found in the bedrock along the upper edge of this arch. By reversing the bend in the plan, advantage could be taken of a high point in the bedrock below the pothole, and the structure was therefore finally built on this new line. On account of this unusual alinement the dam presents an anomalous appearance which is hard to understand unless conditions which caused the change in the design are known.

The drainage basin above Relief reservoir consists chiefly of bare rock ridges and domes with only here and there a small amount of timber; its area is 29.1 square miles. Precipitation is chiefly in the form of snow, and the reservoir receives its supply from melting snow fields. The reservoir was constructed solely for the use of the power plant and the stored waters are entirely controlled by the company.

Strawberry reservoirs.—The old storage reservoirs on the headwaters of South Fork, known as Big Dam and Upper and Main Strawberry reservoirs, were small lakes formed by timber-crib dams constructed about 1856. These old crib dams no longer hold water up to the original level, for parts of the crests have been carried away and the structures have settled. They were built by the Tuolumne County Water Co. and used as a mining supply, and later their use was coupled with the development of power by Tuolumne County Water & Electric Power Co.

The "Big dam" is at present approximately 44 feet high, and its length on the crest is 385 feet. The capacity of the reservoir is 1,890 acre-feet, or 82,328,000 cubic feet. When constructed the dam was about 18 feet higher than it is at present, and the capacity of the reservoir formed by it was 4,000 acre-feet. The elevation of the reservoir is about 7,300 feet, and the catchment area above it is 18.2 square miles.

The dam at Upper Strawberry reservoir is 40 feet high and 300 feet long on the crest. The area of the reservoir is 50 acres, and its capacity is 1,180 acre-feet, or 51,401,000 cubic feet.

During the years 1913 to 1916 Main Strawberry dam was replaced by a rock-fill dam about 135 feet high to maximum water level and 140 feet to crest level.[70] This dam has increased the area of the reservoir from 82 to 294 acres and its capacity from 52,600,000 to 779,724,000 cubic feet (at elevation 5,615). The crest of the new dam is 5,620 feet above sea level and its length 612 feet. The spillway lip is 8 feet below the crest, is 100 feet long, and 4,500 second-feet in capacity. The crest width of the dam is 15 feet, the upstream face practically 1:1, and the downstream slope 3:1. The dam contains over 288,000 cubic yards of rock fill, finished on the upstream face by over 35,500 cubic yards of derrick and hand laid granite faced with a reinforced-concrete slab containing over 6,000 cubic yards of concrete and 182 tons of steel. The outlet is a tunnel through bedrock at one end of the dam. The inlet to this tunnel is a reinforced-concrete tower with internal diameter of 7 feet, in which six 30-inch sluice gates are set at various elevations. The outlet of the tunnel is a steel pipe 40 feet long and 6 feet in diameter containing four 14-inch needle valves and two 22-inch gate valves by means of which the delivery from the reservoir is accurately regulated. The dam was finished during November, 1916. The drainage area above the dam is 28 square miles; about 65 per cent of the water stored will be available for use in power development on the Middle Fork; the rest will be utilized as a supply for mines on South Fork and will pass through the Phoenix plant.

CONDUITS.

Main canal.—The main intake dam (Pl. XXXVIII, *B*) of the Stanislaus plant is at Sand Bar Flat on the Middle Fork of the Stanislaus, 30 miles down the river from the storage reservoir at Relief. The water liberated from storage is therefore turned directly into he stream bed and allowed to flow down through the natural channel.

The crest of the intake dam is at an elevation of 2,703.5 feet, and the dam is of the rock-filled crib type, is about 20 feet high, and is planked on both surfaces. The upstream face of the dam slopes 3 to 1 and the downstream face 2 to 1. The maximum flood flow yet recorded over the dam occurred March 22, 1907, when the discharge was 9,763 second-feet. The canal heading is above and at right angles to the dam at its south end. The head works are constructed of

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[70] Above the bed of the stream. The lowest point in the foundations is 30 feet below the stream bed.

concrete and rubble masonry laid in concrete. Water is admitted through 10 arched gateways 3 feet 9 inches wide by 7 feet deep, each controlled by a sliding timber gate, operated from the top of the wall by a ratchet and pinion. These gates admit the water into a masonry settling basin at the head of the canal. The floor of the basin is 1 foot below the flume bottom, and sediment may be removed from it through three 8-inch sand pipes which discharge through sluices in the rock retaining wall just below the end of the dam. At the lower end of the settling basin, in line with the end of the dam, there is a timber bridge from which the three headgates of the canal proper are operated by gears similar to those in use on the inlet gates.

The entire conduit line, except for a short stretch of canal adjoining the forebay reservoir and one tunnel, is in a trestle-supported timber flume, 9 feet wide by 6.5 feet deep, the capacity being 300 second-feet. The original length of the conduit was 80,000 feet and that of the flume 78,000 feet; one section of the original flume was eliminated in 1913 by a tunnel which is 1,590 feet long, 8 feet 6 inches wide, 6 feet to the spring line of its arched roof, and its floor and sides are lined with concrete. The grade on the flume line is 1.9 feet per thousand, giving 148 feet total fall, to which should be added 1.7 feet, the fall in the ditch near the forebay.

The planking of the flume box is 1⅞ inches by 12 inches and is battened at the seams with five-eighths by 4 inch strips. A plank footway which carries a light, narrow-gage railroad is laid along the top of the flume in the center of the bents. The inspectors and repairman travel up and down this line on small handcars, and material for current repair work is transported on flat cars. The flume is supported on trestle bents spaced 15 feet on centers and constructed of 10 by 10 inch timbers.

At its lower end the flume joins an earth ditch which runs to the forebay. The ditch is 2,000 feet long, 12.2 feet wide on bottom, and about 8 feet deep; its side slopes are ½: 1, and its grade is 0.83 foot per thousand.

The South Fork diversion canal does not discharge directly into this conduit, but into the head of one of the side canyons just above Sand Bar, and its discharge is picked up with the water from Relief at the main conduit heading. The diversion follows the line of the old Philadelphia ditch, which was constructed for hydraulic mining about 1858. Water is diverted into the South Fork conduit by a small rubble masonry dam 12 feet high and 55 feet long. Most of the conduit is side-hill ditch, with bottom width of 3 feet, side slope 1 to 1, carrying water to a depth of 3.22 feet, with outer embankment rising 1.5 feet above the normal water surface. The top width of outer embankment is 3 feet. The grade of the ditch is 1 foot in 1,000, and its capacity 50 cubic feet per second, with a mean velocity of 2.5 feet per second. The flume boxes are 4 feet wide by 3 feet 10 inches deep and carry water to a depth of 3 feet. The flume grade is also 1 in 1,000, giving a capacity of 50 cubic feet per second, with a mean velocity of 4.17 feet. The length of the ditch section is 22,984 feet, and the flume aggregates 2,778 feet.

A penstock from the point where the Philadelphia ditch discharged into the basin of Middle Fork to the Spring Gap power house, on the main river near Bakers Crossing, was installed during 1921. The capacity of the new plant is 7,500 kilovolt-amperes, and the head is 1,865 feet.

Forebay.—In choosing the site of the Stanislaus forebay, at the lower end of the main conduit, advantage was taken of a saddle in the crest of a spur extending out into the canyon. Dams were constructed near the upper ends of the small canyons heading on each side of this saddle, thus forming a small reservoir which is shallowest at its center and deepest near the two dams at its ends. The two dams are made of earth fill and have a maximum height of about 50 feet each. The ridge in the center of the reservoir was not disturbed but left in place, so that silt could be removed from the eastern part of the basin (into which the conduit discharges) without interfering with the operation of the plant. The west dam (the larger of the two), through which the pressure mains lead, is 1,000 feet long on the crest, 10 feet wide on top, slopes 2½ to 1 on the upper and 1½ to 1 on the lower face, and contains 84,000 cubic yards of fill. The capacity of the reservoir is 14,000,000 cubic feet. A spillway 25 feet long and 2.73 feet deep is provided in the forebay embankment.

Pressure pipe.—Until 1919 the power house was served from the forebay by only two composite lines. The total length of each pressure pipe from the forebay to the power house is 4,618 feet, divided into three sections—the first 299 feet of steel, the second 1,259 feet of wood-stave pipe, and the third 3,060 feet of steel pipe. The first section of each line is a $\frac{5}{16}$-inch riveted steel pipe, 299 feet long, laid on a 5 per cent grade under the earth dam at the west end of the reservoir. Just beyond the rock retaining wall at the lower toe of the dam a standpipe 55 feet high and 12 inches in diameter rises from each main (Pl. XXXV, *A*, p. 223), and in each main, just before it reaches the standpipe, is a wicket valve. Sixteen feet beyond these gates the wood-stave pipes begin. Both these wood-stave pipes and the steel pipes under the dam are 66 inches inside diameter. The wood-stave section of the lines winds around the hillside to the edge of the main Stanislaus Canyon. The pipes are laid on a 2 per cent grade and at their lower ends the lines are subjected to a maximum head of 102.5 feet and are cross connected and fitted with gate valves (Pl. XXXVIII, *C*). The two riveted steel pressure pipes which begin at this cross connection extend the entire distance to the power house.

At the head of the drop the steel pipes are 48⅞ inches inside diameter and are constructed of plates one-fourth inch thick; at their lower ends they are 40 inches in outside diameter and 1 inch thick. At the point where the head reaches 624 feet the pipe is changed from lap riveted to butt strap.

The lower ends of the pressure pipes are cross connected by a header from which two 38-inch supply pipes are taken off to the three original units and a third supply line to the fourth unit. The 38-inch pipes are castings, with a main branch of the Y 38 inches in diameter, running directly toward an end unit in the power house, and a smaller branch, 31 inches in diameter, running in toward the center unit of the original installation. Each main branch continues to a point just outside the power-house wall, where it divides through a Y into two pipes 22 inches in diameter, which serve the two wheels of one of the original end units. The final 22-inch supply pipe leading to the nozzle of each separate rotor is fitted with a 20-inch gate valve, designed to be operated either by hand or by water-motor drive. When a fourth unit was added it was necessary to take a third branch line from the downstream end of the header. This branch runs directly toward the power house and feeds the fourth unit through another Y, each branch of which serves one rotor.

In the alinement of the two steel pipes just described most of the bends are above the rapid drop. The wood-stave section runs on a long curve around the hill from the forebay toward the main canyon. Below the point where wood joins steel the pipes make three bends to the power house. In profile the main descent begins at the lower end of the wood-stave pipe. The gradient increases rapidly below the point and from the break at the edge of the canyon to the power house the slope is about 52 per cent. The wood-stave pipe is uncovered and the steel pipe covered.

The output of the plant was limited to 33,000 kilovolt-amperes by lack of capacity of these penstocks. A third penstock similar to the other two was therefore completed in 1921, permitting the power house to carry the whole rated capacity of the generators, 40,000 kilovolt-amperes.

The elevation of the nozzles is 1,057.5 feet above sea level, and water surface in the forebay 2,555.3 feet. The static head is 1,497.8 feet and the working head 1,400 feet.

GENERATING STATION.

Power house.—The Stanislaus power house (Pl. XXXVIII, *A*) consists of two steel-frame buildings, walled and roofed with corrugated galvanized iron. A generator house, 153 feet long by 44 feet wide by 33 feet high to the lower member of the roof trusses, is placed along the river bank, and a switch house of the same length but only 31 feet wide is built against and directly behind it. The switch house is of about the same height as the generator house, but as it is on the slope of the hill its floor is at a higher level than that of the main building. A Louvre ventilator runs the full length of the generator roof peak.

The power house was originally designed for three units of 6,700 kilovolt-amperes capacity, but in 1909 all the generators were rewound, so that their rating was raised from 6,700 to 8,500 kilovolt-amperes, and a fourth unit of the same type was added, thereby increasing the total capacity of the station from 26,800 kilovolt-amperes to 34,000 kilovolt-amperes.[71] The third penstock permits the four machines to carry about 40,000 kilovolt-amperes. The units are placed in line, with shafts parallel to the main axis of the building but nearer its front wall. An exciter bay, 86 feet long by 13 feet deep, projects out from the front of the building and is covered by a lean-to roof. Opening into the back of the generator room (but contained in the switch house) are six bays, each 16 feet long by 16 feet deep, containing the four banks of transformers. The switchboard is on a raised balcony that projects out from between the central transformer bays and is 10 feet above the main generator floor. An iron stairway leads from the back of this balcony to the two switch galleries on the third floor of the switch house, 26 feet above the main floor. The low-tension gallery is in the front and the high-tension gallery in the back of the top floor, and both extend the full length of the building. The space in the switch house back of the transformer bays and below the switch galleries is occupied by the electro-pneumatic control mechanism of the high-tension switches.

The pressure pipes enter at the back of the power house under the main floor and are carried by very direct routes to their respective units. The nozzle centers are 2 feet 6 inches below the floor level of the generator room. The discharge from the wheels is through straight arched wasteways in the foundations, so that the water does not have to be deflected by baffle plates but is discharged directly over the river.

Hydraulic equipment.—The impulse wheels are of the Pelton double overhung type, a single rotor being carried on each end of the shaft, which is a hollow forging 28 feet long, 20 inches in diameter at the generator, and 16.5 inches at the journals near the water wheels. The pair of wheels on each unit has a combined maximum rating of 12,000 horsepower. The rotors are of the solid-disk type with 20 buckets bolted around the rim, each bucket being held in place by two bolts. The diameter of the rotors to bucket centers is 74¼ inches. The pair of 6-inch deflecting needle nozzles operating each

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[71] See p. 298 for other notes on changes in capacity.

unit is raised and lowered by a Pelton governor; the position of the needles is controlled by hand.

Generators.—The generators are General Electric ATB 18-pole 4,000-volt 1,228-ampere 3-phase 60-cycle machines operated at 400 revolutions per minute, and their bearings have both ordinary ring and forced-oil lubrication, with provision for water cooling. The generators were originally designed for 6,700 kilovolt-amperes; their capacity was later increased to 8,500 kilovolt-amperes each by rewinding, and then to 10,000 kilovolt-amperes by the installation of a forced-draft system. The original pipe lines have not, however, supplied enough water for all four units to carry more than 33,000 kilovolt-amperes until the installation of the new (third) penstock line.

Exciters.—The exciter equipment consists of two motor-generator sets of the same type, with a Pelton wheel combined in each. The generators are General Electric MP 6-pole 300-kilowatt 135-volt 2,222-ampere continuous-current machines, operated at 720 revolutions per minute. Each can be driven either by the Pelton wheel or by the General Electric type I 10-pole 4,000-volt 58-ampere 450 horsepower induction motor mounted on the same shaft.

Transformers.—Each of the six bays in the back of the generator room contains two General Electric form BI 1-phase 60-cycle 4,000/60,000-volt 2,233-kilowatt transformers, connected in banks of three in the ordinary manner, notwithstanding the fact that they are installed in pairs. The connections are delta on the generator side and Y with grounded neutral on the line side to give 104,000 volts. There is also one bank containing three 1,000-kilowatt transformers supplying the 17,000-volt distribution line of the Tuolumne district. This bank is provided with a 3-phase induction-type General Electric 150-kilovolt-ampere regulator on the low-voltage side.

Wiring.—Each of the leads from a generator is carried through a duct in the floor and up through the walls of the transformer cells to the low-tension switch gallery, where it passes through an oil switch to a tie bus. From the tie bus there are two leads, one runs to a main transformer direct and the other to the 4,000-volt bus, each passing through an oil switch en route. The Tuolumne transformers are the only banks run from the 4,000-volt bus; the main transformers do not connect to it. On the secondary side of the main transformers the leads connect to the 104,000-volt bus through oil switches. The high-tension bus is sectionized at its center, and the leads from it to the two main lines run from the center of each section through oil switches. All the low-tension switches are General Electric motor-operated remote-control 1,200-ampere 15,000-volt, type H3. The high-tension switches are General

Electric pneumatically operated 300-ampere 110,000-volt, form T. The General Electric type T switches on the two 104,000-kilovolt lines are being replaced with Westinghouse electric solenoid-operated type G11 automatic oil switches.

SPRING GAP PLANT.

LOCATION.

The Spring Gap power house and pressure pipe were constructed by Pacific Gas & Electric Co. during 1921 to utilize the fall between the lower end of the Philadelphia ditch and the Middle Fork of Stanislaus River on the system leased from Sierra & San Francisco Power Co. The development was completed and put into commercial operation September 16, 1921.

The location of the Spring Gap development is shown on Plate XXVII (in pocket). The power house is in sec. 21, T. 4 N., R. 17 E., on the Middle Fork of Stanislaus River, above the Sand Bar intake of the Stanislaus plant.

SOURCE OF WATER SUPPLY.

The entire supply for the development is drawn from storage and natural flow of the South Fork of Stanislaus River. That drainage basin and the storage and diversion works, with the exception of the pressure pipe, are completely described on pages 304–310, in connection with the Stanislaus plant.

PRESSURE PIPE.

In order to use the available head, a concrete-box forebay was constructed at the end of the Philadelphia ditch, near the point where it had hitherto discharged into a natural watercourse leading down to the Middle Fork, and a single steel pressure pipe of the following dimensions was built.

TABLE 50a.—*Pressure pipe at Spring Gap plant.*

Plate thickness.	Outside diameter.	Type of pipe.	Length.
Inches.	*Inches.*		*Feet.*
¼	37¼	Lapwelded	440
5/16	37¼	do	570
⅜	37¼	do	474
7/16	37¼	do	282
½	37¼	do	246
9/16	37¼	do	403
9/16	37¼	Butt riveted	753
⅝	37¼	do	537
⅝	[a] 37¼–31⅝	do	15
⅝	31⅝	do	1,043
11/16	31⅝	do	180
¾	31⅝	do	418
13/16	31⅝	do	953
⅞	31⅝	do	247
15/16	31⅝	do	233
1	31⅝	do	211
1 1/16	31⅝	do	248
			7,253

[a] Taper section.

The elevation of the water surface at the forebay is 4,873.75 feet, and that of the center of the nozzle at the power house 3,008.75 feet, giving a total static head of 1,865 feet.

GENERATING STATION.

Power house.—The main unit, auxiliary equipment, and transformers are housed in a single building 53 feet 6 inches long by 44 feet 6 inches wide, fronting northward on the south bank of the Middle Fork of Stanislaus River.

The generator and transformer room occupies the entire interior of the building, with the exception of a switchboard compartment that is partitioned off near the back wall. The shaft of the single horizontal unit is parallel to and 13 feet from the front wall of the building, in the east end of the generator room; and the bank of three transformers is in a pit 4 feet deep, 10 feet wide, and 30 feet long, along the west end of the room. The governor is immediately back of the unit, between it and the front of the switchboard compartment. The oil-pressure tanks and gate valve in the pipe line are between the switchboard compartment and the east end of the room. The low-tension switch cells are arranged along the back wall at the west end of the room. The station air compressor is installed near the front wall between the generator and the transformers, and the dressing room in the northeast corner near the water wheel. A steel rolling door 13 feet wide in the back part of the east wall and a small door in the west end afford access to the interior.

High-tension leads from the transformers are carried upward to pillar insulators and thence out through three large double-glazed windows in the west end of the building just under the eaves; an 8-inch circular hole is cut in the inner pane of glass and a 12-inch circular hole in the outer pane. Lines dead-ended to strain insulators fastened to the end of the building above the outlets extend to a steel switch frame west of the generating station. High-tension oil switches and disconnecting switches are installed at this point.

Hydraulic equipment.—The pressure pipe entering from the back under the floor level at the west end of the station connects through a 28-inch gate valve to the gooseneck nozzle casting of the single impulse wheel. The runner of the single overhung wheel is 87 inches in diameter, and the maximum rating of the wheel is 9,500 horsepower, with a guaranteed efficiency of 83 per cent; when developing 8,500 horsepower the guaranteed efficiency is 84 per cent. The wheel is equipped with the interlocking type of buckets. The nozzle is stationary, with oil-pressure governor control.

Generators.—The single generator, direct-connected to the overhung impulse wheel, is a General Electric ATB 6,600-volt alternator rated at 7,500 kilovolt-amperes (or 6,000 kilowatts at 0.8 power factor) and operated at 514 revolutions per minute.

Exciter.—A General Electric MPC 6-pole 42-kilowatt continuous-current exciter is direct-connected on the end of the generator shaft opposite the water wheel.

Transformers.—A bank of three General Electric 2,500 kilovolt-ampere transformers of the outdoor type step up the generator potential of 6,600 volts to 110,000 volts for transmission over the branch line extending down the canyon of the Middle Fork to the Stanislaus power house, where connection is made to the steel-tower transmission line running to the San Francisco Bay region. The transformers are connected delta on the low and Y with grounded neutral on the high tension side. No lightning arresters are installed. The low-tension switching equipment is entirely inside the generating station, and the high-tension equipment entirely outside.

PHOENIX PLANT.

LOCATION.

The Phoenix plant was put into operation by Tuolumne County Water & Electric Co. about 1901 and was taken over by Sierra & San Francisco Power Co. at the same time that it absorbed The Stanislaus Electric Power Co. The power house is in sec. 16, T. 2 N., R. 15 E., on the edge of a small stream bed. The intake is in sec. 25, T. 3 N., R. 16 E.; the conduit traverses secs. 25, 26, 34, and 35, T. 3 N., R. 16 E., and secs. 3, 4, 5, and 6, T. 2 N., R. 16 E.

The plant receives part of the water impounded by Big dam and by Upper Strawberry and Main Strawberry reservoirs.

SOURCE OF WATER SUPPLY.

Water is supplied to the Phoenix plant through an old mining ditch that heads on the South Fork of Stanislaus River about 14 miles northeast of Sonora and just below the old Lyon dam. In general the drainage area and reservoirs that serve the Phoenix plant are those tributary to the South Fork diversion of the Stanislaus plant (see pp. 305–308), but the drainage area above the intake of the old Phoenix plant is 19 square miles larger, the total being 68 square miles.

CONDUIT.

The diversion canal is a mining ditch called the Main Tuolumne ditch, 52 second-feet in capacity, heading at altitude 4,000 feet above sea level and passing from the basin of the South Fork over into the Sullivan Creek basin, where it distributes water to mines in the vicinity of Columbia. Before reaching the mines, however, a large part of the water was originally dropped from the ditch into a canyon, down which it flowed into Sullivan Creek and into the Phoenix reservoir. Below the reservoir it was again diverted from the creek into supply ditches for several of the mines around Sonora. The Phoenix plant was built to utilize the drop from the first ditch into the canyon above Phoenix reservoir. The length of the conduit from the intake to the pipe line is 13,200 feet, of which about 1½ miles is flume and the rest ditch. The ditch is 6 feet wide on bottom, 15 feet wide on surface, has a grade of 1½ feet in 1,000, and carries 52 second-feet. At the head of the pipe there is a small timber forebay. A single lap-riveted steel pressure pipe, 5,400 feet long and varying from 30 inches down to 18 inches in diameter, supplies the power house. The pipe follows down along the point of a ridge and is buried its entire length. At its lower end it runs into a header that extends along the side of the power house. From this header branches are carried down to the impulse wheels, three of which are arranged in a wheel trench along the outside of the power-house foundation. The static head is 930 feet.

GENERATING STATION.

Power house.—The power house is an old wooden building, 105.5 feet long by 31 feet wide. The header at the end of the pipe line lies along the side of the building toward the canyon, and the free discharge from the last units is almost parallel to the creek and into one edge of it. In the building, on the same side as the header and close to the side wall, are three 375-kilovolt-ampere Stanley generators, in a row, with their shafts projecting through the side wall of the foundation to their respective impulse wheels in the wheel trench outside. In the downstream end of the building and in the same row as the three generators is the wheel housing of a newer unit, a General Electric 750-kilovolt-ampere generator, which did not form part of the original installation. The shaft of this wheel and that of the generator to which it is coupled by a flexible leather coupling cross the end of the power house. In the angle between this unit and the row of three which formed the original installation is a raised platform on which are the switching equipment, disconnecting switches, and multigap lightning arresters. The transformers are in a small frame house about 200 feet from the downstream end of the main building.

Hydraulic equipment.—The 628-horsepower Pelton water wheels of the first three units are arranged one after another down the length of the narrow wheel pit. They are not provided with closed housing but run on bearings in the side of the covered pit. The discharge from the first wheel, therefore, passes under the next two wheels, and so on. The wheels are 60 inches in diameter to bucket centers, and each is equipped with 26 buckets. The fourth unit is operated by a 1,000-horsepower Pelton wheel, of newer type, mounted in a sheet-metal housing; its rotor is 72 inches in diameter and provided with 20 buckets. All the wheels are governed by deflectors operated by Lombard governors, type H.

Generators.—Generators Nos. 1 to 3 are of the old Stanley SKC type, designed to generate 2,400-volt 66-cycle alternating current at 400 revolutions per minute and rated at 375 kilovolt-amperes each.[72] The fourth unit is a General Electric ATB 750-kilovolt-ampere 2,400-volt 181-ampere 3-phase 60-cycle machine, operated at 333 revolutions per minute. The total rated capacity of the power house is therefore 1,875 kilovolt-amperes. Each of the first three generators is direct-connected on the same shaft as its wheel, and the fourth generator is connected to its water wheel with flexible leather coupling.

Exciters.—Excitation for each of the first three units is furnished by exciters connected to the generator shafts. These exciters are an Eddy Electric Co. 15-kilowatt 60-volt 250-ampere continuous-current generator operated at 1,000 revolutions per minute, and a National type CS 7½ 10-kilowatt 125-ampere 80-volt exciter operated at 1,450 revolutions per minute. The exciter for the fourth unit is a General Electric MP 17-kilowatt 60-volt 285-ampere 4-pole continuous-current generator, also belted to the shaft of the main generator; its speed is 750 revolutions per minute.

Transformers.—The nine Stanley SKC 150-kilowatt single-phase 2,300/15,000-volt water-cooled transformers installed in the separate transformer house are connected delta on both sides.

A double-circuit line from the station runs direct to Sonora, and beyond into the mining region.

Multigap lightning arresters are mounted above the raised platform in the power house.

KNIGHTS FERRY PLANT.[72a]

LOCATION.

The Knights Ferry plant was put into operation by Consolidated Stanislaus Water Power Co. in 1895 and was purchased by Sierra & San Francisco Power Co. in July, 1910. The power house and diversion dam are in sec. 29, T. 1 S., R. 12 E., on the north side of Stanislaus River, where the highway bridge crosses at Knights Ferry.

SOURCE OF WATER SUPPLY.

The Knights Ferry plant receives its entire supply from the main Stanislaus River.[73] Originally the diversion was made by two methods. One unit was supplied from the ditch of the San Joaquin

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[72] These machines are now operated to give 60 cycles and are paralleled with the other units of the system.

[72a] The Knights Ferry plant was put out of commission when the Sierra & San Francisco system was leased to Pacific Gas & Electric Co., January 1, 1920.

[73] For records of discharge of Stanislaus River at Knights Ferry see U. S. Geol. Survey Water-Supply Papers as follows: 299, pp. 318–341 (all records up to June 30, 1912); 331, pp. 196–198 (1911–12); 361, pp. 233–235 (1912–13); 391, pp. 185–187 (1913–14); 411, pp. 198–201 (1914–15); 441, 165–169 (1915–16); 461, pp. 166–167 (1916–17); 481, pp. 162–164 (1917–18).

Canal & Irrigation Co. which runs along the hill just north of the power house and the other unit supplied by diversion from the river at the power house. So much water is diverted above the plant that a description of the tributary drainage basin is omitted.

GENERATING STATION.

Power house.—The power house is an old stone structure originally used for a mill. It houses two units, which are set in separate rooms and at different levels.

Hydraulic equipment.—Unit No. 1 has a 1,200-horsepower Stillwell-Bierce 27-inch horizontal turbine, which formerly received its water under a head of 150 feet (including 15 feet draft) from the irrigation ditch of San Joaquin Canal & Irrigation Co. The use of this unit has been discontinued.

Unit No. 2 is run by rope drive from a horizontal shaft which is geared to three vertical Stillwell-Bierce turbines operating under a head of 14 feet in a turbine pit along the outer wall of the building. Two of these wheels are 60 inches and the other is 40 inches in diameter; their combined rating is 1,000 horsepower. The water supply for all three is diverted through a headrace by a timber-crib dam across the stream some 300 feet above the power house. This unit is now in intermittent use for its regulative effect rather than as a source of power.

Generators.—The two generators are of the same type—Westinghouse 750-kilovolt-ampere 500-volt 750-ampere 2-phase 60-cycle alternators, operated at 400 revolutions per minute.

Exciters.—The exciters are 125-volt 4-pole Westinghouse dynamos driven by belt from the generator shafts at 1,200 revolutions per minute.

Transformers.—In a small house at one side of the main generator building are two banks of two Westinghouse 375-kilowatt 1-phase 60-cycle 500/15,000 self-cooled transformers.

The lightning arresters are of Westinghouse shunted-gap type.

LA GRANGE PLANT.[73a]

LOCATION.

The La Grange power house is on the south bank of Tuolumne River just above La Grange, about 1½ miles below the La Grange dam. The intake is on the south bank of the Tuolumne about 9 miles above the La Grange irrigation dam, at an elevation of 600 feet above sea level. The intake is in sec. 6, T. 2 S., R. 15 E. The conduit traverses secs. 6, 7, 18, 19, and 30 of that township; secs.

[73a] The La Grange ditch and power house have been purchased by the Turlock and Modesto irrigation districts, in order to permit the building of the Don Pedro reservoir; the power house will be dismantled.

25, 36, 35, and 34, T. 2 S., R. 14 E.; and secs. 3, 10, 9, 16, 21, and 20, T. 3 S., R. 14 E., to the power house in the SE. ¼ sec. 20. The plant was originally constructed and put into commission by the La Grange Water & Power Co. in 1907. The system was acquired by Yosemite Power Co. June 1, 1911, and sold to Sierra & San Francisco Power Co. October 1, 1917. The right to 66 second-feet continuous use of water was acquired with the La Grange plant. The company has since sold the use of this water for six months of the year to the Waterford irrigation district and operates the power plant only during the remaining months.

SOURCE OF WATER SUPPLY.

The drainage basin (Pl. XXXIX, in pocket) contributing water to the La Grange power plant comprises 1,450 square miles lying above an intake dam on Tuolumne River in sec. 6, T. 2 S., R. 15 E. Elevations within this area range from 600 to 12,000 feet or more, at the crest of the Sierra. The basin is similar to the basins described in connection with Stanislaus plant (pp. 304–306), and the flow of the streams is affected by many diversions. The La Grange dam—the high masonry dam of the Turlock and Modesto irrigation districts—which is below the intake of the La Grange plant, diverts the entire low flow of the Tuolumne for irrigation.[74]

No storage is utilized in connection with the La Grange power plant.

CONDUIT.

Water is diverted by a temporary brush-and-rock dam into an old ditch constructed for hydraulic mining. The total length of the conduit is about 88,000 feet, and its maximum capacity 66 second-feet.

At its lower end the conduit discharges into a small forebay reservoir, with a capacity of about 6,500,000 cubic feet, formed by an earth dam in a hollow on the ridge above the power house. From this reservoir the water passes through headgates into several hundred feet of ditch leading to a concrete box forebay at the head of the pressure pipe.

The pressure pipe consists of a single lap-riveted steel pipe 1,160 feet long, laid in a trench and covered. The line is made up of 360 feet of 48-inch, 400 feet of 36-inch, and 400 feet of 30-inch pipe. The pipe is all lap riveted, and varies in thickness from No. 10 to one-fourth inch. The effective head is 210 feet.

GENERATING STATION.

Power house.—The La Grange buildings comprise a main generating station facing the river, a transformer house next to its upstream

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[74] For records of flow for this part of Tuolumne River see U. S. Geol. Survey Water-Supply Papers as follows: 299, pp. 250–296, 419 (up to June 30, 1912); 331, pp. 182–194 (1911–12); 361, pp. 186–221 (1912–13); 391, pp. 159–173 (1913–14); 411, pp. 183–186 (1914–15); 441, pp. 144–149, 159–163 (1915–16); 461, pp. 144–148 (1916–17); 481, pp. 159–163 (1917–18).

end, and a lightning-arrester shelter back of the transformer house and between it and the hill. The power house is a wooden-framed galvanized-iron building 40 feet long by 31 feet wide inside, set on concrete foundations. It contains two units, rated at 450-kilovolt amperes each, which are placed across one end of the generator room. The pipe line branches just back of the center of the generator building, and the two branches pass through the wall above the floor to the turbines, which are placed at each end of the room, next to the back wall. One branch of the pipe is controlled by a hydraulically operated and the other by a hand-operated gate valve. Both units are provided with draft tubes which project down into a raceway running from the building out into a natural channel leading to the river. The turbines are coupled to their generators by fly-wheel couplings, the type of coupling used in both units necessitating a rather long shaft, so that the generators are both near the front wall of the small generator room. The switchboard is set out from the front wall, between the generators. The governors are placed between the two units, as are the exciters. This brings the entire auxiliary equipment directly in front of the switchboard.

Hydraulic equipment.—One unit is operated by a 38-inch Pelton-Francis turbine installed in 1909, rated at 800 horsepower maximum, 650 horsepower normal, and operated at 450 revolutions per minute, and the other by a 31-inch Victor wheel which was put in when the power house was first designed and which is rated at 800 horsepower at 450 revolutions per minute. The former is controlled by a Pelton governor and is provided with a relief valve; the latter is controlled by a Lombard governor, type Q. Each governor is operated by its own oil system, each system being supplied with oil by its own pump belted to the generator shaft. The shaft of the unit operated by the Pelton-Francis is equipped with a fly wheel.

Generators.—Both generators are Westinghouse alternating-current revolving-field machines of 450-kilovolt-ampere capacity, delivering 23.6 amperes 3-phase 60-cycle current at 11,000 volts potential, operating at 450 revolutions per minute.

Exciters.—There are two exciters—one a motor-generator set, the other driven by a small turbine. The motor-generator set consists of a Westinghouse 30-horsepower 220-volt 74.5-ampere induction motor driving a Westinghouse 20-kilowatt 160-ampere continuous-current 125-volt generator. The generator of the turbine set is a Westinghouse 12½-kilowatt 125-volt 100-ampere continuous-current machine. The first unit operates at 1,135 and the second at 1,100 revolutions per minute.

A General Electric type CQ 7-kilowatt 125-volt 56-ampere continuous-current generator, belted to one of the main generator shafts to operate at a speed of 1,425 revolutions per minute, furnishes direct current for station lights.

Transformers.—The station is equipped with three General Electric 300-kilowatt single-phase 60-cycle 30,000 to 11,000 form HRP water-cooled transformers, connected delta on the low-tension side, set in cells which are separated by concrete walls. The cells open toward the river through double doors of galvanized iron on wooden frames.

Wiring.—A four-panel switchboard has replaced the three-panel board formerly in use.

The first panel controls the two exciters and the station lighting direct-current generator. Panels Nos. 2 and 3 control two of the generators (one each). Panel No. 4 holds the Tirrill regulator and is also the feeder panel for the line running to the transformers.

The generator and line switches are General Electric type K-12. The switchboard is mounted on a pipe framework and is set 8 feet 2 inches from the wall in about the same position as the board which it replaced.

Both generators operate in parallel, although there are two distinct feeder circuits, both taking current at 11,000 volts from the bus bars. One circuit goes to the transformers, which raise the voltage to 30,000, and the other circuit transmits direct at 11,000 volts.

The outlet for the 11,000-volt power is at the lower end of the building through three inclined tile outlets. The lines to the transformer house pass through similar outlets in the upstream end of the generator building and into the transformer house through tile openings and are then led out through similar openings through disconnecting switches to the line.

The 11,000-volt lines are carried to a frame which runs along above these doors and below the broad eaves of the corrugated-iron roof.

On the outgoing 11,000-volt lines there is a Westinghouse shunted-gap arrester, and on the 30,000-volt lines there are three aluminum lighting arresters with a spare to be used in case of accident. Choke coils are mounted on the 11,000-volt lines inside and at the downstream end of the power house. The 30,000-volt aluminum arresters are back of the transformer house under a corrugated-iron shelter.

STEAM-ELECTRIC PLANTS.

NORTH BEACH STEAM PLANT.

Location.—The North Beach steam plant is near Fort Mason, on Beach Street between Buchanan and Laguna streets. It was built by the United Railroads of San Francisco and put into commission by that company in August, 1903. The original installation comprised two reciprocating engines direct connected to four 1,200-kilowatt generators. The plant was purchased by Sierra & San Francisco Power Co. for its main steam reserve when that company began to furnish the power to the railways. In 1908 the reciprocating engines were replaced by the installation of a General Electric 5,000-kilovolt-ampere 25-cycle turbo-generator. In 1910 this unit was reconstructed to a rating of 9,000 kilovolt-amperes at 60 cycles, and a second unit of the same capacity (9,000 kilovolt-amperes) was installed. In November, 1917, a third General Electric 9,000-kilovolt-ampere 60-cycle unit was installed, giving the plant a total capacity of 27,000 kilovolt-amperes in three units.

Buildings.—The equipment is housed in two brick buildings which are built side by side on concrete foundations and are provided with wood-sheathed roofs covered with tar paper, carried on steel trusses. Substation F of Pacific Gas & Electric Co. was installed in the west end of the building in September, 1914. The generator house, 337 feet long by 48 feet wide and 56 feet clear in height to the lower chord of the roof trusses, is parallel to the shore; and immediately adjoining it is the boiler house, 335 feet long by 58.75 feet wide and 56 feet to the lower members of the roof trusses.

The single stack which serves the plant was originally built entirely of brick and was 152 feet high and 14.5 feet in inside diameter. At the time of the earthquake, in 1906, the structure suffered considerable damage, and in rebuilding it the part above the level of the eaves of the boiler room was replaced by a steel stack, giving a total height of 111.5 feet, and in 1921 brickwork was added to restore it to its original height. The boilers are set against the back wall of the boiler house and face toward the wall that separates the boiler and generator rooms. Flues lead from the boilers to the base of the stack, which is just outside the back wall of the building.

The turbo-generators now installed are much more compact than the old reciprocating engines and occupy only the central part of the original generator room. At each side of them there is ample room for additional units. The old generator floor (which was even with the top of the pedestal foundations of the reciprocating units) has been partly cut away to accommodate the turbine bases on the basement floor. The circulating pumps of the old condensing system were left in their original position, in the basement at the west end of the plant, and only the piping was remodeled.

Mechanical equipment.—Eight 524-horsepower boilers were installed in 1903; six 600-horsepower boilers were added in 1908; two 600-horsepower boilers and two 686-horsepower boilers provided with superheaters were installed in 1913, giving a total of 18 boilers with a combined rated capacity of 10,364 horsepower. All the boilers are of the Babcock & Wilcox water-tube type and are fired with fuel oil.

All the auxiliary electrical and mechanical equipment (except the circulating pumps) is in the section of the generator room occupied by the two turbines—part of it in the basement between the turbine foundations, part on the main floor, and part in the galleries against the front and back walls.

The 3-pass Wheeler surface condenser for unit No. 1 has 15,000 square feet of cooling surface, is supported on a steel frame, and is placed against the back wall of the basement and opposite its unit; a broad S-coupling connects the top of the condenser with the turbine base. The Worthington condenser for No. 2 unit forms the base of its turbine, upon which the whole unit rests. A Worthington condenser with 16,000 square feet of cooling surface forms the base of unit No. 3.

The station is provided with two Webster open feed-water heaters and one Elliot feed-water heater, rated at 10,000 horsepower. It is also provided with a Best & Co. water softener installed in October, 1918, for the purpose of treating all make-up water used in the plant.

A fuel-oil storage tank, 90 feet in diameter and 27 feet deep, with a capacity of 30,000 barrels, located in the yard opposite the plant, receives its supply through a 5-inch and 6-inch mixed pipe line about 1,500 feet long from a barge dock on the shores of the bay.

Circulating water for cooling the condensers is drawn from San Francisco Bay through three 30-inch intake pipes and discharged back into the bay through three 30-inch outlet pipes by two 24-inch centrifugal pumps operated by Union Iron Works marine engines installed in 1903, one motor-driven Wheeler 24-inch centrifugal pump installed in 1908, and one Worthington 20-inch centrifugal pump installed in 1908. The first three pumps are connected together so that either engine-driven pump can supply No. 2 condenser, and either the Wheeler motor-driven pump or the No. 2 engine-driven pump can supply No. 1 condenser. The Worthington motor-driven pump supplies No. 3 condenser alone and has no connection to the others.

In the basement between the turbine bases there are two Worthington 2-stage turbine hot-well pumps, each run by a Terry steam turbine which operates at 1,050 revolutions per minute with 150 pounds steam pressure. The third pump is a Janesville 2-stage turbine hot-well pump, operated by a motor at 700 revolutions per minute. The fourth pump is a Worthington 4-inch 2-stage centrifugal, driven by motor.

The dry-vacuum pumps are on the main floor just over these sets and consist of one 9 by 26 by 12 inch and two 10 by 26 by 12 inch Wheeler pumps and one 12 by 27 by 18 inch Laidlaw-Dunn-Gordon pump.

In the basement between the two main turbine bases are three Deane 14 by 3½ by 12 inch and one Worthington 12 by 3 by 18 inch oil-pressure pumps that act on the accumulator, which maintains a pressure of 1,000 pounds per square inch in the turbine step bearings. The weighted plunger of the accumulator is between the pumps and the front wall of the building and extends upward through a well hole in the main floor. The well is just midway between the two main units, and the dry-vacuum pumps are between it and the back wall. About 8 feet above, in an iron-framed gallery, are two Webster-Starr vacuum-feed water heaters of 5,000-horsepower capacity each.

At each side of the accumulator, in the basement, there is a set of two 5½ by 3¾ by 5 inch Deane oil pumps; each set supplies the guide bearings and governor of the turbine near it. A fifth pump, 5¼ by 3½ by 5 inch, serves the same purpose. Between each set of pumps and the base of the adjacent turbine is a Turner oil filter.

Electrical equipment.—The three main turbo-generators are General Electric-Curtis form H 5-stage 9,000-kilovolt-ampere 472-ampere 11,000-volt 3-phase 60-cycle alternating-current machines, operated at 720 revolutions per minute and at 175 pounds steam pressure, condensing but without superheat.

On the west side of unit No. 2 and on the main floor of the building are one motor-driven and two steam-driven exciters.

No. 1 steam-driven exciter is a General Electric type C form T 4-pole 125-kilowatt 125-volt 1,000-ampere continuous-current generator, direct-connected to a Curtis noncondensing turbine which receives steam at 175 pounds pressure and operates at 2,400 revolutions per minute. No. 2 steam-driven exciter is a General Electric type MP form L 6-pole 75-kilowatt 125-volt 600-ampere continuous-current machine, driven at 250 revolutions per minute by a compound noncondensing marine engine furnished by the Union Iron Works. All the steam-driven auxiliaries are operated noncondensing; they exhaust into the feed-water heating system.

The motor-generator set contains a General Electric type MP form L 8-pole 200-kilowatt 125-volt 1,600-ampere direct-current generator, driven at 500 revolutions per minute by a General Electric type I form K 3-phase 60-cycle 440-volt 350-ampere 300-horsepower induction motor.

The main switchboard is in a gallery running along the front wall between the two turbines. The board is at the center of the gallery and the switches and switch cells are at each end.

Under the gallery are the bus-bar cells and a board governing the motor exciter, motor-driven circulating pump, and station power. At one end of this auxiliary board are two motor-driven blowers and four air-blast transformers of 185-kilowatt capacity each. The ratio of the transformers is 11,000/440 and they serve only the plant auxiliaries.

The only incoming circuits are two 11,000-volt feeders from Great Western Power Co.'s North Beach steam plant, and the outgoing circuits are five of the same voltage which run to the Turk and Fillmore substation and one to the Mason and Washington substation of the United Railroads. Both incoming lines pass through a General Electric type H3 form F 300-ampere 1,500-volt oil switch. There is also one switch of the same pattern on the lead to the auxiliary bus, on each generator lead, and on one of the outgoing feeders. The second feeder is provided with two of these switches, and the third and fourth feeders are controlled by General Electric type H oil switches, one in each line.

MONTEREY STEAM PLANT.

Location.—The largest of the three steam-electric generating stations on the system of Coast Valleys Gas & Electric Co. is that near the bay shore in the northern outskirts of the city of Monterey. The equipment of the plant now stands as when constructed by Monterey County Gas & Electric Co., in 1907–8, on the site of an earlier and much smaller station.

Buildings.—The entire generating plant, including boilers, is housed in a single L-shaped building facing northward toward the bay shore, measuring 47 feet 6 inches deep on the eastern and 63 feet on the western end with a frontage of 112 feet 6 inches. The boilers are arranged in a row along the main axis of the building and in its east or narrrow end. The generating and auxiliary equipment is in duplicate throughout, and is arranged symmetrically on each side of the main axis, and in the west end of the building. The ell, 15 feet 6 inches deep, back of the west end of the generator room, accommodates only substation equipment—such as motor-generator sets for the street railway operated by the company.

The main frame of the building is of structural steel, with an auxiliary frame of wood between the main steel members; the covering is corrugated galvanized iron. A runway, supporting a traveling crane of 20,000 pounds' capacity, commands the generator floor. The foundations of the building and the floor are constructed of concrete. All pump pits have been made as shallow as possible, and to accomplish this the generators have been raised above the main floor level on truncated cone bases of concrete about 7 feet high.

The boilers are arranged in two banks of two each. The side of the first bank is not more than 18 inches from the east end wall of the building; between it and the second bank there is a clear opening of 6 feet, and back of both banks a clear space of 8 feet 6 inches to the north or front wall of the building. At the west end of the row of boilers are the two boiler-feed pumps, arranged on each side of the main axis of the room. Between these and the turbine foundations are the feed-water heater and the step-bearing oil filter. All the above equipment is on the main floor level of the station. Next in order toward the west end of the room come the turbine bases, and between them is a pit 2 feet 6 inches deep, containing the step-bearing pumps. Directly beyond the turbine bases, in another pit of the same depth, are the duplicate wet-vacuum and condenser circulating pumps. The condensers are supported above the main floor level, against the sides of their respective turbine bases and above the pit. On the west edge of the pit are the duplicate dry-vacuum pumps with duplicate exciter sets between them. Between these pumps and the west end of the building and parallel to the west wall is the eight-panel switchboard. The duplicate fuel-oil pumps are set between the feed-water pumps and the back of the building. The steam pipe from the top of each boiler curves down to a steam main which runs toward the turbines along the front wall of the building and is supported at a height of 7 feet 6 inches above the floor level on two concrete columns.

Mechanical equipment.—The boiler-feed water is drawn from the city mains and the fuel oil from the pipe line of the Associated Oil Co., which reaches the coast at Monterey. Cooling water for the condenser is drawn through a composite main from Monterey Bay, just in front of the plant. The diameter of the pipe that rises from the bay to the floor of a short dock is 10 inches. From the outer to the inner end of the dock the intake line consists of two 8-inch pipes, and at the shore these two join a single line of 12-inch pipe running to the plant. As at the Redondo and Long Beach plants, clogging of the pipe with kelp sometimes causes considerable trouble. The outlet pipe is 14 inches in diameter and discharges into a ditch in front of the building and thence into the bay.

At the east end of the plant is a bank of two Babcock & Wilcox water-tube boilers, each rated at 250 horsepower, and a second bank of two, each of which is rated at 400 horsepower. All the boilers are operated at 160 pounds maximum pressure and are fired with fuel oil, and all the furnaces are connected to a single steel stack, held in position by steel guy cables and set on a steel frame about 6 feet square built between the back ends and rising to the top of the two banks of boilers. Two Snow 4½ by 2¾ by 4 inch duplex pumps furnish oil, two Snow 7 by 4½ by 8 inch duplex pumps feed water, and two Worthington 6 by 2¼ by 6 inch duplex pumps maintain step-bearing pressure. Dry vacuum is maintained by two Wheeler rotative 6 by 14 by 10 inch pumps, and wet vacuum by two 5 by 10 by 10 inch simplex pumps. Each of the two centrifugal circulating pumps, driven by a Wheeler 8 by 8 inch marine engine, delivers cooling water to a Wheeler condenser with a horizontal cylindrical shell.

Electrical equipment.—The two main units are General Electric ATB 4-pole 2,300-volt 126-ampere 500-kilovolt-ampere 3-phase 60-cycle vertical turbo-generators.

Each of the duplicate exciter sets is a General Electric 6-pole 125-volt 80-ampere 10-kilowatt direct-current generator, driven at 450 revolutions per minute by a direct-connected 6½ by 5 inch General Electric marine engine.

SALINAS STEAM PLANT.

History.—The original steam electric plant at Salinas was built about October, 1888, by Salinas City Gas & Water Co. and finally passed into the control of Monterey County Gas & Electric Co., which made important additions to the station. Part of the boiler equipment has been removed since the construction of the transmission line connecting the plant to the Monterey steam plant and to the hydroelectric lines of Sierra & San Francisco Power Co.

Buildings.—The Salinas steam plant, including the substation and waterworks, and the Salinas gas plant are housed in a group of buildings at the corner of Pajaro and Sausal streets in the city of Salinas. The building containing the generating and substation equipment of the steam plant is constructed of brick, has concrete foundations and generator settings, and a wooden roof system with corrugated galvanized-iron covering. Both the walls and the roof of boiler house are of corrugated galvanized iron. The generator room measures approximately 77 feet by 30 feet and contains two engines, one a Lane & Bodley and the other a Hamilton-Corliss. Each of these is belted to a single National Electric 150-kilovolt-ampere 2,200-volt alternating-current generator, operated at 600 revolutions per minute. The 2-phase generators first installed have been remodeled to give 3-phase current.

Two exciters were originally installed in the station, but one of these has been removed. The one remaining is a National Electric 80-volt 125-ampere 10-kilowatt direct-current generator, operated at 1,450 revolutions per minute by a belt driven from the end of one of the main generator shafts. One of the generators is connected with the transmission system in such a manner that it may be used as a motor to drive the pumps of the city water system, which are set in a pit in one end of the generating room.

Mechanical equipment.—The Sterling boiler still in place is rated at 250 horsepower and is supplied with water by a Knowles 6 by 4 by 6 inch duplex boiler feed pump. The single steel stack is supported by guy cables and is set on steel breeching on the back of the boiler walls. One boiler similar to that now in place has been removed.

TRANSMISSION AND DISTRIBUTION SYSTEM.

The main tower lines from the Stanislaus power house to Mission San Jose and Bay Shore substation, in South San Francisco, naturally form the most important part of the company's transmission system.

The first line was completed as far as Mission San Jose, on the southeast shore of San Francisco Bay, and power delivered, at 60,000 volts potential, to Pacific Gas & Electric Co. at that place October 15, 1908, at 11.45 a. m. The three circuits from Stanislaus power house to the Mission are carried on one single circuit (Pl. XXXVI, *B*, p. 256) and one double-circuit tower line. The line of double-circuit towers was continued from the mission to San Francisco and the first power delivered at 104,000 volts to Bay Shore substation May 13, 1910. The second circuit was strung into Bay Shore substation at a later date. The delivery to Pacific Gas & Electric Co. at Mission San Jose had in the meantime been discontinued (Apr. 30, 1910, at midnight) and since then the connection between the companies has been used only for emergency service.

Up to January 15, 1911, no distribution was undertaken from the main tower lines, but after that time branches were made in the San Joaquin Valley and power delivered to Stockton (over the line of the Western States Gas & Electric Co.), Tracy, and Modesto.

Late in 1912 a long branch line was built from the Port Marion (Guadalupe) substation, at the lower end of San Francisco Bay, down Santa Clara Valley, passing west of San Jose and through Gilroy to Salinas. Power is not distributed locally along this line, but is wholesaled at Salinas to Coast Valleys Gas & Electric Co., which supplies the towns in Salinas Valley and as far west as Monterey and Pacific Grove.

The pole lines belonging to the old system of Tuolumne County Water & Electric Power Co., extending through the mining regions in the vicinity of Sonora and Angels Camp, were purchased by Sierra & San Francisco Power Co. in 1909 and connected to the Stanislaus plant, so that power could be delivered from either end of the system.

The lines running out of the old Knights Ferry plant, of Consolidated Stanislaus Water Power Co. as far north as Copperopolis and out into the valley to a terminus at Modesto, were bought in July, 1910, and were connected at Modesto substation to a branch from the main tower line as long as the Knights Ferry plant was operated.

Two types of towers are used on the section of the lines from the Stanislaus power house to the substation at Mission San Jose. The south line is carried on double-circuit towers with a height of either 35 or 50 feet to the lowest wire; the north line is carried on single-circuit towers either 35 or 50 feet to the lowest wire. From Mission San Jose to San Francisco there is a single double circuit tower line of the 50-foot type (Pl. XXXVI, *B*).

At several places the tower lines cross navigable channels or streams over which a certain minimum clearance height has to be maintained, as, for example, at San Joaquin crossing, at the south end of San Francisco Bay, and at several points along the west side of the bay. In these places special towers, either 112 feet high to the lower wire and 138 feet over all or 137.5 feet to the lower wire and 163 feet over all, are used; these measurements do not include foundations. The standard towers measure 50 feet to the lower wire and are 75 feet 6 inches high from the ground surface to the top of tower, or 82 feet over all, including the foundations. Most of the special towers and many of the standard towers in the San Francisco Bay region are supported on pile foundations. For the 50-foot towers one pile is driven at each corner, for the 112-foot towers two piles are driven, and for the 137.5-foot towers three piles at each corner. The pile tops were cut off below water line and capped with reinforced concrete, to which the tower is anchored. In ordinary country the standard foundation consists of a short stub formed by two angles bolted to the corner post of the tower at the ground surface and extending nearly vertically downward, being spread slightly at the bottom and bolted to a foot plate of steel channel.

The heavy two-circuit 50-foot towers used at 90° angles on the Stanislaus line weigh 9,140 pounds [75] without foundations, towers used at 30° angles weigh 5,324 pounds and their foundations 775 pounds, and 7,678 pounds for 42° angle tower (5,623 pounds) with foundation 2,055 pounds. The 35-foot single-circuit towers weigh 800 pounds less than the 50-foot standards.

The total length of the line from Stanislaus power house to Bay Shore substation is 137 miles. The average spans are 850 feet. Each conductor is a cable composed of six strands of copper with a total cross section equivalent to 2/0 Brown & Sharpe gage and a hemp core. The 5-part suspension insulators are tested to 90,000 volts per part and a mechanical strain of 5,000 pounds.

Details of the transmission system on December 31, 1918, when the company made its last full report, are given in Table 51.

TABLE 51.—*Transmission lines of Sierra & San Francisco and Coast Valleys Gas & Electric systems in operation Dec. 31, 1918.*

Sierra & San Francisco Power Co.

District.	Length.	Supports.	Voltage.	Number of circuits.
	Miles.			
Stanislaus to San Francisco	136.95	Steel towers	104,000	2
Manteca [a]	44.30	Wood poles	60,000	1
Do	55.50	do	30,000	1
Do	.48	do	17,000	1
Do	140.45	do	15,000	1
Do	3.0	do	11,000	1
Do	41.18	do	6,600	1
Do	8.50	do	6,000	1
Do	105.09	do	4,000	1
Do	98.77	do	15,000	1
Tuolumne	15.92	do	15,000	2

[a] Includes Modesto, Oakdale, Tracy, and vicinity.

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[75] Crozier, H. W., Jour. Electricity, vol. 28, p. 87.

TABLE 51.—*Transmission lines of Sierra & San Francisco and Coast Valleys Gas & Electric systems in operation Dec. 31, 1918*—Continued.

Sierra & San Francisco Power Co.—Continued.

District.	Length.	Supports.	Voltage.	Number of circuits.
	Miles.			
Santa Clara [b]	53.18	Steel towers	55,000	1
Do	24.5	do	55,000	1
Stanislaus to Spring Gap	20.0	Wood poles	17,000	1
Bay Shore [c]	.19	do	11,000	4
Do	5.12	do	11,000	3
Do	5.18	do	11,000	2
Do	3.96	do	11,000	1
Do	.20	do [d]	11,000	6
Do	.16	do	11,000	2
Do	2.63	do	11,000	1
Do	.30	Concrete conduit	11,000	5
Do	.76	do	11,000	2
Do	.48	do	11,000	1
Do	.24	do	11,000	5
Do	1.14	do [d]	11,000	5
Do	1.21	do [e]	11,000	2
Do	2.29	do [f]	11,000	1
	771.68			

Coast Valleys Gas & Electric Co.

District.	Length.	Supports.	Voltage.	Number of circuits.
Salinas to Soledad	25.00	Poles	60,000	1
Salinas to King City	20.31	do	30,000	1
Salinas to Monterey	20.25	do	22,000	1
Soledad to New Idria	25.00	do	30,000	1
	90.56			

[b] Includes Por Marion to Salinas.

[c] Includes San Francisco and vicinity.

[d] Owned by United Railroads.

[e] Owned by Universal Gas & Electric Co.

[f] Joint operation.

Nearly the entire length of the transmission line from Port Marion (Guadalupe) substation south to Salinas is built of cedar poles 60 feet long and 10 inches in diameter at the top, provided with three cross arms each, which are 6 by 6 inches in cross section and 10 feet long. For a short distance below Port Marion, on the marshes around San Francisco Bay, the line is carried by standard steel towers, and there is also another stretch of the same type in the mountains south of Gilroy, where by use of towers advantage can be taken of long spans in the rough country. These are the only places where poles are not used.

A 3-phase circuit supported on 4-part suspension insulators is to be carried on each side of the poles, but at the end of 1919 only one circuit has been strung; this is of No. 1 copper and is operated at 60,000 volts. The wires are suspended directly above each other with a vertical clearance of 6 feet 6 inches. The distance from the conductors to the pole is 52 inches and to the cross arm below 36 inches. On the sections of the transmission where towers are used the conductors are aluminum cables of capacity equivalent to No. 1 copper.

The wooden-pole 1-circuit 33,000-volt transmission system which was acquired by Sierra & San Francisco Power Co. in 1917 from Yosemite Power Co. included 4.42 miles of line in the Turlock district, 19.64 miles in the La Grange district, and 8.97 miles in the Hughson district, a total of 33.03 miles of 33,000-volt line, in addition to the short 11,000-volt lines at the La Grange power house. The transmission lines operated by both Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co. are given in Table 51.

The number of substations and consumers for both companies are given by years in Table 52.

Information in regard to the substations that belong to the Sierra & San Francisco Power Co. which it operates under lease, and the substations of Coast Valleys Gas & Electric Co. for 1919 is presented in Table 53.

TABLE 52.—*Number of substations and length of distribution lines of Sierra & San Francisco Power system (including Coast Valleys and Yosemite Power companies), 1913–1918.*

Year.	Sierra & San Francisco Power Co.	Coast Valleys Gas & Electric Co.	Yosemite Power Co.	Sierra & San Francisco Power Co.	Coast Valleys Gas & Electric Co.	Yosemite Power Co.
1913	6	8	10	204.54	208.14	51.19
1914	6	8	5	247.89	224.03	43.83
1915	6	8	5	256.65	231.02	87.43
1916	6	8	7	265.75	251.15	78.29
1917	6	10	....	317.26	261.16	....
1918	6	10	....	326.31	277.53	....

TABLE 53.—*Substations operated by Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co. Dec. 31, 1919.*

District and substation.	Location.	Type of building.	Size.	Began operating.	Voltage of incoming circuits.	Voltage of outgoing circuits.	Service.	Capacity.	Equipment.
Substation buildings owned by United Railroads and equipped and operated by Sierra & San Francisco Power Co. in or near San Francisco:									
			Feet.		*Volts.*	*Volts.*		*Kilowatts.*	
Millbrae..........	Millbrae........	Brick, steel craneway system, and steel crane, cinder reinforced-concrete roof on steel frame.	40 by 75	1906	a 12,000	b 600	Serves the southern end of the San Mateo line of the United Railroads through two feeders, one running north and the other south over the system.	1,000	Two motor generators, each consisting of one General Electric type MPC form H 6-500-514 600-volt 833-ampere continuous-current generator and one General Electric type 1 form K 14-750-514 440-volt 860-ampere 750-horsepower motor. Six General Electric 1-phase 60-cycle 275-kilowatt 13,200/440-volt air-blast transformers, and two blowers, one on each transformer bank, each run by General Electric 3-horsepower induction motor.
Geneva Avenue..	Corner Geneva and San Jose avenues.	Brick..........	40 by 80	1906	a 12,000	b 600	Connected in with Millbrae on Cemetery and suburban lines, also in multiple with Bryant substation on Mission feeders and Turk and Fillmore substation on Guerrero Street line; other feeders to Visitacion Valley line, Ingleside line, Ocean Avenue, and Parkside.	3,000	Two 1,500-kilowatt General Electric synchronous-motor generators, 11,000-volt 2-bearing units with direct-connected exciters, identical in type with those in Turk Street substation. (See below.)

[a] Alternating current.

[b] Direct current.

TABLE 53.—*Substations operated by Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co. Dec. 31, 1919*—Continued.

District and substation.	Location.	Type of building.	Size.	Began operating.	Voltage of incoming circuits.	Voltage of outgoing circuits.	Service.	Capacity.	Equipment.
Substation buildings owned by United Railroads, etc.—Continued.			*Feet.*		*Volts.*	*Volts.*		*Kilowatts.*	
Bryant Avenue...	Corner Bryant avenue and Eleventh Street.	Brick, steel truss.	80 by 200	1905	*a* 12,000	*b* 600	Feeds area south of Market Street not handled in conjunction with Geneva substation. In with Turk Street substation and Mason and Washington substation on number of feeders north of Market Street	9,000	Six 1,500-kilowatt synchronous motor generators, 11,000-volt alternating current, 6,000 volts direct current, 2-bearing units with direct-connected exciters. One 330-kilowatt 11-kilovolt/440-volt 3-phase transformer feeds the 200-kilowatt induction motor generator set for direct-current local distribution 110/220 3-wire.
Turk and Fillmore	Corner Turk and Fillmore streets.	Brick building, concrete slab roof on steel frame.	75 by 125	1905	*a* 12,000	*b* 600	Carries majority of feeders north of Market, Beach lines, etc.	9,000	Six motor generator sets, each consisting of one General Electric MPC form H 12-1,500-360 600-volt 2,500-ampere continuous-current generator, one General Electric type ATI form C class 20-1,780/360/11,000-volt 99-ampere 2,150-horsepower 60-cycle synchronous motor, one General Electric MP form L 6-23-360 125-volt 104-ampere continuous-current exciter on end of each shaft.
Mason and Washington (substation owned by United Railroad Co.).	Mason and Washington streets.	Brick..........	(*c*)	1914	11,000	*b* 600	North Beach lines, Lower Sutter and Market streets.	1,500	Three 525-kilowatt air-blast transformers, one 5-horsepower blower motor and fan, and one 1,500-kilowatt rotary converter, General Electric, 600 revolutions per minute.

Substations owned by Sierra & San Francisco Power Co., and located on its transmission system:									
Stanislaus	In end of the Stanislaus power house.			Aug., 1909	(d)	a 17,000	Serves the old system of the Tuolumne County Electric Power Co. (16,000 volts) and Strawberry dam construction.	3,000	Three General Electric 1-phase 60-cycle 1,000-kilowatt water-cooled transformers, 4,000 Y/16,000-16,200-17,100-18,000.
Manteca	Manteca	Steel frame, walls plastered on steel fabric.	33¾ by 72	Oct. 16, 1912	104,000	30,000	One circuit serves line owned by Western States Gas & Electric Co. running from the substation north to Stockton.	6,750	Three General Electric 1-phase 60-cycle 750-kilowatt 104,000/30,000 Y water-cooled transformers (1 spare transformer), three 1,500-kilowatt 1-phase 104,000 Y/17,000-volt and three 75-kilowatt 17,000/4,000-volt water-cooled transformers.
West Side irrigation district substation.						17,000	Modesto circuits Nos. 1 and 2 supply Farrington, Oakdale, Arena, Modesto; Turner line supplies Tidewater & Southern Ry., Summer home tract circuit, and Tracy.	3,750	
Modesto						4,000	Manteca local	3,000	
Port Marion, formerly called Guadalupe.	Near Alviso, south end of San Francisco Bay.	Steel frame, walls plastered on steel fabric.	40 by 72	Dec. 10, 1912e Mar., 1913f	104,000	60,000	Serves the Gilroy branch line to Salinas substation of Coast Valleys Gas & Electric Co.	6,000	Three General Electric 1-phase 60-cycle 1,000-kilowatt 104,000/60,000 water-cooled transformers (1 spare transformer).
Bay Shore	South San Francisco	Reinforced concrete.	120 by 53	Jan., 1910	104,000	a 12,000	Serves power to San Francisco substations.	22,500	Six General Electric 1-phase 60-cycle 3,750-kilowatt 104,000/12,000 water-cooled transformers (1 spare transformer).
						b 500	Trolley line in vicinity	800	Two 400-kilowatt rotary converters.
									Five 185-kilowatt air-blast transformers, General Electric 13,200-440 2-phase Scott connection.
Tracy	Tracy	Plaster on metal.	12 by 14	Aug., 1911	17,000	a 2,300	Tracy and vicinity, series of street lights.	700	Three Westinghouse 1-phase 60-cycle 100-kilowatt 16,500/6,600-2,300 self-cooled transformers.

a Alternating current.
b Direct current.
c Located in cable station and car barn.
d From generator busses.
e Temporary station.
f Present station.

TABLE 53.—*Substations operated by Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co. Dec. 31, 1919*—Continued.

District and substation.	Location.	Type of building.	Size.	Began operating.	Voltage of incoming circuits.	Voltage of outgoing circuits.	Service.	Capacity.	Equipment.
Substations owned by Sierra & San Francisco Power Co., etc.—Continued.			*Feet*		*Volts.*	*Volts.*		*Kilowatts.*	
Salida	Salida	Corrugated iron.	16 by 16	Sept., 1911	17,000	a 2,300	Salida and rural vicinity.	225	Three General Electric 1-phase 60-cycle 75-kilowatt 16,500/2,300 self-cooled transformers connected in closed delta.
Turner (station building, property Tidewater & Southern Ry.).	Turner	Concrete		Nov. 15, 1913				300 500	Three 100-kilowatt 17,000/400 transformers. Two 250-kilowatt motor generators.
Modesto	Modesto	Steel frame building with plastered walls on steel fabric.	20 by 50	Dec. 1, 1911	(b)	a 2,300 c 1,200	Modesto and vicinity, street lights. Tidewater & Southern Ry.	2,100	Three General Electric 1-phase 60-cycle 350-kilowatt 15,000/2,300 water-cooled transformers, three 1-phase 60-cycle 150-kilowatt 30,000/2,300 self-cooled transformers (the last three receive power from the plant at La Grange), and three 100-kilowatt Westinghouse 15,000/400-volt for Tidewater & Southern motor-generator set.
Oakdale	Oakdale	Wood			15,000		Oakdale and vicinity, series of street lights.	300	Two Westinghouse 1-phase 60-cycle 150-kilowatt self-cooled transformers, connected 3-phase 2-phase by Scott method, 17,000 to 2,300 volts.
Copperopolis	Copperopolis				104,000	17,000	Copperopolis and mining circuits.	1,200	Three General Electric 1-phase 60-cycle 400-kilowatt water-cooled transformers.
Escalon	Escalon	Concrete	16 by 16	Apr. 1, 1912	15,000	4,000	Escalon and vicinity	225	Three 75-kilowatt General Electric 15,000/2,300-volt Y.
Clifton Court		Outdoor			16,500	2,300	Local light and power	300	Three Westinghouse 1-phase 60-cycle 100-kilowatt self-cooled transformers.
Lathrop	Lathrop	do			15,000	2,300	do	300	Three General Electric 1-phase 60-cycle 100-kilowatt self-cooled transformers.
Ripon	Ripon	do			16,500	2,300	do	150	Two Westinghouse 1-phase 60 cycle 75-kilowatt self-cooled transformers.

Paradise	Paradise road	do			15,000	2,300	do	75	Three General Electric 1-phase 60-cycle 25-kilowatt self-cooled transformers.
Riverbank	Riverbank	do			15,000	2,300	do	150	Two Westinghouse 1-phase 60-cycle 75-kilowatt self-cooled transformers.
Avena	Avena	do			15,000	2,300	do	225	Three General Electric 1-phase 60-cycle 75-kilowatt self-cooled transformers.
Farmington	Farmington	do			16,500	2,300	do	225	Three General Electric 1-phase 60-cycle 25-kilowatt self-cooled transformers.
Mariposa	Near Escalon	do			16,500	2,300	do	75	Three Maloney 1-phase 60-cycle 25-kilowatt self-cooled transformers.
Banta	Banta	do			16,500	2,300	do	30	Three General Electric 1-phase 60-cycle 10-kilowatt self-cooled transformers.
Sylvan	Near Sylvan	do			16,500	2,400	do	150	Three Westinghouse 1-phase 60-cycle 50-kilowatt self-cooled transformers.
Sonora	Sonora	Corrugated iron on wooden frame.			14,000	2,400	do	75	One Stanley 75-kilowatt 60-cycle water-cooled transformer.
					15,000	2,300	do	150	One Stanley 150-kilowatt 60-cycle water-cooled transformer.
Escalon	Escalon	Concrete	16 by 16	Apr. 1, 1912	15,000	4,000	Escalon and vicinity	225	Three 75-kilowatt General Electric 15,000/2,300-volt Y.
Coburn								375	
Greenfield								900	
Substations owned by Coast Valleys Gas & Electric Co.: Monterey Steam (stand-by and substation).	Near Southern Pacific station, Monterey.	Corrugated iron on wooden frame.	111 by 54	(*d*)	20,000	*a* 2,300 *c* 600	Monterey plant serves street lights in Monterey and vicinity and Salinas over a 3-phase circuit of No. 4 copper 20 miles long. Supplies Monterey & Pacific Grove Ry. with direct current and Monterey, Carmel, and Pacific Grove with alternating current.	1,000 450 750	Two 500-kilowatt Curtis turbo generators. One 300-kilowatt General Electric induction motor-generator set, one 150-kilowatt National Electric Co. synchronous motor-generator set. Four General Electric 250-kilowatt, 2,200/22,000-volt oil-insulated self-cooled transformers, one bank of three and a spare.
Salinas (stand-by and substation).	Near Southern Pacific station	Brick walls, wood roof trusses, corrugated-iron roof.	40 by 29	Dec. 12, 1913[b]	55,000 from Port Marion; 20,000 from Monterey.	20,000 to Monterey; 30,000 to Kings City; 2,300 Salinas.	Salinas substation is only one receiving power from line running south from Port Marion. It serves entire system of Coast Valleys Gas & Electric Co.	3,000 300	Three General Electric 1-phase 60-cycle, 1,000-kilowatt, 55,000/32,000, 22,000/2,300 water-cooled transformers. Two 150-kilowatt General Electric alternators, 3-phase 2,300-volt engine rope drive (stand-by).

[a] Alternating current. [b] Two circuits: 15,000 from Manteca and 30,000/2,300 from the Yosemite Co. power plant at La Grange. [c] Direct current. [d] Acquired from old company.

TABLE 53.—*Substations operated by Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co. Dec. 31, 1919*—Continued.

District and substation.	Location.	Type of building.	Size.	Began operating.	Voltage of incoming circuits.	Voltage of outgoing circuits.	Service.	Capacity.	Equipment.
Substations owned by Coast Valleys Gas & Electric Co.—Con.			*Feet.*		*Volts.*	*Volts.*		*Kilowatts.*	
Hilltown	2 miles southwest of Salinas on the Monterey Road.	Corrugated iron on wooden frame.	12 by 16	(a)	20,000	2,300	Rural vicinity and Spreckels Sugar Co.	450	Three General Electric 60-cycle 150-kilowatt 22,000/2,200-volt self-cooled transformers.
Chualar	1 mile north of Chualar.	do	16 by 20	(b)	30,000	2,300	Town of Chualar and rural vicinity.	450	Three Westinghouse 1-phase 60-cycle 150-kilowatt 32,000/2,300 self-cooled transformers connected in open delta.
Soledad	North end of town of Soledad.	do	16 by 28	Oct., 1912	30,000	2,300	Soledad and vicinity	300	Two Westinghouse 1-phase 60-cycle 150-kilowatt 32,000/2,300 self-cooled transformers connected in open delta.
King City	North end of King City near Southern Pacific R. R.	do	50 by 26½	Dec., 1912	30,000	2,300 4,000	Kings City and vicinity, series of street lights.	300	Three Westinghouse 1-phase 60-cycle 500-kilowatt 32,000/2,300 self-cooled transformers.
Los Coches	On Kings City road.	do	16 by 28	Jan., 1913	30,000	4,000 Y-2,300	Los Coches rural section.	450	Three Westinghouse 1-phase 60-cycle 150-kilowatt 32,000/2,300 self-cooled transformers
Gonzales	North end of Gonzales.	do	16 by 28	May, 1913	30,000	4,000 Y-2,300	Gonzales and rural vicinity.	450	Three Westinghouse 1-phase 60-cycle 150-kilowatt 32,000 2,300 self-cooled transformers.

[a] Rebuilt Mar., 1913.

[b] Acquired from old company.

GREAT WESTERN POWER SYSTEM.

HISTORY.

CORPORATIONS INCLUDED.

The companies included in what is usually termed the Great Western Power system were, until the end of May, 1915, Great Western Power Co. and its subsidiaries, City Electric Co. and California Electric Generating Co. The system was controlled by Western Power Co., a New Jersey corporation, through its ownership of all but director's qualifying shares of Great Western Power Co. On June 1, 1915, the stock of Consolidated Electric Co. was acquired by Great Western Power Co., and on June 5 a general financial reorganization and extension of both the holding and the operating companies was begun.

This reorganization was begun by the incorporation June 5 of a new holding company—Western Power Corporation—under the laws of New York to acquire stock control of Western Power Co. (of New Jersey), the former holding company, as well as Great Western Power Co., City Electric Co., California Electric Generating Co., and Consolidated Electric Co. On November 23, 1915, Great Western Power Co. of California was incorporated under the laws of California, to take over the properties and business of Great Western Power Co., City Electric Co., California Electric Generating Co., and Consolidated Electric Co. This transfer was completed June 1, 1919, and as a result of the reorganization the number of corporations in the system was reduced to three—Great Western Power Co. of California, owning and operating as a combined system the properties that belonged to the several operating companies; California Electric Generating Co., owning the Oakland steam plant, operated by Great Western Power Co. of California through assignment of the original lease to Great Western Power Co.; and Western Power Corporation (of New York), a holding company for the stock of Great Western Power Co. of California. Details concerning finances of the holding and operating companies are presented in Appendix A to this report.

ORIGIN OF GREAT WESTERN POWER CO.

The possibility of utilizing the North Fork of Feather River for the water-power developments now being carried out by Great Western Power Co. of California was discovered in 1901 by Mr. Julius M. Howells, a member of the American Society of Civil Engineers, who was then practicing his profession in Los Angeles. For several years there had been considerable activity in the development of hydroelectric power in the southern part of the State, and the two principal companies in that region were planning to put in additional plants far to the north on Kern River. This activity reminded Mr. Howells that some twenty years before, while carrying on certain work in Plumas County for Prof. Agassiz of Harvard University, he had noticed near Big Meadows an exceptional site for the storage of water. On reexamining the topographic map of that region, Mr. Howells was so impressed with the elevation of Big Meadows and the rapid fall of Feather River below that point that he made a hurried reconnaissance of the region and was confirmed in his opinion that Big Meadows afforded one of the best natural reservoir sites in the country.

After diligent efforts to interest capital in the project of acquiring the reservoir site and the necessary lands along Feather River for dams, aqueducts, pole lines, and power sites for utilizing the waters to be stored in a reservoir at Big Meadows and the very considerable natural flow of the tributaries that enter the stream below that site, Mr. Howells succeeded in interesting Mr. E. T. Earl, of Los Angeles, and some other gentlemen sufficiently to induce them to make the preliminary purchases of lands at Big Meadows. Western Power Co., a California corporation (not to be confounded with the New Jersey company of the same name), was organized on March 24, 1902, and to this company the acquired lands and water rights were transferred.

It was then discovered that about 16 miles from Oroville and about 65 miles down the river from Big Meadows, at a point called Big Bend, a tunnel had been driven through the neck of an oxbow in the river to divert the waters from the channel around the bend and thus bare the stream bed sufficiently to permit placer mining. This mining project had been organized by a Buffalo manufacturer of patent medicine, Dr. R. V. Pierce, who had incorporated the Big Bend Tunnel & Mining Co., a New York corporation, and had completed the tunnel in the early eighties. Either because of lack of gold or of the enormous expense involved in the work the company as a mining project failed. After the organization of Western Power Co., however, the promoters of the Big Meadows scheme found that the owners of the tunnel and property at Big Bend had become aware of the opportunity there offered for the generation of power and that Eureka Power Co. had under way a project for a hydroelectric plant at Big Bend. Western Power Co. bought out the rights of Eureka Power Co. and united them with its rights at Big Meadows and in that vicinity. Obviously the Big Bend project in alien hands would have derived without cost all the advantages of any storage developed at Big Meadows.

While Mr. E. T. Earl and his associates were making their first moves in the vicinity of Big Meadows, another group was considering the same project, though neither group was aware of the other's plans. Before it became known that Mr. Earl and his associates had acquired the land and water locations at Big Meadows the other group filed locations on the water of Feather River at the point where it leaves the Big Meadows, acquired from the Central Pacific Railroad 3,300 acres of land at and above Big Bend, and planned a development at Big Bend in opposition to the Pierce project. On the same day on which the second group filed the water locations at Big Meadows it also filed claims on the water of the river at the orifice of the tunnel and, according to the plan disclosed, proposed to carry the water in a canal to a point far downstream. These conflicting projects made it difficult to finance the Big Meadows and Big Bend projects of Western Power Co.

Further difficulties were disclosed by surveys which showed that the Government map of the vicinity of Big Bend was in error in showing the location of the intake of the tunnel and that the Pierce people did not have any dam site in the neighborhood of the intake. On the contrary, the site which they had once used for a temporary dam during their mining operations was part of the land which the adversary group had acquired from the railroad company. The adversary group, which had incorporated under the name Golden State Power Co., was not aware of the extent of its ownership at and near the intake of the Big Bend tunnel. Mr. Earl and his associates took up their projects in February, 1902, and by April, during which month they filed their water appropriations, had acquired considerable acreage in and about Big Meadows. Western Power Co. actively prosecuted its project throughout 1902 and during that year had taken over the Feather River Power Co. and Big Bend rights. Then came the financial stringency of 1903, called "the rich man's panic," when securities on the New York Stock Exchange shrunk several billions of dollars. This stringency prevented any success in financing Western Power Co.'s project. In 1904, however, Western Power Co., after efforts extending over a year or more, succeeded in enlisting New York capital in the enterprise, the chief stockholder being Mr. Edwin Hawley of New York City. Some of his associates were connected with the American Tobacco Co., and he was also aided by Mr. Clarence Mackay and a number of others, including some financiers in Boston and in New York who were already interested in the development of water power in California. The New York capitalists investigated the matter and organized Great Western Power Co., to which were transferred all the rights of Western Power Co. of California, which included all the rights of the Earl and the Pierce groups. The successful financing of Great Western Power Co. compelled Golden State Power Co. to transfer its land rights and interfering water claims to Great Western Power Co.

Prior to the organization of Great Western Power Co., in 1906, the Pierce properties were fully paid for, but while the company's securities were being underwritten the earthquake and fire of April 18, 1906, paralyzed business in San Francisco. This disaster checked the progress of the company, but it was able to recover so far that by the fall of 1906 the work of enlarging the tunnel at Big Bend was begun and carried on actively until the Big Bend plant (see pp. 364–372 was put into operation.

This plant, with the transmission lines extending to Oakland and into the territory to the north of San Francisco Bay, the lands and reservoir at Big Meadows, and several undeveloped power sites below the reservoir and above Big Bend constituted the properties of Great Western Power Co. The entire system, however, included the Oakland steam plant, held under the name of California Electric Generating Co., the system of City Electric Co. in San Francisco, with its North Beach steam plant, and the system of the Consolidated Electric Co. in San Francisco and Oakland, with several small steam electric stations. (See p. 344.[75a]) The San Francisco and Oakland properties and the tower transmission line from Big Bend are connected into one large system by three power cables laid under San Francisco Bay.

SUBSIDIARY COMPANIES.

CALIFORNIA ELECTRIC GENERATING CO.

California Electric Generating Co. (incorporated under the laws of California Nov. 23, 1908) was organized by Great Western Power Co. to build and own the Oakland steam plant. The plant was leased to the Great Western Power Co. by California Electric Generating Co. on a rental which provided for taxes, interest and sinking fund for the bonded debt, and 6 per cent dividend on preferred stock after January 1, 1913. The interest on the bonds was guaranteed by Great Western Power Co. The plant was, for all practical purposes, a generating station of Great Western Power Co., although for fiscal reasons it was carried as the property of a separate corporation.

CITY ELECTRIC CO.

City Electric Co., incorporated under the laws of California January 9, 1907, began service in San Francisco from its North Beach steam plant in October of the same year. Stock control of the company was bought in 1911 by Great Western Power Co. for a consideration generally quoted as $80 per share. The latter company testified before the Railroad Commission that it paid for the stock $151,912.50 in cash, $2,500,000 in Great Western Power Co. stock, and $3,750,000 in Great Western Power Co. bonds. On January 29, 1912, the first

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[75a] Great Western Power Co. also purchased in June, 1911, Peoples Electric Light & Power Co., which had obtained franchises for an electric system in San Leandro; in March, 1912, South Sacramento Power Co., operating a distribution system in South Sacramento; on Sept. 1, 1916, Half Moon Bay Light & Power Co., operating a transmission and distribution system from San Francisco south to Half Moon Bay

submarine power cable under San Francisco Bay connected the City Electric Co.'s system to the hydroelectric line of Great Western Power Co.[76]

CONSOLIDATED ELECTRIC CO.

Consolidated Electric Co. was incorporated by Great Western Power Co. February 2, 1915, under the laws of California, to accomplish the transfer to Great Western Power system of certain electric properties then controlled by United Properties Co. of California.

United Properties Co. of California was incorporated December 30, 1910, under the laws of Delaware, with a capitalization of $200,000,000 as a holding corporation for numerous companies controlled or owned by F. M. Smith, William F. Tevis, and Albert Hanford. United Properties Co. acquired in addition to the steam-electric properties in Oakland and San Francisco (see p. 344) traction systems in Oakland, including the "Key Route" ferry line to San Francisco, a nonoperating hydroelectric company owning properties on American River, nonoperating and operating water companies, railroad companies, and various other minor properties. The undeveloped hydroelectric properties were held by San Francisco-Oakland Terminal Power Co., which was incorporated March 12, 1912, with an authorized capital of $10,000,000 preferred and $20,000,000 common stock, all owned by United Properties Co. The Smith-Hanford-Tevis group intended eventually to supply, from water power developed on American River, the market that had been built up by the small steam-electric systems in San Francisco and Oakland, but before this work could be successfully carried out United Properties Co. became involved in financial difficulties that led to its reorganization or dissolution.

The steam-electric properties in San Francisco and Oakland were controlled by United Properties Co. indirectly through United Light & Power Co. of New Jersey, a holding corporation for United Light & Power Co. of California, which in turn was a holding and operating corporation for the properties of four smaller companies.

United Light & Power Co. of New Jersey was incorporated with an authorized capital of $3,000,000 January 6, 1911, chiefly to acquire the capital stock (over 96 per cent) and assist in financing United Light & Power Co. of California, which had been organized previously,

United Light & Power Co. of California was incorporated May 2. 1910, with an authorized capital of $2,000,000 preferred stock and $4,000,000 common stock, for the purpose of consolidating through stock control and operation Equitable Light & Power Co., Consumers Light & Power Co., and Southside Light Power Co. (all of

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[76] The financial tables in Appendix A to this report give certain data for City Electric Co. for the years preceding 1911, but control of the City Electric Co. was not obtained by Great Western Power Co., until July 1, 1911. City Electric Co. had acquired in October, 1908, Martel Power Co., organized to construct a local distribution system in San Francisco.

San Francisco), and Central Oakland Light & Power Co. (of Oakland).[77]

In disposing of stocks and properties of United Light & Power Co. of New Jersey and its subsidiaries, United Properties Co. (or allied interests) first transferred them to E. W. Wilson, who in turn transferred them to Consolidated Electric Co. formed for that purpose by Great Western Power Co. The securities transferred were as follows:

TABLE 54.—*Securities transferred to Consolidated Electric Co.*

Company.	Security.	Shares.	Par value.	Per cent of total outstanding.
Consumers Light & Power Co	Common stock	9,248	$10	92.5
Equitable Light & Power Co	do	50,000	10	100
Do	Preferred	25,000	10	100
Central Oakland Light & Power Co	Common	70,208	10	73
Do	Preferred	18,707	10	81.5
Southside Light & Power Co	Common	75,000	10	100
Do	Preferred	25,000	10	100
United Light & Power Co. (of New Jersey)	Common	30,000	100	100
United Light & Power Co. (of California)	do	398,213	10	100
Do	Preferred	199,610	10	100

Consolidated Electric Co. issued all but three (director's qualifying shares) of its 100 shares, par value $100, to Great Western Power Co., and also authorized a mortgage to secure $2,500,000 in 40-year 5 per

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[77] When acquired by Consolidated Electric Co. United Light & Power Co. of California was operating under a 10-year lease expiring December 30, 1921, the Yerba Buena steam-electric station belonging to San Francisco-Oakland and San Jose Consolidated Railway, and was supplying under an exclusive contract all power for the "Key Route system" of electric railways in Oakland and Berkeley. The plant is at the corner of Thirty-sixth and Hannah streets in Oakland, had a capacity of 7,350 kilowatts, and has been practically superseded by motor generators supplied with power from the Great Western system.

United Light & Power Co. owned the site and generating station at 120 Minna Street, San Francisco, generally referred to as belonging to Southside Light & Power Co. The latter concern, however, operated the plant under lease from United Light & Power Co. and was controlled by it through stock ownership. The plant had a capacity of 700 kilowatts, but has been entirely dismantled and its load connected to the other lines of the Great Western Power Co. The territory covered by the Southside distribution system was south of Market Street.

Consumers Light & Power Co. owned and operated a steam-electric station in the basement of the Whitney-Building, 133 Geary Street, San Francisco, with an electric generating capacity of 725 kilowatts; the site of the plant was controlled under lease. Operation of the plant has been discontinued and its load is connected to other lines of the Great Western system. Consumers Light & Power Co. also owned several small stations that served steam only. The territory served by the company was north of Market and east of Powell streets.

Equitable Light & Power Co. operated in the basement of the Phelan Building, San Francisco, a station for supplying both electricity and steam for heating. The capacity of the plant was 1,000 kilowatts; the site was rented. The plant is still operating. The company also maintained another small station, which supplied steam only. The territory served by the company was north of Market and west of Powell streets.

Central Oakland Light & Power Co. owned and operated a central generating station at Second and Alice streets, Oakland, with a generating capacity of 2,000 kilowatts. The plant is maintained as a substation but discontinued as a generating station. The company also owned a 75-kilowatt generator and 240-horsepower boiler, in the basement of St. Marks Hotel, in Oakland, which still supply steam and electricity to the hotel and neighboring small users.

The distribution system, owned jointly by Consumers Light & Power Co., Equitable Light & Power Co., and United Light & Power Co. in San Francisco, comprised about 26,146 feet of line occupying in general the same trenches as the steam-distributing systems belonging to the various companies. The electric distribution system in Oakland, belonging to the Central Oakland Light & Power Co. consisted of 50,760 feet of overhead lines and 15,450 feet of underground lines.

cent bonds; of the $2,318,000 in bonds of this issue to be immediately authenticated $2,024,500 was to be delivered to E. W. Wilson in payment of the purchase price of the various properties, $243,000 was to be reserved for underlying issues (Consumers Light & Power Co. and Central Oakland Light & Power Co.), and $50,500 in bonds was to be sold at not less than 80, to cover necessary expenses of rehabilitation of plants. Great Western Power Co. was to repurchase $400,000 of bonds within four years to be held as a sinking fund under Great Western Power Co. first-mortgage issue.

MARKET.

TERRITORY AND POPULATION.

The transmission lines of Great Western Power Co. of California distribute power in Alameda, Butte, Contra Costa, Napa, Placer, Plumas, Sacramento, San Francisco, San Mateo, Solano, Sonoma, Sutter, and Yolo counties.

The area and population of these counties are shown in Table 9; and the general features of the counties are briefly characterized in the notes on pages 66–72.

The population of communities served is shown in Table 55, which follows:

TABLE 55.—*Communities served by Great Western Power Co. of California.*

Incorporated places.

Town.	County.	Population.			
		1890	1900	1910	1920
Albany	Alameda			808	2,462
Berkeley	do	5,101	13,214	40,434	56,036
Concord	Contra Costa			703	912
Emeryville	Alameda	228	1,016	2,613	2,390
Fairfield	Solano			834	1,008
Martinez	Contra Costa	1,600	1,380	2,115	3,858
Napa	Napa	4,395	4,036	5,791	6,757
Oakland	Alameda	48,682	66,960	150,174	216,261
Petaluma	Sonoma	3,692	3,871	5,880	6,226
Pittsburg	Contra Costa			2,372	4,715
Richmond	do			6,802	16,843
Rio Vista	Solano	648	682	884	1,104
Rocklin	Placer	1,056	1,050	1,026	643
Roseville	do			2,608	4,477
Sacramento	Sacramento	26,386	29,282	44,696	65,908
San Francisco	San Francisco	298,997	342,782	416,912	506,676
Santa Rosa	Sonoma	5,220	6,673	7,817	8,758
San Leandro	Alameda		2,253	3,471	5,703
		396,005	473,199	695,940	910,737

Unincorporated places.

Fruitvale	Alameda County.
San Lorenzo	Do.
Bay Point	Contra Costa County.
Gaylord mine	Eldorado County.
Folsom dredges	Sacramento County.
Fair Oaks	Do.
Florin	Do.
Sheldon	Sacramento County.
Wilton	Do.
Hood River	Do.
Courtland	Do.
Vorden	Do.
Walnut Grove	Do.
Denverton	Solano County.

LOAD.

An excellent idea of the relative amounts of different classes of load on the Great Western Power system may be obtained from Table 56, showing classified sales in kilowatt-hours and connected load in kilowatts. Up to and including 1918 separate figures are given for the different operating companies, and intercompany exchanges of power are eliminated. Great Western Power Co. of California took over and consolidated for operation all companies on June 1, 1919; but the sales and connected load for 1919 represent the full year, January 1 to December 31, and therefore include operation of the subcompanies for the first five months. The 1920 figures cover the entire system.

A more detailed study of the statistics of sales and connected load in 1920 shows that the only sales for municipal arc lighting were in the Napa district (35,000 kilowatt-hours, with 8 kilowatts connected). The largest sales for municipal incandescent lighting were in the Santa Rosa district (206,000 kilowatt-hours, with 59 kilowatts connected) and the Napa district (119,000 kilowatt-hours and 27 kilowatts connected). Sales for miscellaneous municipal lighting were insignificant, amounting to but 10,000 kilowatt-hours for all districts. The principal sales for municipal power were in the Oakland district (3,380,000 kilowatt-hours), Sacramento district (444,000 kilowatt-hours and 973 kilowatts connected), Napa district (392,000 kilowatt-hours and 123 kilowatts connected), and Santa Rosa district (364,000 kilowatt-hours and 153 kilowatts connected). In sales for commercial flat-rate lighting the Sacramento district ranked first (38,000 kilowatt-hours and 91 kilowatts connected), followed by the Napa district (23,000 kilowatt-hours and 5 kilowatts connected) and the Rio Vista district (20,000 kilowatt-hours and 5 kilowatts connected). Sales for commercial metered lighting were largest in the San Francisco district (24,773,000 kilowatt-hours and 18,830 kilowatts connected), followed in order by the Oakland district (5,629,000 kilowatt-hours and 9,245 kilowatts connected) and the Sacramento district (4,156,000 kilowatt-hours and 7,104 kilowatts connected). Sales for commercial power at flat rate were largest in the Rio Vista district (784,000 kilowatt-hours and 294 kilowatts connected), followed in order by the San Francisco district (338,000 kilowatt-hours and 71 kilowatts connected) and the Oakland district (304,000 kilowatt-hours and 104 kilowatts connected). Metered sales of commercial power were largest in the Oakland district (112,964,000 kilowatt-hours and 65,415 kilowatts connected), Sacramento district (35,290,000 kilowatt-hours and 21,380 kilowatts connected), and San Francisco district (32,797,000 kilowatt-hours and 35,810 kilowatts connected). The largest sales of railway power were in the Oakland district (21,311,000 kilowatt-hours and

15,889 kilowatts connected) and the Rio Vista district (2,492,000 kilowatt-hours and 1,500 kilowatts connected). The largest deliveries to other electric corporations were in the Oakland district (10,509,000 kilowatt-hours and 8,412 kilowatts connected) and the Sacramento district (3,400,000 kilowatt-hours and 5,320 kilowatts connected). The only important breakdown service was in the Oakland district (130,000 kilowatt-hours and 237 kilowatts connected). The only important miscellaneous electric revenue was in the Oakland district (551,000 kilowatt-hours and 2,138 kilowatts connected).

TABLE 56.—*Sales and connected load, Great Western Power Co. and subsidiaries, 1913–1920.*

1913.

	Great Western Power Co.	City Electric Co.	Total.	Per cent.
SALES (KILOWATT-HOURS).				
Lighting:				
Municipal—				
Arc lamps	185,602	....	185,602	....
Incandescent lamps	363,379	....	363,379	0.1
Miscellaneous	348,613	....	348,613	.1
Commercial—				
Flat rate	6,001,246	4,877	6,006,123	2.1
Metered	3,526,785	12,996,488	16,523,273	6.0
Power:				
Municipal	1,162,461	....	1,162,461	.4
Commercial—				
Flat rate	36,268	9,142	45,410	....
Metered	71,443,191	11,855,826	83,299,017	30.1
Railway	7,657,946	31,189,837	38,847,783	14.2
Other electrical corporations [a]	127,478,700	1,130,937	128,609,637	47.0
Miscellaneous	1,266	56,027	57,293	....
	218,205,457	57,243,134	275,448,591	100.0
CONNECTED LOAD (KILOWATTS).				
Lighting:				
Residence	7,180	4,516	11,696	9.6
Commercial	3,445	13,548	16,993	14.0
Municipal	401	....	401	.3
All other	548	395	943	.8
Power:				
Industrial	27,134	11,084	38,218	31.4
Agricultural	3,594	....	3,594	3.0
All other	40,778	8,895	49,673	40.9
	83,080	38,438	121,518	100.0

1914.

	Great Western Power Co.	City Electric Co.	Total.	Per cent.
SALES (KILOWATT-HOURS).				
Lighting:				
Municipal—				
Arc lamps	188,230	....	188,230	....
Incandescent lamps	350,237	....	350,237	0.1
Miscellaneous	357,650	114,744	472,394	.2
Commercial—				
Flat rate	4,843,385	6,359	4,849,744	2.0
Metered	4,726,413	13,086,961	17,813,374	7.3
Power:				
Municipal	879,408	127,945	1,007,353	.4
Commercial—				
Flat rate	58,679	32,423	91,102	....
Metered	66,326,114	13,211,674	79,537,788	32.0
Railway	11,168,186	32,060,050	43,228,236	17.4
Other electrical corporations [a]	99,098,036	1,724,027	100,822,063	40.6
Miscellaneous	2,054	110,147	112,201	....
	187,998,392	60,474,330	248,472,722	100.0

[a] Sales to system corporations eliminated.

TABLE 56.—*Sales and connected load, Great Western Power Co. and subsidiaries, 1913–1920*—Continued.

1914—Continued.

	Great Western Power Co.	City Electric Co.	Total.	Per cent.
CONNECTED LOAD (KILOWATTS).				
Lighting:				
Residence	7,118	1,329	8,447	6.6
Commercial	6,477	21,463	27,940	21.9
Municipal	398	410	808	.6
All other	22	406	428	.3
Power:				
Industrial	22,737	12,960	35,697	28.1
Agricultural	7,723	....	7,723	6.0
All other	40,095	6,468	46,563	36.5
	84,570	43,036	127,606	100.0

1915.[a]

	Great Western Power Co.	City Electric Co.	Total.	Per cent.
SALES (KILOWATT-HOURS).				
Lighting:				
Municipal—				
Arc lamps	[b] 174,017	....	174,017	....
Incandescent lamps	348,142	....	348,142	0.1
Miscellaneous	123,041	119,144	242,185	.1
Commercial—				
Flat rate	2,499,963	13,707	2,513,670	1.0
Metered	6,426,177	16,122,516	22,548,693	8.6
Power:				
Municipal	805,324	208,375	1,013,699	.4
Commercial—				
Flat rate	340,400	51,078	391,478	.1
Metered	73,749,407	15,522,809	89,272,216	34.0
Railway	15,525,835	32,093,650	47,619,485	18.1
Other electrical corporations[c]	97,355,932	1,708,582	99,064,514	37.6
Miscellaneous	2,723	56,851	59,574	....
	197,350,961	65,896,712	263,247,673	100.0
CONNECTED LOAD (KILOWATTS).				
Lighting:				
Municipal—				
Arc lamps	29	....	29	....
Incandescent lamps	100	....	100	....
Miscellaneous	17	....	17	....
Commercial—				
Flat rate	854	37	891	0.5
Metered	15,293	24,823	40,116	23.7
Power:				
Municipal	311	156	467	.3
Commercial—				
Flat rate	209	41	250	.2
Metered	50,466	36,121	86,587	51.2
Railway	18,837	4,000	22,837	13.5
Other electrical corporations	16,853	820	17,673	10.5
Miscellaneous	....	136	136	.1
	102,969	66,134	169,103	100.0

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[a] Consolidated Electric Co. reported that record of sales for 1915 was not available.
[b] Includnig Great Western Power Co. of California.
[c] Sales to system corporations eliminated.

NOTE.—In 1915 Great Western Power Co. of California reported 96 kilowatts industrial power connected, but did not report sales. The company was connected to Great Western at Clayton, but purchased no power.

TABLE 56.—*Sales and connected load, Great Western Power Co. and subsidiaries, 1913–1920*—Continued.

1916.

	Great Western Power Co.[a]	City Electric Co.	Total.	Per cent.
SALES (KILOWATT-HOURS).				
Lighting:				
Municipal—				
Arc lamps	154,753		154,753	
Incandescent lamps	305,354		305,354	0.1
Miscellaneous	8,477		8,477	
Commercial—				
Flat rate	1,623,413	37,327	1,660,740	.6
Metered	8,252,975	21,238,238	29,491,213	9.7
Power:				
Municipal	1,104,256	119,226	1,223,482	.4
Commercial—				
Flat rate	991,356	183,009	1,174,365	.4
Metered	96,646,121	22,146,048	118,792,169	38.9
Railway	24,979,409	32,156,694	57,136,103	18.7
Other electrical corporations[b]	94,945,500	348,528	95,294,028	31.2
Miscellaneous	1,685	103,845	105,530	
	229,013,299	76,332,915	305,346,214	100.0
CONNECTED LOAD (KILOWATTS).				
Lighting:				
Municipal—				
Arc lamps	32		32	
Incandescent lamps	85		85	
Miscellaneous	11		11	
Commercial—				
Flat rate	701	40	741	0.4
Metered	17,558	27,217	44,775	25.4
Power:				
Municipal	1,285	138	1,423	.8
Commercial—				
Flat rate	240	127	367	.2
Metered	61,688	25,379	87,067	49.5
Railway	18,156	4,770	22,926	13.1
Other electrical corporations	18,011	70	18,081	10.3
Miscellaneous		612	612	.3
	117,767	58,353	176,120	100.0

1917.

	Great Western Power Co.	Great Western Power Co. of California.	City Electric Co.	Total.	Per cent.
SALES (KILOWATT-HOURS).					
Lighting:					
Municipal—					
Arc lamps	80,000			80,000	0.1
Incandescent lamps	351,000			351,000	.1
Miscellaneous	11,000			11,000	
Commercial—					
Flat rate	1,019,000	18,000	103,000	1,140,000	.3
Metered	8,458,000	57,000	24,362,000	32,877,000	9.8
Power:					
Municipal	976,000		132,000	1,108,000	.3
Commercial—					
Flat rate	1,461,000	4,000	501,000	1,966,000	.6
Metered	121,385,000	183,000	26,465,000	148,033,000	44.1
Railway	26,698,000		27,451,000	54,149,000	16.1
Other electrical corporations[b]	95,994,900		1,100	95,996,000	28.6
Miscellaneous	2,000		67,000	69,000	
	256,435,900	262,000	79,082,100	335,780,000	100.0

[a] Including Great Western Power Co. of California.

[b] Sales to system corporations eliminated.

TABLE 56.—*Sales and connected load, Great Western Power Co. and subsidiaries, 1913–1920*—Continued.

1917—Continued.

	Great Western Power Co.	Great Western Power Co. of California.	City Electric Co.	Total.	Per cent.
CONNECTED LOAD (KILOWATTS).					
Lighting:					
Municipal—					
Arc lamps	8			8	
Incandescent lamps	113			113	
Miscellaneous	24			24	
Commercial—					
Flat rate	333	10	8	351	0.1
Metered	19,176	166	23,960	43,302	22.4
Power:					
Municipal	1,311		138	1,449	.7
Commercial—					
Flat rate	426	3	109	538	.3
Metered	79,264	323	31,279	110,866	57.4
Railway	18,178			18,178	9.4
Other electrical corporations	18,162		70	18,232	9.4
Miscellaneous			555	555	.3
	136,995	502	56,119	193,616	100.0

1918.

	Great Western Power Co.	Great Western Power Co. of California.	City Electric Co.	Total.	Per cent.
SALES (KILOWATT-HOURS).					
Lighting:					
Municipal—					
Arc lamps	42,000			42,000	0.1
Incandescent lamps	357,000			357,000	.1
Miscellaneous	16,000			16,000	
Commercial—					
Flat rate	389,000	15,000	86,000	490,000	.1
Metered	8,570,000	52,000	23,179,000	31,801,000	9.5
Power:					
Municipal	2,340,000		147,000	2,487,000	.7
Commercial—					
Flat rate	1,460,000	3,000	380,000	1,843,000	.6
Metered	157,995,000	184,000	29,073,000	187,252,000	55.9
Railway	26,619,000			26,619,000	7.9
Other electrical corporations[a]	82,891,300		990,800	83,882,100	25.0
Miscellaneous	29,000		18,000	47,000	.1
	280,708,300	254,000	53,873,800	334,836,100	100.0
CONNECTED LOAD (KILOWATTS).					
Lighting:					
Municipal—					
Arc lamps	8			8	
Incandescent lamps	98			98	
Miscellaneous	17			17	
Commercial—					
Flat rate	74	10	2	86	
Metered	19,464	162	26,215	45,841	21.6
Power:					
Municipal	3,434		138	3,572	1.7
Commercial—					
Flat rate	366	3	91	460	.2
Metered	97,380	356	29,030	126,766	59.8
Railway	18,178			18,178	8.5
Other electrical corporations	17,363		10	17,373	8.2
Miscellaneous	5		113	118	
	156,387	531	55,599	212,517	100.0

[a] Sales to system corporations eliminated.

TABLE 56.—*Sales and connected load, Great Western Power Co. and subsidiaries, 1913–1920*—Continued.

1919.

[Great Western Power Co. of California.]

Class of load.	Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatt-hours.	Per cent of total.
Municipal street lighting:				
Arc	39,470	....	8	....
Incandescent	363,015	0.1	115	....
Municipal lighting, miscellaneous	10,504	....	17	....
Municipal power	5,660,343	1.9	4,601	2.2
Commercial lighting:				
Flat rate	112,895	.1	30	....
Metered	31,613,826	10.5	42,057	20.4
Commercial power:				
Flat rate	1,846,713	.6	557	.3
Metered	191,884,714	63.9	123,370	60.1
Railway power	27,114,335	9.1	19,207	9.3
Other electric corporations	41,018,617	13.7	14,655	7.3
Breakdown service	....	....	278	.1
Miscellaneous electric	389,826	.1	669	.3
	300,054,258	100.0	205,564	100.0

1920.

[Great Western Power Co. of California.]

Municipal street lighting:				
Arc	35,000	....	8	....
Incandescent	360,000	0.1	113	....
Municipal lighting, miscellaneous	10,000	....	18	....
Municipal power	4,745,000	1.6	1,426	0.7
Commercial lighting:				
Flat rate	108,000	.1	113	....
Metered	36,564,000	12.7	40,778	18.0
Commercial power:				
Flat rate	2,258,000	.8	696	.3
Metered	201,295,000	69.9	143,469	63.3
Railway power	27,343,000	9.5	19,908	8.8
Other electric corporations	14,356,000	5.0	17,910	7.9
Breakdown service	151,000	.1	296	.1
Miscellaneous electric	644,000	.2	2,238	.9
	287,869,000	100.0	226,973	100.0

Plate XL shows the mean monthly load on all plants of the Great Western Power system, reduced from kilowatt-hour outputs from the generating stations. Practically all the hydroelectric power shown was generated at the Big Bend plant, the Butt Creek plant supplying but a relatively small amount from 1915 to 1920 and the Caribou plant part of the power for April, May, and June, 1921. The steam-electric power was generated almost entirely at the North Beach plant of City Electric Co., the Oakland steam stand-by plant operating only at infrequent intervals. Steam power generated subsequent to June, 1915, included the relatively minor output of Consolidated Electric Co.'s plants, formerly operated by United Light & Power Co. of California.

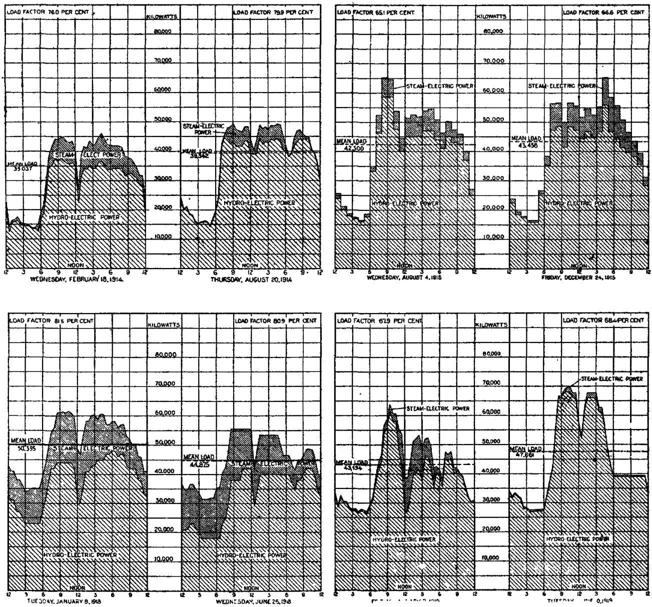


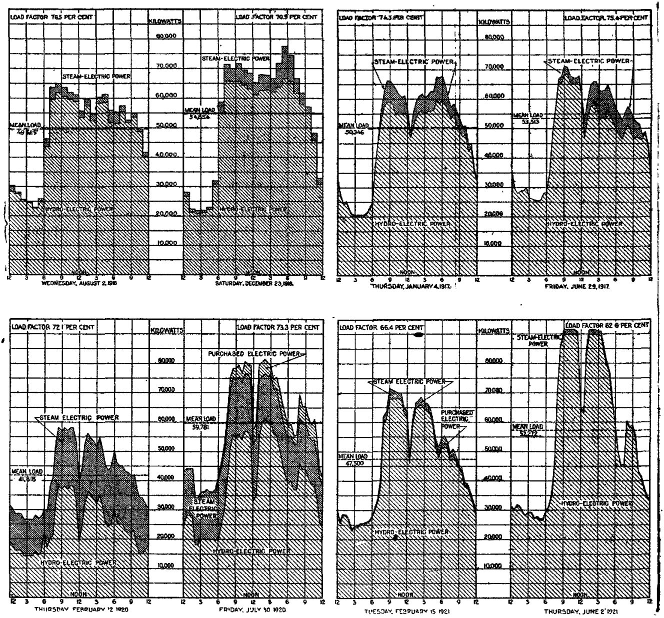
FIGURE 13.—Great Western Power system,

Power generated and purchased by the system is shown in Table 58.

Typical load curves for the Great Western system are given in figure 13. These curves show a high load factor and a relatively large amount of power furnished by hydroelectric plants.

TABLE 57.—*Growth of load on lines of Great Western Power system, 1912–1920.*

Year.	Number of consumers.	Number of street lamps.		Connected load.
		Arc.	Incandescent.	
				Horsepower.
1912	11,300	97	765	162,834
1913	15,011	97	765	162,834
1914	16,998	97	765	170,992
1915	20,154	97	765	226,598
1916	23,606	97	765	236,001
1917	26,742			259,445
1918	27,399			284,773
1919	28,734			275,456
1920	31,179			304,144



daily load curves, 1913–1921.

TABLE 58.—*Power generated and purchased by Great Western Power Co., 1908–1920.*

Year.	Generated.		Total.[a]	Mean.	Peak.	Load factor.
	Hydro-electric.	Steam-electric.				
	Kilowatt-hours.	*Kilowatt-hours.*	*Kilowatt-hours.*	*Horse-power.*	*Horse-power.*	*Per cent.*
1908	....	34,145,000	34,145,000	5,220	....	....
1909	114,377,000	47,750,000	162,127,000	24,800	....	....
1910	187,639,000	52,427,000	240,066,000	36,700	....	....
1911	151,900,000	52,427,000	203,327,000	31,100	....	....
1912	234,050,000	60,640,000	294,690,000	45,000	68,000	66.2
1913	261,902,000	70,215,000	332,117,000	50,800	72,300	70.3
1914	282,044,000	31,392,000	313,436,000	48,000	75,300	63.8
1915	318,266,000	25,703,000	343,969,000	52,600	83,300	63.2
1916	375,829,000	32,552,000	408,381,000	62,500	99,500	62.8
1917	432,859,000	25,142,000	458,001,000	70,100	99,000	70.8
1918	378,203,000	73,086,000	451,289,000	69,100	101,150	68.3
1919	373,669,360	41,725,674	415,395,034	63,541	113,712	55.9
1920	325,257,000	82,206,000	407,463,000	62,329	108,004	57.7

[a] The quantity of power purchased is negligible.

Monthly load factors for the system, shown graphically at the bottom of Plate XL, range from 56 to 81 per cent. Daily load factors shown in the curves of figure 13, range from 62.6 to 81.5 per cent.

ELECTRIC SYSTEM.

GENERAL RELATIONS.

Great Western Power Co. of California operates or maintains in operating condition (Oct. 31, 1921) two hydroelectric and five steam stations.[77a] Of these the Big Bend plant is the chief source of power. The North Beach steam plant generates auxiliary power and serves as a stand-by plant; Oakland steam plant serves as a secondary steam reserve plant but under usual conditions generates little or no power. Whitney and Phelan steam plants in San Francisco and St. Marks steam plant in Oakland (acquired through Consolidated Electric Co.) are operated only in emergency or when steam is needed for heating the buildings which are supplied by the first three. Minna Street steam plant in San Francisco and Alice steam plant in Oakland (acquired through Consolidated Electric Co.) were changed to substations in the fall of 1915. Yerba Buena steam plant, in Oakland, was leased from San Francisco-Oakland Terminal Railways ("Key Route") but has been operated only during very low water, such as occurred in 1918.

The Butt Creek hydroelectric plant, which from 1912 to 1914 was used only for supplying power for construction work on Big Meadows dam, in October, 1915, began supplying power commercially from a line run northeastward from the plant to some copper mines.

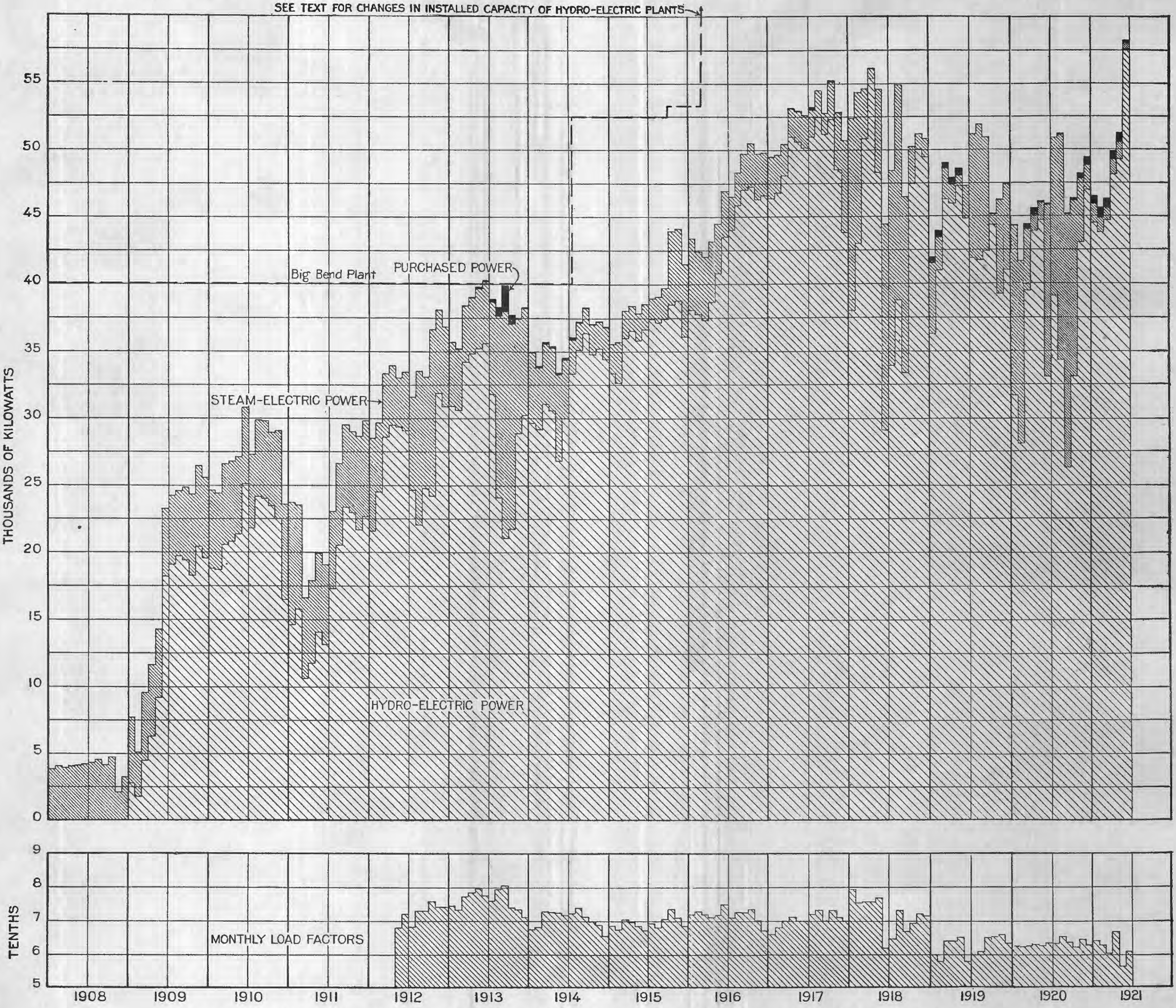
FEATHER RIVER SYSTEM.

LOCATION.

The hydroelectric developments of Great Western Power Co. of California are confined entirely to the North Fork of Feather River, where the company has outlined a consecutive series of six plants, utilizing the entire fall between its Big Meadows reservoir and the Sacramento Valley near Oroville. It has also tentatively planned a power development on Bucks Creek, tributary to the North Fork, but this development will probably be delayed until after the construction of the principal plants.

The Caribou and Big Bend plants are the only plants along North Fork yet completed, and no work has been done on the other four, although the Big Meadows reservoir or Lake Almanor will regulate the water supply available through the entire series of plants. The Caribou plant is at the head of the series and diverts immediately from Lake Almanor. The Big Bend plant is next to the lowest in the series, reckoning downstream.

[77a] In 1921 the Butt Creek plant was put out of commission on the completion of the far larger Caribou plant. The Great Western system has also relinquished operation of the Yerba Buena steam plant.



GREAT WESTERN POWER SYSTEM, MEAN MONTHLY LOADS AND LOAD FACTORS, 1908-1921.

SOURCE OF WATER SUPPLY.

The part of Feather River basin (Pl. XLI, in pocket) supplying water for the Big Bend plant embraces 1,940 square miles, drained by the North Fork, in Plumas and Lassen counties, about 170 miles northeast of San Francisco. The true source of North Fork is in Warner Creek and its tributary streams, which head on the shoulders of Lassen Peak and flow southeast into the Big Meadows. From the lower end of the Meadows the stream, reinforced by the discharge of very large springs, flows southwestward, receiving midway between the meadows and Big Bend intake Indian Creek,[78] which drains the extreme eastern part of the basin through its tributaries Squaw Queen and Red Clover creeks.

The headwater basin is not of the true alpine type, as are the headwaters of the Kern, Kings, and San Joaquin rivers, farther south in the Sierra, but is rather rolling in contour and for the most part is heavily covered with pine forests interspersed with mountain meadows.

The elevations, at no place very great, range from 1,000 feet at the intake, to 10,437 feet at the crest of Lassen Peak on the extreme northwest edge of the basin. Along the boundaries, except on the shoulder of Lassen Peak, very little of the country rises to more than 7,000 feet, though most of it approaches 6,500 feet. Inside the boundaries Mount Ingalls, in the southeast part of the basin, is the highest peak, and its elevation is only 8,377 feet.

In much of the southern part of the drainage basin the rocks exposed are shale and slate, but in the Big Meadows and Lassen Peak country they are volcanic. In the region of volcanic rocks the streams are fed by numerous springs and show the great tendency to regularity in flow, usual under such conditions, instead of the flashy, torrential flow so common in streams draining regions characterized by granitic formations.

A comparison of the stream-flow records obtained at the Big Meadows dam site with those taken at the Big Bend intake during a five-year period shows several points of interest. The records compared cover the period October 1, 1905, to September 30, 1910, except for several months in 1909, for which they are lacking. The area of tributary drainage basin at Big Meadows dam is 479 square miles, or 24.2 per cent of the tributary area at Big Bend. The total run-off for the period (not including months of defective records) was 3,610,000 acre-feet at Big Meadows and 12,610,000 acre-feet at the intake—that is, 28.6 per cent of the total run-off came from the 24.2 per cent of drainage area above Big Meadows. The highest discharge at Big Bend was 118,000 second-feet March 19, 1907; the corresponding discharge at Big Meadows was 9,850 second-feet, or 8.4 per cent of the total. The lowest discharge at

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[78] The stretch of Indian Creek below the mouth of Spanish Creek is sometimes known as East Branch.

Big Bend was 960 second-feet September 16, 1908; the corresponding discharge at Big Meadows was 610 second-feet, or 63.5 per cent of the total.

The foregoing figures representing floods and low flows for the period are the extremes, and it would be unwise to draw general conclusions from them, but a general review of the records available seems to show very consistent peculiarities. The total run-off during a long term of years from the lava country above Big Meadows may be only 2 or 3 per cent higher than the run-off from an equal area in the rest of the drainage basin, but the distribution of the flow of any one year is far different. If a uniform discharge per square mile from the entire 1,940 square miles of drainage basin is considered the normal, it is uniformly true that in the months of low flow the discharge at Big Meadows is above normal, whereas in the months of flood flow it is below normal. In short, owing to the volcanic formations on the slopes of Lassen Peak, floods are not so high and the low flow not so extreme nor so prolonged at Big Meadows as in the southern and eastern parts of the basin.[79]

Records of rainfall within the basin are scattered but indicate a mean seasonal fall of at least 40 inches throughout all its parts and a probable maximum of about 75 inches in the more favored districts. If the minimum falls below 40 inches anywhere it will doubtless be in the extreme eastern part of the basin near the drier side of the mountains.

The area tributary to Butt Creek at the intake of the second tunnel of the Caribou project embraces 75 square miles. It is a narrow, curving, irregular area, about 18 miles long east and west and 4 miles in average width. The general course of the stream for the 10 miles from its headwaters (on the divide separating it from Butte Creek) to the central part of its basin, is almost due east. From this point it turns and flows southeasterly into North Fork of Feather River 5 miles below the Big Meadows dam site and 9 miles above the mouth of Yellow Creek, the next tributary to the west.

In general the region consists of heavily forested rolling upland, with steep slopes in the lower walls of the main canyon. The basin is in the lava formation so characteristic of northeastern California. Records of rainfall obtained in the region directly west of the plant as well as a few taken at the lower end of Butt Valley indicate that the average seasonal precipitation is about 60 inches.

Elevations in the basin range from 4,000 feet at the intake to 7,831 feet on the highest summit, but most of the area is less than 5,000 feet above sea level. The snow disappears entirely early in

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[79] For records of stream flow of North Fork of Feather River above Big Bend see U. S. Geol. Survey Water-Supply Papers as follows: 298, pp. 182–202 (up to June 30, 1912); 331, pp. 278–288 (1911–12); 361, pp. 309–313 (1912–13); 391, pp. 228–231 (1913–14); 411, pp. 237–245 (1914–15); 441, pp. 212–221 (1915–16); 461, pp. 208–217 (1916–17); 481, pp. 200–209 (1917–18).

summer, and were it not for the regulative effect of the porous lavas the flow late in fall and in winter would be extremely low. Owing to the favorable geologic conditions, however, the flow of the creek during the dry season is maintained far better than that of many streams of the same size draining areas in the Sierra.[80]

RESERVOIR.

The Big Meadows reservoir site on North Fork of Feather River is one of the largest in the United States. The original plans called for the construction of a multiple-arch dam, 130 feet high and 1,150 feet long, which would have flooded about 29,000 acres and impounded 1,250,000 acre-feet, or 54,000,000,000 cubic feet of water, but in 1913, after construction had been begun at the most favorable dam site, interests adverse to the plan lodged with the State Railroad Commission complaint against the type of the proposed structure. In the meantime further explorations of the dam site brought to light certain unfavorable conditions in the bedrock.

A hydraulic-fill dam with 3:1 slopes on both upstream and downstream faces was therefore substituted. The upstream slope is paved with 2-foot and the downstream with a 5-foot rock revetment. Rock-fill toes are used on both sides of the dam. The plans provide for a dam 100 feet high ultimately, with crest elevation of 4,480 feet above sea level, a spillway level of 4,475 feet with flashboards, or 4,465 feet without flashboards. According to this plan the eventual area of the reservoir at altitude of 4,475 feet will be 22,300 acres, and its capacity 30,492,000,000 cubic feet or 700,000 acre-feet instead of the 1,250,000 acre-feet which would have been impounded with the 130-foot dam originally planned.

Capacity curves of the reservoir are shown in figure 14.

During the field season of 1913 the dam was completed to a height of 92 feet, which gave a crest elevation of 4,472 feet, crest length 640 feet, crest width 80 feet, spillway level 4,450 feet, and width of spillway 240 feet. A cut-off wall of 50-foot steel sheet piling was driven across the bed of the stream near the center line of the dam; the top of this cut-off is about 4,407 feet above sea level; the linear length of the cut-off along the axis of the dam is about 130 feet.

Water is discharged from the reservoir through a 10-foot concrete-lined tunnel which was driven through the hillside at the west end of the dam. Two bends in the tunnel bring the outlet directly below the toe of the dam on the downstream side. Water is admitted to the tunnel through a reinforced-concrete intake tower provided with sliding gates and trash racks. The elevation of invert of the tunnel at the intake tower is 4,400 feet above sea level. The water-surface

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[80] For records of flow of Butt Creek see U. S. Geol. Survey Water-Supply Papers as follows: 298, pp 223–230 (up to June 30, 1912); 331, pp. 282–285 (1911–12); 361, pp. 316–318 (1912–13); 391, pp. 232–234 (1913–14); 411, pp. 241–242 (1914–15); 441, pp. 217–218 (1915–16); 461, pp. 213–214 (1916–17); 481, pp. 205–206 (1917–18).

elevation at completion of construction in 1913 was 4,450 feet, giving an area of 14,000 acres and a capacity of 9,583,200,000 cubic feet or 224,000 acre-feet. In June, 1917, the dam was completed to a height permitting storage to an elevation of 4,455 feet, giving a capacity of 13,068,000,000 cubic feet or 300,000 acre-feet.

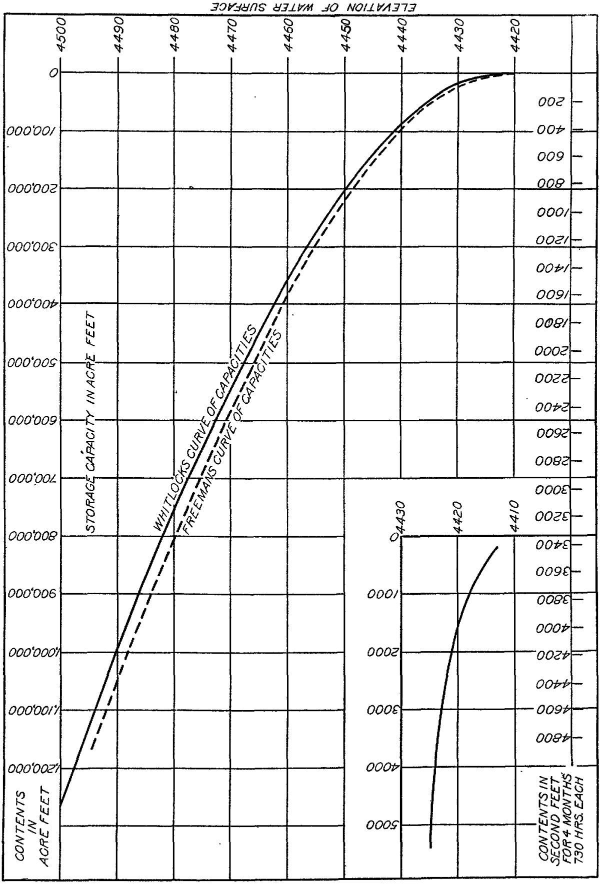


FIGURE 14.—Great Western Power Co. of California, capacity curves of Lake Almanor (Big Meadows reservoir).

The Big Meadows storage reservoir, now christened Lake Almanor will, when raised to the 4,475-foot level, have a capacity of 700,000 acre-feet and flood part or all of secs. 1, 2, 3, 10, 11, and 12 of T. 27

N., R. 7 E., secs. 3, 4, 5, 6, 7, 8, 9, 10, 15, 16, 17, 18, 20, 21, 22, and 28 of T. 27 N., R. 8 E., secs. 9, 10, 11, 14, 15, 16, 17, 20, 21, 22, 23, 25, 26, 27, 28, 29, 32, 33, 34, 35, and 36 of T. 28 N., R. 7 E., and secs. 19, 20, 21, 28, 29, 30, 31, 32, 33, and 34 of T. 28 N., R. 8 E.

The only other developed storage on the basin is the unimportant Round Valley reservoir on Indian Creek, but there are extensive undeveloped sites in the Indian Creek basin.

The company originally intended to develop 106,560 acre-feet of storage in Butt Valley by the construction of a 115-foot dam at the present point of second diversion for the Caribou plant, and to use the Butt Creek supply through an enlargement of the small Butt Creek plant[80a] that was operated from 1911 to 1921. The construction of the Caribou project superseded this old plan, however, and it seems improbable that a large storage reservoir on Butt Creek will ever be necessary.

CARIBOU PLANT.

LOCATION.

The Caribou plant, which diverts directly from the southwest side of Lake Almanor, on the North Fork of Feather River, was constructed by Stone & Webster (Inc.). Many difficulties were encountered in completing the tunnel from Lake Almanor into Butt Creek, and the plant did not go into operation until April 7, 1921.

The plant diverts water from Lake Almanor southwestward into the drainage basin of Butt Creek through Prattville (No. 1) tunnel. The discharge from this tunnel is allowed to flow down Butt Creek 6 miles to a second intake and is there diverted through Caribou (No. 2) tunnel to the power house on North Fork 1 mile below the mouth of Butt Creek.

The intake of the Prattville tunnel is in the SW. ¼ NE. ¼ sec. 11, T. 27 N., R. 7 E.; the tunnel traverses secs. 11, 14, 15, and 22 of that township, and the outlet of the tunnel at Butt Creek is in the NE. ¼ NW. ¼ sec. 22. The intake of the Caribou tunnel is on Butt Creek in the SE. ¼ SW. ¼ sec. 12, T. 26 N., R. 7 E., and the tunnel traverses secs. 12, 13, and 24 of that township; the diversion dam, which is located practically on the site of the old diversion dam of Butt Creek plant, is at the quarter corner on the line between secs. 12 and 13. The Caribou power house is directly at the south portal of the Caribou tunnel, in the NE. ¼ NW. ¼ sec. 25 and the SE. ¼ SW. ¼ sec. 24, T. 26 N., R. 7 E.

[80a] The Butt Creek plant, operated for construction purposes from 1911 to October, 1915, and commercially thereafter, diverted the unregulated flow of Butt Creek at the present intake of Caribou tunnel No. 2 and conducted water through a flume 8,460 feet long to the head of a pressure pipe leading to a small power house on Butt Creek near its junction with North Fork, where two 400-kilovolt-ampere units were operated by impulse wheels under a head of 856 feet. Power was used at Lake Almanor dam for construction and for local service in the general vicinity of the plant. The plant was shut down upon completion of the Caribou development and will be dismantled.

CONDUIT.

A permanent reinforced-concrete control tower equipped with gates, stop-log slots, etc., was constructed near the head of No. 1 tunnel before the completion of the Caribou plant, and a temporary connection was made with Lake Almanor, where permanent inlet works were under construction at the end of 1921.

The present maximum water-surface elevation of Lake Almanor, determined by the flashboard crest in the spillway, is 4,555 feet above sea level. The inlet tower at the head of Prattville (No. 1) tunnel is 55 feet west of the flood level of the lake and is connected with the lake by a channel 35 feet wide at the bottom (elevation 4,425 feet above sea level). The sides of the channel as constructed rise vertically to elevation 4,431.5 feet, then on a slope of 1½:1 to elevation 4,445 feet, where there is a berm of 4 feet, above which the sides are sloped 1½:1 to the ground surface. The channel extends into the lake 250 feet on a uniform section and then spreads to a width of 450 feet.

The channel terminates at concrete wing walls leading to an open-faced tower 10 feet wide by 12 feet deep in plan at the upper end of the tunnel. There is a gradual drop in the bottom of the inlet between the concrete wing walls, so that although the lip where the structure joins the bottom of the channel is 4,425 feet above sea level, the bottom of the tower is only 4,416 feet. The tops of the wing walls are 4,456 feet and the top of the tower 4,465 feet above seal level. The tower is not provided with gates, the discharge through the conduit being controlled by the main tower connected to the inlet tower by 170 feet of timber-lined tunnel 7 by 7 feet in cross section. The second or control tower is similar to that at the head of tunnel No. 2, described in detail below.

From the control tower to the lower portal of the Prattville tunnel the grade, form of section, and type of lining all vary. The capacity is 900 second-feet.

The elevation of the tunnel floor at the concrete inlet lip is 4,425 feet, and that of the floor of the tunnel at Butt Creek is 4,305 feet, giving a total drop of 120 feet in a length of 11,725 feet.

Water discharged from the lower end of Prattville tunnel flows down Butt Creek 6 miles to the intake of the Caribou (No. 2) tunnel, where it is diverted by a rock and hydraulically filled dam 26 feet high, 40 feet wide on top, and 110 feet wide on the bottom, formed by dumping tunnel spoil on the upstream and downstream toes and filling in between with sluiced material. A concrete-lined spillway 60 feet wide provided with flash boards is installed at the east end of the dam, or on the side opposite the tunnel intake.

The elevation at the top of the dam is 4,096 feet, at the top of the flashboards 4,091 feet, and at the spillway lip 4,086 feet.

The reinforced-concrete gate structure at the head of the Caribou tunnel is 30 feet in clear horizontal width of opening at its mouth and narrows to a tunnel width of 9 feet about 15 feet back from the screen frame at the mouth. The vertical depth of the intake from the operating floor at the top of the structure (elevation 4,117 feet) to the invert of the tunnel (elevation 4,068 feet) is 49 feet. The structure is designed for a maximum high-water level of 4,113 feet, or 45 feet above the tunnel invert. The mouth of the intake is divided into three equal openings by two reinforced-concrete piers with reinforced-concrete struts between them supporting a frame of 15-inch 42-pound steel I beams against which rests a vertical screen of 3½ by ⅜ inch flat steel bars. Flow through the inlet is controlled by a 9-foot gate valve just inside the tunnel opening. The stem of the valve rises through a vertical gate slot to motor-driven gears at the top of the structure. Slots for stop logs are provided upstream from the valve, and a 2½ by 10 foot air shaft covered with a grating opens from the roof of the tunnel to the top of the structure immediately below the gate. A by-pass is also provided, and a circular vertical inspection shaft 3 feet in inside diameter rises from the roof of the tunnel 10 feet downstream from the air shaft. This inspection shaft is provided with a ladder.

The capacity of the Caribou tunnel is 1,200 second-feet, or 300 second-feet more than that of the Prattville tunnel, in order to accommodate the additional supply received from the 75 square miles of the Butt Creek drainage area. From the intake on Butt Creek to the head of the main drop the tunnel is lined with concrete and is of circular finished section 10 feet in diameter. The length of the tunnel from the intake to the main drop is 9,213 feet, its invert elevation at the upper end is 4,068 feet and at the lower end 4,000 feet above sea level, giving a drop of 68 feet, or 7.3 feet per thousand.

At 58 feet upstream from the lower end of the tunnel a concrete surge chamber was excavated upward to the ground surface of the mountain side. This chamber was lined with reinforced concrete and is 29 feet in inside diameter. The crest of the concrete rises to an elevation of 4,153 feet above sea level, or about 150 feet above the top of the tunnel. A tunnel spillway with an opening 15 feet wide by 5 feet deep narrowing rapidly to a width of 6 feet leaves the surge chamber at an elevation of 4,015 feet and discharges into a gully leading down to the main river.

Many changes were made in the design of the pressure line between the lower end of the main tunnel to the power house after construction was started.

The first 554 feet (on a 28° slope) from the head of the main pressure drop is circular tunnel 9 feet 8 inches in interior diameter with reinforced-concrete lining and a $\frac{3}{16}$-inch steel plate interlining. The lower end of this pressure tunnel connects through a concrete bulkhead to a 581-foot concrete-lined tunnel (on a 4° slope) that will eventually contain three 66-inch steel pipes, only two of which have been installed. At the lower end of this tunnel the two pipes emerge from the hillside and run in an open trench for a distance of 548 feet (on 24° to 48° slope), then bend down into another tunnel shaft (on a 68° slope) a distance of 463 feet, and then turn nearly horizontal, run 495 feet to the portal directly behind the power house, and continue thence 154 feet to the nozzle casting. Each 66-inch pipe is reduced to 60 inches at an elevation of 3,280 feet in the upper part of the inclined shaft, and each 60-inch pipe branches at elevation 3,231 feet into two 42-inch pipes. These run first downward through the shaft and then horizontally through the last tunnel to the power house. A stub connection for a fourth 66-inch line to be installed later was provided at the head of the main drop just below the surge chamber. This line will not be laid in the tunnels already constructed.

GENERATING STATION.

Power house.—The Caribou power house (Pl. XXXVII, *C*, p. 306) is a reinforced steel and concrete structure almost identical in general arrangement with the Big Creek power house No. 1, shown in plan and cross section by Plates LXII and LXIII, (p. 644), with the lightning-arrester room eliminated and the upper part of the power house therefore narrowed.

The total outside length of the power house when the installation is complete will be 308 feet 6 inches, and its depth 94 feet 3 inches from front to back wall of the main building, or 104 feet 3 inches to the back wall of the valve house. The present structure includes only the 178 feet of the east end of the power house, giving room for three of the ultimate installation of six units, together with sufficient auxiliary equipment. Its height from the basement-floor level to the ridge of its flat pitched roof is 120 feet 1¾ inches.

The width of the generator room is 46 feet 9 inches and its clear height 42 feet; the height from the floor to the top of the rails supporting the traveling crane is 31 feet.

The depth from front to back of the transformer bays is 17 feet, of the low-tension switch room 19 feet 6 inches, and of the valve house 8 feet 6 inches. The units now in place or to be installed in the future are arranged as in the Big Creek plant, in line near the front wall of the generator room.

Hydraulic equipment.—Each of the four 42-inch pressure lines connects in the gate house at the back wall of the power house with a 42-inch hydraulically operated gate valve arranged for remote control from the switchboard. Each line feeds but one wheel, although the units are of the double overhung type. The two lines for each unit are 14 feet 6 inches apart on centers in the gate house. Each line terminates in an 11-inch needle nozzle, designed to operate in connection with a relief valve discharging through an elbow into the tailrace. The relief valve opens as the nozzle closes and is then slowly closed in such manner as to avoid too sudden a raise in pressure in the pipe line.

The wheel (Pls. XXXVII, *D*, and XLII, *B*) on each end of the generator shaft is rated at 15,000 horsepower, is 155 inches in diameter on the center line of the jet, and carries 21 buckets, which are exceptionally large, each measuring 34⅞ inches wide by 27 inches deep. The speed of the units is exceptionally low, being 171.4 revolutions per minute. The entire hydraulic equipment—wheels, governors, by-passes, relief valves, etc.—was supplied by the Allis-Chalmers Co.

Generators.—The two generators now in place are General Electric 22,223-kilovolt-ampere 11,000-volt 3-phase 60-cycle alternators; being direct-connected to the wheels, their speed is 171.4 revolutions per minute.

Exciters.—The exciter sets are in the west end of the power house between the sites of units 3 and 4 of the final development. Each of these sets consists of a 600-kilowatt 250-volt General Electric direct-current machine, connected to an 800-horsepower impulse wheel and to a 900-horsepower induction motor. A third exciter set is eventually to be installed in the area between sets 1 and 2 and the back of the power house, but under the switchboard balcony instead of on the main generator floor.

Transformers.—Unlike the transformer equipment at Big Bend the transformers at the Caribou power house are of the single-phase type, the bank of three for each generator unit being placed in open bays directly between the unit and the back wall of the power house. The station is equipped with two banks of General Electric water-cooled single-phase 60-cycle 7,500-kilovolt-ampere transformers, and a spare for connection into either bank in case of emergency. The transformers are 11,000 volts on the low-tension side; on the high-tension side several taps give the following voltages with delta and Y connections, respectively: 63,600/110,000, 69,200/120,000, 86,700/150,000, 95,270/165,000. They are now connected for 165,000 volts on the outgoing line.

Wiring.—The wiring connections are practically the same as in the Big Creek plant. (See Pl. LXIII, p. 644.) A single-circuit steel tower line runs down the North Fork from the Caribou power house to the

Big Bend power house, and a new steel tower line parallels the original Big Bend line from that point to a point near the Brighton substation, south of Sacramento, and thence turns westward and southward across Carquinez Straits near the span of Pacific Gas & Electric Co. at Port Costa. The line terminates at Valona substation, on the south side of the straits.

BIG BEND PLANT.

LOCATION.

The Big Bend plant, on the North Fork of Feather River, 14 miles above Oroville, was put into operation by Great Western Power Co. December 22, 1908, with four 10,000-kilovolt-ampere units. In the fall of 1913 and spring of 1914 the power house was extended, and July 15, 1914, unit No. 5, of 12,500-kilovolt-ampere capacity, was added. Unit No. 6, of the same capacity as No. 5, was added March 1, 1916, bringing the installed capacity up to 65,000 kilovolt amperes. The plant has the distinction of being the largest in California.

The intake is in sec. 36, T. 22 N., R. 4 E.; the conduit traverses sec. 36, T. 22 N., R. 4 E., secs. 1, 11, 12, 14, T. 21 N., R. 4 E.; the power house is in sec. 14, T. 21 N., R. 4 E.

CONDUIT.

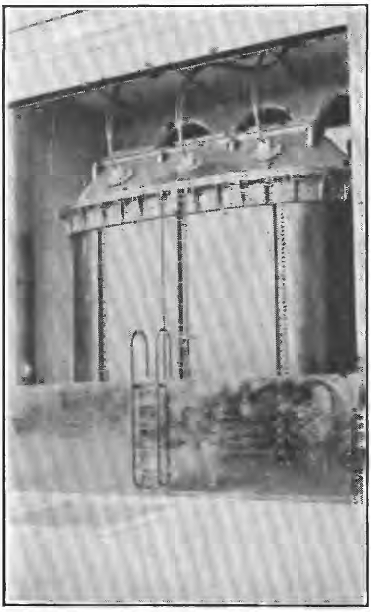
The Big Bend plant utilizes a tunnel that was constructed about 25 years ago by a mining company through the narrowest part of the neck of land in the oxbow loop that was then followed by the river, the object being to lay bare the 10 miles of river bed around the loop so that its gravels might be prospected for gold. The project was a financial failure and the tunnel was not utilized again until it was put into operation for power development by Great Western Power Co.

The intake dam of the Big Bend plant (Pl. XLIII, *C*) is an arched concrete ogee overflow dam with maximum height of 80 feet (30 feet above river bed) and crest length of 330 feet. The radius of its arched crest is 250 feet and the length of its long chord 304 feet. The crest elevation of the dam, as finally completed, is 910 feet (U. S. Geological Survey datum). According to the original plan of the system upon which the turbines of the first four units of the power house were designed, the crest level was to be at an elevation of 1,000 feet, a height that would have given 90 feet more head, as the tunnel line is operated under pressure. Some question arose as to the quality of the foundations at the dam site and it was finally decided to put in the lower structure. In July, 1912, a wood flashboard frame with steel yokes, designed to carry 12-inch boards set at an angle of 45° and raise the water level to 920 feet, was fitted to the crest of the dam. A flood in January, 1914, carried away the flashboards

A. INTAKE TOWER, BIG BEND PLANT.

B. IMPULSE WHEEL BUCKETS, CARIBOU POWER HOUSE.

Photograph by Stone & Webster, Inc.

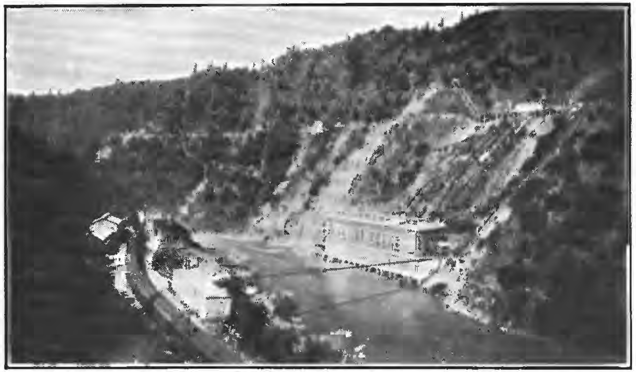


C. 10,000-KILOWATT 3-PHASE TRANSFORMER, BIG BEND PLANT.

D. GENERATOR ROOM, BIG BEND PLANT.

Photograph by the company.

HYDROELECTRIC SYSTEM OF GREAT WESTERN POWER CO. OF CALIFORNIA.



A. BIG BEND POWER HOUSE, GREAT WESTERN POWER CO. OF CALIFORNIA.

Photograph by the company.

B. MANIFOLD AT LOWER END OF TUNNEL, BIG BEND PLANT, GREAT WESTERN POWER CO. OF CALIFORNIA.

C. INTAKE DAM OF BIG BEND PLANT, GREAT WESTERN POWER CO. OF CALIFORNIA.

Photograph by the company.

D. SAN JOAQUIN POWER HOUSE NO. 2, SAN JOAQUIN LIGHT & POWER CORPORATION.

A. KERCKHOFF POWER HOUSE

Photograph by Laval Co.

B. GENERATOR ROOM, SAN JOAQUIN POWER HOUSE.

C. SAN JOAQUIN POWER HOUSE.

D. CRANE VALLEY POWER HOUSE AND CONDUIT OF PLANT NO. 3.

HYDROELECTRIC SYSTEM OF SAN JOAQUIN LIGHT & POWER CORPORATION.

and somewhat injured the framework, but this injury was soon repaired, and the flashboards have since been in constant use.

The tower (Pl. XLII, *A*) through which water is admitted to the head of the tunnel is built on bedrock foundation in the edge of the reservoir, several hundred feet upstream from the dam. The elevation of the platform top of the present tower is 950 feet. The tower is a cylindrical shaft 28 feet in inside diameter, with walls varying in thickness from about 9 feet at the bottom to 7 feet at the top. This unusual thickness is, of course, on account of the greater height to which it was originally intended to construct the tower. Twelve wing walls extend out radially from the body of the tower and in the bays between these walls, at three levels, are sets of rectangular intakes, covered by flap valves which are lifted by means of rods extending to the top of the tower. The bottom edge of the lower set of inlets is at 895 feet elevation, and that of the upper set at 917 feet. The intake apertures are inclined at about 30° from the vertical, and the flap valves covering them are hinged at the upper edge. Each aperture is 4 feet by 3 feet 3 inches. A short concrete culvert connects the base of the tower to the mouth of the tunnel. In addition to the three sets of inlets, there are four gates in the base of the tower on a level with the culvert floor and opposite its mouth. Each of the openings is 5 feet wide by 12 feet 3 inches deep and is fitted with a trash rack and sliding gate. These intakes were used when the tower was under construction and they were closed by stop logs when the higher inlets were put in service.

The original or mining tunnel discharged into the bottom of Dark Canyon, down which the water flowed into the river channel below the site of power house. The first 11,768 feet of this tunnel were utilized in the new plant by bulkheading off 250 feet at its lower end and enlarging the rest. From the bulkhead a new tunnel, 3,400 feet long, was driven, at an angle of about 30° with the lower part of the old one, to a new portal on the brow of the hill above the power site. The old tunnel was 16 feet wide and 12 feet high to its flat-arched roof. This cross section was enlarged on a horseshoe shape with net width of 13½ feet at the bottom of the side walls and 14 feet at the spring line of the roof. The roof arch is semicircular and has a radius of 7 feet. The height of the spring line of the arch is 9 feet 7½ inches from the bottom of the side walls and 10 feet 9¾ inches from the bottom of the invert floor. The net area of the tunnel is 220 square feet. The normal thickness of concrete in the roof arch was designed to be 12 inches and that of the side walls 6 inches.

Part of the new tunnel ran through soft ground which had to be timbered. The inside width of this timbered portion of the line is 16 feet; the walls are 6 feet high and perpendicular; the roof is a semicircular arch of 8 feet radius; the invert floor has a drop of 1 foot 5¼" inches at its center. The normal thickness of concrete in the roof arch is 18 inches with a minimum of 12 inches and the normal thickness on the side walls is 12 inches with a minimum of 9 inches.

In the vicinity of active springs a 2-inch pipe was run through the lining for every 100 square feet of surface, in order to relieve external water pressure.

The entire line includes 11,768 feet of old and enlarged tunnel, and 3,400 feet of new tunnel or 15,168 feet. The elevation of the floor invert at the head of the tunnel is 866 feet, and that at the lower end is 800 feet. The line, therefore, operates under a head of 44 feet at its upper and 110 feet at its lower end when water surface is even with the crest of the dam.[81]

At its lower end the tunnel discharges into a header pipe (Pl. XLIII, *B*) which is embedded in the concrete lining for 125 feet inside the portal. The header curves horizontally along the side of the hill and is continued into a surge pipe which bends sharply up the hill and ends 140 feet above the horizontal section, or at an elevation of 940 feet above sea level. Both header and surge pipe are supported at frequent intervals on concrete piers that extend down to bedrock, and at the bend where the two pipes join in a massive concrete block anchor the line is completely encased. The surge discharges into a short concrete chute that turns the water into a side gully below the power house.

The total curve in the header at the end of the tunnel is 46° 30′ on a radius of 69 feet. From the end of the curve the line runs on a tangent to the beginning of the surge pipe, 112.5 feet. The total length on the curve is 56 feet along the center line of the pipe. Its inside diameter for this length and for the first 25 feet on the tangent is 16 feet 9 inches. Then comes a 3-foot taper joint, followed by 24 feet of pipe 14 feet 11 inches in inside diameter. At the end of this section there is a 7-foot taper joint to 24 feet of 12.5-foot pipe, and then a 5-foot taper to 24 feet of 9-foot pipe which runs to the surge pipe. The surge pipe is 9 feet in diameter and 302 feet long.

The thickness of plate used in construction of the header is as follows: 1 inch in the 16-foot 9-inch pipe, seven-eighths inch in the 14-foot 11-inch pipe, three-fourths inch in the 12-foot 6-inch pipe, and one-half inch in the 9-foot pipe. The longitudinal seams are triple riveted and the transverse seams double riveted. Both have double butt-strap joints. The entire header pipe is reinforced with hoops which are made from 6 by 3½ by one-half inch angles and are spaced 6 feet on centers. Two manholes and two 12-inch gate valves are provided in the header.

The connections between the header and the pressure pipes are made through cast-steel flanged nipples. The leads for the first two

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[81] These figures are increased to 54 feet and 120 feet, respectively, when the flashboards are in place.

pressure pipes are taken off from the straight section of the 16-foot 9-inch pipe, and the third and fourth from the 14-foot 11-inch pipe. At these connections the pipe is further reinforced by an inner plate. The connection to the exciter pipe is made through a nipple fastened to the taper at the lower end of the 14-foot 11-inch section. The nipples for the fifth and sixth pipes are fastened to the 12-foot 6-inch and those to be used for the seventh and eighth units (not yet installed) to the 9-foot section; the ends of these last two nipples are capped until needed. In each pressure line, just after leaving the header, there is a butterfly valve, a gate valve, and an air valve, all of which are sheltered by a valve house. The gate valve in the first four pressure pipes are operated by an electric motor under remote-control from the generator floor at the power house. Hydraulic instead of electric motor control was adopted for the gate valves of the fifth and sixth pressure lines. Water pressure for operating these gates is furnished by gravity from a tank high up on the hillside above the header; water is raised to the tank by a motor-driven pump.

Beyond the valves the lines turn abruptly down the hill to the power house. At the end of the first length of pipe there is an expansion joint in each line. The four lines serving the four original units are of a uniform inside diameter of 5 feet for their entire length, which averages about 600 feet each; the minimum thickness of material is 10 millimeters and the maximum thickness 17 millimeters; the pipe, which is of the lap-welded type, was shipped in sections about 16½ feet long, by its German manufacturers. The ends of the sections in the four lines are joined by expanded riveted seams, so that the rivet heads do not contract the stream in the pipe. The pipes are supported on concrete piers about 30 feet apart, which are founded on bedrock. Flow through the lines is controlled entirely by the gates at their heads except for the assistance furnished by the by-pass valves and wicket gates at the turbines. Provision is made for draining the lines through a 12-inch by-pass running from the main pipe above the turbine to the draft tube. All the lines are uncovered throughout their length. At the bend in the lines at the back wall of the power house they are embedded in a very large concrete-block anchorage.

The No. 5 pipe line is of the same type as the first four lines installed, but as the unit is larger than units 1 to 4, it was necessary to make the inside diameter 6 instead of 5 feet. The line is about 600 feet long and varies from 12 to 21 millimeters in plate thickness. Flow from the header into the No. 5 pipe line is controlled by a butterfly gate and a 60-inch gate valve, around both of which there is a 16-inch by-pass. Immediately below the gate valve the line bends down the hill and just below the bend there is an expansion joint.

No. 6 pipe line, completed during 1916, is of riveted instead of lap-welded pipe, is about 600 feet long, and of a uniform diameter of 72 inches. The upper section is of lap-riveted and the lower of butt-strap pipe. In the lap-riveted section, the thickness of plate varies from three-eighths to five-eighths inch and in the butt-strap from five-eighths to seven-eighths inch. There are three manholes in the bottom of the pipe and two air valves and one manhole in the top of the pipe.

The pipe serving the No. 1 and No. 3 exciter sets, which were put in when the first part of the power house was constructed, is lap-welded pipe 2 feet in diameter. Exciter No. 2 is supplied from a 24-inch cross connection taken off from pipe lines Nos. 5 and 6 at an elevation of 501 feet. There is a gate valve in the cross connection on each side of its junction with the 24-inch line of the exciter, so that the supply from either or both of the main pipes may be shut off.

The static head at the plant, computed from the crest of the diversion dam, is 44 feet at upper end of tunnel on invert, 110 feet at lower end of tunnel on invert, 414 feet to high-water level at power house, and 455 feet to low-water level at power house.

This head is increased at times of flood by about 20 feet, the depth of water coming over the crest of the diversion dam, and at low water 10 feet by flashboards.

GENERATING STATION.

Power house.—The Big Bend power house (Pl. XLIII, *A*) is on the north bank of Feather River opposite the Western Pacific Railroad, from which it is reached by a suspension footbridge.

Material and machinery for the power house are taken across the river by a cableway 1,200 feet in span, strung between two A frames. The base of the north cableway tower, above the power house, is at an elevation of 860 feet, its height is 45 feet and its top elevation is 905 feet above sea level. The south tower, though itself higher, is at an elevation considerably lower. Its base is at 645 feet above sea level and its height is 60 feet, giving its top an elevation of 705 feet. Over the towers are suspended two 2¼-inch cables. Ten tons can be carried across and up to the header, and 35 tons as far as the power house. The line passes directly over a large hatchway in the power-house roof, through which machinery can be lowered to the main generator floor.

The building has a steel frame and reinforced concrete walls. The foundations are of concrete and rest on bedrock. The roof is nearly flat, and a large Louvre ventilator extends along its center the full length of the building. The roof frame is of steel, and carries a concrete slab covering on steel I-beam purlins. The crest of the roof rises to a height 112 feet above extreme low-water level. The size of the structure and its excellent design give it a very imposing appearance.

Big Bend power house was designed to contain eight units. The original part of the building, completed in 1908, was the east end and afforded room for four units and two exciters. In the fall of 1913 and spring of 1914 the foundations for the full development were completed, and the power house above the foundations was extended far enough westward to accommodate the fifth and sixth units. The part of the building completed in 1908 is 183 feet 6 inches long by 74 feet 6 inches deep; the addition completed in 1914 is 69 feet 6 inches long by 92 feet 6 inches deep, giving the part of the power house already completed a length of 253 feet and a depth which varies from 74 feet 6 inches in the older part of the building to 92 feet 6 inches in the newer part. The exterior view of the power house (Pl. XLIII, *A*) shows foundations for units 7 and 8 at the left end of the building; in the picture the junction of the old and new parts of the building are shown by the variation of color in the concrete.

The generator room is 32 feet 6 inches wide and extends the full length of the front of the building. Its general arrangement is shown in Plate XLII, *D*. All the main units are of the vertical type and are arranged in a row along the front of the generator room with centers 11 feet 6½ inches from the front wall. The floor level in the generator room is at an elevation of 506 feet, and below it are two basement floors. The middle floor accommodates the lower bearings and is at an elevation of 494 feet in the older part and 491 feet in the newer part of the building. The lower floor—the turbine floor—is at an elevation of 481.5 feet in the older and 477.25 feet in the newer part of the power house. The turbine centers of units 1 to 4 are at an elevation of 477.5 feet and those of units 5 and 6 at an elevation of 473 feet. The turbine casings and the lower end of the penstocks in the older part of the building are set in the massive concrete of the power-house foundations, but in the newer part of the power house a pit running down to elevation 465.25 gives access to the lower end of the penstock, upper end of the draft tube, and lower side of the turbine casings, which are supported by a heavy concrete setting.

The back half of the building above the level of the generator floor contains the transformers and switching equipment. The transformers are of the 3-phase type and are in open bays facing out into the generator room. Directly above them is the low-tension switching gallery and apparatus, and back of them and of this low-tension gallery is the high-tension switching gallery. In the older part of the building the floor elevation of this high-tension gallery is the same as that of the generators and transformers; in the newer portion the floor of the high-tension gallery is 11 feet above the generator floor. The low-tension gallery is at an elevation of 529.5 feet throughout the power house.

The track for the 50-ton traveling crane runs along bracket supports on the steel columns down each side of the generator room, and is 37 feet 6 inches above the floor.

The first four pressure pipes enter the back of the building well below the generator room floor and curve gently to a horizontal just back of the turbines. The fifth and sixth pipes enter slightly above the generator level and then follow the same general course. The draft tubes run vertically down from the turbines and then turn gradually out to discharge into the pool in the river at the face of the power-house foundations.

Hydraulic equipment.—The turbines are I. P. Morris 60-inch Francis vertical inward-flow machines, designed to be operated at a speed of 400 revolutions per minute. The first four were designed to operate under a head of 525 feet, but by putting in an intake dam that is 90 feet lower than that originally planned, this head was reduced to a maximum of 455 feet (without flashboards). The extreme draft from the center of the first four turbines to low water is 22½ feet. These machines are rated at 18,000 horsepower under the head for which they were designed and have turned out a maximum of 14,500 horsepower under test at a head of 435 feet. They are provided with bronze runners and cast-steel guide vanes and volute casings. Relief valves were not originally provided but were added after the plant was put into operation. The rotating shaft, carrying turbine runner and generator field, revolves on an oil disk thrust bearing. Each of these bearings has to support a total revolving weight of 145,000 pounds, of which 119,500 pounds is in the generator rotor, and 25,500 pounds in the runner and shaft. Oil is supplied to the bearing at 250 pounds pressure per square inch by a horizontal triple pump which is driven from the turbine shaft. A pump of the same type, but driven by a motor, is held in reserve. There are three guide bearings on each shaft, one above the generator, the second below it, and the third in the head of the turbine.

The I. P. Morris 60-inch Francis turbines of units Nos. 5 and 6 were designed to deliver a maximum of 18,500 horsepower when operated at 400 revolutions per minute under the heads now utilized at the plant. The general arrangement of each is very similar to that of the first four units. The main vertical shaft of the unit, however, instead of being supported by an oil-pressure thrust bearing is carried on a combined oil-pressure and roller bearing at the top of the generator, which is supplemented by a guide bearing between the generator and turbine. The weight of the revolving element—main shaft and generator and turbine rotors—is 83 tons.

Generators.—The first four generators (Pl. XLII, *D*) are General Electric ATB form V 3-phase 60-cycle 10,000-kilovolt-ampere machines, operating at 400 revolutions per minute, which deliver normally 525 amperes at 11,000 volts but have an overload capacity of 25 per cent. The lower part of each revolving-field structure is provided with a heavy band or ring to which a powerful hydraulic brake may be applied to hold the rotor against leakage through the turbine gates. The General Electric Co.'s shop tests of the generators showed a full-load efficiency of 97.1 per cent, three-fourths load, 96.4 per cent, and one-half load, 95 per cent. For the first few years of their operation generators Nos. 1 to 4 were not provided with forced ventilation, but all the units in the plant are now equipped with casings and air is forced up from the base of the units and discharged through air shafts extending through the front wall of the power house on a level with the top of the generators.

Oil pressure for the governors of the main units is furnished by a central governor oil-pressure system.

Generators Nos. 5 and 6 are General Electric ATB 18-pole 3-phase 60-cycle machines, with maximum ratings (each) of 12,500-kilovolt-amperes, 11,500 volts, 627 amperes, operated at 400 revolutions per minute.

Exciters.—The two exciters installed when the power house was first built, and designated Nos. 1 and 3, are General Electric 250-kilowatt type MP 6-pole 250-volt 1,000-ampere direct-current generators, each of which is driven at 500 revolutions per minute by an I. P. Morris impulse wheel mounted on the same shaft. Exciter No. 2, installed at the same time as main unit No. 5, is a General Electric MPC 250-volt 2,000-ampere 500-kilowatt direct-current generator, operated at 900 revolutions per minute by a Pelton Francis turbine.

Transformers.—Contrary to the ordinary rule in California plants, the transformers (Pl. XLII, *C*) at Big Bend are of the 3-phase type; that is, the three phases are all contained within one case. They are of General Electric make and have a ratio of 11,000 to 100,000. The capacity of each transformer is 10,000 kilovolt-amperes, and they are designed for 50 per cent overload for two hours. The connection is delta on both low and high tension sides. As originally installed the entire front of each transformer bay was open. A short time after the plant began operation one of the transformer casings burst and spilled its oil over the floor of the generator room. A riveted-steel apron was then put across the front of each bay to such a height that the bay will hold all the oil of the casing if similar accident should occur.

The transformers for units Nos. 5 and 6, like those for Nos. 1 to 4, are of the 3-phase type, and have a ratio of 11,000 to 100,000 volts, with delta connections, and a rated capacity of 10,000 kilovolt-amperes.

Wiring.—The motor-operated rheostat, governor motors, and main circuits are controlled from a switch gallery equipped with a main switchboard of the benchboard type. The gallery projects from the central part of the back wall of the generator room and is 23 feet 6 inches above the generator floor. Beneath the gallery on the main floor and against the back wall of the generator room is an auxiliary board which controls the station circuits, auxiliary motors, and such penstock gate valves as are electrically operated.

The leads from each of the original units were carried through 11,000-volt oil switches, either to the transformer direct or to the 11,000-volt bus, which in turn was connected through similar switches to the transformer. The transformer was connected to either north or south high-tension bus through vertical pneumatically operated 100,000-volt oil switches, which were among the first of their type put on the market. In the newer part of the power house the oil-switching equipment is of the present standard types.

The wiring layouts for units Nos. 5 and 6 are similar. Each unit can be connected through oil switches and disconnecting switches either directly to the low-tension side of its transformer or to the 11,000-volt bus. The high-tension side of the transformer can be connected through oil switches and disconnecting switches to either the north or south 100,000-volt busses. Either the north or the south high-tension bus can be connected to the No. 1 line, outside of the building, through oil and disconnecting switches; the north bus can be connected to the No. 2 line outside of the building or to the south bus connected to the high-tension bus of the older part of the plant through oil and disconnecting switches. The low-tension oil switches are General Electric, type H–3, and the high-tension oil switches are General Electric type F form K–15 100,000-volt 100-ampere. A spare transformer is installed in the extreme west end of the power house for use in emergency, although in the older part of the power house no such precaution was taken.

When the power house was first put into operation it was equipped with aluminum lightning arresters, which were mounted on the roof. The arresters proved unsatisfactory and after considerable trouble with them they were discarded. The station has since operated without protective equipment.

STEAM-ELECTRIC PLANTS.

NORTH BEACH STEAM PLANT.

History.—The North Beach steam plant on the corner of Beach and Mason streets, San Francisco, was put into operation in October, 1907, by City Electric Co. When control of that company was purchased by Great Western Power Co., it was decided to connect the City Electric system to the hydroelectric lines through a cable laid from

Oakland to the Folsom Street substation in San Francisco. This cable, the first of its kind laid under San Francisco Bay, was completed January 23, 1912, and began delivering power in San Francisco on January 29, since which time the North Beach steam plant has served chiefly as a steam reserve and as an aid to regulation of voltage in the San Francisco district.

Two 2,500-kilovolt-ampere units at North Beach went into commission in October, 1907, a 6,000-kilovolt-ampere unit was added in September, 1908, and a 10,000-kilovolt-ampere unit was added February 14, 1910. In 1916–17 the first two units were removed from the North Beach station and installed in a new plant on Bush Street.[82]

Buildings.—The power house is built of reinforced concrete and roofed with concrete slabs supported on reinforced beams and is 137½ feet square. A single cross-wall divides it into two parts—a boiler room and a generator room. The generator room is 46 by 137½ feet; the boiler room occupies the rest of the space. There is no basement under the boiler room, but the generator floor is raised slightly above the floor level of the rest of the plant, and a shallow excavation under the room forms a basement.

The switchboard runs along the east side of the generator room and is raised on a compartment containing the switch cells, so that the switchboard floor is 12 feet above the main floor of the room. The 6,000-kilovolt-ampere unit is directly opposite the switchboard, and the 10,000-kilovolt-ampere unit is in the east end of the building. The entire generator floor is commanded by an electric traveling crane, which moves on rails laid on the shoulders of the concrete columns of the side walls.

The boilers are arranged in the boiler room at right angles to the main axis of the generator room.

Mechanical equipment.—The 12 Babcock & Wilcox water-tube boilers are arranged in three rows of four each. Six boilers are of 600 and six of 700 horsepower rating. The tubes of both sizes of boiler are 4 inches in diameter and 18 feet long, and each boiler has three 42-inch drums of half-inch plating, 22 feet three-eighths inch long, tested for 200 pounds steam pressure. The 600-horsepower boilers have 294 tubes arranged 21 wide and 14 high, and the 700 horsepower boilers 336 tubes, 24 wide and 14 high. Between the backs of the two central rows of boilers there is an alleyway about 6 feet wide, and the rows are divided at the center by a transverse passage about 4 feet wide.

Feed water is obtained from a deep well and from the city mains and is served to the boilers by a 16 by 25 inch and 12 by 24 inch Worthing-

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[82] The Bush Street station, which was ready for operation early in 1917, generates power only when supplying steam to office buildings in the neighboring business districts.

ton pump, and by a 4-stage centrifugal pump, operated by a Kerr steam turbine which is rated at 150 brake horsepower at 750 revolutions per minute. The combined capacity of the feed pumps is 1,500 gallons per minute. The feed-water heaters, of which there are two, are of the Cochrane type.

The two condensers are of the Wheeler surface type. The smaller condenser has 18,000 square feet of cooling surface, and the larger 25,000 square feet. The circulating water supply is taken in from San Francisco Bay through a 42-inch iron main which opens into the bay below tide level and runs down grade toward the plant.

The smaller condenser is supplied from the main by a 3-stage Worthington centrifugal pump, with 30-inch intake and 24-inch discharge, which is operated by a 300-horsepower Kerr steam turbine, at 1,200 revolutions per minute. This equipment replaces a centrifugal pump which was operated by a reciprocating engine. Its capacity is 260 gallons per minute.

The supply for the larger condenser is also handled by a centrifugal pump, with 36-inch suction and 30-inch discharge, which can deliver 400 gallons per minute. This is driven by a Harrisburg 15 by 17 inch side-crank engine, designed to operate at from 175 to 250 revolutions per minute. The engine and pump are direct-connected. The Wheeler 12 by 30 by 18 inch dry vacuum pump for the same unit is directly behind the circulating pump and engine. Exhaust from all of the auxiliaries is used in feed-water and fuel heaters.

In the fuel-oil heaters steam is utilized over 300 square feet, and the resulting temperature of the oil when it is received by the burners, is approximately 175°. The oil supply comes from two tanks—one of 10,000 and the other of 30,000 gallons capacity—at some little distance from the plant. It is delivered to the burners through a separator, by pumps which are regulated automatically by the steam pressure in the boilers. The firing is from the front toward the back of the furnace and the burners are of the Hammel type.

Electrical equipment.—The smaller or 6,000-kilovolt-ampere unit has a two-hour overload rating of 7,500 kilovolt-amperes, is of the Westinghouse-Parsons type, and operates at 175 pounds steam pressure with 45° superheat.

The larger unit has a normal rating of 10,000 kilovolt-amperes and a two-hour overload capacity of 15,000 kilovolt-amperes. Its speed is 1,800 revolutions per minute, and the turbine operates at 175 pounds with 50° superheat. Both the turbines are designed for 28-inch vacuum. Both generators are 4-pole 3-phase 60-cycle 11,000-volt machines connected Y grounded. Two exciters are installed, one a General Electric CC form T 800-ampere 125-volt 100-kilowatt generator run at 2,400 revolutions per minute, by a Curtis turbine, which receives steam at 175 pounds pressure and operates noncondensing. The other is a motor generator set made up of a Westinghouse CCL 2-phase 240-volt induction motor, with 100-horsepower capacity and a speed of 690 revolutions per minute, direct connected to a 125-volt 600-ampere 75-kilowatt continuous-current generator. In addition to these sets, the end of the main shaft of the large unit carries a direct-connected 600-ampere 125-volt 75-kilowatt interpole exciter.

BUSH STREET STEAM PLANT.

Location.—Bush Street power house, on the north side of Bush Street between Grant Avenue and Stockton Street, San Francisco, is not only a steam-electric generating station but also a central station for steam heating and a substation. It was constructed by Great Western Power Co. The station began delivering high-pressure steam for heating December 7, 1916, but did not generate electric energy until November 8, 1917.

Building.—The power house is a three-story reinforced-concrete building, with steel frame. The boilers and generators occupy the basement, the voltage regulators on the substation circuits occupy the second, and the more important substation equipment the third or top floor. The floor level of the boiler room is 94.5 feet above sea level, the regulator room, or second floor, is 113.5 feet, and the substation, or third floor, 131 feet. The building is 68 feet 6 inches wide and 137 feet deep, except the basement, which extends under the sidewalk and is therefore 152 feet long. Owing to the steep grade on Bush Street in front of the plant the height of the front wall of the building is 52 feet 6 inches at the west side and 63 feet 6 inches at the east side. This grade in the street brings the sidewalk level up to an entry on the second or mezzanine floor at the west side of the plant. Back of the vestibule the feeder regulator room extends the full depth of the power house but is only 15 feet wide. The generator and boiler room occupies the rest of the space and extends the full height from basement to third or substation floor. The single room housing the substation extends the full width and depth of the third floor, over both generating station and regulating room. The following description is confined entirely to the generating station.

Boilers for the completed plant will be installed in two rows facing toward a central longitudinal aisle, 8 feet 6 inches wide, running down the center of the basement. Six boilers, or about one-half of the ultimate equipment, are now (1921) installed and occupy a space 88 feet long by 21 feet wide on the west side of the room. Four more boilers can be accommodated in a reserved space, 64 feet long by 21 feet wide, on the east side of the room, and the space that will remain between them and the generators is now occupied by feed pumps and exciters, the feed-water heaters being raised above this auxiliary equipment on a steel frame. Between the exciters and boilers and the front wall of the building the turbines are installed on a steel platform 32 feet 6 inches long and 24 feet wide, which raises the turbine bases 8 feet 11 inches and the gangway surrounding them 10 feet 10 inches above the basement floor. The turbo-generators are arranged on this deck with their main shafts parallel to the front of the power house, and the connections and the steam main which conveys the exhaust of the turbines to the heating system serving the adjoining business and apartment-house district occupy a large part of the space under the deck. What remains is occupied by auxiliary apparatus and by a dressing room for the employees.

Mechanical equipment.—Two Stirling water-tube boilers of 275 and four of 350 horsepower, or a total of 1,950 horsepower, are now installed. Two Worthington 4 C. L. multistage centrifugal pumps operated by Westinghouse steam turbines, two Blake 12 by 7 by 18 inch vertical reciprocating pumps, and two Worthington 8 by 5 by 12 inch pumps of the same type are installed to deliver feed water from the mains of the Spring Valley Water Co. The plant is operated noncondensing, since the exhaust steam is used for heating. Oil is supplied to the burners from tanks under the sidewalk by two 4 by 2¾ by 4 inch Worthington duplex oil pumps set under the turbine deck. Both the quantity of oil supplied to the burners and the draft in the furnaces are controlled automatically. Feed water is heated by two Elliott open heaters of 2,500 horsepower rating each.

Electrical equipment.—The two turbo-generators now in the Bush Street station were originally installed in the North Beach plant of City Electric Co. They are Westinghouse-Parsons 11,000-volt 131-ampere 2,500-kilovolt-ampere 3-phase 60-cycle machines, operated at 1,200 revolutions per minute.

Exciting current is supplied by two Westinghouse 125-volt 400-ampere 50-kilowatt direct-current turbo-generators, operated at 2,250 revolutions per minute.

The Bush Street station was designed primarily as a central heating establishment, from which electric energy developed incidentally could be delivered to the neighboring distributing system at the generator potential of 11,000 volts.

PHELAN STEAM PLANT.

Location.—The Phelan steam plant, so called from its location in the basement of the Phelan Building, Market and O'Farrell streets, San Francisco, was put into operation by United Light & Power Co. in 1909 and was acquired by the Great Western Power system June 1, 1915, through Consolidated Electric Co. but was not operated by the system until October.

Generator room.—The entire generating and boiler equipment is installed in the basement and subbasement, and the station not only furnishes a small amount of electric current to the building and city distribution but delivers exhaust steam for heating buildings through an underground system of steam conduits.

The boilers, pumps, and auxiliary equipment are installed on the concrete floor of the subbasement. The turbo-generators are raised on a steel deck. The turbine platform is commanded by a traveling crane.

Mechanical equipment.—Steam for operation of the plant and subsequent distribution through the duct system is supplied by two 230, two 390, and one 320 horsepower (a total of 1,560) Stirling water-tube boilers, fired with oil supplied from a storage tank under the sidewalk by two Worthington duplex pumps. Boiler-feed water is delivered by two Blake 12 by 7 by 18 inch vertical feed pumps, above which the feed-water heater is mounted on a steel frame.

Electrical equipment.—The two main units are Westinghouse-Parsons 2,400-volt 156-ampere 750-kilovolt-ampere 3-phase 60-cycle turbo-generators operating at a speed of 3,600 revolutions per minute. Exciting current is furnished by a Westinghouse 125-volt 200-ampere 25-kilowatt continuous-current turbo-generators operated at 3,500 revolutions per minute, on the turbine deck beside the main unit.

Aside from the generating equipment the station also contains two 300-kilowatt and one 30-kilowatt direct-current motor-generator sets and other substation equipment.

OAKLAND STEAM PLANT.

Location.—The Oakland steam-reserve plant of the Great Western Power system is on the shores of the estuary in Oakland, was constructed by California Electric Generating Co., and was put into operation November 27, 1909.

Building.—The equipment is housed in a single building, which is 155 feet long by 134 feet wide and is divided by a longitudinal wall into a boiler house 60.25 feet and generator room 73.33 feet wide. The boiler house is covered by a lean-to and the generator room by a peaked roof. Both roofs are of concrete-slab construction and are carried on steel trusses with extremely flat slopes. A Louvre ventilator extends along the peak of the generator room the full length of the building. The height of the boiler room is only 32 feet from the main floor to the lower chord of the roof trusses, but that of the generator room is 50 feet. The building rests on monolithic concrete foundations laid on 3,184 piles. The main framework of the building is of steel, and between its members there is a lighter frame to support the double plastered metal-lath walls.

The boilers are placed in a single row with their backs toward the division wall but are separated from it by enough space to accommodate the bases of the two steel stacks, between which there is also certain auxiliary apparatus.

The three horizontal turbines are on the second-floor level of the generator room and are placed close to the side of the wall dividing it from the boiler room. The shafts of the three units are parallel to each other and at right angles to the main axis of the room. The second story is completely floored except for a large well, 30 by 28 feet, between the first and second turbines, and a still larger one, 38 by 58 feet, between the third turbine and the end of the building. On the same floor with and just opposite the turbines are the switch cells, the motor-generator exciter, and two auxiliary panels with the small transformers that serve the apparatus. In the part of this second floor, along the opposite side of the plant from the boiler house and at the side of the large well, is the main switchboard. The second floor (and the part of the ground floor in the open wells) is commanded throughout by a 30-ton motor-operated traveling crane.

Most of the auxiliaries, such as turbo-exciters, pumps, and feed-water heaters, are on the ground floor in the two wells. The condensers are carried in the arched foundations of the main units. The space along the north side of the plant under the main switchboard and switch cells is walled off by a continuous transverse wall through which doors open from the generator room into store rooms, and the superintendent's office. From the store rooms access may be had by means of stairways to the bus bar compartments on a mezzanine floor.

The intake and discharge tunnels for the condenser cooling supply run from a concrete intake on the shores of the estuary directly to and under the plant, one line passing under the condensers of the main units. The tunnels are 4 feet wide by 10 feet high. Oil is piped to the plant from a 10,000-gallon tank, which is located near the intake and is supplied from barges.

Along the north side of the buildings outside and opposite the bus bar cells, is a steel frame which supports the circuits from the plant and connections to the outgoing lines.

Mechanical equipment.—The plant is equipped with six 600-horsepower Babcock & Wilcox vertical-header water-tube boilers, arranged in three banks of two; each boiler contains 294 4-inch tubes 18 feet long (arranged 21 rows wide and 14 high) and three 42-inch drums 21 feet ½ inch long and nine-sixteenths of an inch thick, is built to stand 225 pounds steam pressure, and is fired from the back toward the front by four Champion oil burners. Each furnace has 6,000 square feet of heating surface, and the steam is superheated to 125° by a Babcock & Wilcox superheater.

The two self-supporting steel stacks extend to a height of 150 feet above the main floor of the plant and are 9 feet 6 inches in inside diameter. The smoke flues from the boilers to the bases of the stacks are steel and are provided with sliding dampers. The firing apparatus is served by two Worthington 7½ by 5 by 6 inch duplex pumps set on the main floor opposite the center of the row of boilers.

The three condensers are of the Alberger counter-current surface type, with 8,000 square feet of cooling area each. Each condenser has its own 16-inch centrifugal circulating pump, which is driven by an Alberger 9 by 10 inch vertical engine and delivers 6,800 gallons per minute. The condensers are in the arched foundations under the turbines and are raised several feet above the main floor of the plant. The three circulating pumps are placed alongside of the foundations of their respective units and close to the condensers. On the main floor alongside the turbine foundations and directly in front of the circulating pumps are three Alberger rotative dry-vacuum pumps 10 by 22 by 13 inches. One of them is in the well beside generator No. 3, and two are in the smaller well between generators Nos. 1 and 2. A 3-inch centrifugal wet-vacuum pump, driven at 2,000 revolutions per minute by a Kerr steam turbine, is set on the main floor between the foundation of each unit and the boiler-room wall. A small duplex priming pump for the condenser is set on the main floor beside the base of each turbine.

The boilers are fed by four Eppinger-Carpenter 14 by 8½ by 16 inch duplex "outside-end-packed" pumps having a total capacity of 1,000 gallons a minute. Two of the pumps are on the main floor near unit No. 3 and two on the main floor between the foundations of units Nos. 1 and 2. Between the two feed pumps of each pair there is a vertical cast-iron feed-water heater provided with 1,600 square feet of heating surface of ¾-inch brass tubing, so arranged that the water passes twice through the heater before going to the boilers. The steam supply for the heater comes from the exhausts of auxiliaries, all of which are operated noncondensing.

Under the arch between the foundations of the second and third units there is a Turner 6 by 4 by 3 foot oil filter, operated in connection with two 4½ by 3¾ by 4 inch Worthington oil-supply pumps.

Between the bases of the stacks, in the boiler room, there are two air compressors; one is a Sullivan 10 by 12 inch machine, belt-driven by General Electric 60-horsepower induction motor; the other is a Hendy Manufacturing Co. (Gardiner) 10 by 12 inch machine driven through flexible chain by a General Electric 60-horsepower 440-volt induction motor. These two compressors feed through branches into a common main to a receiver placed against the back wall between them.

Electrical equipment.—The three main generating units are General Electric ATB 6-pole form HT 3,500-kilovolt-ampere 184-ampere 11,000-volt 3-phase 60-cycle alternators, driven at 1,200 revolutions per minute, operated condensing by five-stage horizontal form J Curtis turbines under steam pressure of 205 pounds, superheated to 125°. A Sturtevant blower on the generator end of the main shaft forces air down through a duct into the base of the generator and out through its armature coils.

Excitation is furnished by a General Electric MPC 6-pole interpole 75-kilowatt form L 600-ampere 125-volt continuous-current generator mounted on the same bed with a General Electric type I 6-pole form K 3-phase 60-cycle 120-ampere 440-volt induction motor, operating at 1,200 revolutions per minute, and by two General Electric CC 4-pole 75-kilowatt form T 600-ampere 125-volt continuous-current turbo-generators, run by Curtis horizontal 75-kilowatt form C turbines operating at 2,400 revolutions per minute, noncondensing, under 205 pounds steam pressure. The motor generator is on the second or turbine floor between the switchboard and the switch cells and almost opposite the end of No. 3 unit; the turbogenerator exciters are on the main floor, one near the base of unit No. 3, and the other between units Nos. 1 and 2.

The plant is equipped with a General Electric "benchboard" switchboard, containing six panels. Panel 1 controls the three exciters and the station power; panel 2 controls generator No. 1 and Bay cables Nos. 1 and 2; panel 3 controls generator No. 2 and the Third Street and Fifth Avenue feeders to Oakland; panel 4 is a sectionizer; and panel 5 controls generator No. 3. Panel 6 is blank.

The seven General Electric type F form H3 300-ampere 15,000-volt switches are of the solenoid-operated remote-control design. The three phases of each circuit are mounted in a single reinforced-concrete structure containing three cells, though one group of six cells is accommodated in one box.

Near the sixth switch cell is an auxiliary switchboard of two panels. The first panel, which controls the motor-generator exciter, centrifugal pump, crane, and air-compressor circuits, is supplied from a General Electric type HT form RP 3-phase 50-cycle 110-kilowatt 11,000 Y/460–230 transformer; the second panel controls the station lighting and receives its power through a General Electric type H 3-phase 60-cycle form G 11,000/110–220–25,000-volt transformer and a General Electric type H 3-phase 60-cycle form G 11,000–9,900/120–240–480-volt transformer.

The leads from the generators are carried to the bus compartments under the oil switch cells through ducts laid in the concrete floor.

From the bus, connection is made to the oil switches above through disconnecting switches. The leads from the oil switches are carried through ducts in the floor and up between the plastered walls of the building to brackets and thence through wall-bushing outlets just under the crane runway. The field rheostats are mounted on brackets in the same compartment which contains the disconnecting switches, just under the main oil switch cells. They, as well as the oil switches, are operated by remote control from the bench board. The leads are carried from the board to this apparatus through recesses in the lower side of the floor, in which they are held by metal strip covers. The plant connects with the 11,000-volt system, and therefore does not step up the generator voltage.

YERBA BUENA STEAM PLANT.[82a]

Location.—Yerba Buena steam plant in Oakland, on the east shore of San Francisco Bay, near the "Key Route" pier, was constructed by San Francisco-Oakland Terminal Railway to furnish power for the electric railways in Oakland and vicinity. The plant was leased in 1915 by Great Western Power Co. at the same time that it acquired the properties of Consolidated Electric Co. and its subsidiaries. Motor-generator equipment, supplied from the general transmission system of Great Western Power Co. was installed after the plant was leased, and the steam equipment has since been operated only at irregular intervals, in times of emergency or extremely low water.

Building.—The entire equipment is housed in a single building with steel frame and corrugated galvanized covering and roof. The building is 212 feet long north and south by 123 feet deep from east to west, with an ell 124 feet long north and south by 65 feet deep, putting out from the southern end of the eastern side of the main structure. The station is therefore 123 feet deep at its north and 188 feet deep at its south end. An L-shaped boiler and engine room occupies the entire west and south fronts of the station, being 210 feet long on the west side by 84½ feet deep, with an eastward extension 100 feet deep by 107½ feet long at the southern part of its east side.

A storage-battery room 90 feet long north and south by 34½ feet wide east and west occupies the northeast corner of the station, and a storage room and office space measuring 13 feet north and south by 49 feet east and west occupies the north side of the ell with substation equipment arranged in front of it in the part of the ell not occupied by engines and boilers.

Mechanical equipment.—Fourteen water-tube boilers arranged in seven banks and facing out into the generator room occupy the entire west wall of the station, and three banks, of which only two

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[82a] The Great Western system has now (1921) relinquished the operation of this station.

have been installed, were designed to occupy the space along the east wall of the ell. Passages 2 feet 6 inches in the clear were left between banks at the west side of the station and passages 4 feet 6 inches wide between banks at the east side. The western boilers are served by a single reinforced-concrete stack 10 feet in diameter 80 feet high, and the eastern boiler equipment by a single self-supporting steel stack 10 feet in diameter 120 feet high. All the boilers are equipped with Hammel oil-burning furnaces.

Four of the five main units constituting the original equipment of the plant were arranged in a row with shafts in line in front of the boilers down the west side of the station. The fifth unit is located in front of the fourth in the base of the ell with its shaft parallel to the south wall of the building. Unit No. 1 in the north end has been removed. All the others are still in place and are operated by cross-compound Corliss engines, operated condensing with condenser equipment placed in pits in the basement.

The cooling supply for the condensers is drawn from and discharged into San Francisco Bay. Boiler feed water is supplied from the city mains to the 14 boilers on the west side of the plant by 3 Snow duplex 8 by 5 by 10 inch feed pumps placed between the third and fourth banks of boilers near the center of the station. The boilers on the east side of the plant are supplied by 2 Wheeler duplex 12 by 7¼ by 12 inch feed pumps located near the base of the stack at the northeast corner of the ell. Oil is supplied from two 35,000-gallon oil tanks on the premises by duplicate equipment of duplex pumps on each side of the power house.

Electrical equipment.—All of the main units are continuous-current railway generators, unit No. 2 being a Westinghouse 600-kilowatt 550-volt 1,091-ampere generator, operated at 100 revolutions per minute; Nos. 3 and 4 are General Electric type MP 1,600-kilowatt 575-volt machines, operated at 75 revolutions per minute; generator No. 5 is a General Electric type MP 2,700-kilowatt 575-volt 4,700-ampere generator also operating at 75 revolutions per minute; giving a total installed capacity of 6,500 kilowatts or 8,710 horsepower for the entire station.

Since the installation of the motor generators receiving power from the Great Western system and delivering it to the street railway, the system's electric generating equipment has been operated only in case of special emergency or during extremely low water.

TRANSMISSION AND DISTRIBUTION SYSTEM.

MAIN TRUNK LINE.

The 100,000-volt main trunk transmission line from the Big Bend plant runs almost due south through Oroville and Marysville to the Brighton substation, southeast of Sacramento, and a short distance beyond the substation it turns to the southwest and traverses the low lands of the south bank of Sacramento River, crossing near Isleton to the chain of islands between the main Sacramento and the mouth of the San Joaquin. At Antioch it crosses the lower stretch of the San Joaquin just before that stream enters Suisun Bay. From Antioch the line runs over the hills to Oakland. The right of way is owned in fee. The line is 154.7 miles long, including 27 miles in the Big Bend district, 14 in the Sacramento, 23 in the Rio Vista, and 30.7 in the Oakland districts.

This trunk consists of a single line of galvanized-steel towers, carrying two 3-phase circuits on suspended insulators, and includes 1,044 standard towers, 42 transposition towers, 78 angle towers, 4 anchor towers, and 17 special towers (such as those at river crossings). Standard towers are 76 feet 3 inches from the ground to the extreme apex, and were originally provided with a 6-foot stub below the ground surface at each of the four corners resting at the lower end on steel channel foot plates. Concrete filling was later put in around these stubs.

The portion of the tower from the ground to the first cross arm is battered from a spread of 17 feet at the ground to 2 feet 1½ inches at the cross arm, from which point upward to the third cross arm the section of the tower is rectangular, with latticed sides. Each corner of the lower part of the tower is composed of a structural system built up in the form of two triangular pyramids set base to base. The apex of one of these pyramids is at the ground surface, that of the other is at the cross arm, and an angle iron joining apexes forms the straight corner post of the tower.

The height to the first cross arm is 51 feet 2 inches; to the second 61 feet 2 inches; and to the third 71 feet 2 inches. Above the point where the third cross arm is fastened the tower is peaked with a structural-steel cap 5 feet 1 inch high, and the apex of this peak carries the steel ground line.

The six conductors of the two 3-phase circuits are of 6-strand copper cable with a hemp core. Each cable is equivalent to a No. 000 copper wire. The conductors are supported by 4-part and 5-part suspension insulators, each unit of which has been tested to 50,000 volts. The normal span between towers is 750 feet, with a clearance at the center of 30 feet. The line is operated with delta connection. The longest span (at the Antioch crossing) is 2,740 feet, with 300-foot special towers.

Standard and transposition towers weigh 3,535 pounds, the angle towers 11,000 pounds, and the anchor towers 5,000 pounds. All towers are placed on concrete footings and 189 towers are on piles.

TABLE 59.—*Insulators on Great Western Power Co.'s transmission lines, Big Bend to Oakland.*

Type.	Parts per set.	Sets on dead ends.	Sets on suspension.
Thomas disk	5	102	4,509
Thomas Fishtail	4	60	537
Do	5	12	114
General Electric	4	306	18
Locke	4	732	1,149
Do	3	....	59

The total weight of copper in the main circuits is 2,670,938 pounds, to which should be added 17,910 pounds of 3/0 Monott copper-clad stranded steel wire, used in the span across San Joaquin River. The total weight of the ⅜-inch stranded steel-cable ground wire is 257,400 pounds.

In crossing marsh land along the rivers each corner of the tower is founded on a single pile capped with a concrete block. The piles are about 12 feet long and are cut off just below the water level. The concrete block above each pile is about 8 feet in height, 2 feet square at its top, and 2 feet 3 inches at its base. The top of the pile is encased by the base of the concrete block and tied to it by two loops of iron. The stub of the tower leg extends down into the concrete.

The towers in this marsh land were originally set with comparatively small steel footings and without pile or concrete foundation, but after several miles of tower line had been carried down by a severe wind storm that followed a protracted and heavy rain, concrete was added to all tower footings and the towers were strengthened by the addition of cross bracing near the bottom.

The company completed a new steel-tower transmission line from the Caribou plant, near the mouth of Butt Creek, down the North Fork of Feather River to the Big Bend plant and thence paralleling the original transmission line to a point somewhat south of Brighton substation; thence turning in a southerly direction to a crossing of Carquinez Straits immediately west of the Pacific Gas & Electric span and connecting to the older system of Great Western Power Co. at Valona substation, on the south side of the Straits.

SUBMARINE CABLES.

The Great Western Power system operates 29 submarine cables, with aggregate length of 88,768 feet, of which 2 are of 2,200 volts, 2 of 4,000 volts, 6 of 11,000 volts, and 19 of 22,000 volts potential. All these except the three bay cables are at river crossings and at the crossing of Carquinez Straits.

The Great Western's cable crossing the bay from the end of the 100,000-volt power line was the first of its kind to be used for the transmission of electric power from Oakland or other bay points to

San Francisco. The cable laying was completed January 23, 1912, but owing to defective splices, which ruptured when it was being tested, operation was not begun until January 29.

The eastern terminus of the crossing is at the Western Pacific mole in Oakland, and the western is at Folsom Street wharf in San Francisco. At the Oakland end the cable receives power from the hydroelectric system and in San Francisco connects with the network originally operated by the City Electric Co. The total length of the cable between the ends of the two docks is 18,800 feet and the total length overall from land to land is 19,800 feet. The additional 1,000 feet on the ends is a cable specially protected to withstand injury from interference by passing vessels.

The main cable contains three 4/0 tinned conductors, each consisting of 19 strands of soft-drawn copper wire. Each conductor is encased in a rubber coating five thirty-seconds of an inch thick, which is wound with a single layer of rubber-faced tape and is finally covered with a winding of varnished cambric two thirty-seconds of an inch thick. The three separate insulated conductors of this type are wound together with a pitch of 24 inches, and the resulting cable is built up in circular form with jute filler held in shape by a winding of six thirty-seconds of an inch of varnished cambric. This winding is surrounded by a sheet of ⅛-inch lead and around this sheet there is four thirty-seconds of an inch of jute, which lies directly under the armoring of 37 No. 4 galvanized-steel wires wound with a pitch of 24 inches. Over this armoring is a cover of three thirty-seconds of an inch of tarred jute with sand and lime finish.[83] The diameter of the cable is 3.75 inches and its weight 17½ pounds per foot.

The cable has a maximum capacity of 6,200 kilovolt-amperes when submerged in water of 55° temperature. A safe maximum temperature for the cable may be considered as 130°. The cable was designed for 12,000 volts but was tested to a maximum of 32,000 volts. It is operated Y grounded.

The laying of the second 11,000-volt cable under the bay by the company was completed June 18, 1914, and laying of the third by way of Goat Island early in 1916.

BRANCH TRANSMISSION LINES.

In addition to the main tower lines described in the preceding paragraphs a short branch tower line extends from the Oakland substation northeastward into the Moraga Valley in Contra Costa County. This line is operated at 100,000 volts and is of the standard construction used on the main line.

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[83] Naphtaly, S. D., The trans-Bay cable of the Great Western Power Co.: Jour. Electricity, p. 340, Mar. 16, 1912; p. 1, July 4, 1914 (second cable); p. 427, June 3, 1916 (third cable).

In addition to the steel tower lines several 22,000-volt branch lines run out of the Brighton, Isleton, and Cowell substations. The longest and most important of these is that which runs from Isleton westward to a point north of Suisun Bay to feed the Vallejo, Petaluma, and Santa Rosa districts. The extent of the branch lines may be seen by referring to the general transmission map (Pl. I, in pocket).

TABLE 60.—*Transmission lines operated by the Great Western Power system Dec. 31, 1909–1920.*

Year.	Lines.[a]	Submarine cable.	Year.	Lines.[a]	Submarine cable.
1909	154.7	....	1915	154.7	12.6
1910	154.7	....	1916	154.7	16.77
1911	154.7	5.00	1917	170.2	16.77
1912	154.7	6.6	1918	170.2	16.77
1913	154.7	7.6	1919	174.7	16.77
1914	154.7	12.6	1920	174.7	16.81

[a] Double-circuit tower line.

TABLE 61.—*Transmission lines operated by Great Western Power Co. Dec. 31, 1920.*

District.	Miles constructed.	Number of circuits.
Big Bend	26	2-3 phase.
Sacramento	70	Do.
Rio Vista	28	Do.
Oakland	35.2	Do.
Do	15.5	1-3 phase.
	174.7	

NOTE.—Character of supports throughout, 75-foot steel tower; voltage throughout, 100,000.

SUBSTATIONS.

Detailed data on the substations of the Great Western Power system as they stood at the end of December, 1920, will be found in Table 62.

TABLE 62.—*Substations operated by Great Western Power system Dec. 31, 1920.*

District and substation.	Location.	Type of building.	Size to nearest foot.	Began operating.	Voltage of incoming circuits.	Voltage of outgoing circuits.	Service.	Capacity.
Big Meadows:					*Volts.*	*Volts.*		
Veramont	2 miles from Taylorsville.	Wooden frame covered with corrugated iron.	41 by 27.	Dec., 1917	44,000	22,000	Receives 44,000 volts from Big Bend power house. Serves lighting and commercial load to copper mines.	3,450-kilovolt-ampere transformers.
Greenville	1 mile from Greenville	Steel frame covered with corrugated iron.	12 by 14.	June, 1916	22,000	2,200	Receives from Butt Creek station. Delivers to Stone & Webster Construction Co. and for light and power in Greenville.	2,200-volt 50 kilovolt-ampere transformers.
Big Bend: Big Bend power house.	16 miles above Oroville, on North Fork of Feather River.	Steel frame; outdoor substation.	41 by 27.	Dec., 1908	11,000	44,000	Receives 11,000 volts from Big Bend power house. Transmits to Veramont substation.	6,900-kilovolt-ampere transformers.
Marysville: Arboga	5 miles south of Marysville.	Steel frame covered with corrugated iron.	26 by 56.	June, 1917	100,000	22,000	Receives from Big Bend power house. Delivers power for irrigation, lighting, and farming to adjacent region.	4,000-kilovolt-ampere transformers.
Sacramento:								
Brighton	Brighton	Reinforced concrete.	98 by 48. [a]43 by 47. [b]53 by 33.	Nov., 1909 Jan. 1917 Nov., 1909	100,000	22,000	Supplies city of Sacramento through Sacramento substation, Roseville, Natomas; also dredgers, pumping and irrigation plants in island district.	11,250-kilovolt-ampere transformers.
Sacramento	Sacramento	Reinforced concrete: steel roof trusses.	30 by 46.	Jan. 1911	22,000	[c]2,200 [d]500	Receives 22,000 volts on two circuits from Brighton. Furnishes commercial load in Sacramento and vicinity.	4,500-kilovolt-ampere transformers; motor-generator set, 350 kilowatts.
Northwestern:								
Isleton	1 mile from Isleton	Steel frame covered with corrugated iron.	30 by 30 and 9 by 9.	Jan., 1912	100,000	22,000 2,200	22,000 volts to Venice. 22,000 in town of Isleton; also irrigation and pumping load.	3,750-kilovolt-ampere transformers.
Napa	Napa	Reinforced concrete.	28 by 24.	Sept., 1912	22,000	2,400	Receives from Isleton and Valona at 22,000 volts. Carry lighting, commercial load, and electrical railroad in Napa and vicinity. Delivers 22,000 to Petaluma and Santa Rosa.	3,000-kilovolt-ampere transformers.
Petaluma	Hopper Street, Petaluma.	Reinforced concrete.	27 by 40.	do	22,000	2,400	Receives 22,000 volts from Napa and Santa Rosa. Furnishes light and power in Petaluma, city of Petaluma, and vicinity.	900-kilovolt-ampere transformers.

[a] Addition.

[b] Sectionalizing house.

[c] Alternating current.

[d] Direct current.

TABLE 62.—*Substations operated by Great Western Power system Dec. 31, 1920*—Continued.

District and substation.	Location.	Type of building.	Size to nearest foot.	Began operating.	Voltage of incoming circuits.	Voltage of outgoing circuits.	Service.	Capacity.
Northwestern—Contd.					*Volts.*	*Volts.*		
Santa Rosa	E and First streets, Santa Rosa.	Reinforced concrete.	27 by 40	Sept., 1912	22,000	2,400	Receives from Petaluma at 22,000 volts or from Snow Mountain Water and Power Co. at 55,000 (1,500 kilovolt-ampere capacity). Furnishes light and power in city of Santa Rosa and vicinity.	900-kilovolt-ampere transformers.
Oakland:								
Antioch	Antioch	do	97 by 36	Apr., 1914	100,000	22,000	Receives voltage from Big Bend power house. Supplies Brentwood and Great Western Electro-Chemical Co.	3,750-kilovolt-amper transformers.
Cowell	Cowell Cement Works, 3 miles from Concord.	do	27 by 47	Jan., 1909	100,000	400	Cowell cement plant	3,750-kilovolt-ampere transformers.
Clayton	Clayton, 2 miles from Concord.	Steel frame covered with corrugated iron.	36 by 60	Sept., 1911	100,000	22,000	Receives voltage from Big Bend power house. Supplies Clayton and vicinity, largest delivery to Pacific Electro-Metals Co.	3,750-kilovolt-ampere transformers.
Oakland (Fourth Avenue).	Fourth Avenue and West Thirty-seventh Street, Oakland.	Steel frame; concrete wall and floors.	57 by 163	Dec., 1908	100,000	55,000 11,000	Receives from Big Bend at 100,000 volts, 60,000 to Pacific Gas & Electric Co., 11,000 commercial load Oakland, Richmond, and San Francisco through bay cable.	11,000-volt 30,000-kilovolt-ampere and 60,000 volt 10,000-kilovolt-ampere transformers.
Valona	1 mile from Crockett	Temporary wooden frame covered with corrugated iron.	38 by 56	Apr., 1918	100,000	11,000 22,000	Receives voltage from Oakland substation. Delivers 11,000 to Richmond, 22,000 to northwestern division and local district.	11,000-volt 5,250-kilovolt-ampere and 22,000-volt 5,250-kilovolt-ampere transformers.
Yerba Buena steam plant.	Fortieth Street, Oakland.	Brick with steel truss roof and corrugated-iron covering.[c]		Oct., 1915	11,000	[a]11,000 [b]600	Receives voltage from Oakland substation. Delivers to San Francisco by way of bay cable. Supplies 600 volts direct current for interurban railroad.	Three 3,250-kilowatt motor-generator sets.
Alice Street	First and Alice streets, Oakland.	Steel frame with concrete walls.		do	11,000	4,000	Receives from Oakland substation. Delivers commercial and lighting load in Oakland.	1,500-kilovolt-ampere transformers.
St. Marks	Basement St. Marks Hotel, Oakland.			do	4,000	[b]250 [b]125	Receives from Oakland substation by way of Alice Street substation. Delivers direct-current commercial load in Oakland.	300-kilowatt motor-generator set.

San Francisco;							
Yerba Buena Island	Yerba Buena Island, San Francisco Bay.	Reinforced concrete.	17 by 34	Apr., 1916	11,000	[a]11,000 [a]2,400 [a]240	Receives from Oakland substation by way of Yerba Buena steam-plant substation. Delivers 2,400 to United States naval training station.	2,400-volt 600 kilovolt-ampere and 240-volt 300 kilovolt-ampere transformers.
North Beach steam plant.	Beach and Mason streets, San Francisco.	Steel frame: reinforced concrete.	....	....	11,000	11,000	Terminal for bay cables from Oakland. Has steam station for "standby" service. Switches out commercial power to street, railroads, and industries.	No transformers.
Harrison Street	Harrison between Seventh and Eighth streets, San Francisco.	Reinforced concrete.	75 by 75	Feb., 1915	11,000	[a]11,000 [b]500 [b]250 [b]125	Receives from Oakland substation. Delivers miscellaneous light and power load to San Francisco.	1,000-kilowatt motor-generator sets.
Bush Street	Bush Street between Grant Avenue and Stockton Street, San Francisco.	Steel frame with concrete walls.	90 by 137.	Nov., 1917	11,000	[a]11,000 [b]500 [b]250 [b]125	Receives from Oakland substation, by way of Harrison Street substation and North Beach steam plant. Delivers miscellaneous light and power load to San Francisco.	2,500-kilowatt motor-generator sets.
Post Street	Post Street between Polk and Larkin streets, San Francisco.	Reinforced concrete.	19 by 100.	Mar., 1913	11,000	[a]11,000 [b]500 [b]250 [b]125	Receives from Oakland substation by way of Bush Street, Harrison Street, and North Beach substations. Delivers miscellaneous light and power load to San Francisco.	500-kilowatt motor-generator sets.

[a] Alternating current.

[b] Direct current.

[c] Property of San Francisco-Oakland Terminal R. R.

NOTE.—In addition to the stations listed in detail above, the company was operating a 6,000-kilowatt substation at Caribou power house, a 1,500-kilowatt station at Butt Creek, and a 3,600-kilowatt station at Richmond.

TABLE 63.—*Overhead and underground distribution conduits of the Great Western Power system.*

Year.	Number of substations.	Overhead distributing lines.	Underground cable.	Year.	Number of substations.	Overhead distributing lines.	Underground cable.
		Miles.	*Miles.*			*Miles.*	*Miles.*
1909	4			1915	15	1,266	141
1910	5			1916	15	1,308	147
1911	8			1917	16	1,389	157
1912	11			1918	23	1,480	157
1913	9	1,052	53	1919	23	1,559	163
1914	11	1,093	130	1920	24	1,785	200

WESTERN STATES GAS & ELECTRIC CO.

HISTORY.

CORPORATE RELATIONS.

Western States Gas & Electric Co. was incorporated under the laws of California November 30, 1910, by H. M. Byllesby & Co., of Chicago, to acquire and operate three distinct power systems in California. The first of these systems, centered in and around Stockton, was formed by the union of the properties of American River Electric Co. with those of Stockton Gas & Electric Corporation. The second, referred to as the Eureka or Northern system, supplied the territory around Eureka on Humboldt Bay and consisted of the properties formerly owned by Humboldt Gas & Electric Co. The third, or so-called Richmond system, embraced the properties of Richmond Light & Power Corporation, which was operating a local distribution system in and around the town of Richmond, on the east shore of San Francisco Bay, north of Oakland; the Richmond system generates no power but is supplied by power purchased from Pacific Gas & Electric Co.

Western States Gas & Electric Co. (of California) is controlled through stock ownership by Western States Gas & Electric Co. (of Delaware), which in turn is controlled through stock ownership by Standard Gas & Electric Co. Standard Gas & Electric Co. not only controls indirectly Western States Gas & Electric Co. (of California) but also controls other California properties in and near San Diego, as well as public utilities in other States. The San Diego properties are not included in the holdings of Western States Gas & Electric Co. (of California) nor do they operate any hydroelectric plants.

STOCKTON SYSTEM.

STOCKTON GAS & ELECTRIC CORPORATION.

Stockton Gas & Electric Corporation was incorporated July 30, 1907, as successor of Stockton Gas & Electric Co., which was incorporated November 24, 1894. Stockton Gas & Electric Co. was in turn successor of Stockton Gas Light & Heat Co., incorporated April 20, 1888. These earlier companies had for many years supplied the city of Stockton and its immediate vicinity with gas and electricity. Until the completion of the lines of The Standard Electric Co. of California,[84] with its generating plant at Electra on Mokelumne River, the entire supply of electricity was generated at steam stations in Stockton. After the completition of Electra plant, Stockton Gas & Electric Co. purchased a large part of its power from the Electra lines. In 1905 American River Electric Co. completed its transmission lines from its plant on the South Fork of American River, near Placerville, to Stockton, and thereafter Stockton Gas & Electric Co. began to purchase power from the new concern.

AMERICAN RIVER ELECTRIC CO.

American River Electric Co. was incorporated April 17, 1903, under the laws of California, by San Francisco capitalists, and proceeded at once to construct a hydroelectric plant on South Fork of American River, directly northeast of Placerville. The plant began operation December 29, 1903, but the lines from the plant to Stockton were not completed until 1905. Two transmission lines, both terminating in Stockton, were constructed, one following a northern route by way of Folsom and Florin, and the other a southern route through Jackson, Valley Springs, and Harmony Grove. The company established a steam plant with a single 1500-kilowatt turbogenerator in Stockton in 1907, and, even prior to its acquisition by Western States Gas & Electric Co., it supplied a large part of the power used by Stockton Gas & Electric Corporation.

Power now turned out by the American River plant has been supplemented by a large quantity purchased from Pacific Gas & Electric Co., Sierra & San Francisco Power Co., and Great Western Power Co., and the rest of the power needed on the system is obtained from the Stockton steam station.

Since Western States Gas & Electric Co. acquired the properties of Stockton Gas & Electric Corporation and American River Electric Co., a large amount of reconstruction work has been completed, especially in the transmission and distribution systems.

EUREKA SYSTEM.

Humboldt Gas & Electric Co. was incorporated February 26, 1907, for the purpose of consolidating North Mountain Power Co. and Eureka Lighting Co.; it also controlled and supplied power to Fortuna Light Co., Ferndale Electric Light Co., and Arcata Light & Power Co. The properties of all of these companies are now con-

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[84] Now owned by Pacific Gas & Electric Co. Not to be confused with Standard Gas & Electric Co., the Byllesby holding corporation.

solidated into the Eureka or Northern system of Western States Gas & Electric Co.

The only hydroelectric plant on this system was constructed and operated by North Mountain Power Co. on Trinity River near Junction City but receives its water supply from Canyon Creek. The transmission line from the plant to Eureka is about 65 miles long. (See p. 415.) Hydroelectric power was first delivered in Eureka from the Junction City plant in June, 1905, and prior to that time the city was supplied with electric power by Eureka Lighting Co., incorporated March 15, 1894. Before its properties were acquired by Humboldt Gas & Electric Co., stock control of Eureka Lighting Co. was in hands of Pacific Lighting Corporation, incorporated in 1907, and its predecessor, Pacific Lighting Co., incorporated in 1886. Both Pacific Lighting Co. and Pacific Lighting Corporation were holding companies and controlled, in addition to Eureka Lighting Co., Los Angeles Gas & Electric Co. and Pasadena Consolidated Gas Co. Control of Eureka Lighting Co. was transferred to Humboldt Gas & Electric Co. shortly after the latter was incorporated.

RICHMOND SYSTEM.

The Richmond system, operated by Richmond Light & Power Corporation and transferred by it to Western States Gas & Electric Co. in December, 1910, is restricted in its operation to the immediate vicinity of the town of Richmond on San Francisco Bay, and has since its acquisition been entirely a distribution system, the small steam-electric plant formerly operated having been shut down upon the signing of the long-term power contract with Pacific Gas & Electric Co. Richmond Light & Power Corporation was organized June 6, 1910, as successor of Richmond Light & Power Co., incorporated in turn November 10, 1902, as successor of Richmond Light & Water Co., incorporated November 23, 1901.

MARKET.

TERRITORY AND POPULATION.

The area and population of the counties traversed by the transmission lines of the three systems belonging to the Western States Co. are given in detail in Table 9 (p. 64), and the general features of the counties are briefly described on pages 66–72.

The population of the incorporated places served by the systems is shown in Table 64, which follows:

TABLE 64.—*Population of incorporated places served by Western States Gas & Electric Co.*

City or town.	County.	Population.			
		1890	1900	1910	1920
EUREKA SYSTEM.					
Arcata	Humboldt	962	952	1,121	1,486
Blue Lake	do			507	441
Eureka[a]	do	4,858	7,327	11,845	12,923
Ferndale	do	763	846	905	919
Fortuna	do			883	986
Total		6,583	9,125	15,261	16,755
STOCKTON SYSTEM.					
Lodi	San Joaquin			2,967	4,850
Placerville	Eldorado	1,690	1,748	1,914	1,650
Plymouth	Amador				657
Stockton[a]	San Joaquin	14,424	17,506	23,253	40,296
Total		16,114	19,254	28,134	47,453
RICHMOND SYSTEM.					
Richmond	Contra Costa			6,802	16,843
Grand total		22,697	28,379	50,197	81,051

[a] Serves gas as well as electricity.

The following unincorporated places are also served: Elk Grove, Galt, Florin, Plymouth, Lockeford, Sheldon, Natomas, Jenny Lind, Camino, Valley Springs, and several mines by the lines of the Stockton system; Alton, Carlotta, Fields Landing, Hydesville, Rohnerville, Loleta by the Eureka system; and Stege and San Pablo by the Richmond system.

In the area served by the Eureka system the company has no competitors. In the San Joaquin market certain territory in and around Stockton and at other points along the line has always been served by this company or by its predecessors in interest. The territory about Stockton was confirmed to the company by decision rendered in the contest with Oro Electric Corporation by the Railroad Commission August 15, 1913, after a satisfactory showing by the company that at the time it was making every effort to consolidate and improve the systems which it had acquired from Stockton Gas & Electric Corporation and American River Electric Co.

In the hearing on this case it was shown that before the passage of the public utility law the company had been obliged to enter into contracts and purchase power wholesale from Pacific Gas & Electric Co. and from Sierra & San Francisco Power Co. in order to avoid the entry of these companies into the field as competitors. As the rates under the contract with Sierra & San Francisco Power Co. were found to be too high to permit the Western States Co. to maintain rates to consumers considered equitable by the Railroad Commission of California, the Western States Co. entered complaint before the commission in 1914; the rate under the contract was, however, lowered by mutual agreement between the companies and the new rate was ratified by the commission September 1, 1914. (See Appendix B.)

LOAD.

Two daily load curves for the Stockton system for the years 1915 to 1921 and for the Eureka system for the years 1918 to 1921 are given in figures 18 and 19, which show by separate curves the hydroelectric power and steam power generated and the power purchased from other companies.

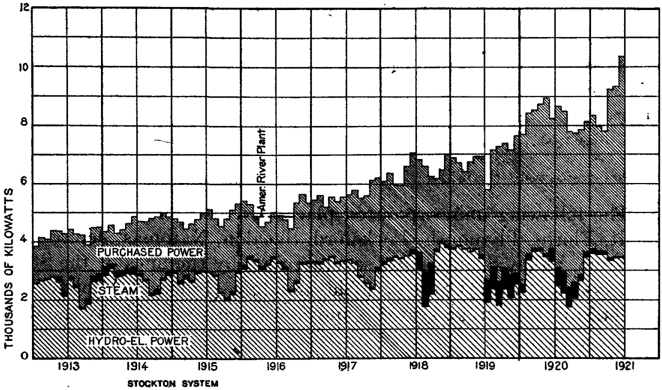


FIGURE 15.—Western States Gas & Electric Co., mean monthly loads, Stockton system, 1913–1921.

The load factors of the daily curves for the Stockton system range from 69.8 to 87.6 per cent.

Available information regarding growth of load on the lines operated by Western States systems is presented in Table 65, which shows sales in kilowatt-hours and connected load in kilowatts. (See also Table 225, Appendix A.)

The mean monthly loads carried by the three separate systems for the years 1913 to 1921, computed from monthly outputs in kilowatt-hours of the hydroelectric and steam stations on the Stockton and Eureka systems and the power purchased on all the three systems are shown graphically in figures 15 to 17.

Monthly load factors are not available, but annual load factors for 1914 to 1920 are given on page 402.

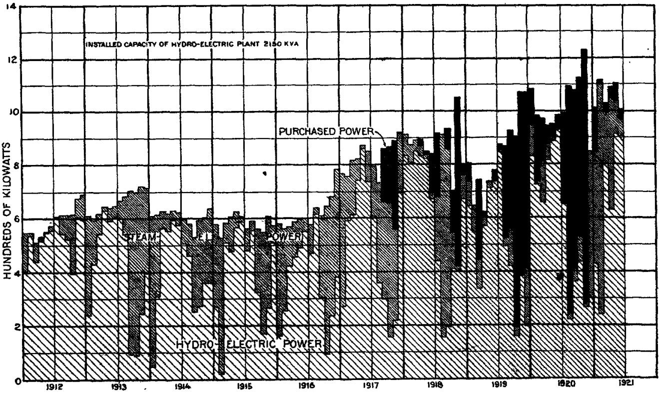


Figure 16.—Western States Gas & Electric Co., mean monthly loads, Eureka system, 1912-1921.

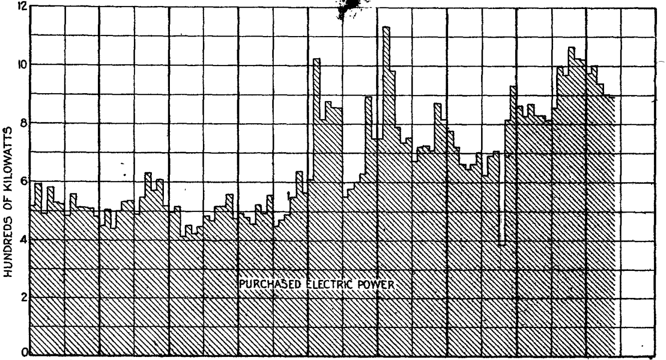


Figure 17.—Western States Gas & Electric Co., mean monthly loads, Richmond system, 1913-1921.

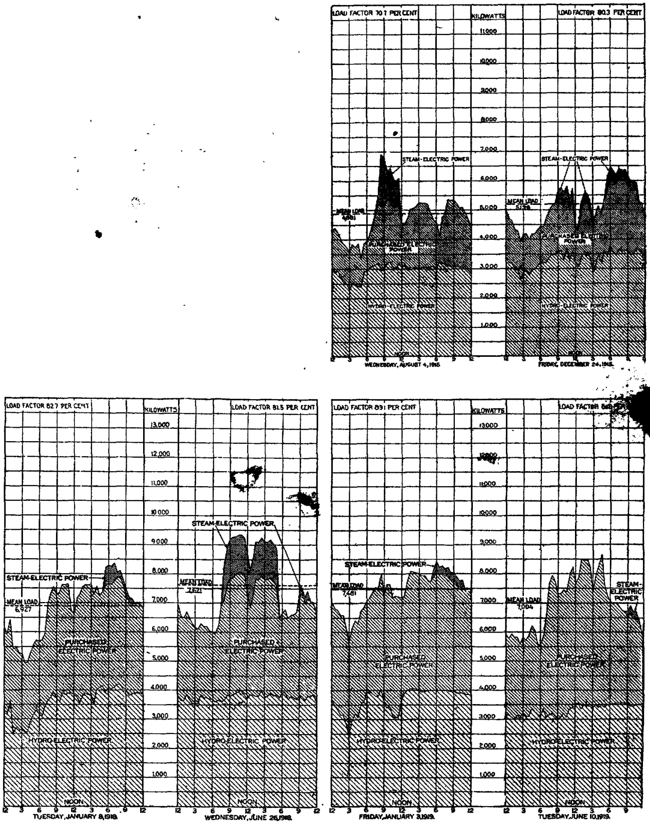
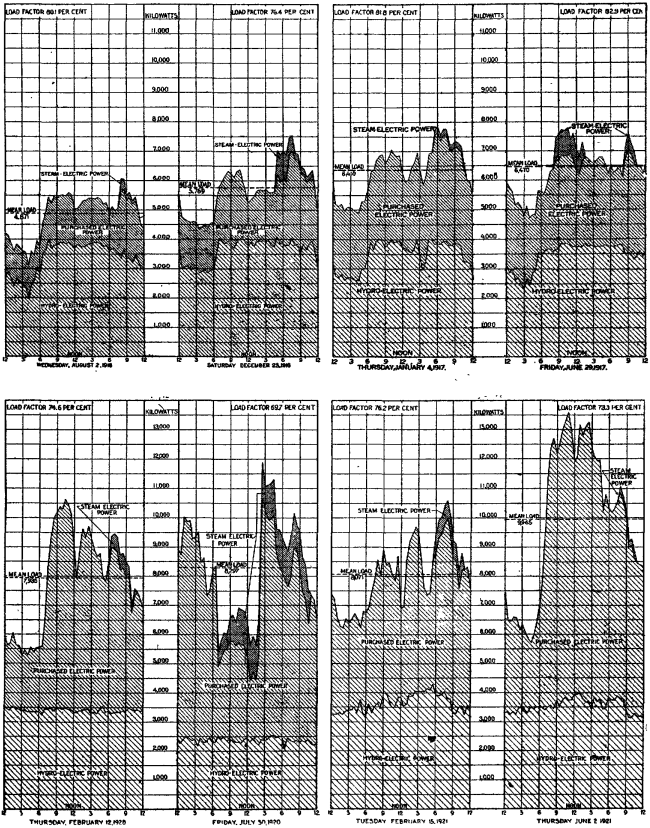


FIGURE 18.—Western States Gas & Electric Co.,



daily load curves, Stockton system, 1915 1921.

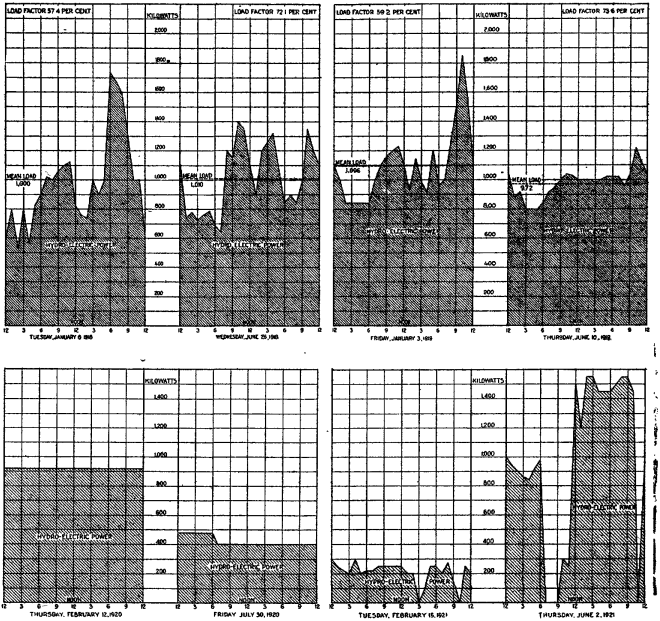


FIGURE 19.—Western States Gas & Electric Co., daily load curves, Eureka system, 1918–1921.

TABLE 65.—*Sales and connected load, Western States Gas & Electric Co., 1913–1920.*

	1913				1914			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Stockton system.								
Lighting:								
Municipal	1,022,736	3.3	253.20	1.3	1,037,298	3.1	266.20	1.2
All other	5,618,175	18.6	7,355.42	39.0	4,448,951	13.4	8,437.72	38.7
Power:								
Agricultural	1,854,709	6.1	10,965.53	58.0	1,558,327	4.7	12,799.16	58.7
All other	15,882,990	52.4			19,467,224	58.8		
Railway	5,704,143	18.8	321.00	1.7	6,053,106	18.3	297.00	1.4
Used by company	228,293	.8	....	....	578,739	1.7	....	....
	30,311,046	100.0	18,895.15	100.0	33,143,645	100.0	21,800.08	100.0
Eureka system.								
Lighting:								
Commercial	1,570,900	39.1	3,679.49	66.8	1,491,396	43.7	3,913.0	68.9
Municipal	244,465	6.1	80.81	1.4	255,462	7.4	87.3	1.5
Power: Industrial	2,197,694	54.8	1,756.32	31.8	1,670,438	48.9	1,680.8	29.6
	4,013,059	100.0	5,516.62	100.0	3,417,296	100.0	5,681.1	100.0
Richmond system.								
Lighting:								
Commercial	835,534	18.3	2,522.45	42.8	967,744	21.0	3,065.91	47.2
Municipal	181,998	4.0	57.67	.9	267,633	5.8	61.19	.9
Power: Industrial	3,531,739	77.7	3,321.06	56.3	3,368,398	73.2	3,365.65	51.9
	4,549,271	100.0	5,901.18	100.0	4,603,775	100.0	6,492.75	100.0

	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Stockton system.								
Lighting:								
Municipal	1,059,101	3.0	354.64	1.4	1,067,460	3.1	293	1.1
All other	4,859,884	14.0	9,162.59	38.7	5,343,697	18.0	10,259	39.2
Power:								
Agricultural	1,656,770	4.8	12,864.41	54.4	2,060,066	6.0	14,327	54.7
All other	20,398,764	58.8			19,038,515	55.1		
Railway	5,949,978	17.1	1,300.00	5.5	6,139,289	17.8	1,300	5.0
Used by company	788,359	2.3	....	....	881,091	....	....	....
	34,712,856	100.0	23,681.64	100.0	34,530,118	100.0	26,179	100.0
Eureka system.								
Lighting:								
Commercial	2,021,074	43.3	4,023.0	67.9	2,113,456	41.7	4,369	61.0
Municipal	302,077	6.5	87.8	1.5	283,556	5.5	106	1.5
Power: Industrial	2,346,653	50.2	1,812.3	30.6	2,677,448	52.8	2,682	37.5
	4,669,804	100.0	5,923.1	100.0	5,074,460	100.0	7,157	100.0
Richmond system.								
Lighting:								
Commercial	997,527	23.8	3,554.14	50.4	1,284,997	28.4	4,013	49.3
Municipal	267,562	6.4	64.39	.9	335,296	7.4	67	.8
Power: Industrial	2,928,985	69.8	3,428.81	48.7	2,904,707	64.2	4,057	49.9
	4,194,074	100.0	7,047.04	100.0	4,525,000	100.0	8,137	100.0

TABLE 65.—*Sales and connected load, Western States Gas & Electric Co., 1913–1920*—Continued.

	1917				1918			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilo-watts.	Per cent of total.
Stockton system.								
Lighting:								
Municipal—								
Street	1,129,438	2.3	297.98	1.0	1,144,000	2.5	308	0.9
Commercial—								
Business	8,515,091	17.7	11,449.11	39.3	7,861,000	17.5	12,735	37.0
Residence								
Power:								
Commercial—								
Industrial	32,173,073	66.8	16,194.74	55.6	25,294,000	56.8	20,195	58.7
Agricultural					4,044,000	9.0		
Railway	6,357,367	13.2	1,180.00	4.1	6,383,000	14.2	1,180	3.4
	48,174,969	100.0	29,121.83	100.0	44,926,000	100.0	34,418	100.0
Eureka system.								
Lighting:								
Municipal—								
Street	240,000	4.9	106.50	1.5	257,000	4.7	107	1.4
Miscellaneous	38,000	.8	20.30	.2	23,000	.4	20	....
Commercial—								
Business	1,402,000	28.6	4,476.70	59.7	1,211,000	22.4	4,618	57.3
Residence								
Power:								
Municipal	33,000	.7	125.50	1.7	63,000	1.1	126	1.7
Commercial—								
Industrial	3,182,000	65.0	2,768.00	36.9	3,860,000	71.4	3,190	39.6
Agricultural								
	4,895,000	100.0	7,497.00	100.0	5,414,000	100.0	8,061	100.0
Richmond system.								
Lighting:								
Municipal—								
Street	359,960	6.2	62.29	0.7	505,000	8.2	73	0.7
Miscellaneous	....	......	77.00	.9	14,000	.2	77	.8
Commercial—								
Business	879,348	15.1	1,123.00	12.4	1,143,000	18.6	1,081	10.9
Residence			3,306.32	36.5			3,858	39.0
Power:								
Municipal	9,766	.1	15.00	.1	6,000	.1	120	1.2
Commercial—								
Industrial	4,591,048	78.6	787.00	8.7	4,462,000	72.9	4,114	41.6
Agricultural								
Other	....	......	3,680.04	40.7	....	....	....	....
	5,840,122	100.0	9,050.65	100.0	6,130,000	100.0	9,893	100.0

TABLE 65.—*Sales and connected load, Western States Gas & Electric Co., 1913–1920*—Continued.

Class of load.	1919				1920			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Stockton system.								
Lighting:								
Residence and commercial	6,775,000	13.2	14,169	37.0	8,551,000	14.7	15,727	36.5
Municipal	1,161,000	2.3	322	.8	1,209,000	2.1	335	.8
Power:								
Industrial	32,617,000	63.5	21,745	56.7	35,310,000	60.5	25,741	59.7
Agricultural	4,406,000	8.5			6,466,000	11.1		
Municipal	......	......	......	......	......	......	......	......
Railway	6,426,000	12.5	1,167	3.0	6,784,000	11.6	1,154	2.7
Other	......	......	953	2.5	......	......	141	.3
Other electrical corporations	......	......	......	......	......	......	......	......
	51,385,000	100.0	38,356	100.0	58,320,000	100.0	43,098	100.0
Eureka system.								
Lighting:								
Residence and commercial	1,593,000	26.1	5,086.19	58.3	1,770,924	25.3	5,447.72	56.2
Municipal	456,000	7.4	125.10	1.4	382,849	5.5	107.50	1.1
Power:								
Industrial	3,093,000	50.7	2,985.69	34.2	3,551,376	50.8	3,527.68	36.3
Agricultural	......	......			1,901	......	53.00	.5
Municipal	274,000	4.5	125.50	1.5	316,943	4.5	68.30	.7
Railway	690,000	11.3	402.00	4.6	940,000	13.4	402.00	4.2
Other	......	......	......	......	32,731	.5	95.42	1.0
Other electrical corporations	......	......	......	......	......	......	......	......
	6,106,000	100.0	8,724.48	100.0	6,996,724	100.0	9,701.62	100.0
Richmond system.								
Lighting:								
Residence	1,344,000	24.0	4,226.63	40.7	1,141,563	16.2	4,530.38	39.3
Municipal	370,000	6.6	152.73	1.4	423,694	6.0	97.13	.8
Commercial	(a)	......	1,095.52	10.6	454,671	6.4	1,253.07	10.9
Power:								
Industrial	3,886,000	69.3	4,199.79	40.5	4,972,149	70.4	5,397.75	46.9
Agricultural	......	......						
Municipal	7,000	.1	120.00	1.2	2,920	.1	71.25	.6
Railway	......	......	......	......	......	......	......	......
Other	......	......	581.33	5.6	65,000	.9	168.00	1.5
Other electrical corporations	......	......	......	......	......	......	......	......
	5,607,000	100.0	10,376.00	100.0	7,059,997	100.0	11,517.58	100.0

[a] Included with "Residence."

TABLE 65a.—*Summary of operating data for Stockton system.*

Year	Electric consumers.			Connected load.		
	Lighting.	Power.	Total.	Incandescent. lamps.[a]	Municipal arcs.	Motors (rated horsepower).
1913	6,937	1,154	8,091	117,066	631	14,699
1914	7,485	1,234	8,719	128,710	657	17,065
1915	8,264	1,319	9,583	138,645	1,031	17,153
1916	9,167	1,420	11,587	149,849	1,103	19,103
1917	10,256	1,630	11,886	162,981	1,130	21,589
1918	11,005	1,862	12,867	182,342	1,275	26,927
1919	12,237	2,106	14,343	196,798	1,306	30,264
1920	13,591	2,563	16,154	213,665	1,356	34,321

TABLE 65a.—*Summary of operating data for Stockton system*—Continued.

Year.	Power generated (kilowatt-hours).			Power purchased (kilowatt-hours).	System total (kilowatt-hours).
	Hydroelectric.	Steam-electric.	Total.		
1911	22,124,520	789,300	22,913,820	6,345,475	29,259,295
1912	22,130,405	987,700	23,109,105	9,923,023	33,032,128
1913	21,540,240	912,200	22,452,440	14,681,670	37,134,110
1914	23,951,000	1,268,700	25,219,700	15,634,850	40,854,550
1915	23,402,320	587,100	23,989,420	18,327,427	42,316,847
1916	27,334,880	577,400	27,912,280	15,654,234	43,566,514
1917	27,292,800	436,100	27,728,900	21,622,027	49,350,927
1918	28,363,280	2,584,900	30,948,180	25,517,744	56,465,924
1919	25,763,440	3,338,500	29,101,940	31,429,973	60,531,913
1920	25,076,900	3,048,900	28,125,800	44,466,059	72,591,859

Year.	Mean load.		System peak (kilowatts).	System load factor (per cent).
	Kilowatts.	Horsepower.		
1911	3,341	4,476		
1912	3,771	5,053		
1913	4,239	5,680		
1914	4,663	6,249	6,692	69.7
1915	4,831	6,473	6,794	71.1
1916	4,973	6,664	7,137	69.6
1917	5,633	7,549	7,692	73.2
1918	6,446	8,638	9,432	68.3
1919	6,910	9,260	14,852	46.5
1920	8,286	11,104	[b] 11,826	70.1

[a] Sixteen candlepower equivalent.

[b] This peak below normal on account of power shortage and curtailment of power. It is estimated by the company that it would have been 16,000 kilowatts if there had been ample power.

ELECTRIC SYSTEM.

GENERAL RELATIONS.

The physical developments on the three systems operated by Western States Gas & Electric Co. October 1, 1921 comprised (1) the American River hydroelectric and Stockton steam-electric stations, on the Stockton system, with an important distribution system in Stockton and local distributions at various points along the two transmission lines from American River plant to Stockton; (2) the Junction City hydroelectric plant of the Eureka system, with a main transmission line running 65 miles almost due west to Eureka, where there is a steam-electric stand-by station; and (3) the Richmond system with electric distribution lines in Richmond, San Pablo, and Stege.

AMERICAN RIVER PLANT.

LOCATION.

The American River plant of Western States Gas & Electric Co.'s Stockton system was constructed by American River Electric Co. in 1903 and began operation December 29 of that year. The intake of the American River canal is in sec. 24, T. 11 N., R. 11 E.; the conduit traverses secs. 20, 21, 24, 25, 26, 27, and 28. The power house is in sec. 20, T. 11 N., R. 11 E., on the north side of South Fork of American River, 100 feet east of the mouth of Rock Creek and about 4 miles, in an air line, northeast of Placerville, Eldorado County, and is about 1,096 feet above sea level. It is fed by the Summerfield ditch, 20 miles in length, which heads on Slab Creek in sec. 28, T. 12 N., R. 12 E., and by a short feeder from One Eye Creek, a small tributary to Rock Creek. Water released from the reservoir flows down a natural channel into the main flume at a point about half a mile above the forebay. Finnon reservoir is in sec. 16, T. 11 N., R. 11 E.

SOURCE OF WATER SUPPLY

The American River plant is operated with water supplied by South Fork of American River (see Pl. XLV, in pocket) from an area that lies almost entirely in Eldorado County but includes a few square miles in Amador and Alpine counties.

South Fork of American River heads in the ponds and marshes in the vicinity of Audrain Lake, near Ralston Peak, on the divide between the American River and Upper Truckee River basins. Echo Lake, north of Audrain, though not naturally tributary to the stream, is diverted into it through a tunnel, and adds materially to the low flow of South Fork. From its headwaters to the point of intake the stream flows almost due west down the center of its basin, which is about 36 miles long by 15 miles wide. The part of the basin north of the main stream is drained almost entirely by Silver Creek, which flows into the South Fork 6 miles above the head dam. The southeastern part of the basin is drained by Silver Fork of South Fork, which flows northwest out of Twin and Silver lakes and joins South Fork 20 miles due east of the intake.

The canyon of the South Fork is 2,000 feet deep, but its features are comparatively regular, for it is flanked in places by high, round-topped ridges. The bare granite domes characteristic of the region drained by American, Mokelumne, and Tuolumne rivers are numerous in the eastern part of the basin. Igneous rocks—granodiorite, andesite, and granite (in order of area of exposure)—form the predominant geologic formations.[85]

Except on the granite ridges of the higher country, the forest cover is good and in most sections is excellent. The heaviest growth of conifers is found along the ridges ranging in elevation from 3,000 to 6,000 feet. In the bottom of the canyon, up to 4,000 feet, there is a good deal of scattering oak.

Rainfall records have been taken for a few seasons at several stations along the Eldorado canal system and at Slippery Ford. Several short records have also been obtained in the Rubicon basin directly

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[85] U. S. Geol. Survey Geol. Atlas, Pyramid Peak folio (No. 31) and Placerville folio (No. 3).

to the north. All these records are too short to afford a basis for general conclusions but apparently indicate that the mean seasonal precipitation varies from 45 inches in the vicinity of the intake to about 70 inches in the region drained by North Fork of Silver Creek and Little Silver Creek. In the southeastern half of the basin the mean seasonal rainfall probably varies from 55 to slightly over 60 inches. Above the 4,500-foot contour most of the precipitation is in the form of snow and occurs between the first of December and the last of March.

Stream flow late in the summer and early in the fall would dwindle to insignificant proportions were it not for water released from storage in Echo, Silver, Medley, and Twin lakes.[86]

RESERVOIRS.

Western States Gas & Electric Co. formerly in low years purchased water from the storage and ditch systems of Sierra Water Supply Co., which owned the Echo, Silver, and Medley Lake reservoirs, on the headwaters of the South Fork of American River. These reservoirs and ditch systems were finally taken over by Western States Co.

At Echo Lake a dam 7 feet high and 400 feet long impounds 1,800 acre-feet, or 78,408,000 cubic feet, of water. At Silver Lake a dam 21 feet high and 180 feet long impounds 5,000 acre-feet, or 217,800,000 cubic feet. At Twin Lakes a dam 19 feet high and 570 feet long impounds 1,000 acre-feet, or 43,560,000 cubic feet. At Medley Lakes storage is formed by three dams; the main dam is 20 feet high and 113 feet long; dam No. 2 is 2 feet high and 41 feet long; and dam No. 3 is 3 feet high and 46 feet long. In addition, the company has formed a storage reservoir on Glen Alpine Creek by the construction of two main and seven auxiliary dams. Main dam No. 1 is 3½ feet high and 33 feet long; dam No. 2 is 4 feet high and 108 feet long; auxiliary dam No. 1 is 7 feet high and 37 feet long; No. 2 is 1½ feet high and 9 feet long; No. 3 is 1.3 feet high and 19 feet long; No. 4 is 6½ feet high and 112 feet long; No. 5 is 1½ feet high and 10 feet long; No. 6 is 6 feet high and 92 feet long; and No. 7 is 2½ feet high and 140 feet long. These dams impound 5,000 acre-feet, or 217,800,000 cubic feet, of water.

CONDUIT.

The main supply for the plant is diverted directly from South Fork, but a small reserve supply is diverted from Slab Creek and from one of the branches of Rock Creek.

The diversion from South Fork of American River is made by means of an overflow rock-filled crib dam, which is 165 feet long on

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[86] For records of discharge of South Fork of American River see U. S. Geol. Survey Water-Supply Papers as follows: 298, pp. 333–338, 393 (up to June 30, 1912); 331, pp. 331–332 (1911–12); 361, pp. 371–373 (1912–13); 391, pp. 270–272 (1913–14); 411, pp. 273–275 (1914–15); 441, pp. 249–250 (1915–16); 461, pp. 244–245 (1916–17); 481, pp. 235–237 (1917–18).

the crest, 41 feet in maximum height, about 25 feet high above stream bed, and abuts on the rock of the canyon wall at both ends. The elevation at the point of diversion is 1,709.5 feet above sea level.

Water is admitted to the conduit at the north end of the dam through timber gates which are operated by handwheels and pinions. The total length of the conduit from the dam to the penstock is 37,301 feet. Of this length the first 25,000 feet is almost entirely in flumes, the use of which is made necessary by the ruggedness of the north side of the canyon which the line traverses. Farther down the canyon the canal is entirely excavated in earth. The grade in both flume and in ditch is uniformly 1 foot per 1,000.

The elevation of the gate sill at the head of the canal is 1,709.5 feet and at the penstock 1,668.7 feet, giving a total fall of 40.8 feet. The ditch section is noteworthy chiefly for its extremely steep side slopes; the width at water surface is 9 feet, the bottom width 5 feet, and the depth 4 feet. The embankment rises 2 feet above the water and the top width of the canal is 13 feet. The canal was designed for a maximum capacity of 158 second-feet.

The flumes are built of 2 by 12 inch planks, with 1 by 4 inch battens, and are supported on trestle bents of two types. The main bents are spaced 16 feet on centers, and are of heavier construction than the intermediate bents, which are spaced only 4 feet on centers. The trestle posts have block footings. The flume box was 6 feet wide by 5 feet deep until the third unit was installed at the power house in 1915, when the depth of the box was increased to 6 feet and the height of the intake dam raised accordingly. On top of the caps there is a 2 by 12 inch footboard for the use of flume inspectors.

At the lower end of the canal there is no forebay, but merely a timber penstock box that serves as heading for the pressure pipes. This structure is 11 feet wide, 60 feet long, and 6 feet deep. At the heading for the pipes the width is increased by intake boxes 5 feet wide, 10 feet long, and 12 feet deep, built out from the side of the structure. Provision was made for three pipes, but the third was not installed until the end of 1915. Water is admitted to these headings from the main penstock through sliding timber gates, 3½ feet wide by 4 feet high, operated from the bridge above by a handwheel and screw. Three of these gates are provided for each pipe. There is also a sluice gate at one end of the structure and a weir spillway on the side that empties into the head of a small spillway flume.

The reserve supply can be obtained at the forebay by a supplementary diversion from Slab Creek to Finnon reservoir. (See Pl. XLV, in pocket.) This supply passes through the Summerfield ditch, formerly used for mining. The capacity of this conduit is 5 second-feet; the width at water surface is 5 feet, width on the bottom 2½ feet, depth of water 2½ feet. The flume section on this line is

30 inches wide by 20 inches deep. There is also a small and unimportant feeder to the reservoir from a branch of Rock Creek. The capacity of the Finnon reservoir is 600 acre-feet.

In the first 400 feet below the forebay two of the three pipe lines leading from the forebay to the power house are built of 36-inch redwood stave pipe which operates at its lower end under a maximum head of 120 feet; from this point to the power house the pipes are made of lap-riveted steel 36 inches in diameter. The thicknesses of plates and the lengths of the various sections are as follows: 400 feet made of No. 10 plates, 150 feet of $\frac{3}{16}$-inch, 150 feet of $\frac{1}{4}$-inch, 150 feet of $\frac{5}{16}$-inch, and 364 feet of $\frac{7}{16}$-inch steel plates.

The third pipe consists of 678 feet of 36-inch redwood stave pipe and 907 feet of 30-inch steel pipe.

Just outside of the power house, each line enters a Y whose branches pass under the power-house floor to the wheels. In these branches and within the power house there are hand-operated gate valves.

The static head between water surface in the penstock, and center of nozzles of power house is 572.65 feet for the first two units and 567.65 feet for the third.

GENERATING STATION.

Power house.—The buildings of the American River plant comprise a generator room facing on the river and a transformer house at the west end of the generator room between it and Rock Creek. On the river side of the transformer house the high-tension switching apparatus is installed in pole-top shelters. The transformer house and power house are both constructed of reinforced concrete, with slate roofs supported on steel roof trusses. The three pole-top switch houses are constructed of corrugated iron. As originally constructed, the power house measured in plan 76 feet 6 inches long by 28 feet 4 inches wide at the floor level, and 31 feet 6 inches wide at the crane level, all measurements being inside the building, which has 18-inch concrete walls. The transformer house measures 38 feet long by 23 feet wide. When the third unit was added late in 1915, the length of the building was increased to 97 feet 6 inches.

All three units are placed in line parallel to the main axis of the generator room, with their wheels very close together.

The governors, oil pumps, and gate valves are between the units and back wall of the room, and the exciters are in the downstream end of the building, between the first unit and the switchboard, which parallels the end wall of the station. Each unit is supplied by its own pressure pipe, which enters the building at right angles to its main axis, directly behind the unit and just under the floor line. At the outside wall there is a Y in the pipe line serving each of the first two units, and just inside the building there is a hand-operated gate valve in each branch of the Y. The discharge from the wheels shoots directly into the river through arched concrete tailraces.

The generator room is commanded by a traveling crane carried on rails laid on shoulders in the concrete walls. The minimum clear height to the rails which support the traveling crane is 16 feet, and clear height to the bottom chord of the roof trusses 22 feet 11 inches in the new part of the building, where the floor is 5 feet 3 inches higher than in the older part.

Hydraulic equipment.—Each wheel is supplied through a stationary needle nozzle with automatic needle by-pass. A Lombard governor, type Q, is connected on both nozzles of each of the first two units. These two units are of the double overhung type, with an impulse wheel on each end of the shaft; the wheels are 67⅝ inches in diameter on pitch line, carry 18 buckets, are rated at 3,000 horsepower for the pair on each unit; they were constructed by the Pelton company and rebuilt by the Doble company. The third unit is operated by a single overhung impulse wheel, which is 75 inches in diameter on the pitch line and is rated at 2,100 horsepower; the wheel is of Pelton-Doble design and construction.

Generators.—The two original generators are Westinghouse 1,500-kilovolt-ampere 3-phase 60-cycle 392-ampere 2,200-volt alternators. They operate at 300 revolutions per minute. The third is an 1,875-kilovolt-ampere 3-phase 60-cycle 472-ampere 2,200-volt alternator operated at 275 revolutions per minute.

Exciters.—The original exciter set is a Westinghouse 75-kilowatt 600-ampere 125-volt direct-current generator, run at 750 revolutions per minute by a Pelton impulse wheel and controlled by a Lombard governor, type F. The exciter added with the third unit is a 75-kilowatt 600-ampere 125-volt direct-current generator, operated by a 30-inch Pelton wheel.

Transformers.—The station is equipped with three Westinghouse 1-phase 60-cycle 66,000/2,200-volt 1,500-kilowatt water-cooled transformers, connected delta on the generator side and Y with grounded neutral on the high-tension side.

Wiring.—The leads from the switchboard to the low-tension side of the transformers are carried through underground ducts between the buildings. Two high-tension lines leave the transformer house through tiled outlets. Each line is fitted with single-phase Westinghouse overload relays. The high-tension switching apparatus consists of three sets of Baum fiber-tub oil switches placed in pole-top shelters. The switches can be operated by levers from the ground beneath. One generator is operated on the Folsom dredger circuit; those on the so-called Stockton line, which follows the southern route to that city, are operated separately.

Horn-gap lightning arresters and pole-top disconnecting switches are mounted just outside the transformer house and between it and the high-tension switches.

JUNCTION CITY PLANT.

LOCATION.

The Junction City power plant was put into commission in June, 1905, by North Mountain Power Co., was purchased from its builders by Humboldt Gas & Electric Co., and passed with the other properties of that company into the hands of Western States Gas & Electric Co. in December, 1910. The intake of the main conduit supplying the plant is on Canyon Creek, in sec. 1, T. 34 N., R. 11 W.; the conduit traverses secs. 1, 12, 13, 24, 25, and 36, T. 34 N., R. 11 W. The power house is on the bank of Trinity River in sec. 36, T. 34 N., R. 11 W. An auxiliary supply is drawn from the Hurtevant ditch, belonging to the Valdor Dredging Co., which is supplied with power by Western States Gas & Electric Co. Western States Gas & Electric Co. has the use of this water only during the life of the power contract, and as soon as the Valdor Co. finishes dredging will remove the low-head unit operated by this supply. The ditch heads on Canyon Creek in sec. 25, and traverses secs. 25 and 36, T. 34 N., R. 11 W. to the power house.

SOURCE OF WATER SUPPLY.

The Junction City plant is operated with water taken not from Trinity River but from Canyon Creek, one of the tributaries flowing into the river from the north. (See Pl. XLVII, in pocket.) The drainage area above the main diversion dams is in the rocky, mountainous Coast Range region, is about 10 miles long from north to south, ranges in width from 1 mile to 6 miles, and comprises about 43 square miles. Altitudes within the area range from about 2,100 to 10,000 feet above sea level. The creek has no large tributaries. Neither stream-gaging nor rainfall stations have been maintained in the basin, but its position on the west slope of the Coast Range indicates a high rate of rainfall.

There is but one small reservoir of about 250 acre-feet capacity in the drainage basin.

CONDUITS.

The main conduit is an old mining ditch into which water is diverted by a small rock-filled crib dam. The conduit is about 7½ miles long, 6,200 feet being in flume and the rest in open ditch, most of which is through earth.[87] The average grade is 1.84 feet per thousand, or 9.73 feet per mile, and the capacity of the canal when new

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[87] A tunnel about 1,500 feet long has been abandoned.

was 80 second-feet. The elevation of the diversion dam is about 2,100 feet, and the total drop along the line 70 feet, giving an elevation of 2,030 feet at the lower end. The conduit empties into a forebay 60 feet long, 14 feet wide, and 10 feet deep, blasted out of solid rock. From the forebay water is admitted to the two pressure lines through sliding gates and inclined trash racks. A dead end is left in the forebay for a third pipe, which has not been installed.

Two pipe lines, identical in design, extend from forebay to the the power house. The first section of pipe below forebay is 505 feet long and 26 inches in diameter, followed by 660 feet of 24-inch pipe, connected to a Y with two 18-inch branches 11 feet long, each of which connects in turn to a section of 18-inch pipe 189 feet long, extending to the power house; giving a total length of 1,365 feet from forebay to power house. The static head developed by these lines is 604 feet.

The Hurtevant ditch, belonging to Valdor Dredging Co. but used temporarily to develop power at the Junction City plant, diverts the remaining flow from Canyon Creek at a point approximately 350 feet lower in elevation than the main head dam. The Hurtevant ditch is 4 feet wide at the top, 3 feet at the bottom, and 2½ feet deep. Slides have reduced the capacity of the ditch to about 22 second-feet. The static head developed by a single 34-inch riveted pipe line from this ditch is 240 feet.

GENERATING STATION.

Power house.—The two older units are in a reinforced-concrete power house measuring 36 by 51 feet, and the third or newest unit is in a corrugated-iron house 24 by 18 feet. The transformers are in a reinforced concrete building 13 feet by 51 feet 6 inches, and the switching equipment in a building 16 by 36 feet. The transformer house is 50 feet from the main power house, and the switch house 20 feet beyond the transformer house.

The two units in the old power house are placed across the generator room with their wheel housings in a lean-to addition just outside of the main wall line of the building. The wheel shafts extend through the wall and are attached to the generator shaft by flexible couplings. The switchboard is in a bay opposite the generators. A 10-ton traveling crane is supported by steel runways in the wall of the main room.

The newest unit is in a corrugated-iron power house with its main shaft parallel to the others. The discharge of all three wheels flows into Trinity River through a tailrace about 300 feet long by 7 feet wide blasted through bedrock.

The newest unit is designated No. 1 and the two in the older building Nos. 2 and 3.

Hydraulic equipment.—Unit No. 1 is operated by a 64-inch 440-horsepower Pelton-Doble wheel direct-connected to the generator shaft, and each of the other units is driven by a pair of 44-inch Pelton wheels with a total capacity of 1,650 horsepower per pair. Each unit is provided with a type O Pelton governor. Each rotor of the twin wheels of units 2 and 3 receives the stream from a single plain deflecting nozzle of 3.5 inches bore.

Unit No. 1 operates under a head of 240 feet and Nos. 2 and 3 under a head of 604 feet.

Generators.—The first two generators, now designated Nos. 2 and 3, were originally 25-cycle machines rated at 750 kilovolt-amperes but were later rewound for operation at 60 cycles. No. 1 unit is a General Electric 250-kilovolt-ampere 2,300-volt 3-phase 60-cycle machine; unit No. 2 is a Western Electric 2,300-volt machine now rated at 1,000 kilovolt-amperes; and No. 3 unit a General Electric 2,300-volt machine now rated at 900 kilovolt-amperes, giving the station a total rated capacity of 2,150 kilovolt-amperes or 2,980 horsepower.

Exciters.—The exciters for all three units are Bullock 45-kilowatt 125-volt, belt-driven from the main shafts of their respective units at 900 revolutions per minute.

Transformers.—The three Allis-Chalmers water-cooled transformers are rated at 600 kilovolt-amperes and have a ratio of 2,300/38,000 volts.

The plant transmits to Eureka, a distance of 65 miles, and is also connected to the lines of Pacific Gas & Eectric Co.

STEAM PLANTS.

STOCKTON PLANT.

Location.—The Stockton steam plant is in the city of Stockton on the northeast bank of Stockton Channel, a backwater of San Joaquin River, and was constructed by Chas. C. Moore & Co. for American River Electric Co. in 1907.

Buildings.—The power house is a steel frame structure on concrete foundation, is covered with corrugated iron and a wooden saw-toothed roof, and is 80 feet long by 59 feet wide. The generator room, including the main unit—exciters, condensers, pumps of various descriptions, motor generators, and switchboards—occupies the front of the station. A view from the front of the building toward the back shows on the right, behind the main turbo-generator unit, the boilers placed in a row parallel to the main axis of the plant in a space 39 feet long by 36 feet wide, and at the left the concrete transformer room, 32 feet long by 23 feet wide. The boiler space is only a backward extension of the generator room, but the transformers are separated from the rest of the station by concrete fire walls.

The turbo-generator unit is slightly to the right of the main axis of the station, with the condenser along its base, parallel to the main axis and between the main unit and the right wall of the station. The circulating pump is between the back end of the condenser and the wall, and the dry-vacuum pump between the front end of the condenser and the wall. The wet-vacuum pump is in a pit between the condenser and the boilers. The boiler feed pump and feed water heater are arranged in a line parallel to the shorter axis of the plant and between the main unit and the boilers. Fuel-oil pumps are immediately back of the condenser's circulating pump.

The two exciter sets are arranged on pedestals and are placed almost on the main axis of the station; one in front and the other back of the main unit. Between them and directly to the left of the main unit is the step-bearing oil filter, with duplicate step-bearing pumps parallel to its base—one back of it and the other in front. The pump which returns the oil after it has passed through the step bearings is in a pit directly under the filter. The two motor generator sets are in line parallel to and to the left of the main axis of the plant, and between them and the left wall, parallel to the latter, are the switchboards, with switching equipment between them and the wall.

The boilers are arranged in two banks and face toward the right wall at the back of the plant. There is a broad space in front of them and a 5-foot aisle between the banks and between the backs of the boiler settings and the concrete wall of the transformer room.

A broad sliding door on the left front of the plant gives access from the exterior to the generator room. Another sliding door is placed between the generator room and the front of the transformer room and a broad passage down the middle of the latter leads to a similar door at the back of the station. On each side of the transformer room are four transformer cells with concrete fire curtains.

The condensing cooling supply is drawn from the slough about 200 feet from the plant. Boiler-feed water is obtained from a well on the premises or from the city mains.

Mechanical equipment.—The boilers are arranged in two banks, each containing two Babcock & Wilcox boilers. Each boiler is rated at 500 horsepower and contains 196 4-inch tubes 18 feet long, arranged 14 high and 14 wide, one mud drum, and two 42-inch steam drums, one-half inch in plate thickness and 23 feet 8⅝ inches long, built to carry 200 pound steam pressure. Make-up water is supplied by two vertical Worthington duplex 9 by 6 by 10 inch boiler-feed pumps. The equipment includes a Cochrane feed water heater.

Oil drawn from tanks on the premises is supplied to the furnace by two Worthington horizontal duplex 6 by 4 by 6 inch pumps.

A Worthington surface-type condenser gives 6,000 square feet of condensing surface. Circulating supply is furnished by a Worthington centrifugal pump driven by a marine engine; both pump and engine are raised on a concrete pedestal opposite and close to the back end of the condenser. A Worthington 8 by 16 by 12 inch rotative dry-vacuum pump is placed opposite and parallel to the front end of the condenser. The motor-driven 2-stage Worthington centrifugal wet-vacuum pump is in a pit back of the condenser.

A 300-gallon Turner oil filter is mounted on a steel frame and oil is supplied to the step-bearing of the vertical unit from the filter by either of two Worthington 6 by 2⅜ by 6 inch duplex oil feed pumps, which can supply pressure as high as 700 pounds; under normal operation 410 pounds will raise the rotor.

The turbine of the vertical unit is a Curtis 1,500-kilowatt form F, designed for operation at 900 revolutions per minute, and at 175 pounds steam pressure, condensing.

Electrical equipment.—The main unit is a General Electric ATB 8-pole 2,300-volt 377-ampere 1,500-kilovolt-ampere 3-phase 60-cycle form T alternating-current generator, which was provided after its installation with a system of forced draft that enables it to carry 2,250 kilovolt-amperes without overheating. This draft is supplied by a motor-driven fan through a duct that leads from the outside of the front wall of the station at the level of the top of the generator. The duct divides at the unit, one branch going to the top and the other to the bottom of the generator. There is a down-turned bell mouth from the outer end of the duct; the air is sucked from outside the plant and forced through the generator windings.

The exciter set near the front of the plant consists of a General Electric class 45 form B 280-ampere 120-volt 35-kilowatt 900-revolutions-per-minute, continuous-current generator, driven by a General Electric type 1 3-phase 60-cycle 220-volt 120-ampere 50-horsepower induction motor. The set is mounted on a cast-iron base and is raised on a concrete pedestal about 2 feet above the main floor level. The second exciter is near the feed-water heater and is driven by a Curtis 35-kilowatt form A turbine, designed to operate noncondensing at a steam pressure of 150 pounds and at 3,600 revolutions per minute. This exciter is a General Electric type C 2-pole form T 120–125-volt 280-ampere 35-kilowatt continuous-current generator, operated at 3,600 revolutions per minute. Both the generator and the turbine of this set also are mounted on the same casting and raised on a concrete pedestal about 2 feet above the ordinary floor level.

The motor-generator set No. 1, near the front wall of the plant, consists of a Westinghouse 580-horsepower 2,200-volt 125-ampere 3-phase 60-cycle motor direct-connected to a Westinghouse 400-kilowatt 600-volt 668-ampere direct-current generator, both operated at 500 revolutions per minute.

No. 2 motor-generator set is between the No. 1 set and the transformer compartment; it consists of a General Electrical type AT 1 10-pole 580-horsepower form C 2,300-volt 145-ampere 3-phase 60-cycle synchronous motor, direct-connected to a General Electric type MPC 4-pole 400-kilowatt form H 667-ampere 550–600-volt continuous-current generator. Both motor and generator are operated at 720 revolutions per minute.

The switchboard consists of 19 panels, of which six control the outgoing and incoming circuits and station equipment. The plant is connected to the American River lines, to a branch from the system of Sierra & San Francisco Power Co., and through two tie lines to station A in Stockton. It serves power locally through 2,200-volt single-phase lighting, 2,200-volt power, and 650-volt direct-current railway circuits.

EUREKA PLANT.

History.—The Eureka steam station is on the south shore of Humboldt Bay in the western part of the city of Eureka. The original generating station on the site of the Eureka steam plant was installed by Eureka Lighting Co. in the days prior to hydroelectric transmission. The plant was remodeled in 1908 and was extensively altered in 1912 after it was acquired by Western States Gas & Electric Co. In 1917 its equipment was further changed by the transfer of a 500-kilovolt-ampere turbo-generator set and the necessary auxiliary equipment from a steam plant that had been maintained by the company in another part of the city.

Buildings.—The entire equipment is installed in a single building with concrete foundations, steel frame, and corrugated-iron covering. The older part of the present building measures about 48 feet square in plan, 26 feet 3 inches from floor to lower cord of roof truss, and has a peaked corrugated-iron roof. The newer part of the building, which was added at the south side of the older part, measures 38 feet 6 inches north and south by 32 feet east and west, so that the entire building is L-shaped in plan and measures about 86 feet 6 inches long and 48 feet deep in its north, and 32 feet deep in its south end. The newer part of the station measures 25 feet in height from the floor to the top of a future crane rail and has a flat-pitch concrete-slab roof.

The boilers are placed in a single row parallel to the north wall of the power house with an open passage ranging from 4 feet 6 inches to 6 feet 6 inches in width between them and the end and side walls. A short distance in front of the boilers a steel bridge, about 13 feet wide, 48 feet long, and 10 feet in height above the main floor level, crosses the full width of the power houses. It is supported by structural-steel columns and accommodates the 500-kilovolt-ampere unit moved into the station in 1917. The feed water heater and weigher, the feed pumps, and most of the auxiliary equipment for the unit are on the main floor immediately below the bridge.

An L-shaped deck, which is supported in the same manner and at the same height as the bridge, extends from its south side into the new part of the plant. This deck ranges in width from 19 to 13 feet and accommodates the 1,875-kilovolt-ampere turbo-generator. Most of the auxiliary equipment for both units is on the main floor of the plant immediately below the decks of the bridges.

Feed water for the boilers may be drawn either from the city mains or from a small stream near the power house. The condenser cooling supply is drawn from the bay through a 36-inch main about 700 feet long and is discharged through a 36-inch main.

A neighboring lumber mill, which burns its own sawdust and waste, supplies steam for keeping the electric-plant boilers heated up ready for stand-by service, and the stand-by use of fuel is thus minimized.

Mechanical equipment.—Steam is furnished by six Stirling water-tube boilers fired with oil and rated at 600 horsepower each. A single steel stack, supported by guy cables, serves the entire boiler equipment.

The feed-water supply may be delivered by either of two Platt Iron Works 12 by 8 by 12 inch Duplex pumps.

Immediately below the 1,875-kilovolt-ampere unit is a Worthington horizontal surface-type condenser, giving a cooling area of 6,250 square feet. The wet vacuum pump, in a pit about 4 feet deep immediately below the condenser, is of the Worthington 3-inch turbine type and is operated by a Terry steam turbine. The circulating pump is a Worthington 2-stage, size 12, driven by a Terry steam turbine at 1,600 revolutions per minute, with 160 pounds steam pressure. The dry vacuum for the unit is maintained by a Laidlaw-Dunn-Gordon 10 by 19 by 18 inch rotative pump. A 35-kilowatt Curtis turbine operated at 160 pounds pressure, noncondensing, drives the General Electric 35-kilowatt 125-volt 180-ampere direct-current exciter for the 1,875-kilovolt-ampere unit.

The condenser for the 500-kilovolt-ampere unit is of the same type as that for the larger machine and is directly below the turbine end of the unit. The circulating water for this condenser is furnished by a centrifugal pump driven by a 15-horsepower motor. In a pit about 6 feet below the main floor level are duplex wet-vacuum pumps. The dry-vacuum pump for the unit is on the main floor and is a Blake rotative 10 by 16 by 12 inch pump.

Electrical equipment.—The main unit is a General Electric horizontal steam turbo-generator, of 1,500-kilowatt capacity, operating condensing at 165 pounds pressure with a speed of 1,800 revolutions per minute. The generator is a General Electric type ATB 4-pole alternating-current machine, delivering 452 amperes at 2,400 volts. The maximum rating of the generator is 1,875 kilovolt-amperes and its normal rating at 80 per cent power factor is 1,500 kilowatts.

The smaller unit installed in 1917 is of the Westinghouse-Parsons horizontal type and is operated at 3,600 revolutions per minute. The generator of this unit is a Westinghouse 2,400-volt 120-ampere 3-phase 60-cycle 500-kilovolt-ampere alternator.

TRANSMISSION AND DISTRIBUTION SYSTEMS.

The transmission lines of the Eureka system of Western States Gas & Electric Co. consist of a main line running from the Junction City plant almost 65 miles due west to Eureka, with 10,000-volt branches extending from that point 20 miles to Arcata and Blue Lake and 24 miles to Fortuna, Loleta, and Ferndale.

The main line from the Junction City plant is a single 3-phase 60-cycle 60,000-volt circuit. The line passes through a rolling, mountainous country, covered in general with a very heavy growth of timber, and is supported by wooden poles. The conductor used is No. 3 (Brown & Sharpe) copper, except on some very long spans which consist of ⅜-inch 7-strand steel cable. The maximum span along the line is 2,250 feet.

The Stockton transmission system consists of two 55,000-volt lines which, running by way of different routes, form a loop from the American River plant near Placerville to Stockton. The line running on the north and west sides of the loop is 88.75 miles long; that running south and east by way of Jenny Lind is 87 miles long. The principal feeders are taken off near Stockton. The conductor on part of the loop is copper and on the rest aluminum. The system is also fed at Manteca by a line 15.5 miles long carrying 29,000-volt power from Sierra & San Francisco tower line.

TABLE 66.—*Single-circuit transmission lines operated by Western States Gas & Electric Co., 1920.*

Division and termini.	Miles of line.	Character of supports.	Voltage.
STOCKTON DIVISION.			
Manteca-Stockton	15.5	Wooden poles	27,000
American River plant-Stockton (north loop)	108.0	do	55,000
American River plant-Stockton (south loop)	91.0	do	55,000
	214.5		
EUREKA DIVISION.			
Weaverville-Junction City	10.0	do	60,000
Junction City-Eureka	65.0	do	60,000
Eureka-Blue Lake	20.0	do	10,000
Eureka-Fortuna and Ferndale	24.0	do	10,000
	119.0		

The Richmond system is a distribution and not a transmission system, as it is confined exclusively to the district in and around the city of Richmond.

In the summer of 1917 the lines of the Eureka system were connected with those of Northern California Power Co. Consolidated at the Junction City plant.

The substations on the Stockton system are given in Table 67, which shows that at the end of 1921 there were on the Stockton system 26 stations with a total capacity of 26,300 kilovolt-amperes, owned by the company. Pacific Gas & Electric Co. delivers power through substation A, in Stockton, substation No. 2, Natoma, and through a connection to the Sacramento Electric Railway; Sierra & San Francisco Power Co. delivers through substation B, in Stockton; the Great Western Power Co. of California through substation No. 1, Natoma, and Sheldon substation.

The combined capacity of substations on the Eureka system is 4,150 kilovolt-amperes, and power from them is distributed through 178.3 miles of primary, and 155.5 miles of secondary overhead lines.

The capacity of the Richmond substation is 2,850 kilovolt-amperes, and power is distributed through 103.6 miles of primary and 216.6 miles of secondary distribution lines.

TABLE 67.—*Substations operated by Western States Gas & Electric Co.*

District and substation.	Location.	Type of building.	Size.	Voltage of incoming circuits.	Service.	Capacity.	Equipment.
Stockton:			*Feet.*	*Volts.*		*Kilowatts.*	
Station A	Stockton			55,000	Serve Stockton and its suburbs with light and power through 560.9 miles of primary overhead distribution lines; in its business section there are also 40.5 miles of underground cable.	2,250	Transformers.
Station B	Stockton steam station	Corrugated iron, with steel frame.	80 by 59	27,000		5,250	Do.
Plymouth	Plymouth, 45 miles northeast of Stockton.			55,000	Plymouth serves town of Plymouth and vicinity with light and power at 2,200 volts, through 1.56 miles of primary overhead distribution lines.	100	Do.
Placerville	Placerville, 60 miles northeast of Stockton.			55,000	Serves town of Placerville with light and power at 2,200 volts, over 22.3 miles of primary overhead distribution lines.	300	Do.
Natoma No. 1	Natoma, 50 miles north of Stockton.	Corrugated iron		55,000	Serves dredgers at 2,200 volts	1,850	Do.
Natoma No. 2	do	do		55,000	do	850	Do.
Natoma No. 3	do			55,000		500	Do.
Natoma No. 4	do	Corrugated iron		55,000	Serves dredgers at 2,200 volts	850	Do.
Florin	Florin, 40 miles north of Stockton.	do		55,000	Serves town of Florin and vicinity with light and power at 2,200 volts, through 171.4 miles of primary overhead distribution.	450	Do.
Elk Grove	Elk Grove, 32 miles north of Stockton.	Outdoor		55,000	Serves town of Elk Grove and vicinity with light and power at 11,000 volts, over 55.6 miles of primary overhead distribution.	750	Do.
Camino	Camino, 7 miles east of Placerville.			55,000	Serves town of Camino and vicinity with light and power at 11,000 volts, through 7 miles of primary overhead distribution.	225	Do.
Copperopolis, French Camp.	Copperopolis, 5 miles south of Stockton.	Corrugated iron		55,000	Serves town of French Camp and vicinity with light and power at 11,000 volts, through 99.8 miles of primary overhead distribution.	450	Do.
Sheldon	Sheldon, 34 miles north of Stockton.			55,000	Serves town of Sheldon and vicinity with light and power at 4,400 volts, through 35.3 miles of primary overhead distribution.	600	Do.
Galt	Galt, 22 miles north of Stockton.	Corrugated iron		55,000	Serves town of Galt and vicinity with light and power at 2,200 volts, through 60.7 miles of primary overhead distribution.	450	Do.
Lodi (municipal)	Lodi, 15 miles north of Stockton.	do		55,000	Serves town of Lodi and vicinity with light and power at 4,400 volts, through 1,151.9 miles of primary overhead distribution.	2,100	Do.
Lodi No. 1	do	do		55,000	Serves Lodi and vicinity at 4,400 volts through 1,151.9 miles of primary overhead distribution.	3,000	Do.
Lodi No. 2	6 miles northeast of Lodi.	do		55,000	Serves Lodi and vicinity at 4,400 volts	1,500	Do.

TABLE 67.—*Substations operated by Western States Gas & Electric Co.*—Continued.

District and substation.	Location.	Type of building.	Size.	Voltage of incoming circuits.	Service.	Capacity.	Equipment.
			Feet.	*Volts.*		*Kilowatts.*	
Lodi No. 3	8 miles southeast of Lodi.	Corrugated iron		55,000	Serves Lodi and vicinity at 4,400 volts	1,000	Transformers.
National Ice Co.	Stockton			55,000	Serves ice company at 2,200 volts	450	Do.
Monarch Foundry	do	Corrugated iron		55,000	Serves foundry at 2,200 volts	750	Do.
Valley Springs	Valley Springs	do		55,000	Serves Valley Springs with light and power at 2,200 volts.	50	Do.
Mather Field	Mills station, 10 miles east of Sacramento.			55,000	Serves U. S. Government aviation field and vicinity at 2,200 volts.	300	Do.
Kroyer	Stockton	Outdoor substation		55,000	Serves area east of Stockton at 2,200 volts	500	Do.
Central California Traction Co. car barns.	do			55,000	Serves traction company at 2,200 volts	825	Do.
Central California Traction Co.	Ampere			55,000	do	825	Do.
Do	Sheldon			55,000	do	825	Do.
Plymouth Consolidated Gold Mines Co.	Plymouth			55,000	Serves mines	1,200	Do.
Jenny Lind	Jenny Lind	Corrugated iron		55,000	Serves town of Jenny Lind with light and power at 2,200 volts.	50	Do.

SNOW MOUNTAIN WATER & POWER CO.

HISTORY.

Snow Mountain Water & Power Co. was incorporated February 13, 1906, to succeed Eel River Power & Irrigation Co. The properties of the old company were taken over March 1, 1906, and work on power and irrigation projects which had been begun by the latter continued until April 18, when, on account of the financial stringency succeeding the earthquake in San Francisco, all work was suspended. In the fall of 1906 work was resumed on the construction of Cape Horn dam on Eel River, tunnel and pipe lines to the Russian River basin, a power house in the vicinity of Potter Valley and transmission lines to Ukiah.

First power was transmitted to Ukiah April 1, 1908, and the transmission lines were further extended during 1908 and 1909. The line was completed from Ukiah to Wrights station, near Santa Rosa, in the summer of 1908 and first connections established with the lines of Pacific Gas & Electric Co. September 8. The line was subsequently continued from Wrights station to the Santa Rosa substation of Pacific Gas & Electric Co.

In 1909 the transmission lines of the company were completed from Felton to St. Helena and down Napa Valley to Oak Knoll.

Snow Mountain Water & Power Co. first delivered electrical energy to Potter Valley in July, 1908; to the Mendocino State Hospital in November, 1909; to California Telephone & Light Co. in October, 1912; to Mount Konocti Light & Power Co. in August, 1911; to Cloverdale Light & Power Co. in August, 1908; to Napa Valley Electric Co. June, 1909.

LOAD.

The company wholesales its entire output to other utilities and to the city of Ukiah and the Mendocino State Hospital. Power was being delivered at the end of 1921 to California Telephone & Light Co. (a distributing company, see p. 1259) at Potter Valley, Talmadge, and Asti; to Napa Valley Electric Co. (a distributing company, see p. 1256) at St. Helena; to Pacific Gas & Electric Co. at Santa Rosa; to Mendocino State Hospital through Talmadge substation, 3 miles southeast of Ukiah; and to the city of Ukiah.

Operating records show the following average and peak loads and annual load factors for the years 1908 to 1920:

TABLE 68.—*Load carried by Snow Mountain Water & Power Co.'s system, 1908–1920.*

Year.	Average for system.	Peak.	Load factor.
	Horsepower.	*Horsepower.*	*Per cent.*
1908	160	400	40
1909	745	5,000	15
1910	3,050	6,600	45
1912	4,300	6,600	65
1913	3,860	6,700	58
1914	3,800	6,700	57
1915	4,200	....	......
1916	3,870	7,100	55
1917	3,760	7,440	51
1918	3,670	8,570	43
1919	4,078	....	......
1920	3,692	....	......

The sales of power to Pacific Gas & Electric Co. and California Telephone & Light Co., the principal purchasers, for the years 1913–1920, are as follows:

TABLE 69.—*Power (in kilowatt-hours) generated and sold by Snow Mountain Water & Power Co., 1913–1920.*

Year.	Power generated.	Sales.		
		Pacific Gas & Electric Co.	California Telephone & Light Co.	Total.
1913	25,234,200	19,624,215	463,050	20,087,265
1914	24,824,700	18,737,614	787,380	19,524,994
1915	27,555,600	20,872,132	942,418	21,814,550
1916	25,312,300	18,477,826	870,240	19,348,064
1917	24,558,300	17,942,437	1,113,696	19,056,133
1918	23,998,500	17,616,384	1,213,003	18,829,387
1919	25,866,800	17,307,442	1,286,100	18,593,542
1920	22,383,000	14,844,817	1,980,100	16,824,917

Power is exchanged between Pacific Gas & Electric Co. and Snow Mountain Water & Power Co. under the terms of a 20-year "give and take" contract, signed August 25, 1908, in which the rate is fixed at 0.505 cent per kilowatt-hour. During times of low water at the Potter Valley plant, Snow Mountain Water & Power Co. has purchased power from Pacific Gas & Electric Co. as follows:

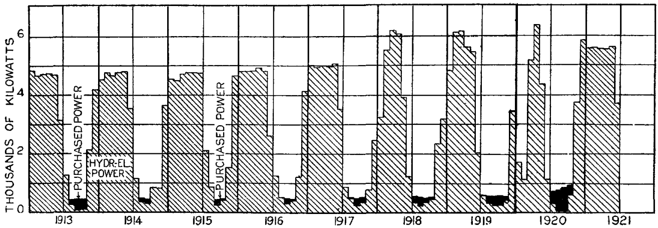

FIGURE 20.—Snow Mountain Water & Power Co., mean monthly loads, 1913-1921.

TABLE 70.—*Power purchased by Snow Mountain Water & Power Co., 1913–1920.*

	Kilowatt-hours.		Kilowatt-hours.
1913	698,175	1917	357,988
1914	220,167	1918	601,289
1915	187,662	1919	789,655
1916	174,230	1920	1,750,069

Mean monthly loads and typical daily load curves are shown graphically in figures 20 and 21.

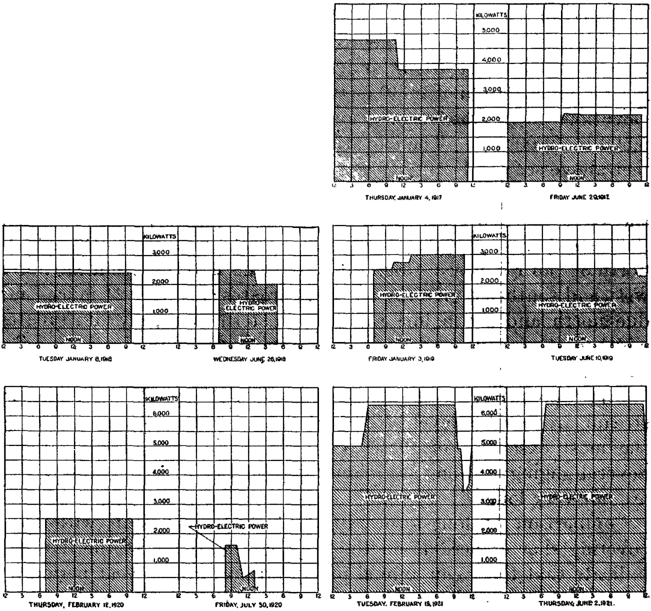

FIGURE 21.—Snow Mountain Water & Power Co., daily load curves, 1917–1921.

ELECTRIC SYSTEM.

POTTER VALLEY GENERATING PLANT.

LOCATION.

The Potter Valley power house is on a small tributary of Russian River in the NW. ¼ sec. 6, T. 17 N., R. 11 W., but the intake dam is on South Fork of Eel River in sec. 30, T. 18 N., R. 11 W., and the tunnel and pressure lines traverse secs. 30 and 31 of that township and sec. 6, T. 17 N., R. 11 W.

The first two units of the Potter Valley plant were put into commission April 1, 1908, a third went into operation March 1, 1910, and the fourth September 15, 1917.

SOURCE OF WATER SUPPLY.

The plant receives its entire water supply from South Eel River, which rises on the west slope of the Coast Range, near the northern boundary of Lake County, and flows south and southwest about 15 miles, then westerly about the same distance to the Cape

Horn dam site. A considerable area in the southwestern part of the basin above the dam site is drained by Rice Fork of Eel River. The highest part of the whole basin is along its eastern boundary, between South Eel River and Rice Fork, where Snow Mountain reaches an elevation of 7,440 feet and Signal Peak 7,460 feet. General elevations along the eastern and northern boundaries range from 5,500 to 7,000 feet. The elevation at the point of diversion is 1,485 feet above sea level.

The 326.5 square miles of drainage basin above what is known as the Cape Horn diversion dam is almost entirely in the California National Forest, directly north of Clear Lake and about 110 miles north of San Francisco. Secondary streams entering from the northwest and southeast give the basin its greatest length—24 miles—in a due north and south line along its eastern boundary, its greatest width east and west through its central portion is about 18 miles. The forest cover is in general very good.

The topography of the basin is decidedly rugged, but along the stream are several level stretches. The company proposes to use the most extensive of these—Gravelly Valley—as a reservoir site. Several gaging stations are maintained on Eel River but the records are not very long.[88]

Comparison of long-term rainfall records at Ukiah with those covering shorter periods on the drainage basin above the dam site indicate that the mean annual precipitation for a 33-year period has been 48.51 inches, the maximum 78.62 and the minimum 25 inches.[89]

RESERVOIRS.

During the summer of 1920 the company began the construction of a cyclopean concrete dam with straight crest and ogee gravity section at the outlet of Gravelly Valley. The elevation of the river bed at this point is 1,795 feet, and the spillway level of the dam now under construction is 1,900 feet above the sea, with a corresponding reservoir area of 2,003 acres and storage capacity of 73,163 acre-feet. Plans already drawn contemplate the possibility of heightening the dam to a spillway level of 1,950 feet, with a corresponding reservoir area of 3,703 acres and storage capacity of 214,813 acre-feet. It was originally intended to construct the dam with a straight crest with a spillway section 485 feet long at an elevation of 1,900 feet, with abutments at either end rising 10 feet higher, the total crest length being 679 feet. After the dam had been completed to a distance of 515 feet from the north abutment, it was decided to

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[88] For records of stream flow on Eel River, see U. S. Geol. Survey Water-Supply Papers as follows: 300 pp. 791–795 (up to Sept. 30, 1911); 361, pp. 391–395 (1910–1913); 391, pp. 278–282 (1913–14); 411, pp. 281–284 (1914–15); 441, pp. 254–256, 323 (1915–16); 461, pp. 249–251, (1916–17); 481, pp. 241–242, 306, (1917–18).

[89] In these computations, by N. A. Eckart, the mean on the drainage basin is assumed to be 130 per cent of that at Ukiah.

connect with the south abutment by constructing the remainder of the dam at an angle of 44° with the original structure, the distance to solid rock being shorter on this line than on the original. The structure is practically complete, with the exception of a small auxiliary power house not yet started.

Of the entire 326.5 miles above the Cape Horn diversion dam, 268 miles is tributary to the Gravelly Valley reservoir site and 58.5 miles lies between it and the diversion dam.

The equalizing storage behind the Cape Horn dam is about 35,000,000 cubic feet.

CONDUIT.

The Cape Horn (or John Day) diversion dam was constructed by Eel River Power & Irrigation Co. and Snow Mountain Water & Power Co. in 1905–1907 from plans prepared by Edwin Duryea, jr., member of the American Society of Civil Engineers. The structure is of a composite type—the spillway being of a concrete gravity section and the rest of the dam hydraulic fill. The spillway is stepped on the downstream face and is founded on solid rock, the maximum height of masonry being 63 feet. It is not built on a straight line but forms an obtuse angle upstream of 153°. The spillway is 288.6 feet long, its lip being at elevation 1,485 feet, and is designed to pass floods to a depth of 20 feet over its crest, equivalent to a discharge of 85,000 second-feet. The greatest flood that has passed the dam occurred January 14, 1910, when the depth was 10.4 feet, equivalent to 33,500 second-feet. A sluice 5 feet in diameter, with pressure-operated sluice gate, is provided in this section for drawing down the reservoir.

At its south end the concrete spillway abuts against solid rock and at its north end against a heavy concrete wing wall which serves as a retaining wall for the end of the earth-fill section of the dam. The elevation of the crest of this section of the dam is 1,513 feet or 28 feet above the lip of the spillway. The crest is 10 feet wide and the slopes are 3:1 on the upstream and 2½:1 on the downstream face. Both faces are heavily riprapped to a point above the high-water levels. The earth section was built by the hydraulic-fill method and is provided with a concrete core wall.

The water supply for the power plant is drawn from the equalizing reservoir by a tunnel which taps the pond at elevation 1,460 feet, 25 feet below the lip of the spillway.[90] A heavy trash rack covers the mouth of the tunnel and prevents the entrance of any drift or other débris which might affect the operation of the wheels. About 200 feet in from the tunnel portal a heavy cast-iron gate, 6 feet by 6 feet 6 inches in size, set in a concrete bulkhead and operated by a worm

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[90] The writer is indebted to Mr. Nelson A. Eckart and to Mr. W. R. Eckart, jr., for many of the data on the Potter Valley conduit.

and gear from the surface, controls the flow of water in the tunnel and pressure line. The principal dimensions of the tunnel are:

Length under pressure	feet..	5,657.4
Top width	do....	5
Height	do....	7½
Bottom width	do....	6
Area of section	square feet..	38.11
Wetted perimeter	feet..	24.26
Grade	per cent..	0.3
Hydraulic radius	feet..	1.57

The tunnel is lined throughout its entire length. The roof and sides are lined with pine timber ranging from 8 to 16 inches in thickness; the sets are placed directly adjoining each other and form a smooth surface of solid timber; the floor is concrete, laid in the segment of a circle and reinforced where necessary. Besides the gate shaft, which affords a means of entrance to the pressure side of the gate, two other shafts tap the tunnel. One, about 50 feet below the gate, was used in driving the north heading after the dam was raised above the level of the tunnel floor; the other shaft, 4 by 5 feet in the clear, sunk after the tunnel was completed, is immediately back of the bulkhead at the connection of the tunnel and steel pipe and serves as a standpipe or surge shaft.

This concrete bulkhead is at station 57+87.4 of the tunnel, is 6½ feet thick, and is well keyed into the sides of the tunnel. A section of steel pipe, tapering from 7 feet in diameter at its mouth to 5 feet 6 inches in diameter at its lower end, where it joins the first length of riveted steel pipe, passes through the bulkhead. This first section of steel pipe, 194 feet long, reaches to a point a short distance beyond the south portal of the tunnel, where it connects with a sand box or settling chamber, which is simply a short length of 10-foot pipe provided with a blow-off valve, by means of which any gravel that has passed the trash rack can be blown out of the pipe line.

Beyond the sand box, for a distance of 367 feet, an 84-inch (inside diameter) wood-stave pipe is laid on a bench excavated from the side hill. It is supported by earth tamped in under the pipe and banked up to a point about one-third the way up the side of the pipe. This pipe is further protected by a corrugated-iron housing, open at the sides to permit a free circulation of air. Concrete gutters protect the pipe foundation from all surface water or seepage.

At the end of the wood-stave section the pipe makes a bend of 30° through a riveted steel elbow and reduces, by means of a taper section, to 5 feet 6 inches diameter—the size of a riveted-steel flanged pipe which extends 825 feet through a concrete-lined tunnel to another taper piece. This second taper increases the size of the line to 7 feet, to connect to a second section of wood-stave pipe, 359 feet long, laid, covered, and protected in the same manner as the first section.

This section of wooden pipe is connected into an 84-inch riveted steel Y, with two 62-inch branches, in each of which there is a heavy cast-iron gate valve. Each branch connects to a pipe that leads down the hill toward the power house, a distance of about 1,800 feet. Each pipe works under a head of 50 feet at its upper end and 465 feet at its lower end, at which point it is nine-sixteenths of an inch thick. Their diameter reduces from 62 inches at the upper end to 58 inches at the lower. Air valves are provided at intervals along the entire pipe line; and at the brow of the hill, immediately below the Y, there is a standpipe 24 inches in diameter, the top of which is carried to an elevation of 32 feet above the crest of the dam at Cape Horn.

The 58-inch pipes terminate in Y's with two 40-inch branches, which taper to 36 inches, where the hydraulically operated gate valves are inserted just outside the power house. These valves are used for cutting off the water from units. The first 62–58 inch pipe down the hill was laid in 1908. The second was not put in until 1911, in the mean time a temporary 30-inch branch had been tapped out of the first line through a semisteel saddle piece for the purpose of supplying water to the third unit, which was installed after the first two.

The present installed capacity of the power plant is 9,000 kilovolt-amperes, but the tunnels and pipe lines are designed for a capacity of 350 second-feet, a flow sufficient to develop 10,000 kilowatts.

After passing through the turbines the water drops into a concrete tailrace, in which it is carried a short distance from the power house before discharging into an excavated canal that leads to a small tributary of Russian River. This canal is built on a right of way 100 feet wide, its total length being about a mile. Maximum normal water surface at the dam is 1,485 feet and the power-house floor 1,014.5 feet above sea level, giving a difference of elevation of 470.5 feet. The tailrace floor is only 6 feet lower than that of the generator room. The effective head at normal rating is 464 feet.

GENERATING STATION.

Power house.—The Potter Valley power house is a concrete building with steel roof trusses and corrugated-iron roof. The main portion of the building is 101 feet 4 inches long and 35 feet 4 inches wide, but on the front there is a bay 9 feet deep and 51 feet 4 inches long. The west end of the bay is 13 feet from the west end of the building. The generator room occupies the entire interior of the building. The power house contains four units, two of which are set across the east end of the room and the other two parallel to the back wall in the west end. The exciter equipment is in the open space between the last two units and the front wall, against which the switchboard is installed. The entire room is commanded by a traveling crane. The transformer house, about 20 feet from the end of and on line with the main axis of the generating station, is 58 feet long. The western half of the building is 10 feet and the eastern half 20 feet deep. At the opposite end of the transformer house from the generating station there is a set of Bowie air-brake disconnecting switches with horn gaps.

Hydraulic equipment.—Units 1 and 2 are operated by 48-inch 4,000-horsepower Platt Iron Works Victor turbines; units 3 and 4 are operated by 50-inch Allis-Chalmers Francis turbines, each rated at 4,000 horsepower and controlled by an Allis-Chalmers governor.

Generators.—Generators 1 and 2, identical in design, are Westinghouse 2,000-kilovolt-ampere 2,300-volt machines, operated at 400 revolutions per minute. Generator 3 is an Allis-Chalmers 3,000-kilovolt-ampere 2,300-volt 750-ampere 3-phase 60-cycle machine, operated at 450 revolutions per minute. Generator 4 is an Allis-Chalmers 2,000-kilovolt-ampere 2,300-volt 502-ampere 3-phase 60-cycle machine, also operated at 450 revolutions per minute.

Exciters.—The original exciter set contained two Westinghouse 55-kilowatt 125-volt 440-ampere continuous-current generators, driven at 850 revolutions per minute by a Pelton impulse wheel mounted between them and connected to them through flexible leather couplings. Exciter set No. 2 is an Allis-Chalmers 80-kilowatt 120-volt 666⅔-ampere direct-current generator operated at 850 revolutions per minute either by an Allis-Chalmers 120-horsepower 2,300-volt motor or by an Allis-Chalmers 150-horsepower turbine controlled by an Allis-Chalmers governor.

Transformers.—Three 2,000-kilovolt-ampere 1-phase 60-cycle oil-insulated water-cooled transformers connected delta on the low tension and Y grounded on the high tension side step potential up from 2,300 to 55,000 volts. A spare transformer is available for use in emergencies.

Wiring.—The leads from the generators are carried in ducts to the switchboard and thence in underground ducts to the west end of the transformer house. The high-tension leads pass out of the opposite end of the building, through square glazed openings, to pin insulators mounted on brackets on the wall. From these there is a short span to the insulator bracket on the frame of the Bowie switches.

TRANSMISSION AND DISTRIBUTION SYSTEM.

The company's transmission system at the end of 1921 consisted of 106.51 miles of pole line carrying one 3-phase 55,000-volt circuit, running southward from Potter Valley plant to Santa Rosa, including a 30.71-mile branch eastward from Fulton to St. Helena and Oak Knoll, and 3 miles of pole line carrying one 3-phase 23,000-volt circuit. A tap 0.33 mile long carrying one 3-phase 55,000-volt circuit connected the main transmission line to the Santa Rosa substation of the Great Western Power Co. A 13.1-mile construction line runs from Potter Valley to the Gravelly Valley (Scott) dam.

The distribution system operated by the company merely suffices for deliveries to its wholesale customers, most of which are made through the transformer equipment at Potter Valley plant, the Talmadge substation 450 kilowatts rated capacity, and the Santa Rosa substation of Pacific Gas & Electric Co.

COAST COUNTIES GAS & ELECTRIC CO.

HISTORY.

Coast Counties Gas & Electric Co. is a consolidation of several small electric and gas systems that formerly operated in the territory between Santa Cruz, Santa Cruz County, and Hollister, San Benito County. Of these small companies Big Creek Light & Power Co. was the only one that owned a hydroelectric plant; all the other electric generating stations were operated by steam.

Coast Counties Gas & Electric Co. is more nearly a transmission and distribution company than a generating concern, as it purchases more than half its power from Pacific Gas & Electric Co. It regularly operates only the small hydroelectric station on Big Creek, in Santa Cruz County, but it generates steam-electric power at a station in Santa Cruz in times of emergency or in connection with heating the plunge baths at Santa Cruz, and at a station in Watsonville in emergencies only.

In addition to its electrical business the company operates gas plants in the cities of Santa Cruz, Watsonville, Hollister, and Gilroy and controls the Union Traction Co., which operates city and interurban lines in the vicinity of Santa Cruz.

MARKET.

TERRITORY AND POPULATION.

The area and population of Monterey,[91] San Benito, Santa Clara, and Santa Cruz counties, which are served in part by the transmission lines of the company, are shown by Table 9 (p. 64), and the general features of the counties are briefly described on pages 66–72. The population of the incorporated communities served is shown by Table 71.

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[91] The system reaches only the extreme northern edge of Monterey County.

TABLE 71.—*Communities served by Coast Counties Gas & Electric Co.*

Incorporated places.

City or town.	County.	Population.			
		1890	1900	1910	1920
Gilroy	Santa Clara	1,694	1,820	2,437	2,862
Hollister	San Benito	1,234	1,315	2,308	2,781
Morgan Hill	Santa Clara			607	646
San Juan	San Benito	463	449	326	501
Santa Cruz	Santa Cruz	5,596	5,659	11,146	10,917
Watsonville	do	2,149	3,528	4,446	5,013
		11,136	12,771	21,270	22,720

Unincorporated places.

Aptos.
Ben Lomond.
Capitola.
Corralitos.
Dunville.
Glen Arbor.
Aromas.
Brookdale.
Chittenden.
Del Mar.
Felton.
Logan.
Mount Hermon.
San Felipe.
Sargents.
Vega.
Coyote.
Pajaro.
San Martin.
Soquel.
Tres Pinos.
Madrone.

LOAD.

Detailed information concerning load carried on the system is not so complete as for most other companies, but the chief load aside from lighting and small manufacturing in the towns is largely agricultural. The connected power load in 1913 was 3,360 kilowatts; in 1914, 3,880; in 1915, 3,982; in 1916, 4,010; in 1917, 3,703 kilowatts; in 1918, 5,010 kilowatts; in 1919, 6,564 kilowatts; in 1920, 8,830 kilowatts.

The connected power load on the various substations December 31, 1920, was as follows: Santa Cruz, Ben Lomond, and Davenport, 1,489; Watsonville and Lilliencranz, 2,368; Hollister, 2,381; and Gilroy and Morgan Hill combined, 2,595 kilowatts; total, 8,833 kilowatts.

Total kilowatt-hour sales for the various years were 5,534,959 in 1914, 5,210,045 in 1915, 6,712,126 in 1916, 6,293,900 in 1917, 7,598,000 in 1918, 8,445,000 in 1919, and 10,182,161 in 1920.

During 1920 the company sold 10,182,161 kilowatt-hours, distributed as follows: Santa Cruz, 3,446,088; Ben Lomond, 150,897; Davenport, 41,884; Watsonville, 2,311,700; Logan, 309,900; Hollister, 2,614,870; Gilroy and Morgan Hill, combined, 1,306,822.

Figures showing growth of connected load are not available, but the growth in number of consumers of gas and electricity for the years 1909 to 1920 is shown in Table 72.

TABLE 72.—*Growth in number of consumers served by Coast Counties Gas & Electric Co.*

Year.	Number of consumers.			Year.	Number of consumers.		
	Gas.	Electricity.	Total.		Gas.	Electricity.	Total.
1909	1,912	3,095	5,007	1915	3,486	6,088	9,574
1910	2,017	3,539	5,556	1916	3,619	6,584	10,203
1911	2,725	4,627	7,352	1917	3,579	6,727	10,306
1912	3,161	4,862	8,023	1918	3,633	7,036	10,669
1913	3,281	5,535	8,816	1919	3,688	7,895	11,583
1914	3,497	5,982	9,479	1920	4,192	9,115	13,307

Of the electric consumers in 1920, 8,284 used light and 816 power. The mean monthly loads for the system, computed from the output in kilowatt-hours of all hydroelectric and steam plants and from kilowatt-hours purchased, are shown in figure 22. Curves showing monthly peaks and daily load are not available.

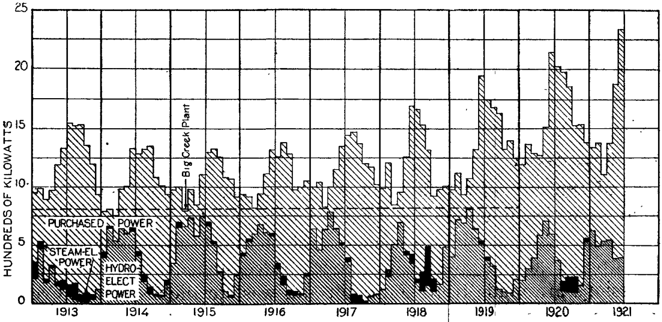

FIGURE 22.—Coast Counties Gas & Electric Co., mean monthly loads, 1913–1921.

The quantity of power generated by steam and hydroelectric plants belonging to the system and purchased from Pacific Gas & Electric Co. through the Davenport and Morgan Hill substations of the latter during the years 1913–1920 are shown by Table 73, which follows.

TABLE 73.—*Electric power (in kilowatt-hours) produced and purchased by Coast Counties Gas & Electric Co., 1913–1920.*

Year.	Generated.		Total.	Power purchased.
	Hydroelectric.	Steam.		
1913	1,240,800	621,880	1,862,680	10,575,953
1914	3,216,240	237,900	3,454,140	5,813,558
1915	4,042,400	114,700	4,157,100	5,071,440
1916	3,161,600	207,400	3,369,000	6,072,699
1917	3,032,000	171,400	3,203,000	7,081,518
1918	2,553,000	595,000	3,148,000	7,335,000
1919	3,586,400	55,300	3,641,700	8,322,800
1920	2,999,200	280,840	3,280,040	10,656,358

ELECTRIC SYSTEM.

BIG CREEK PLANT.

LOCATION.

The only hydroelectric plant on the system is on Big Creek, about 14 miles northwest of the city of Santa Cruz. The main intake is in the NE. ¼ sec. 5 and the power house in the NW. ¼ sec. 8, T. 10 S., R. 3 W. The plant was constructed in 1896 by Fred C. Swanton, of Santa Cruz, aided by local capital, and was sold by its original owners in 1900 to one of the predecessors of Coast Counties Gas & Electric Co.

As originally constructed the plant contained one 150-kilowatt generator. In 1897 another of the same type and capacity was added. In 1899 one of the 150-kilowatt generators was replaced by a machine of 180-kilowatt capacity. In 1902 a 450-kilowatt unit was added, and in 1904 the second 150-kilowatt generator was replaced by a machine of 180-kilowatt capacity. The date of installation of the third 180-kilowatt machine is not available.

SOURCE OF WATER SUPPLY.

Big Creek, from which the plant derives its water supply, rises on the southwest slope of Ben Lomond Mountain, about 14 miles northwest of the city of Santa Cruz, and flows nearly due south to the point at which it enters the Pacific Ocean, about 1½ miles north of El Jarro. Only a relatively small part of the total drainage area of the stream supplies water for power development, for the power diversions are made from the main and west branches of Big Creek and from its principal tributary, Mill Creek, at an elevation of about 1,200 feet. The canyons of these streams are deep, very rough, and are filled with a moderately heavy growth of redwood. On the upper ridges the trees give way to a dense cover of brush, with occasional potreros, or dry mountain meadows. The highest parts of the basin are somewhat more than 2,500 feet above sea level. Rainfall measurements, made by employees of the company, show seasonal rainfall ranging from 19.1 to 45.2 inches. Stream flow dwindles to an almost negligible quantity during the driest months of dry seasons, although the run-off is far above the capacity of the conduit and small storage reservoirs during the rainy season.

RESERVOIRS.

The Big Creek plant is provided with three small reservoirs in addition to an excavated forebay reservoir near the head of the pressure pipes.

The reservoir on Big Creek itself is a short distance above the conduit intake and is formed by a log-crib dam, 12 feet in maximum height and between 60 and 70 feet in length. The area of the reservoir is approximately 1 acre. Its capacity is very small, and it serves merely to store the flow during the day in low-water seasons for use during the peak hours in the evening, thus affording a small amount of pondage in addition to that in the forebay reservoir.

The reservoir on the West Branch of Big Creek was constructed in 1898, and is 500 feet upstream from and about 100 feet higher in elevation than the branch flume leading from West Branch of Big Creek to the main Big Creek flume. The dam is 40 feet high and about 530 feet long on top. It has a timber frame, is faced with plank, and earth has been sluiced in on top of its inclined plank facing to increase the tightness. Maximum area of the reservoir at spillway level is 14 acres and its capacity 89.5 acre-feet. Water is discharged from the reservoir through two sluice pipes, one 14 inches in diameter and the other 16 inches, which run through the dam 30 feet below its crest. In the crest of the dam is a spillway or chute 2.5 feet deep and 5 feet 10 inches wide.

The Mill Creek reservoir, which is a short distance from the head of the conduit, is formed by a timber-crib dam filled with rock and earth. The dam is 73 feet high, 275 feet long on the crest, and 20 feet on the bottom. Its thickness up and down stream at the base is 112 feet, and it has a batter of one in four on both the up and down stream faces. The downstream face, however, is in a rather unfinished condition, having been stepped back at various levels. The face of the dam is covered by three layers of 2-inch planks and 1 layer of 1-inch redwood boards. For its height the dam is decidedly bulky, for it contains approximately 20,000 cubic yards of material. The water stored in the reservoir is discharged through two 14-inch sluice pipes which run through the dam. The capacity of the reservoir is about 400 acre-feet. Construction of the dam was begun early in 1901 and completed in January, 1902.

The forebay reservoir excavated from the top of the ridge at the head of the pressure pipe was originally 30 to 40 feet wide, 400 feet long, 5 to 6 feet deep, and had a capacity of 60,000 cubic feet. It was unlined, however, and has become partly filled up, so that its present capacity is probably 30,000 cubic feet or less.

Surveys by the company's engineers give the drainage areas tributary to the various reservoirs as follows:

	Square miles.
Mill Creek above reservoir dam	0.740
West Branch of Big Creek above reservoir dam	2.026
Big Creek above reservoir dam	7.107
	9.873

CONDUITS.

The main Big Creek conduit is a wooden flume, 30 inches wide, 18 inches deep, and 10,800 feet long, is laid on a grade of 2 feet per thousand, and has a maximum capacity of 15.6 second-feet. About half a mile below its head a small side flume brings in the water from West Branch of Big Creek.

Mill Creek conduit is entirely flume, 16 by 14 inches in cross section and of the closed-box type, laid on a grade of 10 feet per thousand; its capacity is 10 second-feet. At its lower end it runs into the excavated forebay reservoir, which in turn connects through a short section of flume with the penstock box at the lower end of the main Big Creek conduit and at the head of the pressure pipe.

The single-pressure line from the box heading to the power house is 1,965 feet long. Its upper part (about one-half of its total length) is composed of 16-inch iron and the rest of 14-inch riveted steel pipe. The 16-inch pipe is slip jointed, the sections being driven together to secure a tight fit. The 14-inch pipe has leaded sleeve joints, the bands being 6 inches wide and five-sixteenths of an inch thick, with a ⅜-inch lead space. The plate thickness of 16-inch pipe is No. 12 gage; the 14-inch pipe ranges in thickness from No. 10 to No. 5.

The elevation of water surface in the wooden forebay box is 1,116.9 feet above sea level, and the elevation of the nozzle centers at the power house 191.9 feet, giving a static head of 925 feet. Owing to the configuration of the ground and to the methods of joining the sections, the pipe is very crooked, and the losses due to friction are therefore unusually high. Engineers employed by the company have estimated that the maximum power output of the plant is obtained with 15 second-feet of water and an operating head of 800 feet.

GENERATING STATION.

Power house.—Big Creek power house is a wooden structure on the northwest side of the stream at an elevation of 192 feet above sea level. The power house formerly measured 120 feet in length by 40 feet in breadth and contained not only the hydroelectric units but a steam engine of 300 kilowatts capacity, installed in 1900 to drive the generators during the dry season of each year. The steam engines and boilers have since been removed, and the part of the building that houses the boilers has been partly torn down.

Hydraulic equipment.—Units 1 and 2 are of 180-kilovolt-ampere capacity, and each is driven by a single 300-horsepower Pelton wheel set between bearings and equipped with deflecting nozzle; one of them is equipped with a flywheel.

A third 180-kilowatt generator and a 450-kilowatt generator are mounted with shafts in line and are operated by a 52-inch 900-horsepower single Pelton wheel at 514 revolutions per minute. The impulse wheel of this unit has a rigid connection to the shaft of the 180-kilowatt generator but is joined through a flexible leather coupling to a large flywheel on the end of the shaft of the 450-kilowatt machine.

Generators.—The three smaller machines are 180-kilovolt-ampere 1,100-volt 2-phase alternating-current generators. The fourth machine is a Westinghouse 450-kilovolt-ampere 1,100-volt 204-ampere 2-phase 60-cycle alternating-current generator, operated at 514 revolutions per minute.

Exciters.—The station is equipped with two exciters; one of these is a composite unit with a 5-horsepower 125-volt direct-current generator on each end of the main shaft, operated by a Pelton impulse wheel direct-connected on the center of the shaft; the other exciter is an 11-kilowatt 125-volt 90-ampere direct-current generator, also driven by a 15-horsepower Pelton impulse wheel.

Transformers.—The step-up transformer equipment consists of two General Electric 400-kilowatt water-cooled HTQ transformers, which raise the voltage from 1,100 to 22,000. They are connected by the Scott method to give 3-phase current for transmission from the 2-phase current of the generators.

The station is equipped with a set of Westinghouse static interrupters, mounted on the wooden frame of the building, above the switchboard. The stub transmission line from the plant connects with the main line of the company's transmission system 7 miles eastward at Ben Lomond.

STEAM-ELECTRIC PLANTS.

SANTA CRUZ STEAM PLANT.

History.—Santa Cruz steam plant was built by Coast Counties Light & Power Co. in 1907 and was transferred with the other properties of its builders to Coast Counties Gas & Electric Co. in 1912.

Building.—The steam station faces south on the street paralleling the Ocean Beach directly behind the Seaside Casino. The building is of the Mission style, of reinforced-concrete construction, one story high, covered with concrete slab roof supported on steel roof frame. A single longitudinal wall divides the building into the power station proper, running the full width of the front, and a back room which is used for auxiliary equipment.

Five boilers, arranged in two banks of two each, and one separate, are placed in a row parallel to and close to the east end of the generator room. The two vertical reciprocating engines and the single turbogenerator which operate the generating equipment are set on line parallel to the row of boilers down the center of the room. The two old generators that were operated by belts from the vertical engines, two motor generators, and some substation equipment are placed along the west wall of the generator room; the switchboard and other substation equipment is installed along the back or north wall of the room.

Mechanical equipment.—Boilers Nos. 1 and 2 are of Babcock & Wilcox manufacture and have one hundred and twenty-six 4-inch tubes 18 feet long, arranged 14 wide and 9 high; they are equipped with two 36-inch drums 20 feet 4 inches long. Boilers Nos. 3, 4, and 5 are smaller, having only sixty-three 4-inch tubes, 16 feet long, arranged 7 wide and 9 high; each of these is equipped with one 26-inch drum. All the boilers are designed for operation at 160 pounds steam pressure. There is a single self-supporting smokestack of steel; the base of this stack rests on the concrete floor of the plant between boiler banks 1 and 2, with the furnaces connected to it through steel breeching back of the boilers. The boilers are fired by oil supplied by Worthington duplex pumps, set near the base of the stack.

The prime movers for the original generators are two Fitchburg vertical compound engines, connected to their respective generators by belts. This equipment—both generators and engines—is still kept in operating order though seldom used. One of the generators can now be operated by a motor installed beside one of the old compound engines.

Boiler feed water is supplied by two Worthington duplex pumps mounted on a raised concrete foundation on the main floor of the generator room near one of the old vertical engines, and the feed-water heater is near the steam pump. A circulating pump and a Wheeler surface condenser are installed in the basement under the central part of the generator room, near the base of the turbo-generator. The Wheeler 6-by 14 by 10-inch rotative dry-vacuum pump is on the main floor between the turbo-generator and the boilers. Cooling supply for the condenser is drawn through a 16-inch pipe which runs in from an ocean pier and passes under the Casino and the street in front of the steam station. Water is discharged through a 10-inch main.

Electrical equipment.—The turbo-generator is a General Electric-Curtis vertical unit of 500-kilovolt-amperes capacity, operated at 1,800 revolutions per minute, condensing at 140 pounds steam pressure.

The two older belt-driven generators were General Electric MP 4-pole 180-kilowatt 500–590-volt 340-ampere machines, operated at 475 revolutions per minute.

Excitation for the plant is furnished by a General Electric type CE form B 4-pole 11-kilowatt 88-ampere 125-volt direct-current generator, which is belt-driven at 1,200 revolutions per minute by a Sturtevant type VS 5 vertical engine, with 5-inch cylinder and 5-inch stroke.

Two motor generators are operated on the street-car load; the larger one during the rush hours, the smaller in starting and during off-peak hours. Both of these motor-generators are units rebuilt by the Farnsworth Electrical Co. The larger set consists of a form MP 8-pole 375-kilowatt 550–625-volt direct-current generator, direct connected to an ATB form A 535-horsepower 2,200-volt 91-ampere induction motor, operating at 450 revolutions per minute.

The smaller set consists of a General Electric type MP 4-pole 100-kilowatt 500–555-volt 182-ampere direct-current generator and a Westinghouse type C 400-volt 87.5-ampere 2-phase 60-cycle 75-horsepower induction motor.

The station serves not only as a steam reserve and generating station and substation for the city of Santa Cruz but also gives steam heat for the warm-water plunge in the Casino and is equipped with steam-operated fire pumps for the protection of the Casino.

WATSONVILLE STEAM PLANT.

Watsonville steam plant was constructed and put into operation by Watsonville Light & Power Co. and acquired with other properties of that company by Coast Counties Gas & Electric Co.

Building.—The boilers, generating equipment, and auxiliary apparatus are housed in a single galvanized corrugated-iron building with wooden frame, in the outskirts of Watsonville near the Southern Pacific bridge across Pajaro River. The building is about 105 feet long by 50 feet wide. At 50 feet from the rear end of the station is a sunken concrete oil tank to which oil may be delivered through a short supply pipe from tank cars on a siding.

Mechanical equipment.—The boilers are set in the front end of the generating station, separated from the end and side walls by a clear space of about 10 feet. A cross-compound McIntosh & Seymour engine is in the other end of the building and operates a single generator located in the center of the plant. The belt-driven exciter is close to the generator. A vertical cylindrical feed-water heater, two Snow duplex feed pumps, and a fuel-oil heater are in line along the left wall of the station, near the boilers, while the switchboard and transformers are along the right wall near the center of the room and opposite the generator.

Electrical equipment.—The generator is a 750-kilovolt-ampere 3,666-volt 3-phase 60-cycle unit directly driven by the engine.

The exciter is a 20-kilovolt-ampere continuous-current generator operated from a pulley on the shaft of the main generator.

The three transformers are of the oil-insulated self-cooled outdoor type and step the generator voltage up to a potential of 22,000 volts for transmission and distribution. Their capacity is 250 kilovolt-amperes, which gives a total of 750 kilovolt-amperes for the station.

The station normally serves as a stand-by in case of line trouble north or south of Watsonville.

TRANSMISSION AND DISTRIBUTION SYSTEM.

At the end of 1921 the Coast Counties Gas & Electric Co. was transmitting power throughout its territory at a potential of 22,000 volts. All its lines were single-circuit pole lines and their aggregate length 85.7 miles. The capacities of its substations were reported as follows:

TABLE 74.—*Substations operated by Coast Counties Gas & Electric Co.*

	Kilowatts.
Ben Lomond	75
Santa Cruz	1,100
Liliencranz	10
Watsonville	800
Logan	625
Hollister	1,200
Gilroy	900
Morgan Hill	225
	4,935

UTICA MINING CO.

HISTORY.

The Utica Mining Co.—not incorporated—is owned jointly by the Hobart Estate Co., Emma Rose, and Anna G. Lane and has for its primary activity the operation of mines at Angels, Calaveras County. In addition to the mines it owns and operates ditches and reservoirs in Calaveras and Alpine counties and a small power plant near Murphys, Calaveras County. The primary object of both the water and power system is to supply the company's own mines, but surplus power and water are sold to outside users in the vicinity.

ELECTRIC SYSTEM.

UTICA POWER PLANT.

LOCATION.

The main plant operated by Utica Mining Co. is in the vicinity of Murphys, Calaveras County.[91a] The intake is in sec. 35, T. 5 N., R. 15 E.; the conduit traverses sec. 35, T. 5 N., R. 15 E.; secs. 2, 3, 9, 10, 16, 17, 18, 19, 20, 30, and 31, T. 4 N., R. 15 E.; secs. 24, 25, 33, 34, 35, and 36, T. 4 N., R. 14 E.; and secs. 3 and 4, T. 3 N., R. 14 E.; the power house is in sec. 33, T. 4 N., R. 14 E. A secondary supply is diverted into the main conduit at the point where it crosses Mill Creek, and a feeder tunnel about a mile long heading on Beaver Creek in sec. 36, T. 5 N., R. 15 E., and running through secs. 36, 25, and 26 discharges into North Fork about half a mile above the main intake.

[91a] The company has also operated for electric generation during temporary shut-down of its mines a plant of 820 horsepower capacity in the town of Angels.

The first small generating station was built in 1895 at a point a short distance farther downstream than the present power house, but it was abandoned when the second plant was completed in 1898. The second plant was enlarged to its present size during 1911.

SOURCE OF WATER SUPPLY.

North Fork of Stanislaus River, from which the Utica plant receives its entire water supply, rises on the south slopes of the ridge that divides the extreme headwaters of the Stanislaus from those of the North Fork of the Mokelumne; the headwaters, therefore, do not reach the main ridge of the Sierra. The headwaters of Highland Creek, the principal tributary of the North Fork of the Stanislaus, are eastward of the headwaters of North Fork and are therefore nearer the main crest of the range.

North Fork proper rises at an elevation of about 8,000 feet above sea level and flows southwestward 30 miles to the point of diversion. The 167 square miles above the diversion dam lies in Tuolumne and Calaveras counties, about 140 miles east of San Francisco. The drainage basin (see Pl. XXVII, in pocket) is long and narrow, having an average width of about 6 miles. It lies immediately south of the basins of North and South Fork of Mokelumne River and north of that of Middle Fork of the Stanislaus. The canyon is about 1,200 feet deep and in its general characteristics closely resembles the Mokelumne Canyon (see pp. 194–195). The forest cover is, in the main, excellent. Precipitation is about the same as on the Mokelumne and Stanislaus basins. The low flow of the stream[92] is slightly augmented by storage in the Silver Valley, Union (Highland), and Utica reservoirs. The Beaver Creek drainage basin above the supplementary intake ranges from about 4,350 to 7,500 feet in elevation and in topographic and other characteristics is much like the lower part of the main canyon above the principal diversion.

Where the main conduit line crosses Mill Creek there is a supplementary diversion through which an additional 13 miles of drainage area is made tributary to the Utica plant. The general features of this basin are similar to those of the North Fork.

RESERVOIRS.

The plant receives water from three storage reservoirs—Utica reservoir, in secs. 21, 28, and 29, T. 7 N., R. 18 E.; Union reservoir, in secs. 22 and 27, T. 7 N., R. 18 E.; and Silver Valley reservoir, in secs. 3, 4, and 9, T. 7 N., R. 18 E. All of them are in the north-central part of the basin.

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[92] A station was established at the head of the Utica flume on July 14, 1913. The records obtained show that the minimum stream flow comes in October and November, but do not show whether the minimum is greatly affected by storage. For records of discharge of North Fork of Stanislaus River see U. S. Geol. Survey Water-Supply Papers as follows: 391, pp. 184–185 (1914); 411, pp. 193–196 (1914–15); 441, pp. 172–174 (1915–16); 461, pp. 170–171 (1916–17); 481, pp. 166–169 (1917–18).

The Silver Valley reservoir is formed by a dam 45 feet high, 7,270 feet above sea level. Its maximum capacity is 4,594 acre-feet, and its area at that capacity is 178.8 acres. The dam at Highland (Union) reservoir is 32 feet high and 6,816 feet above sea level; the reservoir is 1,983 acre-feet in maximum capacity and 197 acres in area. At Utica reservoir the dam is 52 feet high, 6,780 feet above sea level, and impounds 2,400 acre-feet of water; the area of the reservoir at maximum capacity is 269.8 acres.

It has been proposed to enlarge these reservoirs by raising the dams and also to provide storage at several undeveloped sites. Up to the end of 1921, however, very little new construction had been undertaken.

CONDUIT.

The Utica plant utilizes a ditch system that was constructed many years ago to supply water to the mines in and around Murphys. The main conduits divert the flow of North Fork of Stanislaus River at a point about 11 miles northeast of the town of Murphys. The conduit follows down the northwest side of North Fork Canyon and finally crosses over to the basin of Murphys Creek through a gap in the hills and continues on down the south side of Murphys Creek Canyon for 2 or 3 miles to the head of the pressure pipe. The total length of the line from intake to forebay is 18.35 miles. An important auxiliary supply is diverted into the main conduit by means of a small dam at the Mill Creek crossing, 7.5 miles below the intake, and at other points small feeders from the gulches furnish a supply that can be used during the high water of early spring, to enable the company to make repairs near the head of the conduit.

The capacity of the main conduit line is still limited to about 75 second-feet, although in 1912 and 1913 the company began to enlarge the conduit to a capacity of 250 second-feet. Most of the flumes along the entire line were reconstructed, but up to December 31, 1921, the enlargement of the ditch between the flumes had not been undertaken.

A supplementary supply from Beaver Creek is made available by means of a tunnel that leaves Beaver Creek at the site of the diversion dam and empties into the North Fork of the Stanislaus about 3,500 feet upstream from the North Fork intake. The Beaver Creek tunnel has a clear bottom width of 4.4 feet and a top width of 2.1 feet between the timbers. The clear height of the tunnel is 5.8 feet, but the depth of water is only 2.45 feet, which gives a clear width at water surface of 3.4 feet. The side posts are 8 by 8 inches and the caps are 6 by 6 inches and support 2 by 6 inch lagging. The maximum capacity of the tunnel is about 60 second-feet.

The small diverting dam for the main conduit line is of timber-crib construction, and the dam at Mill Creek is only a masonry sill surmounted by a wooden flashboard 34 inches high.

The first 5.65 miles of the main conduit is in flume 7.5 feet wide, and thereafter sections of ditch are interspersed with short sections of flume 9 feet wide, until the forebay is reached. Both widths of flume are designed to carry water to a depth of 3 feet, and the height of the sides of the flume box is 4 feet. The flume is supported on trestle work, the bents of which are spaced 4 feet on centers and consist of 4 by 6 inch posts, cross-braced by 1 by 8 inch boards. The flume has not been provided with caps, as it is carrying but a small part of the ultimate water supply, but when the conduit is enlarged and the full supply of 250 second-feet is turned through the line the belt courses will be completed by the addition of caps. The footboard, which in California practice is usually supported by the caps, is carried along the top of side posts on the outside of the flume, and the side posts are braced to the ends of the beams with 2 by 4 inch struts. The flume box is built of 1½ by 18 inch boards, two boards being used on the sides and five on the bottom of the narrow and six on the bottom of the wide flume. In both widths of flume there is a 12-inch plank on each side of the box above the water surface. All longitudinal cracks are covered by ½-inch by 4-inch battens. Grades are so adjusted that both widths of flume have the same capacity.

The old mining ditch, which is still in its original condition between the flumes, was designed to have a bottom width of 4.65 feet, side slopes ½ to 1, and a depth to water surface of 2.33 feet; the grade ranges from 15.4 to 21.12 feet per mile. During the many years which it has been in use the form of the section has naturally changed greatly in the various materials; its capacity, 75 second-feet, corresponds to a depth of flow of about 1.5 feet in the reconstructed flume between the various stretches of ditch. When reconstructed the ditch section in rock will have side slopes of ½ to 1, depth to water surface 4.7 feet, bottom width 7 feet, and width of berm 3 feet. In earth sections the side slopes will be 1 to 1, depth of water surface 4.3 feet, bottom width 6.5 feet, and width of berm 3 feet. The outer banks of the ditch will rise approximately 1½ feet above maximum water surface.

The conduit terminates in a small timber box forebay built in two compartments to facilitate cleaning. The pressure pipe is connected to the forebay by a Y, one branch of which leads to each compartment. The pipe is of riveted steel, is about 1,550 feet long, and varies from a diameter of 36 inches at the top to 28 inches at the bottom. Water-surface elevation in the forebay is 2,941.4 feet and the elevation of the center line of nozzles at the power house is 2,414.4 feet, giving a static head of 527 feet.

GENERATING STATION.

Power house.—The power house is a masonry structure built of lava blocks on a bedrock foundation at the side of a small creek into which it discharges. The building contains a single room whose floor is on two levels, the lower part being beside the stream. In this part of the station are the two generators and their impulse wheels. In the upper part, which is on the side away from the stream, are the transformers and auxiliary equipment.

Hydraulic equipment.—Each of the two units is operated by a Pelton wheel with wooden housings. The wheel is supported between bearings and is direct-connected to the generator, but between the two there is a heavy flywheel. Each unit is governed by an early type of Pelton governor.

Generators.—The two generators are Westinghouse stationary field 500-volt 75-ampere 2-phase 60-cycle 750-kilovolt-ampere alternators, and operate at 400 revolutions per minute.

Exciters.—Excitation is furnished by two Pelton driven 125-volt 180-ampere 22.5-kilowatt direct-current generators, operated at 975 revolutions per minute.

Transformers.—The six single-phase transformers are connected by the Scott method to give 3-phase current at 16,500 volts potential for transmission from the 500-volt 2-phase current delivered to them by the generators. These transformers are of the Westinghouse 1-phase oil-cooled type and are of 375 kilowatts capacity.

TRANSMISSION LINES.

Pneumatically controlled switches connect the plant to the lines. Transmission line from the power house to Angels is of No. 1 (Brown & Sharpe) copper and is supported on triple-petticoat glass insulators. The poles are 30 feet long and are spaced 40 to the mile.

HETCH HETCHY POWER SYSTEM, CITY OF SAN FRANCISCO.

HISTORY.

A complete history of the Hetch Hetchy municipal water and power project, now under construction by the city of San Francisco, is entirely outside the scope of this report but is available to those interested in the subject in special engineering reports forming part of the regular reports of the city's board of public works, and in the records of hearings before the Public Lands committees of Congress.

Complete information concerning both municipal water supply and power features of the proposed development are contained in "Hetch Hetchy water supply for San Francisco, 1912," a report by John R. Freeman, consulting engineer, dated July 15, 1912, and published in San Francisco by the authority of the board of supervisors. The outline of the power development as then proposed is given on pages 29–32 of that report, and on page 139 there are comparative profiles of the different plans proposed for the storage and aqueduct system, by C. E. Grunsky in 1902, Marsden Manson in 1908–1911, and John R. Freeman in 1912.

The Hetch Hetchy project will utilize the 459 square miles of the drainage basin of the main Tuolumne (Pl. XXXIX, in pocket) above Hetch Hetchy Valley, 79 square miles of the drainage basin of Eleanor Creek above Lake Eleanor dam, and 114 square miles of the drainage basin of Cherry Creek above the Cherry Valley reservoir, in addition to which there will be available at the Early intake the unregulated supply from the relatively small areas on the main river below Hetch Hetchy reservoir and on Cherry and Eleanor creeks below the reservoirs, and above the intake of the Lower Cherry Creek conduit.

The proposed power developments on the Hetch Hetchy project are confined entirely to the mountain division, and according to the general plan as modified up to October, 1921, comprise four power houses designated respectively power house No. 1, or Lower Cherry Creek development (already completed to furnish power for construction work on the aqueduct); proposed power house No. 2, the lowest on the system at the crossing of Moccasin Creek and at the beginning of the aqueduct proper leading across San Joaquin Valley to San Francisco; proposed power house No. 3, to utilize the fall between Hetch Hetchy reservoir on the main Tuolumne River and Early intake and proposed power house No. 4, on the north bank of Tuolumne River a short distance upstream from the Early intake, to receive water through an aqueduct from Lake Eleanor and Cherry Creek.

The proposed Hetch Hetchy dam will ultimately be 312 feet high above, and will extend to a maximum depth of 118 feet below the stream bed. The dam will be arched and will be 900 feet long and 25 feet thick at the crest, and 290 feet thick at the base. It will be completed in two sections. A contract for the first, 226.5 feet high above the stream bed, was awarded to Utah Construction Co. August 12, 1919, at a cost of $5,447,792.50. The time of completion under this contract is three years; the total yardage is 365,650. The crest elevation of the ultimate dam will be 3,812 feet above sea level and the lowest outlet 3,506 feet. The available capacity will be 348,500 acre-feet. The regulated supply will be available for use through proposed plant No. 3 and then, after rediversion at Early intake, through the proposed Moccasin Creek or No. 2 plant.

The tunnel aqueduct between Early intake and Moccasin Creek forebay, now under construction, is 18.3 miles long and has a capacity of 620 second-feet. Two types of section are being used. Approximately 12 miles will be lined, horseshoe shaped, 10 feet 3 inches wide by 10 feet 3 inches high. About 6 miles will be unlined, approximately rectangular in shape, 13 feet 4 inches wide by 13 feet 6 inches high. The elevation of the portal at Early intake is 2,320 feet and the outlet at Moccasin Creek forebay is 2,170 feet above sea level. The crest elevation of the earth dam at the future Moccasin Creek forebay will be 2,245 feet, the inlet to the pressure pipes 2,130 feet, and the nozzle at the power house 925 feet above sea level.

At the end of September, 1921, the city had completed 68 miles of standard gage railroad from Hetch Hetchy Junction, on the Sierra Railroad, eastward by way of Groveland to Hetch Hetchy dam site; had constructed a multiple-arch dam at the outlet of Lake Eleanor; had completed plant No. 1, or Lower Cherry Creek power development, with transmission line southwestward along line of aqueduct 19 miles to Priest (where connection was made for sale of surplus power to Sierra & San Francisco Power Co.) and 14.5 miles northeastward to Hetch Hetchy; had completed (under contract) the excavation to bedrock foundation for the Hetch Hetchy dam and poured 15,000 cubic yards of concrete in the dam; and had completed the following excavation of the aqueduct tunnels between the Early intake and Moccasin Creek forebay: At Early intake, 7,216 feet of tunnel; at South Fork, 10,660 feet; at Priest, 11,668 feet; at Big Creek, 7,986 feet; at adit 5–6, 2,954 feet; and at adit 8–9, 529 feet, a total of 41,013 feet for the 10 headings; and at Second Garrote, 487 feet of shaft.

LOAD.

The Lower Cherry Creek plant was installed chiefly to furnish power for construction purposes but was connected to Sierra & San Francisco Power Co.'s lines for the double purpose of aiding in the power shortage of 1918–19 and of securing for the city a return on part of its investment.

Mean monthly loads on the system since its inception are shown in figure 23 and daily load curves in Plate XLVI.

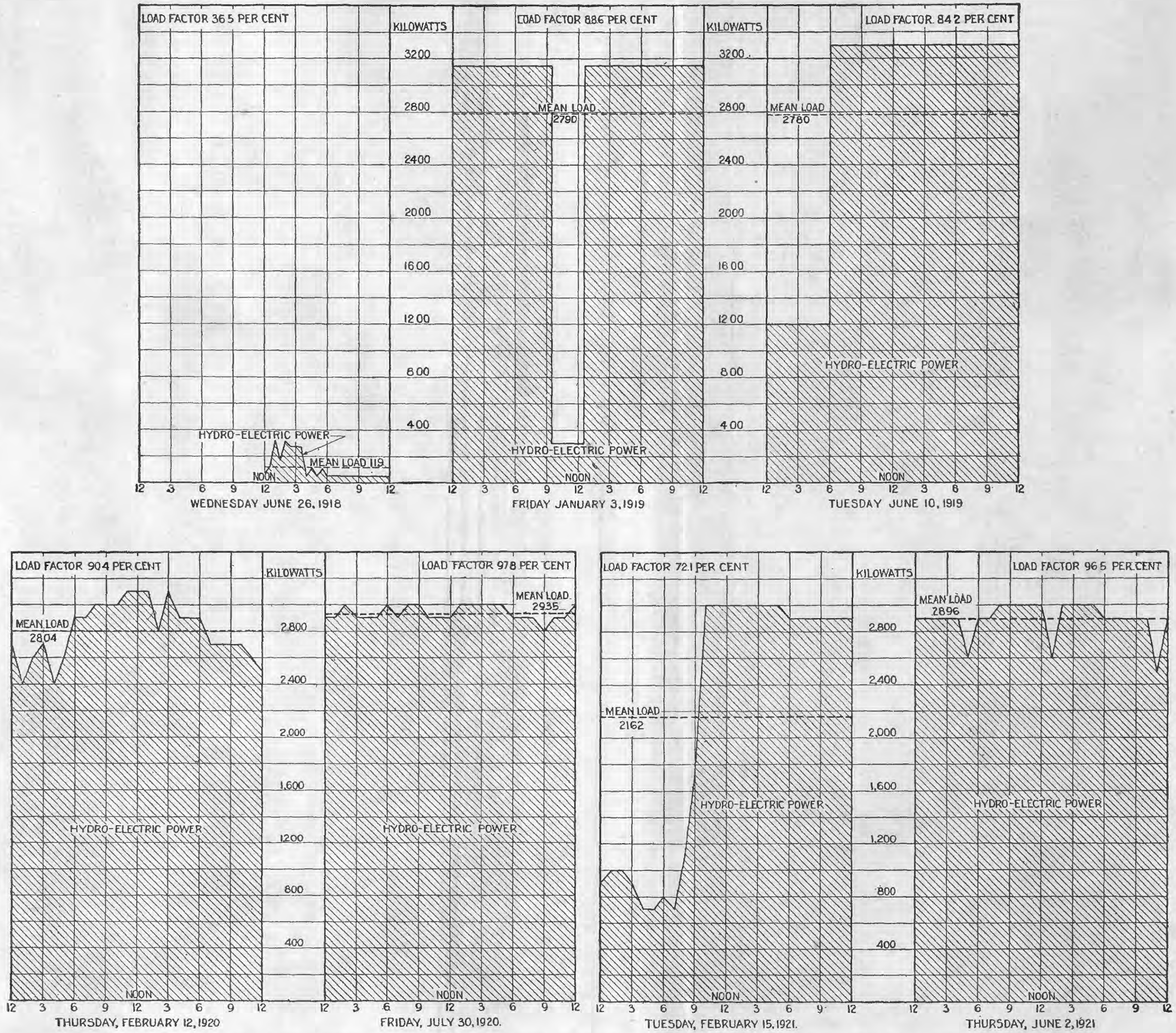
ELECTRIC SYSTEM.

The Lower Cherry Creek power development, the only one completed to date, is described below.

LOWER CHERRY CREEK POWER PLANT.

LOCATION.

The intake of Lower Cherry Creek plant is in sec. 31, T. 1 N., R. 19 E. The conduit traverses that section and secs. 36 and 35, T. 1 N., R. 18 E., secs. 2 and 11, T. 1 S., R. 18 E., terminating in a spillway beyond the head of the pressure pipes. The power house is in the SW. ¼ sec. 2, T. 1 S., R. 18 E. Lake Eleanor dam is in sec. 3, T. 1 N., R. 19 E., and the reservoir floods parts of sec. 3, T. 1 N., R. 19 E., and secs. 34, 35, 36, and 25, T. 2 N., R. 19 E.



CITY OF SAN FRANCISCO HETCH HETCHY POWER SYSTEM, DAILY LOAD CURVES, 1918-1921.

Main plants not yet completed. These curves show only the output of the construction plant.

SOURCE OF WATER SUPPLY.

The total drainage area above Lower Cherry Creek diversion dam is 225 square miles, of which 79 square miles is above Lake Eleanor dam and the remaining 146 square miles on Cherry Creek and on Eleanor Creek drainage below Lake Eleanor. Of this area 114 square miles is above Cherry Valley reservoir site.

Eleanor Creek rises at an elevation of about 9,500 feet in the vicinity of Twin Lakes, flows southwestward 15 miles to Lake Eleanor, and thence in the same direction 4½ miles to its junction with Cherry Creek. The principal tributary of Eleanor Creek is Frog Creek, rising at an elevation of about 9,500 feet in the vicinity of Richardson Peak, flowing southwestward parallel to the main stream a distance of 10 miles, and emptying into the upper part of Lake Eleanor. Elevations within Eleanor Creek basin range from about 4,100 feet above sea level at the mouth of the stream to 4,600 feet at Lake Eleanor dam and to a maximum of 10,510 feet at the summit of Bigelow Peak, at the head of the basin. Most of the drainage area is between 4,500 and 7,500 feet in elevation. Much of it is well covered with forest interspersed with bare granite ridges and mountain meadows. Falls Creek, tributary to the Tuolumne at Hetch Hetchy, drains the country southeast and Cherry Creek the country northeast of Eleanor Creek basin.

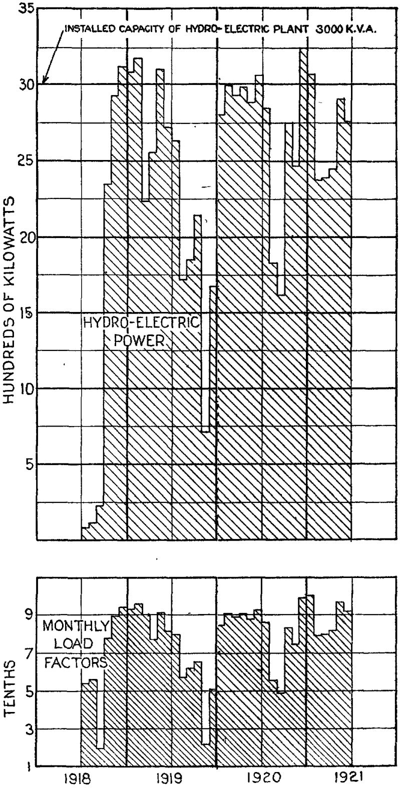


FIGURE 23.—City of San Francisco Hetch Hetchy power system, mean monthly loads and load factors, 1918–1921.

Cherry Creek rises at an elevation of 10,000 feet in the vicinity of Emigrant Meadows, on the main Sierra divide, and flows westward and southwestward, joining the Tuolumne 3 miles below the intake of Lower Cherry Creek power plant and 2 miles below Early intake on the Tuolumne. The elevation at the intake of Lower Cherry Creek power conduit is about 3,500 feet above sea level. Most of the Cherry Creek drainage basin is between 4,500 and 8,500 feet above sea level. The highest points in the drainage area are peaks ranging from 10,000 to 10,800 feet in elevation along the main Sierra divide on the northeast boundary of the basin. The character of the country is much like that of Eleanor Creek. On both streams there are lakes which may eventually be raised for additional storage. The most important site on Cherry Creek is at Cherry Valley.

RESERVOIR.

The only storage developed by the city up to the end of 1921 is at Lake Eleanor, where a multiple-arch dam has been completed forming part of the permanent development but now used to regulate the stream flow through the Lower Cherry Creek power house, installed to furnish power for construction purposes.

The main part of Eleanor dam consists of 20 arches of 40-foot span and 460 feet of low gravity wall. Of this wall 200 feet is constructed as an overflow spillway with removable flashboards. The spillway lip is at an elevation of 4,655 feet, and the top of the flashboards at 4,660 feet. A roadway 10 feet wide is carried by the back of the arch piers and by piers back of the gravity wall. The highest arch measures 70 feet, the foot of the highest buttress is at an elevation of 4,590 feet above sea level, and the top of the dam is 4,661 feet above sea level. Normal maximum water surface is at an elevation of 4,660 feet, at which level the reservoir capacity is 25,300 acre-feet and its surface area 945 acres. The area of the reservoir at the 4,655-foot level is 935 acres and its capacity 22,000 acre-feet. In order to follow the most economical location, the central part of the dam was curved in plan. From the western abutment to the east end of the fifth arch the dam is straight. The next eight arches follow the circumference of a circular curve with central angle of 30° and a radius of 611.35 feet. From the east end of this curved section to the east abutment (seven arches and the gravity wall) the dam is straight. Concrete footings 7 feet wide by 3 feet deep were channeled into the bedrock of the dam site at the bottom of the arch rings, and the rock under the piers was excavated to present a saw-toothed surface in order to prevent sliding on the base. The top width of the gravity section is 3 feet, its upstream face is vertical, and its downstream face battered 2 in 12; its base is carried down to a minimum depth of 2 feet in a trench channeled into bedrock.

Four 24-inch outlet pipes are provided, two at an elevation of 4.619 feet side by side in the base of the twelfth arch from the west end, and two at an elevation of 4,605 feet in the base of the tenth arch from the west end. The upper pair of pipes is fitted with slide gates controlled by rods extending up along the surface of the arch to handwheels at the top of the structure. Flow through the lower outlets is controlled by gate valves under the downstream face of the arch. Both upper and lower outlet pipes start normal to the arch faces, gradually turning up to a horizontal direction, and discharge into stilling pools 4 feet 6 inches deep and about 20 feet long on the bottom. At the lower end of each pool there is a hump or dam in the bottom of the channel sloping up gently on both sides and measuring about 25 feet through the base.

Water discharged from the reservoir flows down Eleanor Creek 4 miles to Cherry Creek and is diverted 4 miles below the junction of the two streams into the conduit of Lower Cherry Creek plant.

CONDUIT.

The entire length of Cherry Creek conduit from intake dam to the extreme lower end is 18,045 feet (3.42 miles), of which 7,172 feet is in three sections of concrete-lined ditch, 5,379 feet in four sections of wooden flume, and 5,494 feet in six tunnels. The lower end of the conduit terminates in a "storage" flume 2,205 feet long, near the center of which the pressure pipes head. The lower half of this flume extends past the power house to a point opposite Early intake of the main Hetch Hetchy aqueduct.

The concrete-lined ditch is normally 5 feet 8 inches wide on the bottom and 13 feet 2 inches wide at water surface when carrying water to its maximum capacity or at a depth of 5 feet above the bottom and 6 inches below the top of the concrete lining. The minimum thickness of concrete is 4 inches, and it is carried out 6 inches on the berms to a minimum thickness of 6 inches. The grade in the lined canal is 1 in 1,000 and (with $n=0.015$) its computed capacity varies from 111 second-feet with a depth of water of 3 feet to a maximum of 281 second-feet with water 5 feet deep.

The flume box is 4 feet 10 inches deep inside. The inside width is 6 feet 6 inches, the caps are 4 by 6 inches, 9 feet long, posts 4 by 6 inches, 5 feet 4 inches long, and sills 4 by 8 inches, 11 feet long. An 18-inch foot plank runs along the center of the caps. The sills are supported on four 6 by 10 inch by 18-foot stringers which in bench flume rest on 6 by 12 inch by 8-foot cedar sills spaced 8 feet center to center, or where trestles are needed, rest on the 8 by 10 inch by 8-foot 6-inch caps of the 3-post trestle bents. The side posts of the trestles are battered 1 in 4. The center post is vertical. All of the posts are 8 by 8 inches in section and their footings rest on concrete blocks 19 inches square at the top, on which they are held in place by ¾-inch dowels. The bents are cross-braced transversely and longitudinally with 2 by 6 inch timbers and are spaced 8 feet center to center.

The grade in flumes is 1.75 feet per thousand, and their capacity (with $n=0.013$) varies from 96 second-feet with a depth of 2½ feet to 130 second-feet with a depth of 3 feet 2 inches and a maximum of 211 second-feet with a depth of 4 feet 6 inches with the ultimate development.

The tunnel cross section is 7 feet 6 inches square with upper corners rounded on a radius of 2 feet 6 inches, and lower corners on a radius of 1 foot. The slope in tunnels is 1.75 or 1.5 per 1,000, and their capacities are figured on an assumed value of *n* in Kutter's formula equal to 0.0225. The computed discharge is 200 second-feet with a depth of 6.04 feet on the lighter and 5.71 feet on the heavier grades.

The dimensions of the single pressure pipe are as follows:

TABLE 75.—*Dimensions of pressure pipe, Lower Cherry Creek plant, Hetch Hetchy power system, city of San Francisco.*

Type of pipe.	Sectional length.	Diameter of pipe.	Plate thickness.
	Feet.	*Inches.*	*Inch.*
Lap joint	18.33	60-42	3/16
Expansion joint	6.00	42	3/16
Lap joint	211.53	42	3/16
Do	149.48	42	1/4
Do	103.26	42	5/16
Do	8.85	42-28	3/8
	497.45		
		3-way Y:	
Do	22.15	28 center branch	1/4
Do	32.96	28 right branch	1/4
Do	32.96	28 left branch	1/4

GENERATING STATION.

Power house.—Lower Cherry Creek power house is a temporary structure with wooden frame and asbestos-protected corrugated-steel siding and roof of No. 24 gage metal. The building is 80 feet 8 inches long by 30 feet wide. The peak of the roof is over the center of the generator room, which is 22 feet wide and extends the full length of the station. Clear height from floor to top of crane rail is 16 feet, and height to lower chord of wooden roof trusses 21 feet. The three units are arranged with shafts in line parallel to the main axis of the building and 7 feet from its back wall, No. 1 unit being in the northwest and No. 3 in the southeast end of the room. The switching and transformer equipment is in an extension 8 feet deep and 80 feet long in front of the generator room. Lavatories, lockers, and a storeroom occupy the space opposite No. 1 generator, the switchboard with auxiliary equipment behind it in the space opposite No. 1 turbine and No. 2 generator, and the transformers the space opposite No. 2 turbine and No. 3 unit. There is a door at each end of the generator room.

Hydraulic equipment.—The castings at the lower ends of the pressure pipes pass through the back wall of the building at the floor line and connect through hydraulically operated gate valves to the turbine casings. Each turbine discharges to the left and downward through a single vertical draft tube, extending down into a sump, from which water is discharged through a tunnel outlet into the stream. The elevations at the power house are as follows:

	Feet.
Water surface at head of pressure pipe (crest of spillway from forebay)	2,596.87
Center of turbine shafts	2,268.66
Floor elevation	2,266.00
Center of pressure pipe at connection to turbine	2,265.25
Water in tailrace (minimum elevation)	2,248.00

Each unit is operated by a 1,500-horsepower Pelton-Francis turbine with single left-hand discharge controlled by a Pelton governor operated in conjunction with a relief valve, immediately in front of the scroll casings discharging down through tubes into the tailrace tunnel. Immediately between the special casting at the lower end of the pressure pipe and the scroll case of the turbine there is a hydraulically operated gate valve (with by-pass) for cutting off the supply to the turbine, and suitable arrangements are made for draining the scroll case into the tailrace.

The 30-inch turbine runner is overhung on the end of the main shaft, which is supported on three bearings, the two generator bearings resting on a heavy cast bedplate and the turbine bearing on the concrete of the foundation. A flywheel is mounted on the shaft between the generator and the turbine bearing.

Generators.—The three main generators are General Electric 1,000-kilovolt-ampere 2,300-volt 3-phase 60-cycle machines.

Exciter.—A General Electric 9-kilowatt 125-volt 72-ampere exciter is mounted on the end of each unit and is direct-connected to the main shaft. There is also a 9-kilowatt motor-generator exciter driven by a 440-volt 15-horsepower induction motor, between the end of the switchboard and the transformers.

Transformers.—The entire station output is stepped up to 22,000 volts by a single bank of three Westinghouse 1,000-kilovolt-ampere single-phase water-cooled transformers. An extra transformer is provided for use in an emergency.

Wiring.—The station busses connect to the transformers through 2,300-volt oil switches, and the transformers to the two main transmission lines through automatic remote-control oil switches. Protection is afforded by choke coils and Westinghouse aluminum-type lightning arresters. The line runs in a southwesterly direction from the power house to a switch station near Intake siding on the Hetch Hetchy Railroad. Thence one line extends southwestward and westward along the general line of the aqueduct to Priest reservoir portal. A branch extends northwestward from that point to a point near Priest, where connection is made to the Sierra & San Francisco Power Co.'s transmission line, now operated by the Pacific Gas & Electric Co., to which surplus power is delivered. The second line runs eastward from Intake siding to Hetch Hetchy dam site.

CHAPTER IV.—SOUTHERN CALIFORNIA MARKET.

TERRITORY COVERED.

AREA AND POPULATION.

The southern California market includes the region extending southward from the southern boundaries of Monterey, San Benito, Stanislaus, Tuolumne, and Alpine counties, Calif., and Douglas and Lyon counties, Nev., to the international line between the United States and Mexico.

The interconnected systems serve several distinct load centers rather than covering the territory with a network as do the northern California lines. Power is distributed in Fresno, Imperial, Inyo, Kern, Kings, Los Angeles, Madera, Mariposa, Merced, Mono, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, Tulare, and Ventura counties, Calif., and Churchill,[93] Esmeralda, Mineral, and Nye counties, Nev.

The area and population of these counties is shown by Table 76, and physical and industrial conditions in each county are briefly described on pages 448–453.

Monterey County is also reached by lines from the southern California market but can not properly be classed in it as all except its extreme southern tip is served by lines of the northern California systems.

The total area of the counties included in the southern California market is 117,884 square miles, including the counties served in western Nevada; the area in which power is actually distributed from hydroelectric lines is far less but very difficult to estimate on account of the centers of distribution being widely separated.

PHYSICAL AND INDUSTRIAL FEATURES OF COUNTIES.

Fresno County.—Fresno County includes an area whose western boundary lies near the crest of the Coast Range and whose eastern boundary is the crest of the Sierra. About half of this area is foothills or mountainous country and the rest is in San Joaquin Valley. The east side of the valley has for many years afforded an excellent market for power in connection with agriculture and in various municipalities. Development in the western part of the valley has

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[93] The line extending into Churchill County was removed after this report went to press, but information concerning that county is here included, as its mines have been regularly supplied by plants described in the text.

TABLE 76.—*Area and population of counties in southern California market.*

County.	Area.	Population.			Class of population.											
					Urban.[a]						Rural.					
		1900	1910	1920	1900		1910		1920		1900		1910		1920	
CALIFORNIA.	*Sq. miles.*					*Per ct.*		*Per ct.*		*Per ct.*		*Per ct.*		*Per ct.*		*Per ct.*
Fresno [b]	5,950	37,862	75,657	128,779	12,470	32.9	29,091	38.5	53,756	41.7	25,392	67.1	46,566	61.5	75,023	58.3
Imperial [c]	4,089		13,591	43,453					17,076	39.3			13,591	100.0	26,377	60.7
Inyo	10,019	4,377	6,974	7,031							4,377	100.0	6,974	100.0	7,031	100.0
Kern	8,003	16,480	37,715	54,843	4,836	29.3	12,727	33.7	21,955	40.0	11,644	70.7	24,988	66.3	32,888	60.0
Kings [d]	1,159	9,871	16,230	22,031	2,929	29.7	4,829	29.8	5,888	26.7	6,942	70.3	11,401	70.2	16,143	73.3
Los Angeles	4,067	170,298	504,131	936,455	120,179	70.6	411,948	81.7	790,629	84.4	50,119	29.4	92,183	18.3	145,826	15.6
Madera [e]	2,112	6,364	8,368	12,203					3,444	28.2	6,364	100.0	8,368	100.0	8,759	71.8
Mariposa	1,463	4,720	3,956	2,775							4,720	100.0	3,956	100.0	2,775	100.0
Merced	1,995	9,215	15,148	24,579			3,102	20.5	3,974	16.2	9,215	100.0	12,046	79.5	20,605	83.8
Mono	3,030	2,167	2,042	960							2,167	100.0	2,042	100.0	960	100.0
Orange	795	19,696	34,436	61,375	4,933	25.0	13,977	40.6	30,310	49.4	14,763	75.0	20,459	59.4	31,065	50.6
Riverside [f]	7,240	17,897	34,696	50,297	7,973	44.5	18,752	54.0	23,470	46.7	9,924	55.5	15,944	46.0	26,827	53.3
San Bernardino [g]	20,157	27,929	56,706	73,401	10,947	39.2	31,482	55.5	45,573	62.1	16,982	60.8	25,224	44.5	27,828	37.9
San Diego [h]	4,221	35,090	61,665	112,248	17,700	50.4	39,578	64.2	85,236	75.9	17,390	49.6	22,087	35.8	27,012	24.1
San Luis Obispo	3,334	16,637	19,383	21,893	3,021	18.2	5,157	26.6	5,895	26.9	13,616	81.8	14,226	73.4	15,998	73.1
Santa Barbara	2,740	18,934	27,738	41,097	6,587	34.8	11,659	42.0	23,384	56.9	12,347	65.2	16,079	58.0	17,713	43.1
Tulare [i]	4,856	18,375	35,440	59,031	3,085	16.8	10,004	28.2	19,365	32.8	15,290	83.2	25,436	71.8	39,666	67.2
Ventura	1,878	14,367	18,347	28,724			5,500	30.0	12,726	44.3	14,367	100.0	12,847	70.0	15,998	55.7
	87,108	430,279	972,223	1,681,175	194,660	45.2	597,806	63.2	1,142,681	68.0	235,619	54.8	374,417	36.8	538,494	32.0
NEVADA.																
Churchill	5,050	830	2,811	4,649							830	100.0	2,811	100.0	4,649	100.0
Esmeralda [j]	7,432	1,972	9,369	[k] 4,258							1,972	100.0	9,369	100.0	[k] 4,258	100.0
Nye	18,294	1,140	7,513	6,504							1,140	100.0	7,513	100.0	6,504	100.0
	30,776	2,802	12,180	15,411							3,942	100.0	19,693	100.0	15,411	100.0
Grand total	117,884	433,081	984,586	1,696,586	194,660	44.9	597,806	60.7	1,142,681	67.4	239,561	55.1	394,110	39.3	553,905	32.6

[a] Includes all incorporated cities and towns of more than 2,500 inhabitants.

[b] Part taken to form Madera County in 1893 and part annexed to Kings in 1909.

[c] Organized from part of San Diego County in 1907; population then estimated at 10,259.

[d] Organized from part of Tulare County in 1893; part of Fresno County annexed in 1909.

[e] Organized from part of Fresno County in 1893.

[f] Organized from part of San Bernardino and San Diego counties in 1893.

[g] Part taken to form part of Riverside County in 1893.

[h] Part taken to form part of Riverside County in 1893; part taken to form Imperial County in 1907.

[i] Part taken to form Kings County in 1893.

[j] Part taken to form Mineral County, Nev., in 1914.

[k] Including 1,848 in Mineral County.

been hampered by lack of water. In the extreme southwestern part of the county, in the vicinity of Coalinga, an extensive market for power has grown up in connection with drilling and pumping in the oil fields.

The county is served by San Joaquin Light & Power Corporation.

A part of Fresno County was taken in 1893 to form Madera County, and in 1909 another part was annexed to Kings County.

Imperial County.—Nearly all the alluvial plain lying between Colorado River and the Coast Range, north of the Gulf of California, is included in Imperial County, which was organized in 1907 from part of San Diego County. Its population was then estimated at 10,250. The climate is dry and hot, and agriculture has developed with wonderful rapidity but depends entirely upon irrigation. The population is concentrated in the reclaimed area near Brawley, Imperial, Calexico, El Centro, and Holtville. The county is served with power by Holton Power Co. (controlled by the Nevada-California Power system).

Inyo County.—Inyo County includes the fertile Owens River valley and a vast area of desert mountains and valleys east of the Sierra. A small amount of power is supplied for municipal use at the scattered towns; otherwise, the only demand for power is for use in chemical works, pumping, and mines.

The area is served with power by The Southern Sierras Power Co. (of the Nevada-California Power system) and by four small plants belonging to the city of Los Angeles.

Kern County.—Kern County extends from the main divide of the Coast Range eastward across the south end of the San Joaquin Valley and Sierra into the desert country that lies east of the main range. Oil-well drilling and pumping and agricultural uses furnish the largest demand for power. The county is served by San Joaquin Light & Power Corporation.

Kings County.—The western tip of Kings County is in the hilly country on the western side of San Joaquin Valley; the rest of it includes the level valley lands around Tulare Lake. A part of Fresno County was annexed to Kings County in 1909.

Agricultural industries and the drilling and pumping of oil wells furnish the chief market for power, which is served by San Joaquin Light & Power Corporation and the northern division of the Southern California Edison system (formerly operated by Mount Whitney Power & Electric Co.).

Los Angeles County.—The main ridge of the San Gabriel Range crosses the central part of Los Angeles County in an easterly direction and divides the rugged and desert country lying in the north half from the Los Angeles and San Gabriel River valleys and the coastal plain to the south and southwest. A belt of the county lying along the southern base of the mountains is given over chiefly to citrus fruits, From this belt to the coast the land is suitable for cultivation.

A comparatively dense and rapidly growing population and an extensive interurban electric-railway system offer a diversified market for a large amount of power. The county is served by Southern California Edison Co., the Los Angeles Bureau of Power & Light, and the steam-electric system of Los Angeles Gas & Electric Corporation.

Madera County.—Madera County was organized from part of Fresno County in 1893. The west end of the county, including about two-fifths of its area, is in San Joaquin Valley; the east end includes the foothills and runs back to the crest of the Sierra. In the east end almost the only industry has been lumbering, but in the west agricultural industries afford an excellent market for power, which is supplied by San Joaquin Light & Power Corporation.

Mariposa County.—Mariposa County extends eastward from the foothills nearly to the crest of the Sierra. Its area is entirely mountainous and its chief industries are those connected with mining and lumbering.

The county is served by San Joaquin Light & Power Corporation, Mariposa Mining & Commercial Co., and by minor extensions from the lines of the Pacific Gas & Electric Co. from the northern California market.

Merced County.—The area included in Merced County extends eastward from the crest of the Mount Hamilton Range across San Joaquin Valley into the foothills of the Sierra. The foothills and mountainous country comprise about two-thirds of the total area and are not important as a power market. The low-lying valley section is rapidly being developed into a well-cultivated agricultural district whose demands for power are growing.

The county is served by San Joaquin Light & Power Corporation and is also reached by the extreme southern extensions of systems serving the northern California market.

Mono County.—Mono County includes the abrupt eastern scarp of the Sierra in Mono Lake basin, and the high desert ranges north and south of the lake. The demand for power comes entirely from mines in and around Bodie and across the Nevada line in Aurora, Lucky Boy, and Hawthorne.

Power is served by the Nevada-California Power system.

Orange County.—Nearly the entire area of Orange County lies in the cultivated plain at the mouth of Santa Ana River, between the foothills and the ocean. Agricultural industries and oil pumping will probably continue to furnish the chief market for power, which is served by Southern California Edison Co.

Riverside County.—About 80 per cent of the area included in Riverside County is rugged, mountainous country and desert, though small artesian belts exist in Coachella Valley and certain lands along the Colorado can be reclaimed. The west end of the county contains some of the finest citrus groves in the State. The chief power demands are for agriculture and manufacturing cement.

Power is furnished by Southern California Edison Co. and The Southern Sierras Power Co.

San Bernardino County.—The population and power market in San Bernardino County are restricted almost entirely to the area lying south and southwest of San Bernardino Mountains. The northern and eastern parts of the county, embracing about 90 per cent of its area, are mountainous or desert. In 1893 a part of the county was taken to form part of Riverside County.

The demands for power, chiefly for agriculture and cement manufacturing, are met by Southern California Edison Co., Ontario Power Co., and The Southern Sierras Power Co.

San Diego County.—San Diego County embraces an area on the western slopes of the Coast Range and the coastal belt of varying width, lying directly north of the international boundary in the extreme southwest corner of the State. Climate and soil are well adapted to intensive agriculture, but development has been handicapped by scarcity of water. The population is confined chiefly to the coastal belt or to the valleys extending back into the foothills, the chief center of population being in and around San Diego.

In 1893 a part of San Diego County was taken to form a part of Riverside County and in 1907 another part, with a population then estimated at 10,250, was organized into Imperial County.

Except for delivery from two small plants, San Diego County was not supplied with hydroelectric energy until May 21, 1918, when Southern California Edison Co. extended its lines to Capistrano and has since delivered power through San Diego Consolidated Gas & Electric Co.

San Luis Obispo County.—San Luis Obispo County includes a mountainous country extending from the crest of the Coast Range westward to the Pacific. In the southwestern part of the county are several fertile valleys susceptible of intensive cultivation, and there are also oil fields which offer a good market for power.

San Joaquin Light & Power Corporation, through Midland Counties Public Service Corporation, supplies the power demands.

Santa Barbara County.—The eastern part of Santa Barbara County includes the rough and rugged Coast Range. The western part, in which the population is concentrated, comprises the agricultural lands of the valleys running down to the coast and the narrow coastal belt between the mountains and the sea south of Santa Barbara. Agricultural demands will probably absorb most of the power as transmission lines are extended. Santa Barbara and vicinity are served by Southern California Edison Co. through Santa Barbara Gas & Electric Co. The north end of the county is reached by the lines of Midland Counties Public Service Corporation served by San Joaquin Light & Power Corporation.

Tulare County.—The western third of Tulare County is on the floor of the San Joaquin Valley between Tulare Lake and the Sierra foothills. The eastern two-thirds—a region of foothills and mountains—extends across the upper part of the Kern River basin to the crest of the Sierra. A part of Tulare County was taken in 1893 to form Kings County.

Most of the population is concentrated in the agricultural districts of the valley and lower slopes of the foothills. The foothill country includes a citrus belt that has become very important. In this agricultural region there is a large demand for power for use in irrigation pumping.

Power is served by the northern division of the Southern California Edison system (formerly operated by Mount Whitney Power & Electric Co.) and San Joaquin Light & Power Corporation.

Ventura County.—The southern half of Ventura County is traversed by several westward-trending valleys which open out into a rather extensive coastal plain. This part of the county uses power for agricultural industries and oil-well pumping. The northern part of the county is mountainous and the market for power will probably always be small.

The county is served by Southern California Edison Co.

Counties in Nevada.—The arid ranges and valleys around Humboldt Lake and Carson Sink are included in Churchill County, Nev. A large area in the county is now being reclaimed under the Truckee-Carson project of the United States Reclamation Service. The only demand for power now comes from the mines and mills near Wonder. Further use will probably include agriculture, light, and power in the small farming towns. The county is served by The Nevada-California Power Co.[94] The small power system operated from the Lahontan dam, furnishing power to the northern part of the county, is not described in this report.

Esmeralda County, Nev., the northern part of which was taken in 1914 to form Mineral County, lies directly east of Mono and Inyo counties, Calif., in the arid valleys and mountain ranges along the west boundary of Nevada. Mines and smelters in the region extending from Millers south to Rhyolite are served with power by The Nevada-California Power Co.

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[94] The market for power in the mines near Wonder having dwindled, The Nevada-California Power Co. has dismantled its line as far south as Hawthorne, Mineral County, since this report was submitted for publication.

OPERATING COMPANIES.

The consolidations that have taken place since the first electric transmission lines went into operation have reduced the operating hydroelectric companies whose lines serve the market to four—San Joaquin Light & Power Corporation, Southern California Edison Co., Ontario Power Co., and The Nevada-California Power system (including The Southern Sierras Power Co. and Holton Power Co.). To these should be added the municipal light and power system of the city of Los Angeles and the electric system operated by Escondido Mutual Water Co.

The part of the San Joaquin Light & Power system from Coalinga westward is operated by Midland Counties Public Service Corporation, but the lines of both companies may be considered a single unit.

The manner in which the consolidations have become effective is shown in the historical data presented for each company.

LENGTH OF TRANSMISSION LINES.

Interconnection of the various companies has resulted in some very long circuits. Through tie between Southern California Edison and the Nevada-California systems at San Bernardino, energy generated at the Big Creek plants could be delivered at Round Mountain, Nev., reaching that point by way of Los Angeles, San Bernardino, and Bishop, a distance of 667 miles.

A very long line now normally operated as a whole extends from Mono Lake, Rush Creek, and Bishop Creek plants on the east side of the Sierra to Imperial Valley and Yuma by way of San Bernardino. The distance from Mono Lake (or Mill Creek) plant to Calexico by way of this transmission line is 481 miles and to Yuma 544 miles. Lines extending northward from Mono Lake to Hawthorne, Nev., make the total distance between the extremities of the transmission system from Hawthorne to Calexico 524 miles and from Hawthorne to Yuma 584 miles.

SAN JOAQUIN LIGHT & POWER AND MIDLAND COUNTIES PUBLIC SERVICE CORPORATIONS.

HISTORY.

PREDECESSORS OF SAN JOAQUIN LIGHT & POWER CORPORATION.

SAN JOAQUIN ELECTRIC CO. AND SAN JOAQUIN POWER CO.

In what may be considered the direct line of succession, the present San Joaquin Light & Power system is the outgrowth of the hydroelectric system constructed in 1895 and 1896 in the vicinity of Fresno by San Joaquin Electric Co.

The accounts of the operations of the Frankfort-Lauffen power transmission in Germany and the early long-distance power transmission from the "Pomona" and Mill Creek No. 1 plants in southern California were watched with eager interest by certain business men and engineers of Fresno.

Early in 1894, when the success of the southern California plants seemed assured, Mr. John S. Eastwood, a practicing civil engineer of Fresno, made an investigation of the various power sites lying within a radius of possible transmission. The most feasible site was along the North Fork of San Joaquin River and seemed almost too good for the relatively simple hydraulic and electrical machinery then available. It appeared from a reconnaissance of this site that by diverting the North Fork at a point where the stream started to drop rapidly into the canyon of the main San Joaquin, the water could be carried along and across the end of a flat-topped point around which the main river curved in what is locally known as Horseshoe Bend. The fall both in the North Fork and in the main stream—nearly 9 miles of channel—could thus be utilized with a conduit about 5 miles long. The head, slightly exceeding 1,400 feet, seemed to many too high for safety of operation, but tentative plans for the development were completed during the last part of 1894, and on April 2, 1895, the San Joaquin Electric Co. was organized for the purpose of building a power plant on the site. The new concern, which was capitalized at $800,000, elected Mr. John J. Seymour as president and Mr. Eastwood, who had prepared the plans for the plant, as chief engineer and superintendent. Work on the plant was begun April 5, 1895, and the plant was put into service in May of the following year, was in continuous operation up to September, 1910, when the first two units of new San Joaquin plant which replaced it, began operation.

San Joaquin No. 1, as the plant was christened, was served by a ditch line between 5 and 6 miles long with a grade of 5.28 feet per mile and a capacity of 75 second-feet. The pressure pipe was 4,100 feet long, the first 1,800 feet being of riveted steel and the rest of lap-welded pipe with lock joints. At its lower end the pipe was 20 inches in diameter and five-eighths of an inch thick. At the end of the power house the pressure main connected with a receiver, 57 feet long and 30 inches in diameter, which extended along the side of the station in the same general line as the main pipe.

The power house was of masonry and was 70 feet long by 36 feet wide. The wheels were arranged along its side in a pit, underneath the receiver, from which they were fed by nozzle branches putting down in a gentle curve. The three Pelton wheels installed when the power house was first started were 57 inches in diameter and of the flywheel type, rated at 500 horsepower each, at a speed of 600 revolutions per minute. The wheel shafts projected through the wall of the power house and were connected to the generator shafts by bolted flanged couplings. The units were controlled by Replogle governors. The three 3-phase generators were 350-kilowatt 700-volt 3-phase 60-cycle machines, operated at 600 revolutions per minute. Two 12½-kilowatt 125-volt multipolar exciters were operated at 1,275 revolutions per minute by separate wheels. Power was stepped up by six 125-kilowatt General Electric air-blast transformers to 11,200 volts[1] for transmission.

Delivery was made at the Fresno substation—a brick structure, 55 by 45 feet in plan, equipped with three 125-kilowatt air-blast 11,200/200-volt transformers, three 75-kilowatt air-blast 11,200/1,000-volt transformers, and three 40-kilowatt air-blast 11,200/3,000-volt and two 80-light brush arc machines driven by two 60-horsepower motors; 200-volt 4-wire distribution was used in the business section of the city, 1,000-volt 3-phase in the residence districts, and 3,000-volt 3-phase for suburban power.

The head of 1,410 feet was at the time very high, and numerous mechanical and hydraulic difficulties were encountered in the early days of the plant.[2] The proper insulation of 36 miles of transmission also presented great difficulties. The main trouble, however, arose from the fact that the company had to introduce electric lighting in the face of active competition with a well-established gas company. The company was also hampered by lack of capital for making extensions and improvements. The bond house which backed it failed, and to cap the climax several dry years (at that time the driest in the history of the country) cut down the stream flow available without storage to almost nothing. In August, 1899, the system went into the hands of a receiver, by whom it was operated until December, 1902, at which time the old company was purchased at a receiver's sale by San Joaquin Power Co., organized for the purpose by W. G. Kerckhoff and A. C. Balch of Pacific Light & Power Co. of Los Angeles.

The properties were purchased by the exchange of $550,000 bonds of the new company for those of the old. The only development

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[1] The potential was raised to 20,000 volts in 1898, to 30,000 in 1906, and finally to 60,000 volts in 1910, when the old power house was abandoned.

[2] As Mr. Eastwood has since remarked: "In those days everything was experimental and everybody connected with the business was a novice." The general public did not know what was to be expected from the machinery and regarded it very much in the nature of an infernal machine. On the day that the transmission was begun appropriate exercises were arranged by the company at the Fresno substation and a large crowd of guests was assembled inside the building. It was arranged that an exhibition should be given by telephoning to the power house to turn on power at a certain given moment, and then connecting to the line the motor which was to drive the transformer blowers. When the power was turned on the motor began to operate satisfactorily and the blast of air started through the duct, over which a part of the transformer equipment had not yet been installed. Suddenly, as the blast gained strength, a tremendous cloud of dust, dirt, shavings, and various kinds of débris left by the carpenters came out of the duct. Most of the guests, thinking that an explosion of some kind had occurred, made a break for the doorway, and it was several minutes before their fears could be allayed.

work undertaken by the company was the addition of a unit to San Joaquin plant No 1, bringing its capacity up to 1,400 kilowatts. The south end of its main transmission line was Hanford.

SAN JOAQUIN LIGHT & POWER CO.

In 1905 San Joaquin Power Co. was reorganized as San Joaquin Light & Power Co. in order to finance the construction of new generating stations and extend the transmission and distribution system. The new company added San Joaquin plant No 3, above plant No. 1 on North Fork of San Joaquin, in April, 1906, and extended its transmission lines in a southeasterly direction down the valley as far as Selma, Reedley, and Kings River. It also carried a line westward as far as Coalinga to supply a distributing company owned by the same interests. In 1905 it built a steam auxiliary station of 1,000-kilowatt capacity in Fresno, and still later, in 1909 and 1910, completed most of the construction of new Crane Valley dam and reservoir and the present San Joaquin plant No. 1, which replaced the old San Joaquin No. 1.

In addition to development of its electric systems, San Joaquin Light & Power Co. organized or acquired control of several local light and water companies, including the steam plant and electric distribution system of Fresno Gas & Electric Co., which it purchased in 1903 for $25,000, giving its notes in payment; the plant of Selma Light & Water Co. purchased in 1907 for $30,000 and assumption of $16,000 outstanding bonds of the local concern. Madera Light & Power Co. was incorporated September 24, 1908, by San Joaquin interests with a capitalization of $50,000, to take over the San Joaquin company's electric distribution system in Madera, in return for which it issued to the San Joaquin company $27,000 par value of its stock. In March, 1908, the San Joaquin company sold its water plant on the east side of the tracks of the Southern Pacific Railroad in Madera to Madera Water Works, organized with a capital stock of $50,000, for the purpose of taking over the properties, in return for which the San Joaquin company received $37,300 in capital stock of the water works; the system on the west side of the tracks was operated through Madera Electric Water Co. In April, 1908, the Selma water plant was transferred to Selma Water Works in the same manner, the San Joaquin company receiving $43,800 par value out of $75,000 authorized capital stock of the new company. In 1909 the electric properties of Sanger Light & Power Co. were purchased for $4,103.25. In 1909, also, the electric properties of Lemoore Light & Power Co. were taken over for $1,977.85, and the company reorganized with a capital stock of $50,000 par value, of which $300 was subscribed by the directors and the balance issued to the treasury; of this balance $8,600 was delivered to San Joaquin Light & Power Co. for its Lemoore property. Tule River Co. was organized to acquire water rights and rights of way on Tule River, which are now utilized in connection with Tule River plant.

In addition to the above companies, which they acquired in the name of San Joaquin Light & Power Co., Messrs. Balch and Kerckhoff and their associates had also formed Coalinga Light & Power Co., which was later reorganized as Coalinga Water & Electric Co. and still later, after the incorporation of San Joaquin Light & Power Corporation, changed its name to Midland Counties Public Service Corporation. The system owned and operated by these companies has never been under direct control of San Joaquin Light & Power Corporation, although it has always been operated in harmony with it.

In 1910 it was necessary to reincorporate San Joaquin Light & Power system for a second time on an enlarged basis, in order to permit the acquisition of Merced Falls Gas & Electric Co., operating in and around Merced, and Power Transit & Light Co., operating in and around Bakersfield. To this end San Joaquin Light & Power Corporation was organized.

PRESENT ORGANIZATION.

INCORPORATION.

San Joaquin Light & Power Corporation was incorporated July 19, 1910, and on August 1 acquired by deed the properties of San Joaquin Light & Power Co., Merced Falls Gas & Electric Co., and Power Transit & Light Co. The authorized capitalization of the new corporation was $25,000,000, against a combined authorized capitalization of $5,750,000 for the three principal corporations absorbed. (See Table 77.)

TABLE 77.—*Constituent companies of San Joaquin Light & Power and Midland Counties Public Service corporations.*

	Date of incorporation.	Control of stock obtained by successor.	Properties deeded to successor.
San Joaquin Light & Power Corporation	July 19, 1910		
San Joaquin Light & Power Co	May 13, 1905		Aug. 1, 1910
San Joaquin Power Co	Aug. 11, 1902	1905	
San Joaquin Electric Co	Apr. 2, 1895		Dec. , 1902
Madera Electric Water Co	Mar. 16, 1907	Mar. 16, 1907	
Madera Water Works	Mar. 6, 1908	Mar. 6, 1908	
Sanger Light & Power Co	Mar. 11, 1908	Mar. 11, 1908	
Fresno Gas & Electric Co			1903
Selma Light & Water Co	Apr. 20, 1901		1907
Madera Light & Power Co	Sept. 24, 1908	Sept. 24, 1908	
Lemoore Light & Power Co	Apr. 21, 1909	Apr. 21, 1909	
Tule River Co			
Merced Falls Gas & Electric Co	Sept. 7, 1899		Aug. 1, 1910
Power Transit & Light Co	Dec. 24, 1902		Aug. 1, 1910
Power Development Co	Oct. 26, 1894		
Bakersfield Gas & Electric Light Co	June 7, 1890		
Bakersfield & Kern Electric Railway Co	Mar. 26, 1900		
Midland Counties Public Service Corporation [a]	Oct. 14, 1913		
Coalinga Water & Electric Co	Nov. 20, 1909	1913	
Midland Counties Gas & Electric Co	Feb. 2, 1912	1913	
San Luis Gas & Electric Co	Apr. 13, 1903	1912	
Santa Maria Gas & Electric Co	Aug. 14, 1907	1912	
Paso Robles Light & Water Co	Mar. 13, 1906	1913	
Russell Robison Water & Electric Co	Apr. 30, 1906	1913	

[a] Midland Counties Public Service Corporation is successor by change of name to Coalinga Water & Electric Co.

PROPERTIES ACQUIRED.

On assuming control of the combined properties San Joaquin Light & Power Corporation found itself in possession of the Fresno system, including the nearly completed San Joaquin plant on the San Joaquin River (with the first two of its four 4,000-kilovolt-ampere units in place), San Joaquin No. 3 plant (with a total capacity of 2,000 kilovolt-amperes), and Fresno steam station (capacity of 540 kilowatts), all feeding into a transmission system centering in Fresno with a single line running northward through Madera, Athlone, and Merced to Merced Falls, a line running southward through Hanford to Corcoran and to Coalinga, with branch lines to Dinuba, Reedley, and Kings River, and a line running westward from Fresno to Kerman. The southern system, which was owned by Power Transit & Light Co., was supplied from the 1,350-kilovolt-ampere hydroelectric plant at the mouth of Kern Canyon, which transmitted to Bakersfield and vicinity over a 2-circuit 10,000-volt line. The Merced Falls system was a local transmission and distributing system, served from a 225-kilovolt-ampere hydroelectric plant at Merced Falls.

In addition to the electric generating, transmission, and distribution systems described in the following pages, San Joaquin Light & Power Corporation or its subsidiaries operates gas plants and distributes natural gas in Bakersfield, Merced, and Selma, supplies water in Madera and Selma, and operates an electric railway in Bakersfield.

NEW WORK.

The company immediately proceeded to complete the construction of new San Joaquin plant and Crane Valley dam, and began work on the new transmission lines to consolidate the entire system and on a large steam reserve station at Bakersfield. In January, 1914, the Tule River plant, with a capacity of 6,000 kilovolt-amperes, was completed. In 1913 the corporation also began construction of the transmission line extending westward from Coalinga to San Luis Obispo and Santa Maria, under contract with Midland Counties Public Service Corporation, and in August, 1916, displaced the old steam plants on the coast system with the larger Betteravia steam plant. Plant No. 2, plant No. 1-A, and Crane valley power house, all on the North Fork of the San Joaquin, were put into operation between 1917 and the early part of 1919, and the Kittridge plant on Merced River was acquired in 1917. The Kerckhoff plant was completed in 1920; the Kern Canyon plant enlarged and the Buttonwillow steam plant built in 1921.

MIDLAND COUNTIES PUBLIC SERVICE CORPORATION.

On November 20, 1909, San Joaquin Light & Power interests formed Coalinga Water & Electric Co., to acquire certain small electric properties which were then operating in and around Coalinga. The distribution system thus acquired has always been supplied with electric energy by San Joaquin Light & Power Corporation. On October 14, 1913, the name of Coalinga Water & Electric Co. was changed to Midland Counties Public Service Corporation, and shortly thereafter the latter acquired all but director's qualifying shares of Midland Counties Gas & Electric Co., Paso Robles Light & Water Co., and Russell Robison Water & Electric Co.

Of these smaller concerns, Midland Counties Gas & Electric Co. had been incorporated in 1912 to consolidate the properties of San Luis Gas & Electric Co. and Santa Maria Gas & Electric Co., which were operating small systems in the cities of San Luis Obispo and Santa Maria. Shortly after this consolidation the capital stock of the new company was purchased jointly, from its organizers, by certain persons connected with San Joaquin Light & Power Corporation and Southern California Edison Co. The latter finally dropped out, leaving the entire control in the hands of San Joaquin Light & Power interests, by whom it was transferred to Midland Counties Public Service Corporation. This part of the system furnished gas and electricity in San Luis Obispo and electricity in Santa Maria; the gas properties were sold in 1920. Paso Robles Light & Water Co. served electricity and water in Paso Robles and electricity in San Miguel; and Russell Robison Water & Electric Co. served electricity and water in Arroyo Grande.[3]

After the coast properties had been obtained by San Joaquin Light & Power interests and had been transferred by them to Midland Counties Public Service Corporation, the latter entered into a contract with San Joaquin Light & Power Corporation, under which, in 1913, the latter constructed a transmission line westward from Coalinga to connect with the isolated systems in the coast towns from Paso Robles south to Santa Maria, and also took over, under an operating contract, the small steam stations belonging to Midland Counties Public Corporation, agreeing in the same contract to furnish all the power necessary for distribution by the latter.

MARKET.

TERRITORY AND POPULATION.

The territory and population served by San Joaquin Light & Power system and by the Midland Counties Public Service Corporation are shown in detail in Table 78, which follows:

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[3] Electric properties in Kings City were purchased by A. G. Wishon, of San Joaquin Light & Power Corporation but were later resold to Coast Valleys Gas & Electric Co.

TABLE 78.—*Incorporated communities served by San Joaquin Light & Power and Midland Counties Public Service corporations.*

San Joaquin system.

City or town.	County.	Population.			
		1890	1900	1910	1920
Bakersfield [a]	Kern	2,626	4,836	12,727	18,638
Clovis	Fresno				1,157
Corcoran	Kings				1,101
Dinuba	Tulare			970	3,400
Firebaugh [b]	Fresno				
Fowler	do			675	1,528
Fresno [c]	do	10,818	12,470	24,892	45,086
Gustine	Merced				716
Hanford	Kings				5,888
Hornitos	Mariposa	276	205	160	100
Kingsburg	Fresno			634	1,316
Lemoore	Kings			1,000	1,355
Los Banos	Merced			745	1,276
McKittrick	Kern				207
Madera	Madera			2,404	3,444
Maricopa	Kern				1,121
Merced	Merced	2,009	1,969	3,102	3,974
Reedley	Fresno				2,447
Sanger	do				2,578
Selma [d]	do	1,150	1,083	1,750	3,158
Taft	Kern				5,317
		16,879	20,563	49,059	101,807

Midland Counties system.

City or town.	County.	1890	1900	1910	1920
Arroyo Grande	San Luis Obispo				760
Coalinga	Fresno			4,199	2,934
Lompoc	Santa Barbara			1,482	1,876
Paso Robles [e]	San Luis Obispo	827	1,224	1,441	1,919
San Luis Obispo	do	2,995	3,021	5,157	5,895
Santa Maria	Santa Barbara			2,260	3,943
		3,822	4,245	14,539	17,327

[a] Also gas and railway power.
[b] Not returned separately.
[c] Also water.
[d] Also gas and water.
[e] Also gas.

The following unincorporated places are also served:

By San Joaquin system.

Alpaugh.
Angiola.
Athlone.
Atwater.
Berenda.
Califa.
Caruthers.
Del Rey.
Dos Palos.
Exchequer
Famoso.
Fellows.
Friant.
Kerman.
Laton.
Le Grande.
Lingard.
Livingston.
Lost Hills.
McFarland.
Malaga.
Mendota.
Merced Falls.
Minturn.
Nipomo.
North Fork.
Olig.
Orosi.
Paige.
Parlier.
Planada.
Pond.
Raisin City.
Raymond.
Snelling.
Stoil.
Sultana.
Waits.
Wasco.
Waukena.
Woodlake.

By Midland Counties system.

Atascadero.
Guadalupe.
Oceano.
Pismo.
San Miguel.
Santa Margarita.
Templeton.

LOAD.

SAN JOAQUIN LIGHT & POWER LOAD.

San Joaquin Light & Power system has generated the entire power supply of Midland Counties Public Service Corporation and its predecessor, Coalinga Water & Electric Co. The sales to Midland Corporation from 1914 to 1920 were:

	Kilowatt-hours.
1914	5,734,800
1915	5,828,600
1916	7,411,900
1917	11,196,008
1918	20,535,940
1919	29,313,920
1920	35,628,680

During the years 1912 to 1915 San Joaquin Light & Power Corporation delivered power on a wholesale contract to Tulare County Power Co., which was absorbed in 1915 by Mount Whitney Power & Electric Co. This contract was dated March 5, 1912, and was modified by a supplementary agreement dated April 7, 1915, and was assumed by Mount Whitney Power Co. when it acquired the properties of Tulare County Power Co. The original agreement limited Tulare County Power Co. to a maximum demand of 1,500 kilowatts; below that maximum the company might purchase such power as it required at a rate of $33.33⅓ per month per horsepower, with a guaranteed minimum payment of $3,333.33 per month. Under this contract 3,395,800 kilowatt-hours were delivered in 1913, 5,130,600 kilowatt-hours in 1914, 4,472,000 kilowatt-hours in 1915, and 976,000 kilowatt-hours in 1916.

In the season of 1913 San Joaquin Light & Power Corporation was compelled by low water to purchase power from both Mount Whitney Power & Electric Co. and from Pacific Light & Power system. Power furnished by Mount Whitney Co. was of minor importance; that purchased from Pacific Light & Power Corporation was received in a roundabout manner, the San Joaquin Co. extending its lines from its Kern Canyon plant about a mile and a half up the river to the Kern River plant No. 1 of Southern California Edison Co. At that station a single 5,000-kilovolt-ampere generator was put exclusively on the San Joaquin load, and the Southern California Edison Co. was reimbursed for the output of this generator by power delivered to its system in Los Angeles by Pacific Light & Power Corporation, with which the San Joaquin corporation had originally contracted for power. This connection at Kern River has been maintained.

The rate of increase in the business handled by the system is shown in Table 79 by kilowatt-hours generated and purchased and in Table 80 by consumers and connected load.

TABLE 79.—*Power generated and purchased by San Joaquin Light & Power Corporation, 1905–1920.*[a]

Year.	Generated.		Total.	Purchased.	Total system.	Mean.	Peak.	Load factor.
	Hydro.	Steam.						
						Horsepower.	*Horsepower.*	*Per cent.*
1905	8,834,270	750,021	9,584,291	None.		1,459		
1906	10,446,100	515,692	10,961,792	None.		1,668	3,465	48.1
1907	12,360,700	8,200	12,368,900	None.		1,883	3,935	47.9
1908	13,021,300	679,609	13,700,909	None.		2,085	3,935	53.0
1909	15,663,700	726,025	16,389,725	None.		2,495	4,335	57.7
1910	19,127,400	2,002,763	21,130,163	None.		3,126	7,535	42.6
1911	42,571,830	2,583,840	45,155,670	None.		6,873	13,335	51.5
1912	67,048,400	3,565,800	70,614,200	None.		10,748	20,135	53.3
1913	51,868,340	43,845,886	95,714,226	6,085,565	101,799,791	15,571	26,237	59.5
1914	106,828,450	1,093,903	107,922,353		107,922,353	16,507	25,862	63.9
1915	106,026,900	199,078	106,225,978		106,225,978	16,249	26,532	61.3
1916	109,054,266	1,866,628	110,920,894		110,920,894	16,921	27,872	60.8
1917	128,580,368	14,549,220	143,129,588		143,129,588	21,894	33,634	65.1
1918	120,783,326	54,180,125	174,963,451	57,135,000	232,098,451	35,503	65,258	54.4
1919	110,241,855	80,379,676	190,621,531	64,030,679	254,652,210	38,954	61,962	62.8
1920	178,703,490	106,561,510	285,265,000	14,748,675	300,013,675	45,892	84,252	54.4

[a] The figures given in the above table up to and including 1917 represent not only power generated but that delivered to the San Joaquin system network. For the years 1918 to 1921 the figures are on the basis of total power generated, with important deliveries to outside companies, notably Pacific Gas & Electric Co.

Classified sales in kilowatt-hours and connected load in kilowatts from 1913 to 1920 are given in Table 81. More detailed figures than are shown in the table disclosed the following distribution of sales during 1920 and connected load at the end of that year:

The most important municipal street-lighting loads on the system are in the Fresno district (1,431,022 kilowatt-hours sold, 432 kilowatts connected) and Bakersfield (606,233 kilowatt-hours sold, 150 kilowatts connected).

Commercial lighting of business establishments was heaviest in the Fresno district (6,161,305 kilowatt-hours sold and 8,485 kilowatts connected), Bakersfield district (2,417,036 kilowatt-hours sold and 403 kilowatts connected), and Taft district (1,732,634 kilowatt-hours sold and 1,180 kilowatts connected), Fresno leading all other districts by a considerable margin. In residence lighting Fresno district leads (3,146,455 kilowatt-hours sold and 10,969 kilowatts connected) and is followed by Bakersfield (1,174,662 kilowatt-hours sold and 4,567 kilowatts connected) and Dinuba district (506,071 kilowatt-hours sold and 1,750 kilowatts connected).

The rest of the lighting load of all classes is fairly evenly distributed among the remaining districts.

The most important deliveries of municipal power were in Madera (405,705 kilowatt-hours sold and 208 kilowatts connected), Fresno (338,371 kilowatt-hours sold and 480 kilowatts connected), and Dinuba (386,657 kilowatt-hours sold and 169 kilowatts connected). Industrial power load was heaviest in Fresno (25,315,908 kilowatt-hours sold and 12,553 kilowatts connected), Bakersfield (11,640,368 kilowatt-hours sold and 3,655 kilowatts connected), Taft (6,430,233 kilowatt-hours sold and 1,639 kilowatts connected), and Merced district (1,359,399 kilowatt-hours sold and 1,098 kilowatts connected). Industrial load sales in the other districts are fairly evenly distributed, ranging from a minimum of 245,000 kilowatt-hours to a maximum of 1,355,000 kilowatt-hours.

The most extensive use of power for agriculture is in the Famoso district (13,094,434 kilowatt-hours sold and 3,553 kilowatts connected). Large loads of this class are also found in the Madera district (6,850,763 kilowatt-hours sold and 3,077 kilowatts connected), Bakersfield district (6,818,169 kilowatt-hours sold and 1,935 kilowatts connected), Fresno district (6,331,853 kilowatt-hours sold and 1,739 kilowatts connected), and Corcoran district (6,321,069 kilowatt-hours sold and 3,160 kilowatts connected).

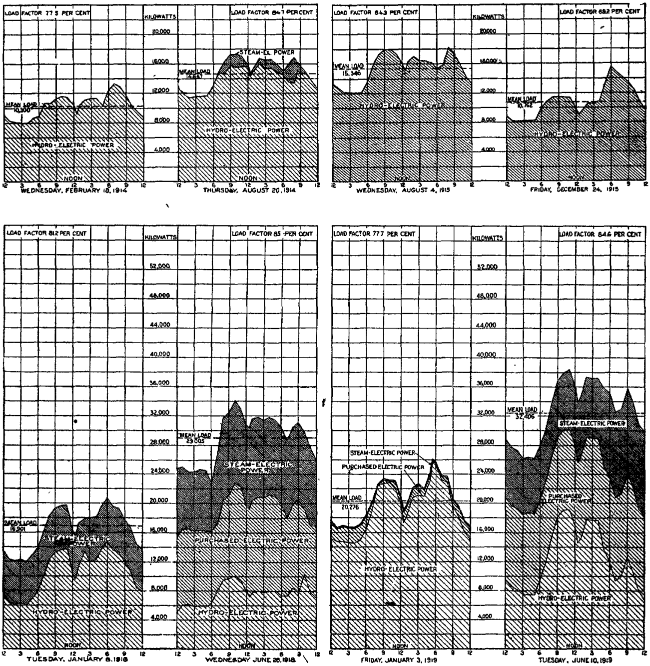


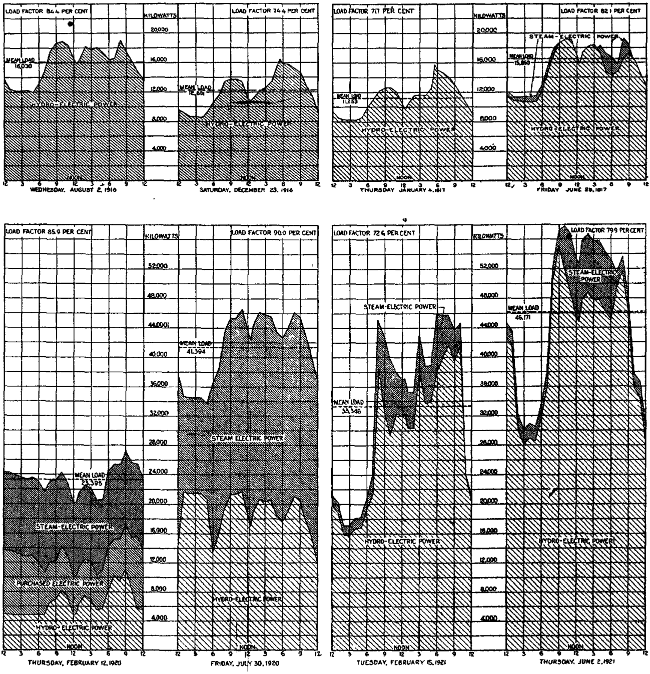
FIGURE 24.—San Joaquin Light & Power

The energy classified as "Other power" in Table 81 was delivered in the Taft district (16,532,599 kilowatt-hours sold and 4,988.8

kilowatts connected) and in the Bakersfield-Kern River district (15,686,766 kilowatt-hours sold and 594 kilowatts connected). All of this power is used in the oil industry.

Railway power was delivered only in Fresno (3,352,003 kilowatt-hours sold and 1,441 kilowatts connected) and in Bakersfield (721,701 kilowatt-hours sold and 430 kilowatts connected).

Sales to "Other electric corporations" totaled 39,655,240 kilowatt-hours and were all in the Fresno district.



Corporation, daily load curves, 1914–1921.

The mean monthly loads of the system computed from station output in kilowatt-hours and the corresponding monthly load factors, 1906–1921, are shown in Plate XLVIII. Up to and including October, 1910, the figure covers only the Fresno system, but after that month the records include also the Merced and Bakersfield divisions. The rapid growth of the load between the end of 1910 and the middle of 1913 is to be accounted for chiefly by the rapid extension of the transmission and distribution lines and the active campaign for new business.

Daily load curves for the system are shown in figure 24. These curves, as well as that shown in Plate XLVIII, make clear the marked seasonal variation in the power demands on the system due chiefly to the large agricultural use. Both monthly and daily curves show the very marked effect of low-water years, such as 1913 and 1918, on the ratio of hydroelectric to steam-electric power.

The daily load curves and mean monthly loads of the system show very high load factors, the daily factors ranging from approximately 69.2 to 90.0 per cent and the monthly load factors from 60 to 80. The annual load factors for several years past have ranged from approximately 55 to 65 per cent.

MIDLAND COUNTIES LOAD.

Classified sales in kilowatt-hours and connected load in kilowatts for the Midland Counties system are given in Table 81.

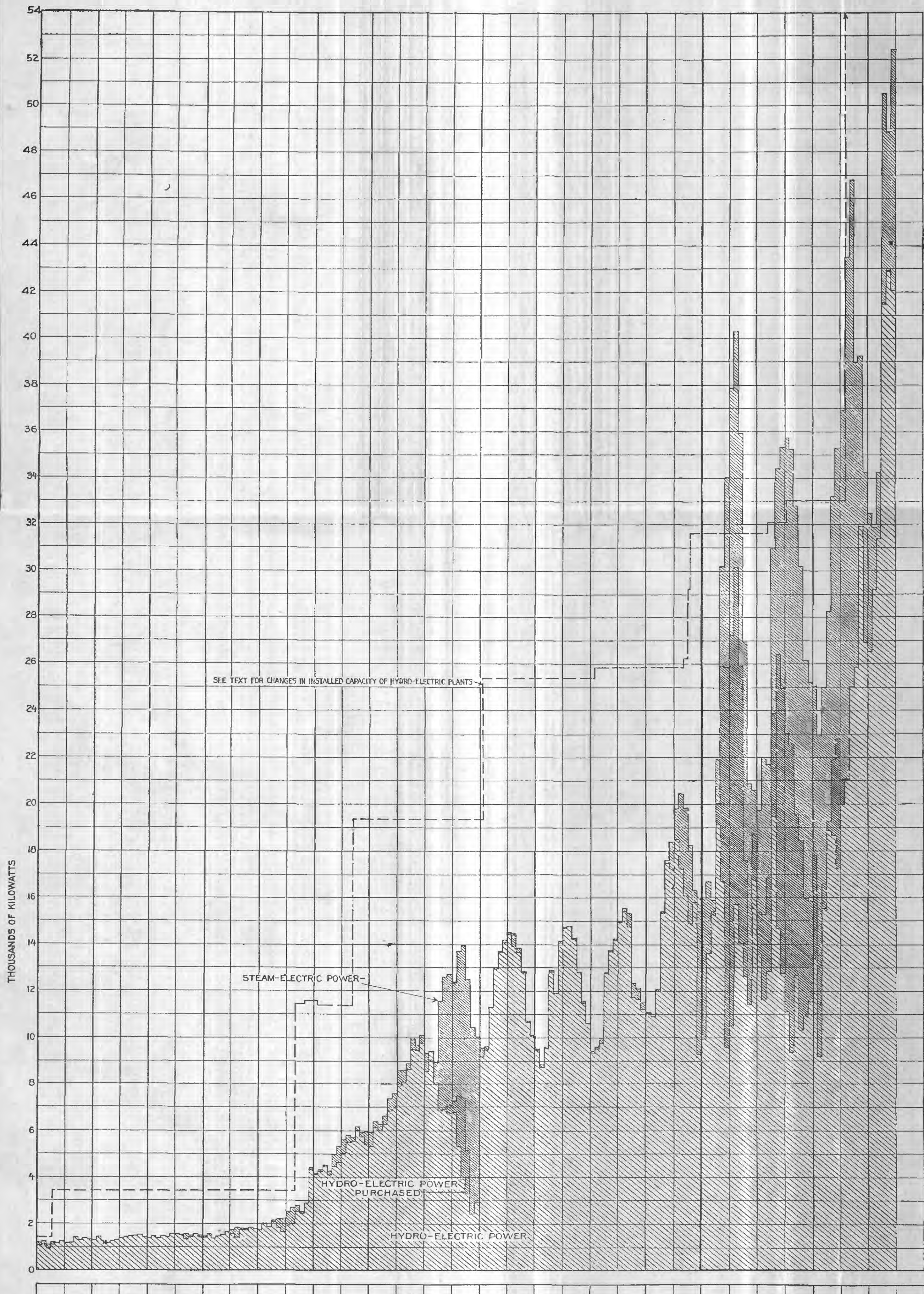
The only municipal lighting loads are in Santa Maria (44,506 kilowatt-hours sold and 15 kilowatts connected) and San Luis Obispo (518 kilowatt-hours sold and 8 kilowatts connected). The largest amounts of business lighting are in Santa Maria (664,200 kilowatt-hours sold and 340 kilowatts connected), San Luis Obispo (466,885 kilowatt-hours sold and 322 kilowatts connected), and Coalinga (338,291 kilowatt-hours sold and 425 kilowatts connected).

San Luis Obispo leads in the amount of residence lighting (352,087 kilowatt-hours sold and 1,861 kilowatts connected) and is followed by Coalinga (261,017 kilowatt-hours sold and 848 kilowatts connected) and Santa Maria (202,354 kilowatt-hours sold and 855 kilowatts connected).

San Luis Obispo ranks first in the use of municipal power (388,590 kilowatt-hours sold and 96 kilowatts connected) and is followed by Paso Robles (266,184 kilowatt-hours sold and 35 kilowatts connected).

The largest demands for industrial power are in the Santa Maria district, where 5,488,048 kilowatt-hours were sold during 1920 and 1,458 kilowatts connected; the San Luis Obispo district, the next in rank, is far behind, with only 736,560 kilowatt-hours sold and 895 kilowatts connected; Coalinga follows closely, with 710,183 kilowatt-hours sold and 397 kilowatts connected; and Paso Robles is last, with 203,415 kilowatt-hours sold and 159 kilowatts connected.

The Santa Maria district also has the largest use of power for agriculture, consuming 309,947 kilowatt-hours during the year 1920, with 80 kilowatts connected; Paso Robles follows, with 297,593 kilowatt-hours sold and 157 kilowatts connected. The other two districts fall far behind, only 60,857 kilowatt-hours having been sold and 68 kilowatts connected in San Luis Obispo and 11,904 kilowatt-hours sold and 19 kilowatts connected in the Coalinga district.



SAN JOAQUIN LIGHT & POWER CORPORATION, MEAN MONTHLY LOADS AND LOAD FACTORS, 1906–1921.

Under the classification "Other power" the company reports the sale of 10,014,363 kilowatt-hours and connected load of 2,998 kilowatts in the Coalinga district, which represents power used in the oil fields, as does 8,211,018 kilowatt-hours sold and 1,904 kilowatts connected in the Santa Maria district. The rest of the load under this classification is in San Luis Obispo.

All railway power is in the Santa Maria district and is used by Pacific Coast Railway Co.

TABLE 80.—*Consumers and connected load, San Joaquin Light & Power Corporation, 1908–1920.*

Year.	Number of consumers.	Connected load.	Year.	Number of consumers.	Connected load.
		Horsepower.			*Horsepower.*
1908	3,721	....	1915	20,480	68,199
1909	4,903	....	1916	23,238	77,141
1910	8,242	....	1917	26,403	84,167
1911	12,568	....	1918	28,604	118,550
1912	15,910	....	1919	31,804	124,315
1913	18,577	60,188	1920	36,073	145,407
1914	19,806	59,308			

TABLE 81.—*Sales and connected load, San Joaquin Light & Power system, 1913–1920*

San Joaquin Light & Power Corporation.

	1913				1914			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	3,521,279	4.8	8,790	19.6	2,587,210	3.2	9,023	20.4
Commercial	6,246,064	8.5	7,370	16.4	6,630,062	8.3	7,639	17.3
Municipal	2,002,150	2.7	708	1.5	1,309,106	1.6	352	.8
Power:								
Industrial	22,028,314	29.9	13,360	29.7	29,691,388	37.2	14,521	32.8
Agricultural	14,517,610	19.7	6,642	14.8	16,480,255	20.6	6,390	14.4
All other power	25,384,105	34.4	8,046	17.9	23,210,891	29.1	6,335	14.3
	73,699,522	100.0	44,916	100.0	79,908,912	100.0	44,260	100.0

	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	2,927,796	3.7	9,792	19.2	3,241,849	4.0	11,760.6	20.5
Commercial	6,924,745	8.7	7,714	15.1	7,238,368	9.0	7,991.0	13.9
Municipal	1,577,133	2.0	389	.8	2,499,883	3.1	971.9	1.6
Power:								
Industrial	26,121,522	33.1	17,558	34.5	29,207,768	36.2	22,989.9	40.0
Agricultural	18,767,408	24.0	7,167	14.1	19,086,776	23.7	6,927.4	12.0
All other power	22,500,096	28.5	8,275	16.3	19,328,080	24.0	6,919.0	12.0
	78,818,700	100.0	50,895	100.0	80,602,724	100.0	57,567.8	100.0

TABLE 81.—*Sales and connected load, San Joaquin Light and Power system, 1913–1920*—Continued.

Class of load.	1917				1918			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Municipal—								
Street	2,248,121	2.0	404.8	0.6	1,887,729	1.3	439.3	0.5
Miscellaneous	1,085,671	1.0	460.5	.7	1,143,130	.8	477.3	.5
Commercial—								
Business	8,980,296	8.1	8,325.0	13.3	9,807,049	6.8	8,270.0	9.4
Residence	3,898,810	3.5	13,400.0	21.3	4,855,896	3.4	14,333.0	16.2
Power:								
Municipal	1,278,365	1.2	1,090.8	1.8	1,364,286	.9	1,610.5	1.8
Commercial—								
Industrial	28,744,248	26.1	18,062.0	28.8	44,671,952	30.9	29,252.3	33.1
Agricultural	31,711,200	28.7	10,736.5	17.1	39,446,240	27.2	17,693.8	20.0
Other commercial	14,606,784	13.3	4,340.0	6.9	13,784,558	9.5	5,582.8	6.3
Railway	4,179,254	3.8	1,392.0	2.2	4,118,105	2.8	1,871.0	2.1
Other electrical corporations	13,546,090	12.3	4,600.0	7.3	23,742,080	16.4	8,940.0	10.1
	110,278,839	100.0	62,811.6	100.0	144,821,025	100.0	88,470.0	100.0

Class of load.	1919				1920			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Municipal—								
Street	2,549,389	1.4	814	0.9	2,463,860	1.0	735	0.7
Miscellaneous	1,238,450	.7	502	.5	....	....	....	....
Commercial	10,823,311	5.9	9,065	9.8	12,739,398	5.4	12,906	11.9
Domestic	5,673,936	3.1	21,633	23.3	6,820,126	2.9	24,934	23.0
Other	....	....	....	....	1,407,166	.6	....	....
Heating and cooking	....	....	....	....	160,458	.1	....	....
Combination light, heat, and power	....	....	....	....	507,084	.2	125	....
Power:								
Municipal	1,420,533	.8	1,533	1.7	1,703,210	.7	1,425	1.3
Commercial—industrial	39,599,565	21.6	21,455	23.1	49,446,785	21.1	24,333	22.5
Agricultural	52,480,703	28.6	18,189	19.6	52,473,128	22.4	20,173	18.6
Other	33,084,653	18.0	10,110	10.9	32,268,789	13.8	9,749	9.0
Railway	3,897,205	2.1	1,396	1.5	4,073,704	1.7	1,320	1.2
Other electrical corporations	32,774,894	17.8	8,054	8.7	70,698,943	30.1	12,786	11.8
	183,542,639	100.0	92,751	100.0	234,762,651	100.0	108,487	100.0

TABLE 81.—*Sales and connected load, San Joaquin Light & Power system, 1913–1920*—Continued.

Midland Counties Public Service Corporation.

Class of load.	1913				1914			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	363,952	8.3	1,499	28.2	369,488	7.8	1,580	29.1
Commercial	721,580	16.5	1,153	21.6	683,829	14.6	1,187	21.8
Municipal	177,118	4.1	80	1.5	194,472	4.1	70	1.3
Power:								
Industrial	2,628,332	60.1	1,966	36.9	2,768,400	59.6	1,842	33.9
Agricultural	300,848	6.9	125	2.3	542,101	11.6	250	4.6
All other	179,496	4.1	[a] 507	9.5	107,300	2.3	[a] 507	9.3
	4,371,326	100.0	5,330	100.0	4,665,590	100.0	5,436	100.0

Class of load.	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	406,239	8.6	1,641	27.1	446,151	6.7	1,958	27.5
Commercial	718,262	15.3	1,224	20.6	739,593	11.1	1,328	18.6
Municipal	175,368	3.7	74	1.2	212,853	3.3	74	1.0
Power:								
Industrial	2,556,015	54.3	2,210	37.1	2,929,887	43.8	2,928	41.1
Agricultural	690,311	14.7	267	5.0	2,135,856	31.9	306	4.3
All other	158,452	3.4	[a] 535	9.0	205,472	3.2	[a] 535	7.5
	4,704,647	100.0	5,951	100.0	6,669,812	100.0	7,129	100.0

Class of load.	1917				1918			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Municipal—								
Street	182,131	17.0	54.9	7.0	114,306	7.0	23.0	2.0
Miscellaneous	43,646	4.0	86.4	11.0	57,744	3.0	82.0	8.0
Commercial	970,678	93.0	1,545.3	195.0	1,341,523	77.0	1,531.0	145.0
Residence	513,678	49.0	1,998.0	252.0	625,331	36.0	2,083.0	198.0
Power:								
Municipal	299,019	29.0	247.4	31.0	550,725	31.0	318.0	30.0
Industrial	3,516,199	338.0	1,952.8	246.0	6,089,723	346.0	3,155.0	300.0
Agricultural	620,817	60.0	313.4	40.0	558,853	32.0	392.5	37.0
Other	4,100,442	394.0	1,561.8	197.0	8,037,169	457.0	2,731.3	259.0
Railway	164,000	16.0	168.0	21.0	190,080	11.0	225.0	21.0
	10,410,610	100.0	7,928.0	100.0	17,565,454	100.0	10,540.8	100.0

[a] Pacific Coast Railway Co., 507 kilowatts.

TABLE 81.—*Sales and connected load, San Joaquin Light & Power system, 1913–1920*—Continued.

Class of load.	1919				1920			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	834,975	3.3	2,083.00	14.5	965,431	3.1	4,127	29.0
Municipal	86,050	.4	105.00	.8	116,366	.4	131	.9
Commercial	1,455,489	6.0	1,531.00	10.7	1,744,821	5.8	1,345	9.4
Power:								
Industrial	7,311,158	30.0	3,586.28	25.0	7,138,206	23.7	2,909	20.4
Agricultural	627,744	2.6	325.00	2.2	680,301	2.3	324	2.2
Municipal	818,689	3.4	652.50	4.5	852,910	2.9	297	2.3
Railway	205,612	.8	225.00	1.6	213,165	.7	168	1.2
Other	13,045,821	53.5	5,846.87	40.7	18,402,148	61.1	4,932	34.6
	24,385,538	100.0	14,354.65	100.0	30,113,348	100.0	14,233	100.0

ELECTRIC SYSTEM.

SAN JOAQUIN PLANTS.

SOURCE OF WATER SUPPLY.

The San Joaquin plants of San Joaquin Light & Power Corporation, with the exception of the Kerckhoff plant, the most recently constructed, are operated with water supplied by the North and South forks of North Fork of San Joaquin River in the vicinity of the town of Northfork, Madera County, about 40 miles northeast of Fresno. The Kerckhoff plant diverts from the main river below the mouth of North Fork.

North Fork of San Joaquin River rises on the south slope of Iron Mountain, at an altitude somewhat exceeding 8,000 feet above sea level, and flows nearly due south to a junction with the main river. Thirteen miles, in an air line, from its source is the Crane Valley dam, and 18 miles from its source it is joined by the South Fork of North Fork. The lowest of the various power intakes is but a short distance above the South Fork junction. South Fork of North Fork rises north of Shuteye Peak, at an elevation of about 7,000 feet, and flows nearly south to its junction with North Fork. The general shape of the combined drainage basins above the junction of the streams is an oval, measuring 18 miles north and south by 8 miles east and west. The area included in the drainage basin and the positions of the hydroelectric plants are shown on Plate XLIX (in pocket).

The area drained by the North Fork above Crane Valley reservoir comprises 52 square miles. A diversion ditch that has been built around the mountain between the North Fork and South Fork of North Fork delivers the discharge up to the capacity of the feeder from 24.5 square miles of the South Fork basin into the Crane Valley reservoir; flow beyond the capacity of the ditch passes over the dam and down South Fork and is available for diversion into the conduit of San Joaquin plant. The drainage area on North Fork below the Crane Valley dam and on South Fork below Browns Creek dam (the intake of the conduit leading to Crane Valley) and above the head of the conduit to the San Joaquin plant comprises 21.5 square miles, but this area is tributary solely to the lower conduit and its run-off can not be stored.

The areas above the points of diversion are summarized as follows:

TABLE 82.—*Drainage areas above North Fork of San Joaquin plants.*

	Square miles.
North Fork drainage basin directly tributary to Crane Valley reservoir	52.0
South Fork drainage tributary to Crane Valley reservoir through Browns Creek ditch	24.5
Tributary to storage and to Crane Valley plant and plant No. 3	76.5
Area below Crane Valley tributary to plant No. 2	5.9
Total tributary to plant No. 2	81.4
Area below Crane Valley and Browns Creek dams but tributary to San Joaquin conduit	21.5
Total tributary to San Joaquin plant	98.0

Elevations within the North Fork drainage area supplying water to the San Joaquin plants range from 2,500 feet at the lowest intake and 3,375 feet at Crane Valley reservoir to about 8,500 feet along the top of the Chiquito Ridge, on the northeast boundary of the basins, and 9,154 feet on the summit of Iron Mountain. Below the junction of North and South forks the canyon of North Fork drops very rapidly to the main San Joaquin River. The basin comprises a rolling mountainous country shut in by high ridges on the east and west. Much of the region is covered by heavy forests. The rocks are chiefly granitic. The mean seasonal precipitation ranges from about 27 inches at San Joaquin power house to about 43.5 inches at Crane Valley reservoir; in the upper part of the basin the seasonal mean is probably 45 inches or more. Natural stream flow at the north and south fork intakes of the new San Joaquin plant has dropped as low as 3.8 second-feet. The minimum seasonal inflow into Crane Valley reservoir was during the year ending September 30, 1913, 18,200 acre-feet,[4] of which 6,320 acre-feet was received from South Fork, through Browns Creek ditch.

CRANE VALLEY RESERVOIR.

The new Crane Valley dam, constructed at the same time as the new San Joaquin No. 1 plant, is an enlargement of an old structure that is

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[4] For records of discharge of North Fork of San Joaquin River see U. S. Geol. Survey Water-Supply Papers as follows: 299, pp. 194–205; 410 (up to Dec. 31, 1911; those for June to December, 1912, were not published); 361, pp. 161–165 (1912–13); 391, pp. 147–151 (1913–14); 411, pp. 144–148 (1914–15); gaging station discontinued in 1915.

now built into its upstream side. The new dam is a composite structure of hydraulic earth fill and rock fill with a concrete core wall. The highest part of the dam is in the rock-fill section, which rises to a maximum height of 150 feet above the lowest point in the base and 125 feet above the outlet from the gate tower. The maximum height of the core wall is 148 feet. The side slopes of the rock-fill section are 1¼:1 on both upstream and downstream faces. At the point where the rock and earth sections of the dam join there is a dry-laid rock retaining wall 10 feet thick. The side slopes of the earth section are 2:1 on both upstream and downstream faces, both of which are riprapped with hand-laid rock. The crest width of the dam is 15 feet in rock fill and 30 feet in the earth-fill section. The concrete core wall has a crest width of 2 feet and a batter of 1 in 50 on each side through the rock fill, and a crest width of 1 foot and a batter of 1 in 75 on each side through the earth-fill dam. The crest line of the dam is not straight but contains two angles; the length of the dam on center line is 1,865 feet. The crest elevation of the new dam is 3,380 feet above sea level. The area of water surface at 3,375 feet, the normal maximum is 1,095 acres, and the capacity of the reservoir at that elevation is 38,060 acre-feet. The yardage in the dam (according to Mr. Hewens, superintendent in charge of its construction) is 400,000 cubic yards of earth fill, 250,000 yards of rock fill, and 15,000 yards of concrete core wall.

Water is admitted through a gate tower to a tunnel outlet passing under the dam. The tower is in the reservoir opposite the center of the dam, and is a reinforced-concrete structure with a maximum height of approximately 131 feet above the lowest point in its foundation. The depth of its interior shaft is 125 feet. The horizontal cross section of the tower is not circular but U-shaped, and the tower has uniform interior dimensions from top to bottom. The base of the U-shaped interior cross section is 6 feet; the distance from base to crown of arch is 6 feet and to radius of arch 3 feet. The walls of the tower are 36 inches thick at the bottom and decrease in thickness toward the top; first to 27 inches, then to 18 inches, and finally to 15 inches. The flat side of the tower is placed toward the outlet tunnel, the invert of which is 2 feet above the base of the interior shaft. The tunnel outlet leads in a curve through the bedrock under the base of the dam. The section of the tunnel is 5 feet wide by 6 feet from the invert to the crown of the circular arched roof. The floor of the outlet is 125 feet below the crest of the dam. The tower is placed in and built against the side of a valve pit which was excavated in the bedrock, and it is therefore supported by the side of the pit for about half of its height, above which it emerges from the pit into the reservoir proper. Water is admitted to the bottom of the valve pit and base of the tower through another tunnel which was excavated horizontally through the rock from deep water above the dam.

There are three separate methods for admitting water to the tower—dashpot gates, rectangular slide gates, and gate valves. Beginning at a point 5 feet above the floor of the outlet tunnel there are twelve 12-inch dashpot gates arranged spirally around the upstream face of the tower at vertical intervals of 5 feet. The topmost of these gates is just above the surface of bedrock, where the tower emerges from the valve pit. At about this level, between 53 and 73 feet above the base of the tower, there are five gate valves. One of these is 20 inches, one 18 inches, and the other three are 12 inches in diameter. Water is admitted to these valves through thimbles that pass through the concrete walls of the tower; the outer end of each thimble is provided with an auxiliary flap valve which is controlled by wire cable from the top of the structure. On the flat side of the tower, at a point 66 feet above the invert of the outlet tunnel, there is a 30-inch square sliding gate, and on the same level as the invert there are three similar gates, two of which are 24 inches square and the other 24 by 36 inches. The discharge from the tower into the head of the outlet tunnel is controlled by two sliding gates 30 inches wide by 6 feet deep. All the sliding gates are operated by rods that extend to the platform at the top of the tower.

At the lower end of the outlet tunnel the water was formerly discharged into the stilling pond (Pl. XLIV, *D*, p. 365) of the division weir at the lower toe of the dam and from this pond discharged over a 38-foot weir into the stream bed or admitted into the head of the conduit leading to plant No. 3. The lower end of the tunnel now connects directly to the pressure pipe of Crane Valley plant (p. 474).

In addition to the tunnel outlet the reservoir is provided with a spillway in a saddle beyond the rocky knoll at the east end of the dam. The upper part of this spillway is paved but the lower part is cut in native granite. The spillway is 70 feet wide, and its floor is 13 feet below the crest of the dam. Its channel is bridged by a flashboard frame, and with 9-foot flashboards in place the water surface of the reservoir may be raised to 3,376 feet, or 1 foot above its normal position and only 4 feet below the top of the dam. The area of the reservoir at the 3,376-foot level is 1,118 acres and its capacity is 39,200 acre-feet.

RELATION OF PLANTS.

The first plant constructed on the San Joaquin—No. 1—diverted water from the North Fork just above the junction of the two forks. Subsequently plant No. 3 was built at a point about 2½ miles upstream from the intake of plant No. 1, and the company then took steps to augment the low flow of the stream by building a small storage reservoir at Crane Valley, just at the head of the conduit leading to power house No. 3. In 1910 the company completed the "New" San Joaquin power house, which was placed close beside the old power house of plant No. 1 (which has been dismantled) and provided additional storage at Crane Valley by raising the dam. Plant No. 2, constructed in 1913 and 1917, uses the 325-foot head between power house No. 3 and intake No. 1.

The great rise in the cost of generating electric energy by steam power, following the entry of the United States into the war, led all the operating companies to concentrate their attention on the possibility of extending at slight cost systems already constructed. As a result of this campaign for economy the San Joaquin Light & Power Corporation installed two automatic plants to utilize small drops in its conduit system on the North Fork of San Joaquin River. One of these was at the outlet of Crane Valley reservoir into the head of the conduit leading to plant No. 3, and the other was at the lower end of the conduit of New San Joaquin plant immediately above Lake Corrinne. The first of these—Crane Valley plant—went into operation early in 1919 but was soon shut down on account of trouble with the transformers and shortage of water during the summer.

Construction of the Kerckhoff plant on San Joaquin River below San Joaquin plant No. 1 was started May 1, 1919, and the first unit was placed in operation August 5, 1920, although the plant was not formally dedicated until August 15. This development receives not only the discharge of North Fork but that of the entire mountain drainage of San Joaquin River. It will profit not only by storage in Crane Valley reservoir but also by storage in reservoirs constructed and proposed by Southern California Edison Co. in the upper San Joaquin basin.

CRANE VALLEY PLANT.

Location.—The intake for the Crane Valley plant is just below Crane Valley reservoir, which is in secs. 9, 14, 15, 16, 21, 22, 23, 24, 25, and 26, T. 7 S., R. 22 E. The plant was completed early in 1919 but did not begin to operate until July.

Conduit.—When construction of the Crane Valley plant was undertaken, 120 feet of 48-inch riveted-steel pressure pipe was concreted into the lower end of the outlet tunnel at Crane Valley dam (pp. 471–473) near the point where it had hitherto discharged into the triangular weir pool at the head of the No. 3 conduit. Below the lower portal of this tunnel, the pipe was extended 127 feet to the power house. A bend and rise in the pipe at the portal carries it up to the normal ground level and through the west wall of the weir pool, parallel to which it runs to a point opposite the conduit head. Then, bending to the right, the pipe parallels the west side of the conduit for about 50 feet to the back wall of the power house, and passing through the wall, connects to the turbine scroll case under the floor. The first 56 feet of pipe below the mouth of the tunnel, 48 inches in diameter, connects to a taper section 4 feet long, reducing to 42 inches and connecting successively to a 42-inch butterfly valve, 23.5 feet of 42-inch pipe, a second 4-foot section tapering from 42 inches to 36 inches, and terminating in 37.5 feet of 36-inch pipe connecting to the turbine. Twelve 12-inch waste pipes are taken off at right angles from the part of the 48-inch line lying parallel to the old weir pool. These branches pass over the wall and discharge downward into the basin at an angle of 45° through right-angle elbows. A hand-operated gate valve is installed in each of these branches at the point where it crosses over the wall.

The power house is directly over the upper end of the No. 3 conduit, and in order to provide settings for the main unit it was necessary to construct a longitudinal pier in the old canal and thicken the west wall of the conduit to form a second pier. On this account the conduit was widened from 12 to 16 feet directly beneath the building, so that water discharged through the by-pass pipes into the weir pool may be delivered to the No. 3 conduit in the normal manner, flowing beneath the Crane Valley power house when it is not in operation. In addition to widening the channel under the power house, a branch channel was constructed to serve as a tailrace and draft pool below the turbine. About 70 feet down the conduit from the power house there is a 32-foot weir lip in the outer wall of the conduit, and 10 feet down the channel from the lower end of this lip, are the new headgates controlling the flow to plant No. 3.

The relative elevations of the various parts of the Crane Valley plant are:

TABLE 83.—*Elevations at Crane Valley plant.*

	Feet.
Maximum water surface in reservoir (flashboards in place)	3,376.00
Spillway lip	3,367.00
Invert of tunnel at lower end	3,254.93
Center line of pressure pipe along weir pool	3,267.78
Center line of pressure pipe at power-house wall	3,261.78
Center line of turbine shaft	3,267.88
Invert of draft tube, outlet	3,247.88
Normal water surface in tailrace	3,258.43
Bottom of conduit lower end of tailrace	3,254.43
Power-house floor	3,264.42

The unit is designed to operate at heads varying between a maximum of 120 and a minimum of 80 feet, giving its maximum efficiency at a head of 100 feet.

Power house.—The Crane Valley power house is a reinforced-concrete building with tile roof supported by steel trusses. It is

42 feet 2 inches long inside, 24 feet 11 inches wide, and 19 feet 6 inches high from floor to lower chord of roof trusses.

Hydraulic equipment.—The single unit is operated by a 32-inch horizontal Pelton-Francis turbine, rated at 1,740 horsepower. The turbine gates are operated by a Crocker-Wheeler 3.5-kilowatt 125-volt direct-current motor governed by a direct-current automatic controller. A centrifugal switch on the main generator shaft shuts the unit down if it drops its load and starts to race. It is necessary for the caretaker at the dam to reconnect the power house to the line after each automatic shutdown.

Generator.—A Westinghouse 2,300-volt 251-ampere 1,000-kilovolt-ampere 3-phase 60-cycle type CS induction generator is connected by bolted flanged couplings to the shaft of the turbine and is designed to operate at 458 revolutions per minute. A direct-current magneto belted to the main shaft is connected to a voltmeter which indicates the speed of the unit.

Transformers.—Three General Electric 400-kilovolt-ampere self-cooled 2,300/40,100–69,500-volt transformers, installed on the conduit embankment in front of the power house, step the potential up to 70,000 volts for transmission.

SAN JOAQUIN PLANT NO. 3.

Location.—The intake of San Joaquin plant No. 3 is in sec. 26, T. 7 S., R. 22 E., and sec. 30, T. 7 S., R. 23 E. The conduit traverses secs. 25, 26, and 35, T. 7 S., R. 22 E.; secs. 2, 11, and 12, T. 8 S., R. 22 E.; and sec. 30, T. 7 S., R. 23 E. The power house is about 2½ miles upstream from the intake of plant No. 1 and is in sec. 12, T. 8 S., R. 22 E. The plant was put into operation April, 1906.

Conduit.—Water is admitted from the stilling pond at the lower end of Crane Valley outlet tunnel or is discharged through Crane Valley power house directly into the head of No. 3 conduit line. The total length of the line from head of canal to head of pressure pipe is 19,714 feet. The conduit follows the west side of North Fork Canyon in a direction almost due south from the dam to the forebay. Most of the conduit is concrete-lined side-hill ditch, 5 feet wide on bottom, 3 feet in maximum depth, and side slopes of 1:1. Above the ditch the slopes of the cut are trimmed to 1½:1, and the outer embankment has an 8-foot berm and slopes of 1½:1. Along the line there are 13 flumes and 4 tunnels of the following lengths and grades:

TABLE 84.—*Length and grade of sections of conduit of San Joaquin plant No. 3.*

Flumes.

No.	Length.	Grade.	No.	Length.	Grade.
	Feet.	*Per cent.*		*Feet.*	*Per cent.*
1	180	0.30	9	430	0.34
2	360	.34	10	190	.31
3	130	.30	11	230	.33
4	310	.30	12	130	.12
5	500	.41	13	180	.35
6	270	.34			
7	1,260	.29		4,340	
8	170	.33			

Tunnels.

No.	Length.	Grade.	No.	Length.	Grade.
1	260	0.30	4	240	0.45
2	160	.34			
3	525	.30		1,185	

Résumé.

	Feet.
Sheet-steel flumes	4,340
Concrete-lined tunnels	1,185
Concrete-lined ditch	13,639
Length of forebay (between tunnels 3 and 4)	550
	19,714
Pressure pipe, 52-inch	3,131
Taper joint, 60–52-inch	20
	22,865

The grade of most of the concrete-lined ditch is 0.15 per cent; the extreme variations in grade are 0.32 per cent maximum and 0.10 per cent minimum.

The flume body is semicircular, 6 feet in diameter, and constructed of 0.125-inch sheet steel. This body, or waterway, is supported on wooden trestles. In each flume there is an unriveted lap in the steel body which serves as an expansion joint. Around the outside of this joint a canvas belt is tightly drawn by turnbuckles.

The tunnels are concrete lined and arched, 5 feet wide and 6 feet high to the crown of the arch.

Near its lower end the conduit enters a small forebay reservoir between the lower portal of tunnel No. 3 and the upper portal of tunnel No. 4. The forebay is formed by an earth dam thrown across a hollow. From the forebay water is admitted through tunnel No. 4 to the intake chamber at the head of the pressure line. In plan the chamber is shaped like a long, narrow V, one side of which forms a waste weir 42 feet long. The maximum depth of water below the weir crest is 15.2 feet. Tunnel No. 4 enters the chamber from one side of the base and the pressure pipe leaves it from a point directly opposite. Water wasted over the weir, when the pressure pipe is closed, enters a concrete-lined raceway which empties into a canyon leading down to North Fork just above the power house. The simple sliding gate which controls the flow of water into the head of the pipe line is raised and lowered by a handwheel and screw, operated from a small gatehouse. This gate admits water to a 20-foot taper section of pipe which is 5 feet in diameter at the upper end, and 52 inches in diameter at its lower end where it joins the main pressure line. The pressure line is a single lap-welded pipe 52 inches in diameter and 3,131 feet long, made up of the following sections:

TABLE 85.—*Sections of pressure pipe, San Joaquin plant No. 3.*

	Length.	Thickness.		Length.	Thickness.
	Feet.	*Inch.*		*Feet.*	*Inch.*
First section	1,141	$\frac{3}{16}$	Fifth section	320	$\frac{3}{8}$
Second section	170	$\frac{7}{32}$	Sixth section	100	$\frac{1}{2}$
Third section	160	$\frac{1}{4}$			
Fourth section	680	$\frac{5}{16}$		2,571	

The pipe is buried throughout its length and is provided with concrete anchorages and with blow-offs.

The elevation of the center line at the head of the pipe is 3,212.85 feet, but on account of the plan of the inlet structure water level is maintained above this to an elevation of 3,225.56 feet—the edge of the 42-foot weir. Reckoning this latter elevation as the maximum water surface there is a static drop of 399.16 feet to the centers of the nozzles at the power house, which are at elevation 2,826.4 feet. The effective head is reported to be 385 feet.

Power house.—San Joaquin No. 3 power house is a monolithic concrete building, the main part of which is 68 feet 3 inches long by 38 feet 10 inches wide. This width is further increased 10 feet by a lean-to which contains the transformer cells and provides a small storeroom. The main part of the building is entirely occupied by the generator room. The main axis of the power house is at right angles to the course of the stream and parallel to the pipe line which enters under the floor and runs along the downstream side of the building. The two units are arranged in line on the opposite side of the generator room from the pipe but parallel to it.

Each machine is provided with two water wheels, one on each end of its shaft. The branches from the pipe lines to the two wheels of the first unit and first wheel of the second unit are made at right angles to and directly from the full-sized 52-inch pipe. Just after the third branch leaves the main pipe, the latter is tapered by a special fitting from a diameter of 52 inches down to 24 inches. This 24-inch section runs on to a point opposite the fourth water wheel, where it turns at right angles to supply the wheel. A gate valve is placed on each branch line at a distance of 5 feet from the axis of the main pressure pipe. The wheels discharge into a concrete weir pool which runs along the upstream side of the plant, and from this pool the water flows back into North Fork.

The switchboard is set parallel to and a short distance from the center of the downstream wall of the generator room. Behind it are the rheostats, and along the wall is the oil-switching equipment. The transformer cells do not open into the main generator room but into the open air outside the power house, each cell being provided with double swinging doors.

Hydraulic equipment.—Each of the two units is operated by two Doble overhung water wheels, one on each end of the shaft. These wheels are 6 feet in diameter, operate at 300 revolutions per minute, and have a combined rated capacity of 1,750 horsepower. Each rotor is supplied through a single stationary needle nozzle, regulated by a Lombard governor, type Q. The governors are operated by oil-pressure system, which is supplied through a pump belted to the generator shaft.

Generators.—The two generators—identical in design—are of the Bullock revolving-field type. They are 3-phase 60-cycle 1,000-kilovolt-ampere machines designed to give 1,050 amperes at 550 volts and to operate at 300 revolutions per minute.

Exciters.—Each exciter forms a part of its main generating unit, being mounted on the generator shaft between the field and one of the bearings. They are 6-pole 125-volt 500-ampere direct-current generators, which, in consequence of their position, operate at the same speed as the main generators—300 revolutions per minute.

Transformers.—The transformer equipment consists of two banks, each containing three 350-kilovolt-ampere single-phase 60-cycle 550/33,000-volt water-cooled transformers.

Wiring.—The three sets of 3-phase high-tension oil switches are of Kellman make and 33,000-volt rating. They are placed along the wall which separates the generator room from the transformer compartment, are supported on brackets, and are operated from the main switchboard. The low-tension bus wiring also is carried along this wall below the high-tension switches, and at each end of the bus are the low-tension knife-blade transformer switches. Leads from these switches are carried directly through into the transformer cells on the opposite side of the wall. The high-tension leads from the transformers to the high-tension switches are brought back through circular apertures in the wall to insulators on the wall of the main room directly above the Kellman switches. The high-tension leads from the switches are carried to bracket insulators still higher up the wall and from these insulators pass out through circular apertures in the wall to the main-line brackets outside the building and above the transformer cells.

SAN JOAQUIN PLANT NO. 2.

Location.—The intake of San Joaquin plant No. 2 is on North Fork of North Fork of San Joaquin River 3,300 feet below power house No. 3 in the SE. ¼ sec. 12, T. 8 S., R. 22 E. The conduit runs southward through secs. 12, 13, 24, and 25 of the same township, and sec. 30, T. 8 S., R. 23 E., to the forebay reservoir in the NW. ¼ sec. 30, T. 8 S., R. 23 E. Pressure pipes run in a southeasterly direction through the same section to the power house, which is located in the SE. ¼ sec. 30, near the head of tunnel No. 5 on the conduit of San Joaquin plant. Construction of this plant was begun by San Joaquin Light & Power Corporation in 1913 but was soon suspended and active work not resumed until 1916; the plant went into operation October 10, 1917.

Conduit.—A small concrete arched dam, about 150 feet long and 25 feet high, with spillway at its east and headgates at its west end, diverts the stream into the upper portal of the first tunnel of No. 2 conduit. The headgates are equipped for remote control through an electric circuit leading to power house No. 3.

The length of the conduit from headgate to forebay reservoir is 15,589 feet, of which 5,614 feet is in ten tunnels, 6,758 feet in concrete-lined ditch, and 3,217 feet in semicircular steel flume. The tunnels are 6 feet clear width and 4½ feet to the spring line of the semicircular arched roof. Their lengths are as follows:

TABLE 86.—*Length of tunnels on conduit of San Joaquin plant No. 2.*

	Feet.		Feet.
1	324	7	60
2	361	8	661
3	565	9	623
4	1,184	10	546
5	200		
6	1,090		5,614

The concrete-lined ditch has a vertical wall on the outside of the channel and slope of 1 : 1 on the inside of the channel. Width at the bottom is 3 feet, width at the water surface is 8 feet, and depth is 5 feet. The steel flumes are semicircular in section 8.4 feet in maximum width. In some of them the stringers along each side of the flume are supported on concrete piers, and in others on trestle bents.

The maximum elevation of the water surface at the intake is 2,820 feet and in the forebay 2,784 feet above sea level, giving a total fall of 36 feet in the conduit, or a mean grade of 2.3 feet per thousand.

The forebay has been formed by constructing an arched rubble dam, about 117 feet long and 27 feet in maximum height, across the head of a small canyon. The maximum capacity of this forebay is 11 acre-feet and its area 2 acres. The elevation of the crest of the dam is 2,786 feet above sea level. The bottom of the dam is pierced by two 12-inch outlet pipes, each fitted with a gate valve at its lower end. Flow into the pressure pipe, which leaves the reservoir at the 2,770.5-foot level, is controlled by a 60-inch sliding gate that is raised and lowered by a wheel and gear at the top of the dam. The dimensions of the pipe are as follows:

TABLE 87.—*Sectional length, diameter, and thickness of pressure pipe, San Joaquin plant No. 2.*

Type.	Length.	Diameter.	Thickness.
	Feet.	*Inches.*	*Inch.*
Double riveted	1,800	60	3/16
Taper	30	60-54	3/16
Double riveted	1,020	54	3/16
Do	210	54	1/4
Do	250	54	5/16
Do	31	54	3/8
Taper	30	54-36	3/8
	3,371		

The first 1,800 feet of the pressure line is on a very flat grade, and 1,790 feet from the forebay, at an elevation of 2,748 feet, there is a 48-inch standpipe 37.5 feet high. Beyond the standpipe the drop is rapid; the pipe is laid in a trench and covered its entire length.

The elevation of floor line of power house is 2,480.4 feet, and water surface in the San Joaquin No. 1 conduit beside the building is about 2,475 feet above sea level. The total fall available, with draft tube, from the forebay elevation of 2,784 feet, disregarding friction losses, is therefore 309 feet.

Power house.—The power house is on the west bank of the conduit of San Joaquin plant No. 1, just above the head of No. 5 tunnel, or about 4,200 feet from the North Fork intake dam. The building, 51 feet 4 inches long by 31 feet wide, is constructed of reinforced concrete, with tile roof supported on a steel truss roof system. The generator room, which occupies the entire interior of the power house, is 50 feet long by 29 feet wide by 20 feet 8 inches high to the top of the crane rail and 24 feet 4 inches to the lower chord of the roof trusses.

The shaft of the single unit is parallel to the main axis of the building. The switchboard is placed along the back wall of the generator room with exciter unit at its left and telephone booth at its right end. A 30,000-pound Cyclops crane commands the entire floor.

The transformers are of the outdoor type and are placed on a terrace near one end of the power house. The high-tension oil switches, also of the outdoor type, are supported on a low steel frame near the end of the transformer bank. Immediately above the oil switches are rotating disconnecting switches mounted on a steel frame work. One 3-phase circuit is carried across the canal to the top of a similar framework and there connects to the transmission line that runs from power house No. 3, farther upstream, to San Joaquin power house No. 1.

Hydraulic equipment.—The 54 to 36 inch reducer at the end of the single pressure pipe connects under the power-house floor to the scroll case of a 5,250-horsepower S. Morgan Smith Francis turbine, with double discharge through elbows that connect to twin draft tubes extending downward and under the outer wall of the building to a tailrace pool in No. 1 conduit. The wheel is provided with a relief valve operating in connection with a Lombard governor, type T. The 46-inch turbine runner is mounted on the same shaft as the generator rotor, and between the generator and turbine bearings the shaft also carried a flywheel. Three of the four bearings are equipped for oil-circulating lubrication.

Electric generator.—The generator is a General Electric ATB 3,000-kilovolt-ampere 2,300-volt 755-ampere 3-phase 60-cycle machine, which operates at 450 revolutions per minute.

Exciter.—The single exciter is a General Electric type DLC 50-kilowatt 125-volt 400-ampere generator, operated at 865 to 900 revolutions per minute, either by an S. Morgan Smith Francis turbine designed for hand regulation or by a General Electric 75-horsepower 2,300-volt induction motor.

Transformers.—The transformers are 1,000-kilowatt 2,300 to 60,000 volt single-phase units of the General Electric water-cooled outdoor type, and are arranged in line on a terrace north of the power house three in a bank, with one spare for use in emergency.

SAN JOAQUIN PLANT NO. 1.

Location.—The intake for San Joaquin plant is in sec. 19, T. 8 S., R. 23 E. The conduit traverses secs. 19, 30, and 31, T. 8 S., R. 23 E., and secs. 5, 6, 7, 8, 18, T. 9 S., R. 23 E. The power house is in sec. 18, T. 9 S., R. 23 E.

South Fork diversion dam.—Although the main intake of the conduit that leads to San Joaquin power house No. 1 is on North Fork at a point just above the junction of the North and South forks (p. 470), a short flume also carries water from a concrete overfall diversion dam on South Fork to the pond above the North Fork dam. The South Fork dam, which was constructed in 1910, has a spillway 111 feet long and 4 feet wide on crest, which has rounding edges and is 2,507.5 feet above sea level. The abutments at the east end of the dam rise 5½ feet above this spillway. The upstream side of the dam is vertical and the downstream side has a batter of 11 in 17. The maximum height of the overfall section is about 20 feet. Near the bottom of the dam at the west end is a 3 by 3 foot undersluice controlled by a sliding timber gate set in a groove in the dam. At the same end of the dam there is also the 4 foot 6 inch by 5-foot headgate of the flume leading to the North Fork diversion dam.

The first section of the conduit connecting the two dams consists of 920 feet of reinforced concrete box flume 5 feet 8 inches wide on the inside by 4 feet deep. The lower end of this concrete flume tapers to a 6-foot semicircular steel flume, with sides raised 12 inches which extends 335 feet to the pond above the North Fork dam.

North Fork diversion dam.—The North Fork diversion dam is a low concrete structure which extends out 60 feet from the east abutment across the channel of the stream and then turns downstream at almost right angles for a distance of 26 feet. This downstream bend connects with the canal headworks. The elevation of the crest of the dam is 2,500 feet above sea level, but water may be raised 4 feet above this by flashboards inserted in channels that project vertically from the top of the dam. The intake of the conduit line is through a tunnel that is almost parallel in direction with the main axis of the dam and is therefore at right angles to the course of the stream. The lower end of the ell in the dam reaches downstream to a point just below the mouth of the tunnel, and between the tunnel portal and this part of the dam, there is a V-shaped channel which narrows to a sluice 7 feet 4 inches wide at a point about 10 feet downstream from the tunnel portal, where the sluice gates are placed. The gates in this sluice and those in the conduit intake are constructed of timber and are hand-operated by pinion gears from platforms above the gate openings. The floor of the sluice gate is 6 feet below that of the intake tunnel and 10 feet below the crest of the dam. The spring line of the arch of the intake tunnel is 4 feet above the tunnel floor and at the same elevation as the top of the masonry portion of the dam—2,500 feet.

Tunnels and ditch line.—From the North Fork dam to the forebay the length of the conduit is 25,140 feet,[5] of which 11,530 feet is in twenty tunnels, 1,070 feet is steel flume, and the remaining 12,540

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[5] This and the following measurements differ somewhat from those given by Mr. Hewens in an article which appeared in the Engineering Record, February 4, 1911. The authority for the measurements given above is as follows:

The total length is according to the official survey notes accompanying the application to the United States Forest Service for permit.

The lengths of the tunnels and their grades are as given on one of the official maps of the San Joaquin Light & Power Corporation, and the lengths of the flumes are scaled from tracings accompanying the application for permit.

The length of the ditch line is obtained by subtracting the lengths of flume and tunnel from the total. The application for permit shows no reinforced-concrete flume line along the main conduit, the only section being on the diversion conduit from South Fork to North Fork.

feet is open ditch, with a reinforced-concrete core wall in the outer bank.

The tunnels are concrete lined throughout, are 5 feet in net width, and are 6 feet high to crown of arch. The lengths and grades are as follows:

TABLE 88.—*Length and grades of tunnels in conduit to San Joaquin plant.*

No.	Length.	Grade.	No.	Length.	Grade.
	Feet.	*Per cent.*		*Feet.*	*Per cent.*
1	696	0.919	12	354	0.197
2	1,441	.19	13	339	.32
3	490	.163	14	500	.10
4	478	.3	15	230	.10
5	987	.43	16	310	.13
6	1,262	.19	17	400	.10
7	580	.32	18	1,148	.10
8	374	.32	19	245	.10
9	390	.28	20	172	.12
10	344	.29			
11	790	.19		11,530	

The outer bank of the side-hill ditches is strengthened by a 6-inch reinforced-concrete cut-off wall, resting on a 6-inch concrete foundation which forms an inverted T-shaped base. The bottom of the wall is about 2 feet below the elevation of the bottom of the ditch and the crest of the wall is carried a foot above the top of the ditch embankment.

The cross sections of the ditch were designed with regard to the slope of the hill, so that the excavation would balance the fill on the lower side, consequently the proportion of width to depth was varied with the angle of slope of the side hill. All three cross sections have uniform side slopes of 1:1, but the bottom widths and depths vary, the first section being 5 feet wide and 4.3 feet deep, the second 6 feet wide and 4 feet deep, and the third 8 feet wide and 3.5 feet deep.

The canal was designed to carry 100 second-feet but as the concrete core wall is 1 foot above the level of the lower embankment, this capacity could be considerably increased. The concrete flume along the South Fork diversion conduit is 5 feet 8 inches wide by 4 feet deep, and has reinforced walls and floor, both 6 inches thick. Reinforced cross beams, spaced 15 feet apart, serve to tie the upper edges of the walls together.

Forebay.—The forebay for San Joaquin plant No. 1 is formed by a small earth dam built across a hollow on the end of the high point directly above the power house. The area of the forebay is 8 acres, and its capacity at maximum water level of 2,403 feet is 27 acre-feet, or 1,175,000 cubic feet. In the bank of the forebay are concrete gate chambers that support trash screens of flat iron bars and admit the water to the two pipe lines that serve the power house.

Pressure pipes.—The pipe lines are not laid parallel but follow divergent routes, passing on opposite sides of a small, rocky point in the face of the hill. The pipes are of composite construction, the upper parts of each line being formed of American-manufactured riveted-steel pipe, and the lower part, which is subjected to heavier pressure, of German lap-welded pipe. The joints in this lap-welded part of the "expanded" type, so that the rivet heads do not obstruct the uniform flow in the pipe by cutting down its diameter. The static head under which both lines are operating at the junction of the lap-riveted and lap-welded sections is about 645 feet. On the sections of the lines which extend from the forebay to the brink of the canyon, and near the lower end of the lines for a short distance above the power house, the grades are moderate, but down the wall of the canyon they are extremely steep, reaching a maximum of about 81 per cent on one line and 77 per cent on the other. The back part of the power-house site was excavated from the hillside, and since the first pressure-pipe line was not laid in tunnel or trench, it runs out to the edge of a ledge and then turns down through a special curved section, making two rather sharp bends in reaching the level of the power-house floor. The lower end of the second pipe line was laid in a deep trench, and therefore does not bend so sharply to the power-house floor. The branches from the pipes to the units are made within the power-house walls. The static head developed is 1,407 feet (with mean water surface in reservoir at 2,396 feet).

Power house.—The San Joaquin power house No. 1 (Pl. XLIV, *C*, p. 365) is a modern structure with a steel frame, carrying double concrete walls plastered on "hyrib" fabric. This double-wall design, giving an air space of about 8 inches between the two plastered surfaces, was adopted in order to provide a building that would be as cool as possible during the terrific summer heat of this region.

In plan the building measures 148 feet long, parallel to the river bank, by 71 feet 9 inches deep. The generator room (Pl. XLIV, *B*) runs the full length of the side of the building toward the river and is 45 feet wide from the front wall to the line of columns in front of the transformer compartments. The two transformer bays are recesses, 13 feet deep by 55 feet 6 inches long, opening into the back of the generator room. Each bay is divided transversely at its center by a fire wall, on each side of which there is room for one bank of transformers. Between the two transformer bays there is a raised switchboard area, with the low-tension switch cells and wiring back of it. Storerooms occupy the space on each side of the low-tension switching apparatus and between the back walls of the transformer bays and the extreme back wall of the building. In the second floor of this back part of the power house above the storerooms, switchboard gallery, and transformer bays are the high-tension switch galleries, bus bars, and wiring. The generator room is covered by a single-pitch and the rest of the building (which is somewhat higher) by a double-pitch roof. Both roofs are carried on steel trusses with very flat slopes.

The generator room measures 26 feet 3 inches in height to the bottom of the crane and 36 feet to the lowest part of the eaves. The back part of the building is 50 feet to the eaves. The elevation of the generator-room floor is 990 feet above sea level, the switchboard gallery is 3½ feet higher, and the floors of the storerooms, which are reached from either side of the switchboard gallery, are 9.7 feet higher than the floor of the generator room. Under the entire switchboard area there is a shallow basement, about 4 feet deep, through which access may be had to the 2,300-volt generator leads.

In each end of the generator room there are two 4,000-kilovolt-ampere units set close together, wheel to wheel, with their shafts in line and parallel to the long axis of the room. Each unit is operated by a single overhung impulse wheel. The space between the two groups of units is occupied by the exciter units.

The pumps and oil-pressure pipes which supply oil to the governors are placed directly beside the generators, and each pump is driven by a belt from the generator shaft.

Hydraulic equipment.—The two pressure lines enter the back of the building, one passing under each of the transformer bays. After entering, each pipe terminates in a Y, and in each branch of the Y there is a hydraulically controlled gate valve. The units as noted are arranged wheel to wheel, so that each branch of a Y leads to a separate unit. The nozzles are of the automatic-needle by-pass type. The wheel diameter on pitch line of buckets is 7 feet 6 inches, and each rotor carries 17 buckets bolted to its rim. Each of the four overhung wheels is rated at 6,100 horsepower, has a speed of 400 revolutions per minute, and operates a single unit. The bore of the nozzles is 7$\frac{3}{16}$ inches.

Generators.—The four generators are General Electric ATB form A revolving-field machines, generating 1,005-ampere 3-phase 60-cycle current at 2,300 volts when operating at 400 revolutions per minute. The bearings of the units have both ring and forced oil lubrication, the latter being furnished by gravity flow from a tank supported in the roof trusses of the generator room. After the oil passes through the bearing case it is received in a filter tank below the floor and pumped back again into the tank in the roof trusses. The bearings are cooled by water circulating through coils in their oil wells as well as by streams drawn by tailrace suction through the hollow main shaft of the units.

Exciters.—Motor-generator exciter unit No. 1 is a General Electric type I 8-150-900/870 form K 3-phase 60-cycle 150-horsepower 33-

ampere 2,300-volt induction motor, installed on the same shaft with a General Electric type MP 6–100–900/870 form L 400-ampere 250-volt continuous-current generator. Exciter unit No. 2 is a General Electric type MP class 6–100–900 form L 400-ampere 250-volt continuous-current machine on the same shaft with a Doble wheel of 180-horsepower capacity and with a General Electric type I class 8–150–900 form K 60-cycle 150-horsepower 34-ampere 2,300-volt induction motor. A third machine is an auxiliary which charges a storage battery used to operate the oil switches. The unit consists of a General Electric type MP class 6–100–900 form L 400-ampere 250-volt continuous-current generator, mounted on the same shaft with and operated by a Doble wheel at 900 revolutions per minute.

Transformers.—The transformer equipment is arranged in four banks, each containing three single-phase General Electric water-cooled form E–1 60-cycle 1,500-kilowatt transformers, with a ratio of 2,300/30,000 or 60,000 volts. They are Y connected on the line side with grounded neutral.

Wiring.—In front of the switchboard bay in the floor of the generator room are four shallow manholes, each of which receives the 2,300-volt leads carried from one of the generators through ducts in the power-house floor. In order to make connection to this central group of manholes from the outer units it is necessary first to run their generator leads back to secondary manholes placed between the units and their respective transformer bays. From each of the manholes near the switchboard the 2,300-volt leads are carried back through the basement under the switchboard gallery to four similar manholes back of the board. Here they pass up through the floor to 2,300-volt oil switches placed in concrete cells. The 2,300-volt switches connect to the low-tension bus bars, which run through ducts in the wall separating the upper part of the transformer compartment from the storerooms. Leads from these bars are carried out through the wall to the transformers. All the low-tension switches are of the General Electric K–12 type.

The high-tension leads from the transformers pass through the wall in the upper part of the transformer cells into the storeroom and thence up through a recess between the two high-tension switching galleries. There they are connected to high-tension bus bars through Kellman oil switches. The outgoing lines are equipped with oil switches of the same type.

The switching equipment in the south bus gallery consists of four 60,000-volt 3-phase Kellman switches which connect the respective banks of transformers to the south bus, one sectionizing switch of the same pattern which cuts the bus in half, two line switches on the east and west trunk lines, and one line switch for the incoming line from power house No. 3. The equipment for the north bus gallery is identical. The high-tension switches are operated by solenoids working on a switch-battery circuit.

The outgoing lines are carried through the wall by means of porcelain bushings set in the center of square concrete outlet panels, 3 feet 6 inches square. These panels are tilted outward at the top about 30°, so that they face slightly downward. The lower edge of the panel is flush with the outside of the wall; the upper edge is therefore outside the wall line and is covered by a hood. The outlet forms a part of the building's wall and is constructed of reinforced concrete.

The two main outgoing lines run southwesterly through Copper Mine substation to the Fresno region.

Lightning protection is furnished by arresters of the General Electric aluminum-cell type, installed in a separate building outside the power house.

SAN JOAQUIN PLANT NO. 1-A.

Location.—Plant 1–A, the second of the automatic hydroelectric stations on the San Joaquin system, is at the lower end of the gravity conduit of No. 1 or San Joaquin plant, just above Lake Corrinne forebay, in sec. 8, T. 9 S., R. 23 E. It went into operation at 2.30 p. m. March 12, 1919.

Conduit.—The conduit serving San Joaquin plant No 1 (described in detail on pages 483–485) passes through a saddle in the hills in the lower part of its course and continues on a normal grade to a point a short distance from Lake Corrinne. Here the gravity line originally discharged into a concrete chute 427 feet long down a heavy grade into a semicircular steel flume 519 feet long, terminating at the forebay. When plant 1–A was constructed a 60-inch steel pipe was installed in place of the concrete chute from the gravity canal to the steel flume to form a wasteway, and both pipe and flume were paralleled by a 60-inch wood-stave pressure pipe leading to the power house, which is located at the head of the reservoir close beside the lower end of the flume.

At the head of these two pipe lines the original ditch has been widened by making an excavation in the hillside large enough to accommodate both the new and the old headgate structures. This widening formed an intake pool roughly triangular in plan, about 100 feet long by 10 feet wide at its upper end and 25 feet wide at its lower end where the gates are installed. A longitudinal wall 4 feet high runs the full length of the pool, parallel to and 10 feet from its inner side, forming a continuation of the original conduit extending to the bulkhead between the old and the new headgates. A spillway 48 feet long in the crest of this central wall carries the entire discharge of the canal when plant 1–A is not operating, thus passing a continuous supply to the main power house. A radial headgate and a trash rack of flat steel bars are installed in the main channel immediately above the head of the new pressure pipe. A wood-stave taper section 24 feet long connects the headgate structure to a wood-stave pressure pipe 916 feet long supported on concrete saddles spaced 8 feet on centers and running first down a gentle slope then nearly horizontally to a riveted steel upturn 60 inches in diameter and one-fourth inch thick at the upper end of the power house. This elbow, or upturn, connects at the back wall of the building with a reducer tapering from a diameter of 60 inches to 54 inches at the butterfly valve inside the building amd immediately adjoining the turbine casing.

The relative elevations of the various pressure systems are as follows:

TABLE 89.—*Elevations in pressure systems, San Joaquin plant No. 1-A.*

	Feet.
Top of gate structure at end of canal	2,446.5
Top of wasteway from main channel to by-pass channel	2,444.5
Bottom of intake basin at head of pressure pipe	2,428.5
Center line of turbine shaft	2,408.5
Power-house floor	2,404.0
Maximum water level in Lake Corrinne forebay reservoir	2,403.0
Mean water level in Lake Corrinne forebay reservoir	2,396.0

The static head between spillway lip at the intake and mean water level in Lake Corrinne is therefore 48.5 feet.

Power house.—Power house 1-A is a reinforced-concrete building with tile roof, distinctively Spanish in architecture and very pleasing in appearance. The tiles are laid on wooden sheathing supported on a steel-truss roof system. The building contains a single room, 56 feet long by 26 feet wide and 19 feet 6 inches high to the lower chord of the roof trusses. The pressure pipe enters through the upper end of the building and connects through a butterfly valve to the cylindrical steel casing of a horizontal turbine, which is direct-connected to the main generator. The shaft of the unit is parallel to the main axis and 8 feet 8 inches from the right wall of the power house. The large diameter of the turbine casing has made it necessary to raise the generator on a concrete base. The switchboard is in the lower end of the power house.

Hydraulic equipment.—The single 36-inch runner of the turbine operates in a long cylindrical case of riveted steel, the supply being admitted axially. Twin draft tubes extend down into arched tailraces running through the power-house foundations into the lake beside the building. The turbine is rated at 600 horsepower when operating at 240 revolutions per minute under a 40-foot head. The wickets of the gate are so designed that they will close automatically if disconnected from the motor control. A float switch at the intake above the pressure pipe connects or disconnects the electric motor operating the turbine wickets as the water rises or falls, thus opening or closing the wicket gates. A centrifugal switch installed on the main shaft of the unit is also connected on the motor circuit, and in case load is dropped and the machine begins to speed up will close the wickets and shut down the power house until such time as it is thrown back on the line by the ditch tender, who is summoned by an electric alarm system.

Generator.—The generator, which is rigidly connected through a bolted flange coupling to the turbine, is a Westinghouse 6,600-volt 37.2-ampere 425-kilovolt-ampere type CS inductor machine, operated at 245 revolutions per minute. The output of the station is transmitted at generator potential, 6,600 volts, to San Joaquin power house No. 1 and there stepped up to 60,000 volts for delivery to the main transmission system.

KERCKHOFF PLANT.

LOCATION.

The Kerckhoff plant is on San Joaquin River about 16 miles along the course of the stream or 12 miles in an air line northeast of Friant, the point where the river leaves the foothills of the Sierra. The development is 30 miles northeast of Fresno.

The plant was constructed by the corporation and was put into commercial operation August 5, 1920.

SOURCE OF WATER SUPPLY.

The entire water supply for the Kerckhoff plant is diverted from San Joaquin River immediately below the tailrace of San Joaquin No. 1 power house, which, however, is supplied from North Fork. The drainage area of the Kerckhoff intake is 1,488 square miles. The mountain basin of the stream has the form of a rough isosceles triangle with base 50 miles long extending northwest and southeast along the crest of the Sierra between Mount Fiske and Rodgers Peak. The distance from the crest of the Sierra to the intake is approximately 40 miles.

The main San Joaquin and its principal tributaries have several features in common with certain other Sierran streams in that the course of the main stream is in general southwest, while the principal tributaries near its headwaters flow through troughs trending in general southeast and northwest, parallel to the main ridge that forms the crest of the Sierra.

South Fork, which on account of its length and the area of its drainage basin may be considered the parent of the main stream, rises in Martha Lake in the extreme southeastern part of the drainage basin, at an elevation of 11,007 feet above sea level, and flows northwestward about 36 miles (measured in an air line) to the eastern base of Balloon Dome, then turns abruptly, flows southwestward for 5 miles, and joins Middle Fork to form the main San Joaquin. From the junction the main river continues with an even more southerly trend about 20 miles to Italian Bar and then resumes a general southwestward course through several long and tortuous bends.

Middle Fork, the tributary secondary in importance only to South Fork, rises in Thousand Island Lake, near Island Pass, at the extreme northern tip of the headwater basin and flows first southeastward and then southward a distance of 12 miles (in an air line) to the vicinity of Pumice Butte. There it turns abruptly and flows westward and then southwestward a distance of 12 miles to its junction with South Fork.

North Fork of Middle Fork, heading on the shoulders of Rodgers Peak, flows due south and joins Middle Fork midway between Pumice Butte and the mouth of South Fork.

In its course from Martha Lake to its junction with the main river South Fork skirts closely the northeastern base of Kaiser Ridge, the great mountain mass that bounds the basin on the west. Its tributaries from the southwest are therefore short and of minor importance. Those entering from the northeast, however, average at least four times the length of those from the southwest, and as they drain the high mountain basins along the west side of the main divide they are of far more economic importance. In order downstream the principal northeast tributaries are Evolution, Piute, Bear, Mono, Warm, and Four Forks creeks, in addition to which there are several very small streams.

Mountain lakes abound in the extreme headwaters of the South Fork, particularly in the Evolution, Piute, and Bear Creek basins.

The Middle Fork of the San Joaquin from its source to the sharp bend westward near Pumice Mountain hugs close to the base of the main divide. Its principal tributaries, unlike those of South Fork, therefore enter from the west and southwest. Those from the east are extremely short and relatively unimportant. In order downstream to the bend the western tributaries are Shadow, Minaret, and King creeks. Between the bend and the junction with the South Fork are Stairway Creek, North Fork of the San Joaquin, and Granite Creek. An extensive basin north of Mono Creek drains into the Middle Fork from the southwest through Fish Creek and its tributaries.

Lakes are much less numerous in the Middle Fork basin than in the South Fork basin. The two largest are Thousand Island Lake (elevation 9,550 feet) and Garnet Lake (elevation 9,704 feet).

A strip of country averaging about 12 miles in width lying on the northwest side of the main stream between the junction of South and Middle forks and the point where it leaves the foothills is drained by Jackass, Chiquito, and Rock creeks. The triangular area between South Fork, the main river, and the southern boundary of the basin is drained into the main stream through Kaiser, Dalton, Big, Stevenson, and Big Sandy creeks.

The southwest exposure of the main divide, within the basin, has prevented the formation of glaciers except in small cirques on the northern shoulders of some of the spurs near the head of South Fork. Two of these glaciers are at the heads of Fourth Recess and Mills Creek, headwater tributaries of Mono Creek. Eight are found in similar locations on the north side of Glacier Divide, an elevated ridge forming the northern boundary of the Evolution Creek drainage basin, extending westward from the main divide near Mount Lamarck. Two others are in the cirques north of the Mount Darwin-Mount Wallace crest, and the last is on the north face of Mount McGee. The lowest of these glaciers is above 11,500 feet, and some of them are above 13,000 feet.

Geologic maps of California show that almost the entire mountain area within the basin of the San Joaquin is occupied by deep-seated granitic rocks, including granite, diorite, granodiorite, and gabbro. There are, however, small areas of Cambrian rocks in the vicinity of Thousand Island Lake and Iron Mountain and small areas of Jurassic rocks on North Fork, as well as volcanic rocks along the west crest of the mountains south of Duck Lake.

The forest cover in the lower hills consists of brush and scattering woodland growth. This gives place to well-forested ridges extending up to about 9,500 feet, above which the cover thins out and the upper ridges and peaks are entirely bare.

The maximum discharge of the stream measured at Friant gaging station, below Kerckhoff intake, is 46,200 second-feet, and the minimum 160 second-feet. With the relatively small amount of storage that has already been developed in the Crane Valley and Huntington Lake reservoirs, the flow at Friant available for 90 per cent of the time amounts to 370 second-feet. This will, of course, be greatly increased when contemplated storage reservoirs in the upper drainage basin are constructed.

DAM AND CONDUIT.

The Kerckhoff dam is in the SE. ¼ SW. ¼ sec. 24, T. 9 S., R. 22 E. Mount Diablo meridian. The reservoir floods portions of secs. 24 and 13 of that township and secs. 17 and 18, T. 9 S., R. 23 E. The tunnel intake is 250 feet upstream from the dam on the south side of the river. The entire conduit, except penstocks, is a pressure tunnel traversing secs. 24, 25, 26, and 35, T. 9 S., R. 22 E.; sec. 35, T. 9 S., R. 22 E.; and sec. 2, T. 10 S., R. 22 E. The pressure pipes run westward from the lower portal of the tunnel across the west boundary of sec. 2 to the power house in the SW. ¼ NE. ¼ sec. 3, T. 10 S., R. 22 E.

The canyon at spillway level is about 363 feet wide. Granite bedrock extends about two-thirds of the way across from the south side of the canyon and schist for the remaining distance to the north abutment.

The elevation of the lowest point in the original channel along the upstream face of the dam was about 888 feet above sea level, and the lowest point anywhere at the site 870 feet. The deepest of 15 holes drilled at the site reached down to elevation 827 feet; the last 25 feet was in granite.

The "constant angle" type of concrete arch was finally selected as the most economical form of structure under the local conditions, as the dam must be of the overfall type, passing a flood with a known maximum of 50,000 second-feet and a possible maximum of 100,000 second-feet over its crest. The thickness of the dam at its base (elevation 880 feet) is 36.1 feet, and its thickness immediately below the spillway is about 12 feet. A short gravity section (above elevation 950 feet) connects each end of the arch to the abutment. The structure contains 23,489 cubic yards of concrete.

In order to permit raising the normal maximum water surface in the reservoir to the tail-race level of San Joaquin No. 1 power house and at the same time insure safety in time of flood, 14 wasteways, 20 feet wide by 14.5 feet deep, were provided in the crest of the dam and are closed except in time of flood by Taintor radial gates. The concrete crest of the spillway under the gates is a parabolic curve, and on the lower side of the lips there is an overhang of several feet which throws the water clear of the base of the dam. A concrete log chute is provided below the last opening at the south end of the dam. The gates are raised by a motor-driven hoist running on a track along the operating platform and receiving its power from a trolley. Stop-log slots are provided in each opening in front of the gates. The crest length of the dam is 570 feet.

The elevations in feet at different points on the structure are bottom, 880; crest of spillway openings, 971.34; top of Taintor gates, 985; top of operating platform, 994.5.

Three sluices, each controlled by a 72-inch sluice gate, pierce the base of the dam near its center. The gates are fitted with geared stems and are operated by hand from the top of the dam.

TABLE 89a.—*Area and capacity of Kerckhoff reservoir at various levels.*

Level.	Elevation.	Reservoir area.	Reservoir capacity.
	Feet.	*Acres.*	*Acre-feet.*
Bottom of reservoir	905		
Spillway lip	971.34	117	2,200
Top of Taintor gates	985	159	4,200

Through an agreement reached with the California State Fish and Game Commission, no fish ladder was provided at the dam, but the company built a hatchery at Crane Valley, on the North Fork of San Joaquin River.

The intake structure at the north portal of the Kerckhoff tunnel is 26 feet wide by 19 feet 6 inches deep in plan. It is set on a concrete foundation resting in bedrock at the south side of the canyon. The elevation of the floor of the inlets is 942 feet, and that of the operating platform on its top 995 feet, so that the entire height of the structure above (but not including) its foundation is 53 feet.

A trash rack or grating of steel bars, resting against eight transverse I-beam supports, covers the entire front of the intake structure from top to bottom, thus giving a maximum area for passage of water into the tunnel with resulting low velocities through the screen. Back of the screen the water passes into the mouths of two inlets with tapered throats, each 8 feet 6 inches wide at its narrowest point, the two being separated by a concrete pier 3 feet in maximum thickness. Stop-log slots extend down from the operating platform on top of the gate structure to the tunnel floor near the entrance of each of these channels, and a gate slot extends from top to bottom back of the stop-log slots. The main gates are built of wood beams bolted together.

A 36-inch square sluice gate is provided above the right-hand channel to pass water into the tunnel over the top of the main gates. The center of the gate is at elevation 963.5 feet, and it is operated by handwheel from the operating platform at the top of the structure. This by-pass may be used to refill the tunnel and equalize the pressure on both sides of the gate if at any time it is emptied with a reservoir full above the gate.

The distance from the north portal or intake of the tunnel to the first adit is 8,164 feet; from the first adit to the second, 3,878 feet; from the second adit to the south portal or upper end of the pressure pipes, 5,873 feet. The alinement of the tunnel is not straight from adit to adit but on seven tangents.

The tunnel is 17 feet wide and 17 feet high from the flat floor to the crown of the roof, which is arched on a radius of 19 feet 3 inches. This gives a depth of 15 feet from the spring line of the arch to the tunnel floor.

The grades in the tunnel and the elevations at the lower end of each section of uniform grade, beginning at the intake, are as follows:

TABLE 89b.—*Grades and elevations in Kerckhoff tunnel.*

Length.	Grade.	Floor elevation at lower end of section.
Feet.	*Per cent.*	*Feet.*
4,091.5	....	941.89
4,128.6	0.0007	939.00
8,750.5	.003	913.23

About 370 feet from the lower portal, where the tunnel connects to the penstock, a surge chamber was excavated through solid rock above the tunnel roof. The lower part of the chamber is in form a truncated cone 40 feet in diameter at the roof of the tunnel (elevation 930 feet), tapering to 17 feet in diameter at elevation 980 feet, above which a circular shaft 17 feet in diameter extends to the ground surface at an approximate elevation of 1,017 feet. The chamber has therefore an area of 1,257 square feet at the top of the tunnel and 227 square feet at its junction with the circular shaft, 50 feet above the tunnel. A spillway 17 feet wide by 12 feet deep opens from the side of the shaft at elevation 1,005 feet, or 20 feet above maximum water surface in the intake reservoir. The floor of this spillway is level for the first 10 feet from the shaft and then slopes downward rapidly, discharging into a ravine leading to the river above the power house.

Three riveted steel pressure pipes extend from the lower end of the tunnel to the scroll cases of their respective turbines in the pit below the generator room of the power house. The pipes are 950 feet long, 8 feet in diameter at the tunnel, and 7 feet in diameter at the point where they connect with the scroll cases. The heads of the pipes are concreted into the lower portal of the tunnel, and an 8-foot electrically operated gate valve controlled from the switchboard at the power house is installed in the head of each line. The gates are provided with by-passes, and the control is so arranged that gate and by-pass must operate in proper sequence.

A 7-foot butterfly valve is installed in each line between the wall of the turbine pit and the point where the pipe connects to the scroll case of the turbine; this valve also is electrically operated by remote control from the switchboard.

Two sets of air valves are installed in each line, each main valve consisting of three minor clusters arranged in vertical branches.

GENERATING STATION.

Power house.—The Kerckhoff power house is on a bench about 60 feet wide blasted out of the canyon wall at an elevation of 675 feet above sea level. The turbine room, from 30 to 35 feet deep, was excavated in this bench, the center lines of the turbines being at elevation 650 feet.

Three separate draft-tube tunnels were excavated downward and outward from the turbine chamber to the river. The upper part of each tunnel was lined with concrete on a stream line spread downward and outward to the horizontal tunnels. The floor elevation of the outer end of these tunnels is 623.50 feet. Wooden gates, sliding in vertical slots, may be used to close them.

In plan the power house (Pl. XLIV, *A*, p. 365) is 98 feet 9 inches long by 44 feet 9 inches deep through the generator and switch room and 36 feet 10 inches deep at the machine-shop end, all outside measurements. From the main-floor level to the parapet outside the height of the building is 45 feet 11 inches. The generator room is 31 feet 8 inches wide by 80 feet long inside, but the west or downstream end connects directly with the machine shop, which adds 15 feet 4 inches to the length of the interior. The machine shop, however, is only 31 feet 7 inches deep in the clear.

A 50-ton electrically operated traveling crane runs on rails spaced 29 feet on centers laid on concrete beams 31.5 feet above the floor. The height of the generator room from the floor (elevation 675 feet) to the lower side of the roof beams is 40 feet 2 inches. The floor of the generator room is formed by a concrete arch over the turbine pit.

The outer wall of the building is carried up 15 feet with a heavy section to resist possible floods.

The low-tension switching equipment and bench board are in a two-story open bay extending the entire length of the back of the generator room and measuring 7 feet deep in the clear. The floor levels in this bay are at elevations of 677.67 and 691 feet; the main floor level at 675 feet. The transformers are on a concrete-floored bench along the back of the power house at an elevation of 695 feet.

The three main units are set in line 10 feet from the inner side of the piers along the front wall of the building. The center of unit No. 1 is 12 feet from the east end of the generator room, and the units are spaced 25 feet on centers. Immediately back of each unit is an Allis-Chalmers governor actuated by governor weights on the main shaft. The governor connects to the relief valve near the scroll case in the turbine pit.

Two exciters are set next to the back of the generator room midway between units 1 and 2 and units 2 and 3. The individual motor-driven oil pump and pressure tank for the governor of each unit is set in the switch and auxiliary bay back of the generator room, nearly opposite its respective unit, and the pumps are interconnected.

Hydraulic equipment.—Each unit is operated by a 62-inch single-runner vertical Francis turbine, and each turbine is supplied through a separate penstock. The specifications called for a maximum output of 15,000 horsepower to generator shaft when operating at 360 revolutions per minute under an effective head of 315 feet. The efficiencies guaranteed were as follows:

TABLE 89c.—*Efficiencies guaranteed for Kerckhoff turbines.*

Percentage of full load.	Efficiency.
	Per cent.
100	80.0
90	85.5
82	88.0
70	86.5
60	83.0
50	79.5

Each of the two exciters is operated at 900 revolutions per minute by a 500-horsepower vertical single-runner Francis turbine.

Generators.—The three units, identical in design, are Allis-Chalmers 14,200-kilovolt-ampere 6,600-volt 1,240-ampere alternating-current generators operated at 360 revolutions per minute, each directly connected to its turbine. The generator rotor shaft and turbine runner of each unit are supported by a Kingsbury bearing at the top of the generator.

Exciters.—The two Allis-Chalmers exciters are identical in design, of the vertical type, resembling in general form the main units. Each exciter contains two generators, one furnishing excitation and the other control current. The exciter is a 300-kilowatt 250-volt continuous-current generator, above which there is a 15-kilowatt 125-volt generator operating on the same shaft delivering control current. The speed of the unit is 900 revolutions per minute.

Transformers.—The transformers have a ratio of 6,600 to 127,000 volts connected delta on the low-tension and Y with grounded neutrals on the high-tension side. They are of the single-phase water-cooled type of 5,000 kilovolt-amperes each.

Wiring.—The leads from each generator pass through disconnecting switches to a short transfer bus, which may be connected through General Electric type H–3 oil switches either directly to the group of transformers serving the unit or to the main 6,600-volt bus. The 6,600-volt bus is sectionized between the switch taps of units 1 and 2. The high-tension side of each set of transformers connects to the 110,000-volt bus through oil switches and disconnecting switches. The high-tension bus is sectionized between units 1 and 2 and units 2 and 3. It connects to the outgoing lines through separate sets of Kellman K–4–B oil switches.

All high-tension busses, switches, etc., are in a steel bus frame on the hillside back of the power house.

Two 110,000-volt transmission lines leave the power house, one running 39 miles south and tieing in to the main transmission system at Sanger substation, the other running 64 miles west and connecting to the main system at Merced. Each line is a single 3-phase circuit of three aluminum cables spaced triangularly 10 feet apart, each having a section of 266,000 circular mills, suspended by 7-unit insulators from wishbone channel-iron cross arms, carried on 60-foot cedar poles with creosoted butts. The normal span on both lines is 580 feet.

TULE RIVER PLANT.

LOCATION.

The Tule River plant is on the Middle Fork of Tule River. (See pp. 666–670.)

The North Fork intake is in the SE. ¼ sec. 7, and the conduit traverses secs. 7 and 18, T. 20 S., R. 31 E., and secs. 13, 24, 23, and 22, T. 20 S., R. 30 E. The South Fork intake will be in the S. ½ sec. 32 T. 20 S., R. 31 E., and the South Fork conduit will traverse secs. 32, 29, and 30, T. 20 S., R. 31 E., and secs. 24, 25, and 23, T. 20 S., R. 30 E. The power house is on the North Fork of Middle Fork of Tule River, on unsurveyed land at a point very close to the section corner common to secs. 22 and 26 of T. 20 S., R. 30 E., at the head of the short branch of the Southern California Edison Co.'s conduit, which diverts from that fork of the stream. It was in fact necessary for the San Joaquin company to reconstruct the Edison intake to obtain the most advantageous site for the power house.

Construction on the tunnel lines of the San Joaquin corporation's Tule River plant was begun in 1908 and the plant was completed and put into operation January 21, 1914.

SOURCE OF WATER SUPPLY.

The general characteristics of the Tule River basin are described on pages 666–667 in connection with the Southern California Edison Co.'s Tule River plant. The total drainage area above the San Joaquin Light & Power Corporation's intake on North Fork of Middle Fork is 34.7 square miles, and that above the proposed intake on South Fork of Middle Fork is 28.4 square miles.

Up to the end of 1921 no storage had been developed in either part of the basin.

CONDUIT.

Although ultimately the Tule River plant will use water from both the North and South branches of Middle Fork of the Tule through conduits 3.27 and 3.36 miles in length, respectively, up to the end of 1921 only the North Fork conduit has been completed. The intake for this branch of the conduit is at the lower end of a pool just above some falls. At this point the stream is divided by a small island, and the water passing through an open channel on the south of the island runs into a natural basin which forms a sand trap above the headgate. At the lower end of the basin, near the point at which the water would naturally fall back into the main stream bed, a low concrete spillway has been constructed almost parallel to the main course of the stream. At the downstream end of this spillway there is a sluice gate for clearing out sand and a headgate for the conduit. Both of these gates are built of plank, and are 5 feet high by 4 feet wide, are operated in vertical slides made of rails, and are lifted by means of racks and pinions carried on wooden frames that rest on the concrete buttresses of the gate. From the gate the first 500 feet of conduit connecting with the upper end of tunnel No. 1 is a concrete-lined ditch 3 feet wide at the bottom, 4 feet wide at the top, and 5 feet deep. From the lower end of this short ditch to the head of the pressure pipe the conduit is almost entirely in tunnel, the adjoining portals of the various tunnels being connected by short stretches of arched concrete culvert.

There are in the 3.27 miles of conduit 26 tunnels, ranging in length from 100 to 1,900 feet. The neat measurements of the tunnels inside the concrete lining are width 3 feet; depth to spring line of circular arched roof 4 feet 6 inches. The grade of the conduit line is 7½ feet per mile. The total length from the intake of the North Fork conduit to the forebay at the lower end of tunnel No. 26 is 16,960 feet. The conduit from the South Fork of Middle Fork will join that from North Fork at the lower end of tunnel No. 24; tunnel No. 25 is below the junction, and on account of having to carry in future the additional supply from the south branch of the conduit system has been made 5 feet wide inside instead of 3 feet. Provision has been made between tunnels No. 25 and No. 26 for a regulating reservoir; at present this section is constructed of wood-stave pipe. Tunnel No. 26 operates under about a 12-foot pressure and is 6 by 6 feet. The elevation of the bottom of the ditch above sea level is 4,020.68 feet at the intake on North Fork, 3,998.5 feet at the lower end of tunnel No. 25, and 3,982.5 feet at the upper end of tunnel No. 26. The capacity of the North Fork conduit is 40 second-feet.

At the lower end of tunnel No. 26 is a circular, reinforced-concrete surge chamber, 30 feet in diameter and 20 feet deep, from which water is admitted into the pressure pipe through two gate valves that are equipped for either manual or electric operation. The electric-operating mechanism can be controlled either from a platform above the surge chamber or by remote control from the power house.

The single pressure pipe is about 3,600 feet long and varies from 36 inches in diameter at the upper end to 30 inches in diameter at the power house; the thickness of the pipe varies from one-fourth to seven-eighths of an inch. The entire line is of the German lap-welded type used at the San Joaquin plant. The elevation of the center line of pipe at the surge chamber is 3,980 feet and the elevation at the power house 2,457 feet, giving a total head of 1,523 feet, not counting the small amount of water over the pipe in the surge chamber. There are no branches in the line until it has passed through the power house wall, where it enters a Y, each branch of which is controlled by a hydraulically operated gate valve. Each branch delivers water to the single overhung wheel of one of the two units.

GENERATING STATION.

Power house.—The power house is a reinforced concrete and steel structure, which measures 65 feet 4 inches in length by 40 feet 6 inches in width and 33 feet to the eaves. The station contains two units placed wheel to wheel; each operated by a single rotor. The pipe line enters at the center of the back of the building, and on each side of it, on the ground floor, are two transformers. The switching apparatus is in a balcony above the transformers.

Hydraulic equipment.—Each unit is operated by a single overhung impulse wheel which is supplied through a needle nozzle of 5⅞-inch bore, operating in connection with a relief valve in the main pressure line. The entire hydraulic and electric equipment was furnished by the Allis-Chalmers Co. Each wheel carries 19 buckets, is 71 inches in diameter on the pitch line, and is rated at 5,000 horsepower.

Generators.—The two generators, identical in design, are Allis-Chalmers 3,000-kilovolt-ampere 2,300-volt 3-phase 60-cycle alternators, operated at 400 revolutions per minute.

Exciters.—A 120-kilowatt 120-volt 1,000-ampere exciter, with sufficient capacity to furnish current for both main units, is mounted on each generator shaft.

Transformers.—The entire output of the plant is stepped up to line voltage by a single bank of three 1-phase 2,300/40,000/69,000 Y 2,000-kilovolt-ampere transformers, and the station is provided with one spare transformer to be used if accident occurs in any of the bank. As the waters of the Tule are highly mineralized and would probably clog up small circulating pipes, the transformer cooling is accomplished by circulating the oil instead of circulating water in coils through the oil, as is the usual practice.

Wiring.—The line outlets are through wall bushings above the door in the end of the power house. The line from the power house runs down the canyon past the Edison Co.'s Tule River plant and out across the valley to Strathmore, where the company has located a switching station to tie the power house in on the East Side line.

The power house is equipped with electrolytic lightning arresters designed for 60,000 volts potential.

KERN CANYON PLANT.

LOCATION.

The Kern Canyon power house is in sec. 6, T. 29 S., R. 30 E., on the northwest bank of Kern River, just where it emerges from the V-shaped notch of the main canyon into San Joaquin Valley. The intake is in sec. 29, T. 28 S., R. 30 E.; the conduit traverses secs. 29, 30, and 31, T. 28 S., R. 30 E., and sec. 6, T. 29 S., R. 30 E.

The original installation at this site was constructed by Power Development Co. and consisted of three General Electric 450-kilovolt-ampere 551-volt generators, each operated by an old Knight type impulse wheel carrying a very large number of small buckets, with each rotor served through six nozzles. The first trial run was made on February 17, 1897, and the station went into commission a few days later.

The plant was purchased by San Joaquin Light & Power Corporation in July, 1910, with the other properties of Power Transit & Light Co., successor to Power Development Co., and in October, 1917, unit No. 3 was replaced by a General Electric type ATB 3,750-kilovolt-ampere 11,000-volt 197-ampere generator direct-connected to an S. Morgan Smith horizontal turbine with double-draft tubes, rated at 5,300 horsepower and operating at 450 revolutions per minute.

In January, 1921, the plant was shut down for complete reconstruction. A new dam and intake was built at the original site, the tunnel was enlarged throughout, a new pressure pipe was installed, and a new power house was constructed. The new installation began operating in August, 1921.

SOURCE OF WATER SUPPLY.

The general characteristics of the drainage basin supplying water to the Kern Canyon plant are outlined in connection with the plants of Southern California Edison Co. on pages 620–622. The area above the Kern Canyon plant, shown on Plate LVII (in pocket), comprises 2,300 square miles.

There is no artificial storage and relatively little natural storage in Kern River basin. Preliminary steps have been taken, however, to form an irrigation district and construct a reservoir at the junction of North and South forks some distance above the Kern Canyon intake.

CONDUIT.

The new intake dam is a concrete weir about 210 feet long, including the intake gate structure. The spillway section is 120 feet long, including four buttresses about 5 feet thick for supporting the flashboards, which leave a net spillway about 100 feet long; a bridge is to be supported above this on the piers. The spillway lip of the weir is 940 feet above sea level, or about 8 feet above the original stream bed. The maximum elevation of the flashboard tops is 948 feet, but it is probable that on account of interference with Kern River No. 1 plant water may not be raised to that level.

The flashboards are so designed that by releasing a key timber they will go out in case of sudden flood, but under ordinary circumstances they may be removed by a traveling chain block supported by steel frame above the concrete structure.

Water is diverted at the east end of the dam through inclined steel trash racks into a concrete silt box. Two 6-foot sluice gates operated by bevel gears from a reinforced-concrete platform at an elevation of 958 feet are so arranged that one serves to remove heavy material accumulated in front of the trash rack and the other drains the sand box immediately behind it. The width of the intake channel is about 35 feet, and below the sand trap the two channels narrow to two 7-foot by 14-foot sliding gates constructed of 8 by 12 inch timbers and operated by threaded rods extending up to bevel-gear stands on an operating platform at an elevation of 962 feet. Stop-log slots are provided on the upstream side of these gates.

The entire conduit is concrete-lined tunnel of the following dimensions:

TABLE 89d.—*Dimensions of tunnel in Kern Canyon plant.*

Section.	Length.	Area of cross section.
	Feet.	*Square feet.*
Intake	18.84	....
Tunnel A	2,911.60	73.3
Transition tunnel	269.59	....
Tunnel B	1,573.60	116.6
Tunnel C	3,662.18	169.0
Special section at surge	27.00	....
	8,462.81	

The tunnel terminates in a short transverse chamber built in part of the old underground forebay. This chamber runs at right angles to the main tunnel and was constructed with the regular tunnel forms. The tunnel enters at one side, and two butterfly valves at the head of the penstocks were installed in the opposite side. One valve 8 feet in diameter is in the pipe line now installed, and one 6 feet in diameter will connect to a pipe serving a second unit.

A sand trap and trash rack were installed in front of the pipe headings, and a 36-inch sluice gate for clearing the sand trap. About 60 feet from the point where the tunnel connects with the forebay a surge shaft 25 feet in diameter was driven vertically upward from the tunnel roof to the ground surface. The outlet from the surge shaft is above the level of the flashboard tops at the intake. The entire tunnel line is operated under pressure.

The single riveted steel pressure pipe now installed is of the following dimensions:

TABLE 89e.—*Dimensions of pressure pipe in Kern Canyon plant.*

Length.	Diameter.	Plate thickness.
Feet.	*Inches.*	*Inch.*
175.9	96	$\frac{5}{16}$
57.6	96	$\frac{3}{8}$
94.1	96	$\frac{7}{16}$
6.8	96–90	$\frac{7}{16}$
33.7	90	$\frac{7}{16}$
115.0	90	$\frac{1}{2}$
82.9	90	$\frac{9}{16}$
566.0		

GENERATING STATION.

Power house.—The new Kern Canyon power house is a reinforced-concrete building with nearly flat concrete-slab roof carried on a reinforced-concrete roof system. The main building is 45 by 36 feet in plan and 55 feet high from the main floor to the top of the parapets. There is, however, a lower flat-roofed addition extending along the entire back wall of the main building; this is 10.2 feet deep in plan, with roof about 20 feet above the main floor.

The west end of the building is of temporary construction, so that it may be extended in future to accommodate an additional unit.

The single vertical unit is centered 20 feet from the upstream end and 14 feet from the front wall of the building, and the generator is raised on a concrete-ring pedestal 6.25 feet above the main floor in such manner as to bring the top of the turbine to practically the main-floor level. It is expected that this arrangement will give certain economies in operation. The entire generator floor is commanded by a crane with 40 feet clear lift.

The 3-panel switchboard is parallel to the upstream end wall and is in the back corner of the generator room. The operating mechanism for the butterfly valve, at the junction of the pipe line and the scroll case of the turbine, is on the main floor in the back of the downstream end of the room, and the relief valve and governor are in the front of the same end. The low-tension bus and switch room is in the small addition to the back of the main building.

The exciter is direct-connected on top of the generator housing above the Kingsbury thrust bearing.

Elevations at various points of the development are as follows:

	Feet.
Top of flashboards at intake (maximum)	948
Top of apron at intake	940
Maximum water surface in forebay	948
Center line of turbine	696
Low water in tailrace	684
Top of tailrace outlet	682
Top of hydraucone	680
Bottom of tailrace	675
Main floor level	702
Top of crane rail	745
Top of parapet	757
Floor level of bus room	705
Roof of bus room	722. 5

The static head from the maximum possible flashboard crest at the intake to low-water level in the tailrace is 264 feet.

The high-tension transformers are on a terrace on a line parallel with the back wall of the power house, downstream from it. High-tension switching equipment and lightning arresters are on a terrace between the transformers and the river, with the high-tension busses supported over them on a steel framework.

Hydraulic equipment.—The lower end of the penstock enters the power house just below the main-floor level at the center of the back wall and connects immediately through a butterfly valve to the riveted steel scroll case of the turbine. The butterfly valve is equipped with remote electric control from the main switchboard. The Allis-Chalmers Francis turbine with vertical shaft is rated at 12,000 horsepower, operating under a head of 230 feet at 257 revolutions per minute. The turbine is equipped with a draft tube and hydraucone regainer. An Allis-Chalmers governor operates in connection with a relief valve.

Generator.—An Allis-Chalmers 10,600-kilovolt-ampere 11,000-volt 3-phase 60-cycle alternating-current generator is direct-connected to the shaft of the turbine, above which it is supported on a reinforced-concrete ring base. The turbine runner, main shaft of the unit, and generator rotor are supported by a Kingsbury bearing at the top of the unit.

Exciter.—The exciter, direct-connected on the main shaft, at the top of the main unit above the Kingsbury bearing, is an Allis-Chalmers 86.4-kilowatt 125-volt compound-wound continuous-current generator. A 25-kilowatt 125-volt continuous-current generator direct-connected to a 40-horsepower impulse wheel equipped with a governor furnishes control and lighting energy.

Transformers.—A bank of three oil-insulated water-cooled Allis-Chalmers 3,600-kilovolt-ampere transformers connected delta on the low-tension and Y with grounded neutral on the high-tension side step the voltage up from 11,000 to 66,000 volts for transmission.

Wiring.—The leads from the generator connect with the low-tension bus through a 1,200-ampere 15,000-volt Westinghouse oil switch, which is installed with disconnecting switches that permit its isolation for repairs. From the low-tension bus lead cables are carried out to the transformers. The high-tension busses on a steel bus frame outdoors are connected to the transformers and to the lines through 300-ampere 70,000-volt electrically controlled Kellman oil switches. Either bus may be connected through oil switches to either of the two outgoing 66,000-volt lines running to Bakersfield and there connecting with the main transmission network of the corporation. Kern River plant No. 1 of Southern California Edison Co. may also be connected through these lines.

MERCED RIVER PLANTS.

SOURCE OF WATER SUPPLY.

Merced River rises at an elevation of about 11,000 feet on the west slope of the secondary ridges west of the headwaters of Tuolumne and San Joaquin rivers, its basin touching the main divide of the Sierra only at Mount Lyell. From its source the stream flows westward and southwestward emerging from the foothills into the San Joaquin Valley at Merced Falls, 60 miles in an air line from its source. Elevations within the basin vary from approximately 350 feet at the mouth of the canyon to 13,090 feet at the summit of Mount Lyell. Sixteen miles from its head the river drops through Nevada and Vernal Falls into Yosemite Valley, through which it flows 4 miles to the head of the lower Merced Canyon. South Fork, rising in the vicinity of Merced Peak, and flowing first southward then westward and finally northwestward, joins the main stream 13 miles southwest of Yosemite Valley.

The course of the main Merced is almost due west from the crest of the Sierra to the station, and the North and South forks enter the main stream almost at right angles. The discharge of the North Fork is small except in flood times; the South Fork, even in the seasons of lowest flow, probably carries from 35 to 45 per cent of the total supply available at the intake. The drainage area above the Merced Falls plant is 1,095 square miles.

The topography of the headwater region is extremely rugged, but below Yosemite Valley it becomes more regular and the stream is shut in by two high brush-covered ridges. North and south of Yosemite Valley the mountain country along the tops of the ridges is well forested, but in the extreme eastern end of the basin are large areas of bare granite.

The low flow of the stream comes almost exclusively from the high country in the eastern part of the basin.

There is no artificial storage in the drainage basin and the low flow is probably affected but slightly by the natural storage in several lakes east of Yosemite Valley. The maximum recorded flood flow was 37,200 second-feet January 30, 1911; November 21, 1901, the river channel was dry; and the discharge has shown wide variations between these extremes.

From the upper part of the basin down to the head of Yosemite Valley there is relatively little forest cover, much of the country being bare granitic ridges and domes. From the valley as far westward as the mouth of South Fork, the ridges are well timbered, the forest cover in the South Fork basin being particularly good and including the Mariposa grove of big trees. In the lower canyon the cover is chiefly brush with scattering trees. Precipitation within the basin probably ranges between 20 inches in the foothills and a maximum of 55 or possibly 60 inches in the higher mountains. There is no artificial storage within the basin and only a small pondage above the diversion dams.

The fall of about 2,200 feet in the main stream between the western boundary of Yosemite National Park and the San Joaquin Valley is rather evenly distributed along the 54 miles of channel, and although part of it is utilized by several low-head power plants none of them are of great importance. Only two (Merced Falls and Kittridge) plants are connected to main transmission systems, and are therefore described in this report. Bagby plant, constructed by Mariposa Commercial & Mining Co. (see Appendix C, Table 312), is operated as a public utility serving a short isolated transmission line. The other plants on the stream belong to and are used to operate mines; one is operated by the Park Service.

KITTRIDGE PLANT.

Location.—Kittridge plant is at Kittridge station on the line of the Yosemite Valley Railroad, Mariposa County. Dam, conduit, and power house are all in sec. 26, T. 3 S., R. 16 E., and are at an elevation of about 850 feet above sea level.

The dam, flume, and power house were constructed in 1900 by Nameless Mining Co., the building housing at first a 20-stamp mill operated by one of the present water wheels. In 1906 the property passed into the hands of Prather Bros., who installed a generator (the present No. 2 unit), and transmitted power to Jasper Point to operate a rock crusher. In 1910 the development was acquired by Crown Lead Gold Mining Co., and a second and larger generator was installed. In 1916, being unable to meet the power demands at certain times, the plant was tied in with the San Joaquin Light & Power system, by which it was finally purchased on September 5, 1917.

Diversion works.—A timber crib dam 200 feet long and averaging about 20 feet high diverts water into a 9 by 16 foot flume 265 feet long through trash racks and a four section sliding timber headgate at the northeast abutment of the dam.

The dam is constructed of 12 by 12 inch timbers laid up in cribs 6 feet square, partly filled with rock. An 18-inch flashboard on the crest of the dam gives 41 acre-feet pondage.

Power house.—The power house is a frame building 50 feet long, 25 feet wide, and 22 feet high to the gable of the shingle roof. It contains two units with a combined capacity of 375 kilovolt-amperes or 525 horsepower.

Hydraulic equipment.—Two 35-inch 300-horsepower single horizontal Leffel-Sampson turbines are installed in the lower end of the flume and discharge through draft tubes 10 feet long, giving a total head of 25 feet. The turbines are controlled by a Woodward governor, type VR-7, rated at 7,000 foot-pounds with a motor-driven pressure pump.

Generators.—Both generators are operated by 24-inch double leather belts from their respective turbines. No. 1 generator is an Allis-Chalmers 225-kilovolt-ampere 2,200-volt 3-phase 60-cycle machine, and No. 2 generator is a 150-kilovolt-ampere 2,200-volt 3-phase 60-cycle machine. No. 1 operates at 600 and No. 2 at 900 revolutions per minute.

Exciters.—An Allis-Chalmers 6.6-kilowatt 120-volt 55-ampere direct-current generator belt driven at 1,650 revolutions per minute and an Allis-Chalmers 4-kilowatt 120-volt 33.3-ampere direct-current generator direct-connected to unit No. 2 and therefore operated at 900 revolutions per minute furnish excitation.

Transformers.—Three Farnsworth oil-insulated self-cooled 75-kilovolt-ampere 2,200/11,000-volt 1-phase 60-cycle transformers and three Allis-Chalmers oil-insulated self-cooled 60-kilovolt-ampere 2,200/6,600-volt 1-phase 60-cycle transformers are installed in a wooden house across the river from the generating station.

Wiring.—A 2,200-volt circuit crosses the river to the transformers and the 10,000-volt circuit is brought back to the high-tension bus at the power house, which may be connected to three outgoing circuits through Kellman automatic switches. The power house ties in through one of these lines to the Merced Falls distribution system.

MERCED FALLS PLANT.

Location.—The Merced Falls plant is in sec. 4, T. 5 S., R. 15 E., on the north bank of Merced River, where it emerges from the mountains into the foothills east of the San Joaquin Valley, about 20 miles northeast of the city of Merced. The work of constructing the present plant[6] was begun late in September, 1915, and the plant completed and put into operation during January, 1916.

Diversion works.—Although there are no storage reservoirs on the stream the pond above the dam has an area of 40 acres and its water level can be raised 3 feet, thus giving a pondage of 120 acre-feet to care for the fluctuating load demands each day. The maximum height of the dam is about 20 feet and its crest length slightly exceeds 500 feet. The structure is of the overfall type and is equipped with low flashboards. The dam is also used as a mill dam by Yosemite Lumber Co.

The power house immediately adjoins the north end of the dam. Water is admitted through steel trash racks and vertical wooden sliding gates to a wheel pit 25 feet wide, 25 feet long, and about 15 feet deep.

Water is discharged from the turbine pit through the runners of the turbine into an 8-foot draft tube projecting downward through the concrete floor of the pit and thence outward toward the river channel, flaring to a diameter of 11 feet at its outer end. The normal elevation of headwater is 336 feet and the lowest elevation of tailwater 314.25 feet, giving a difference of 21.75 feet; the elevation of the crest of the dam is 334.1 feet and the elevation of bottom of turbine pit 321.5 feet.

Power house.—The power house is supported on concrete foundations carried down to bed rock, and is built in the angle between the north wall of the turbine pit and the end of the dam. The building has a wooden frame with corrugated iron covering. It consists of a generator room 18 by 40 feet, with its main axis parallel to the crest of the dam, and an ell over the pulley pit 24 feet long by 19 feet wide extending downstream from the lower side of the generator room.

Hydraulic equipment.—The single prime mover which operates both generators is an S. Morgan Smith 36-inch 750-horsepower double horizontal turbine, submerged in the turbine pit. The turbine shaft projects through a stuffing box in the wall separating the turbine and pulley pits. Twin pulleys are mounted on the main turbine shaft, which is supported by bearings set on the concrete foundations of the pulley pit. The unit is controlled by a Woodward governor, which is

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[6] A mill dam was built at Merced Falls in 1854 and was reconstructed in 1872. The site was first used for the generation of electric power in 1894 by the Mount Gaines Mining Co., which installed a vertical turbine to operate a 135-kilowatt Stanley generator and transmit power to its mine, 14 miles to the east, at a potential of 10,000 volts. In 1896 Merced Falls Gas & Electric Co. installed two 75-kilowatt Brush alternators, operated by two vertical turbines, in a pit adjoining the Mount Gaines unit, and transmitted power to Merced at 10,000 volts. In 1900 the entire installation of both companies was acquired by Merced Falls Gas & Electric Co., in 1901 the wooden dam was replaced by the present concrete dam, and in 1903 the Brush machines were replaced by a Bullock 225-kilowatt generator. In 1910 the Merced transmission line was reconstructed for operation at 30,000 velts. In January, 1911, during a flood, the power house was undermined and wrecked by water flowing around the end of the dam. The power site then stood idle until 1915.

The foregoing historical notes and the following description of the plant are based on an article by A. S. Kalenborn ,engineer of the company, who constructed the plant. (See Jour. Electricity, vol. 36, pp. 445-448, 1916.

placed in the pulley pit. Each of the pulleys on the turbine shaft is 82 inches in diameter and has a 25-inch face. The pulley shaft is 19 feet 4 inches lower than the generator shaft and there is a horizontal distance of 23 feet 11 inches between the planes of the two shafts, so that the belts are inclined on an angle of approximately 39°. The two generators are set on the main axis of the generator room with their pulleys on the adjoining ends of their shafts. Each generator pulley is 26 inches in diameter and has a 25-inch face.

Generators.—The two generators are of the same type—Bullock 250-kilovolt-ampere 2,300-volt 3-phase 60-cycle revolving-field alternators, operated at 600 revolutions per minute.

Exciters.—The exciter of the generator at the south end of the power house is belt-driven from the main shaft. That of the other generator is mounted on the main shaft of the unit.

Transformers.—Power is delivered from the generator at 2,300 volts to three General Electric 150-kilowatt 2,300/11,000-volt transformers, which are installed in a substation about 150 feet from the power house. From this station the power is delivered at 11,000 volts to local distribution lines, mines, and gold dredgers in the district, or stepped up from 11,000 to 30,000 volts by other transformers for transmission to the Merced district.

STEAM PLANTS.

FRESNO PLANT.

History.—The Fresno steam plant is the oldest peak-load and reserve station on the system of the San Joaquin Light & Power Corporation. It began operation October 10, 1905, and up to the time that the Bakersfield steam plant began to deliver power, November 18, 1910, it was the only steam station owned by the company. Since the building of the Bakersfield plant the Fresno station has lost its importance except as a substation. The demand on the Fresno plant is small except in local emergencies or during seasons of prolonged drought. Part of the original equipment is out of commission or has been entirely removed.

Buildings.—The power house is a brick structure 75 by 150 feet in plan, with a corrugated-iron roof supported on wooden trusses. The steam-generating equipment is placed toward the street front of the building, so that the back part of the station is left for substation equipment. The boilers are installed along the front wall of the main room, and the engines, belts, and belt-driven motor generators occupy the center of the station. The long arm of an L-shaped switchboard runs nearly the entire width of the room, just back of the generators. Directly back of the switchboard is a low-tension switch area, and still farther back are the transformer cells, which do not open into the room but into the alley behind the building. The high-tension switches are above the transformer cells, in a gallery opening into the generator room. The high-voltage outlets pass through the end of the building above the switch gallery. At one end of the switchboard, along the side wall, are the small arc transformers for the local lighting circuits.

Mechanical equipment.—Only the generating equipment is considered here. The substation equipment is listed in Table 94. Four Babcock & Wilcox boilers, two of them of 300 and two of 200 horsepower capacity, serve the station.

The only engine now in operating condition is a 750-horsepower McIntosh-Seymore horizontal cross-compound machine.

The auxiliary equipment, such as pumps, condensers, and heaters, is in the basement just in front of the boilers.

Electrical equipment.—The 750-horsepower engine is belt-connected to a pulley that is set beside a 600-kilowatt motor-generator unit, which can be connected to the pulley shaft by a toothed clutch if the electric supply of the motor fails.

BAKERSFIELD PLANT.

History.—A large extension of the San Joaquin Light & Power Corporation's transmission system in 1910, and the absorption of the small electric company operating in and around Bakersfield, made a large auxiliary steam station a necessity. To supply this need the Bakersfield steam plant was designed. A temporary 750-kilovolt-ampere unit (now removed) was put into operation at the plant November 18, 1910. The first permanent unit began to operate April 4, 1911,[7] the second on November 17, 1911, and the third on October 11, 1913.

Buildings.—The station is housed in a steel-frame building, consisting practically of two buildings placed side by side, with common wall, very flat-pitched concrete slab roof, and double, plastered "hyrib" walls. The first building is a boiler house which measures 81 feet 8 inches by 125 feet in plan; the second is the generating station, which measures 60 by 145 feet in plan and is divided into a 1-story generator room, 40 feet wide by 145 feet long, next to the boiler room, and a 3-story switch-gallery space, 20 feet wide by 145 feet long, on the opposite side of the room from the boilers. The generator room rises somewhat higher than the Louvre ventilator of the boiler house and depends for ventilation on windows and transoms in its side walls. The boiler room has been extended 50

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[7] This unit, of 2,500-kilovolt-ampere capacity, together with two 604-horsepower boilers and auxiliary equipment, was removed during 1916 for installation in a new steam plant at Betteravia, in northwestern Santa Barbara County. The latter station serves as steam reserve on lines of Midland Counties Public Service Corporation.

feet to the north and the generating room 20 eet to the north, as noted below.

The boiler room is divided by a wide central aisle that runs along its main axis parallel to the generator room and directly under the raised ventilator in the roof. On each side of and facing this aisle there is a row of boilers. The cross aisles terminate at the doors to the generator room.

The first or ground floor of the switch gallery space contains the low voltage apparatus and busses and the transformer cells. The second gallery, just above the first, contains the 11,000-volt switching equipment, arranged behind a long switchboard that faces out into the generator room. The third or top gallery contains the 60,000-volt switching apparatus and bus and the outlets to the high-tension transmission lines.

The turbo-generators are raised to the level of the second (or switchboard) gallery on arched reinforced-concrete pedestals and are reached from the switchboard by iron gangways supported on brackets. Aside from these gangways, except in the switch galleries, there is no floor above the ground in the generator room. By this open arrangement far better circulation of air is maintained, a matter of great importance, as the locality is one of the warmest in California. The auxiliary equipment, such as circulating pumps, exciter units, and vacuum pumps, is placed on the ground floor around the base of the pedestal foundations of the main units. The feed pumps are between the bases of the second and third units.

Mechanical equipment.—The boilers of the first installation were two batteries, each containing two 304-horsepower Babcock & Wilcox water-tube boilers. The second boiler equipment, installed on the west side of the boiler room, consisted of two similar batteries of two Stirling boilers; each boiler rated under the operating conditions at 604 horsepower, and provided with four hundred and forty 3½-inch water tubes, three 42-inch steam drums, and one 40-inch mud drum. The next addition to the boiler equipment in 1913 was two more batteries, or four 604-horsepower Stirlings. Back of each row of boilers is a passage about 6 feet wide, which permits access for cleaning. The original Babcock & Wilcox boilers were removed in 1920 and replaced by four Stirling boilers of 822-horsepower capacity each. The boiler room was extended 50 feet to the north, and six more 822-horsepower Stirling boilers were added at the same time. These 10 boilers operate at 250 pounds steam pressure and are provided with Babcock & Wilcox superheaters which give 125° superheat. Each bank of boilers in the plant is provided with its own stack. All boilers are equipped for burning natural gas but are so arranged as to be readily changed to burn oil. The oil is supplied from a tank on the premises by two duplex Smith-Vaile 5¼ by 4¾ by 5 inch pumps, and is served through heaters which give it a temperature of 180°. The Stirling boilers are equipped with U-type superheaters. The 604-horsepower boilers operate at 200 pounds pressure and 100° to 125° superheat.

Feed water is supplied by two multistage centrifugal pumps, each with a capacity of 600 gallons per minute. Both pumps are driven by 137-horsepower noncondensing steam turbines. The condensers are all of the Alberger surface type. The condensers for the units originally designated Nos. 2 and 3 have 15,000 square feet of cooling surface each and are inclosed in the arches of the concrete pedestals that support the turbines. The condenser cooling supply is drawn through a 26-inch cast-iron circulating system from an irrigation canal near the plant. The cooling water is delivered to the No. 2 condenser by a Byron Jackson centrifugal pump, operated by a Fleming tandem compound noncondensing side-crank 9 by 17 by 12 inch engine, manufactured by the Harrisburg Engine Co.

The dry vacuum for units Nos. 2 and 3 is maintained by Alberger rotary 12 by 30 by 18 inch pumps. One 3-inch motor-driven and two 4-inch turbine-driven wet vacuum pumps serve the condensers of units Nos. 2 and 3.

The two Cochrane feed-water heaters are placed between units Nos. 2 and 3, next to the wall separating the generator from the boiler room on a level with the main units, and each is of 4,000-horsepower capacity.

In 1920 the generator room was extended 20 feet to the north and a new unit was installed in the position originally occupied by the old No. 1 machine. This unit is provided with a Wheeler condenser having 30,000 square feet of cooling surface and the necessary pumps for circulating water.

A cooling tower for cooling the condensing water in case water is not available from the irrigating ditch has also been added. This tower is large enough to care for the entire plant.

Electrical equipment.—The two remaining turbo-generators of the original installation of three units are of the horizontal type. No. 2 unit, in the center of the generator room, is an Allis-Chalmers Parsons 6,250-kilovolt-ampere 2,300-volt 1,570-ampere 3-phase 60-cycle generator operated at 1,800 revolutions per minute by a 5,000-kilowatt turbine. No. 3 unit, in the south end, is an Allis-Chalmers Parsons 7,800-kilovolt-ampere generator coupled to a 6,250-kilowatt turbine.[8] The new No. 1 unit is an Allis-Chalmers Parsons turbo-generator consisting of a 12,500-kilovolt-ampere 2,300-volt 3,140-ampere 3-phase 60-cycle generator, operated at 1,800 revolutions per

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[8] The company reports that old No. 1 unit (now removed) has carried 2,750 kilowatts for several hours, No. 2 unit 6,250 kilowatts for several weeks, and No. 3 unit 7,800 kilowatts for short periods.

minute by a 12,500-kilowatt turbine. On the wall at the end of each main unit there are two vertical vacuum gages.

The transformers are placed in cells under the switchboard gallery on the ground floor of the generator building, sufficiently far from the side wall of the building to give space for a double row of concrete switch cases. Outdoors at the north end of the plant there are four General Electric single-phase 60-cycle 833-kilowatt 2,300-delta/60,000-Y water-cooled transformers—a bank of three and a spare to be used in emergencies. In the cells in the south end of the plant are seven Allis-Chalmers Bullock type 1-phase 60-cycle 2,100-kilovolt-ampere 2,300-delta/60,000-Y water-cooled transformers. This arrangement provides a single spare for two banks. The transformers for the new No. 1 unit are four Allis-Chalmers 4,166-kilovolt-ampere single-phase 60-cycle 2,300-delta/60,000-Y water-cooled outdoor-type units installed outdoors on the west side of the building; this provides a bank of three with one spare.

The 2,300-volt switching equipment on the ground floor is contained in concrete cases, as is the 11,000-volt equipment on the floor above. The generator and transformer 2,300-volt switch cases are built directly against the back walls of the transformer cells. Immediately opposite, along the side wall of the building, are similar cases containing the feeder switches on local circuits.

The 2,300-volt copper-bar busses are supported on pipe frames that run along the underside of the floor of the switchboard gallery just above the 2,300-volt switch cases. The 2,300-volt outgoing circuits pass through small tile outlets which pierce the end of the building just below the switchboard floor.

In the break in the row of transformer cells, and therefore under the switchboard gallery and the center of the 2,300-volt bus bars, are two motor-generator sets which supply direct current for the operation of the Bakersfield street railways. The first set is a General Electric type DMC 6–225–720 form A 375-ampere 550–600-volt direct-current generator, direct-connected to a General Electric type I class 10–350–720 form K 60-cycle 79/45-ampere 2,300/4,000-volt induction motor; the second set is a General Electric DMC 4–300–720 form H 500-ampere 550–600-volt direct-current generator, direct-connected to a General Electric AT–I 10–345–720 form C 430-horsepower 2,300-volt 87-ampere synchronous motor.

At the side of the motor generator sets is a motor exciter set, consisting of a 100-kilowatt 125-volt direct-current generator, operated by a 2,200-volt induction motor. Near the exciter there is a 4-panel switchboard for the direct-current control. The first panel operates the panel switch; the second, the No. 1 motor generator; the third, the No. 2 motor generator; and the fourth, the No. 1 motor exciter.

In front of these motor generators, on the main floor, alongside the circulating pumps, are the steam exciter units—a General Electric CC 4–75–3,300 type HT 600-ampere 125-volt continuous-current generator driven by a Curtiss 75-kilowatt turbine, and a Westinghouse 150-kilowatt 125-volt compound-wound direct-current generator driven at 900 revolutions per minute through reduction gears by a 150-kilowatt Westinghouse Parsons turbine.

The main switchboard, facing out into the generator room from the second gallery, contains 24 panels. The switchboard is of the General Electric vertical design and is constructed of black slate. Back of the board and midway between it and the power house wall are the isolated concrete switch cells housing the 11,000-volt apparatus. At each end of the switchboard gallery there is a curtain wall between it and the main generator room, so that only the part of the gallery occupied by the switchboard is open into the main room. The high-tension leads, from the transformers below to the 60,000-volt gallery above the switchboard, are carried up through line cells placed directly behind this curtain wall.

The third or 60,000-volt gallery is very similar to the second in its arrangement. At each end are two sets of General Electric K-10 solenoid-operated oil circuit breakers. One of each of these two sets is on the transformers and the other on the outgoing transmission lines. The 60,000-volt bus and leads are of copper tubing, and the busses are suspended from the pipe framework attached to the roof trusses by means of 60,000-volt 4-part insulators attached to the frame by their caps, so that the bus bars are fastened to what would naturally be the insulator pin. The 60,000-volt circuits pass through insulator bushings set in inclined panels in the wall of the power house. The outlet design is similar to that in the San Joaquin power house. (See p. 488.) On a balcony outside and at the north end of the 60,000-volt gallery are the General Electric aluminum-cell lightning arresters.

From the outlets in the wall of the building all wiring is carried to insulators, which are supported on a steel framework that runs along the side of the plant near the switch galleries. From this framework radiate all the outgoing transmission lines except the 60,000-volt lines, which are now carried over the plant to a special line-switching tower 300 feet away.

MIDWAY PLANT.

LOCATION.

The Midway steam plant of San Joaquin Light & Power Corporation was constructed by the company's forces during 1920 and 1921 and was put into operation in June, 1921. It is near Buttonwillow, 25 miles west of Bakersfield and near the Midway oil fields. In addition to the steam plant, it was found necessary on account of the isolated location of the station to construct a machine shop, employees' cottages, and all other buildings necessary for the maintenance of the plant.

GENERATING STATION.

Buildings.—The Midway steam station consists of a boiler house 71 feet 6 inches by 102 feet and a generator and switch room 60 feet 2 inches by 102 feet 3 inches in plan, placed side by side but with only 61 feet of their side walls in common, so that each building projects beyond the end of the other a distance of about 41 feet.

Both buildings have structural-steel frames, concrete walls and floors, and concrete-slab roofs supported on steel roof structures; the slope of the roof slabs is 1 in 12. A large ventilator extends the full length of the ridge of the boiler house.

The boiler house is 32 feet high from floor to lower member of the roof truss and 68 feet 6¾ inches wide inside. The turbine room is 40 feet high from the floor to the top of the crane rail and 50 feet high to the lower member of the roof truss. The width of the generator room between crane-rail centers is 38 feet 4 inches. An addition 18 feet wide runs along the side of the generator building opposite the boiler house. This addition rises 36 feet above the main-floor level, is divided into two floors, and accommodates all the indoor switching apparatus.

A cooling pond 200 by 300 feet is about 150 feet north of the generating station, and the machine and blacksmith shops and compressor house are 100 feet east of the plant.

Mechanical equipment.—Eight Stirling water-tube boilers are installed in four banks of two each, two banks on each side of a central aisle, 20 feet in clear width, running down the main axis of the boiler house. Two aisles about 4 feet 6 inches in clear width give access to the back of the boilers, and transverse aisles separate the banks and give access to the sides of both banks.

Steel breeching at the back of each bank of boilers supports a steel stack 125 feet high and 7 feet 6 inches in diameter, with plates ranging in thickness from five-eighths inch at the bottom to three-eighths inch at the top.

The boilers are designed to operate at 250 pounds pressure with 125° superheat. Each boiler has a heating surface of 8,000 square feet and is ordinarily fired by natural gas drawn through an 8-inch main 9 miles long from the compressor plant of the Midway Gas Co. in the Elk Hills district. Half the boilers are equipped with Apex and half with Duquesne gas burners, and all of them are also provided with Hammel oil burners, supplied in emergency from a 5,000-barrel storage tank near the power house.

Very thorough methods will be used in checking the plant efficiency. Bailey water meters are installed on all boilers, and a V-notch meter measures the boiler feed water. A Venturi meter is installed in the condensate piping, and a Cochrane water meter is installed and so piped that it can be placed in either line and used to check the other meters. Calorimeter tests of the gas fuel and CO_2 measurements of flue gas will be made twice daily.[9]

Both make-up and condenser cooling supplies are delivered from six wells ranging in depth from 350 to 550 feet. The supply is pumped from the wells to a 20,000-gallon steel tank, from which it is delivered under a head of 50 feet to a general system supplying make-up water for the spray and feed systems.

The condenser of the main unit has a cooling surface of 30,000 square feet. Circulating water is supplied to it by a 30-inch centrifugal pump driven by a 150-horsepower steam turbine through reduction gears, and an electrically driven pump of the same type is provided for emergency use. The circulating water is cooled by being forced through 360 spray nozzles and falling into a pond 300 feet long, 200 feet wide, and about 5 feet deep.

The water is delivered to the spray system through a main running down the center of the pond and tapering through reducers from 30 to 12 inches in diameter. At intervals of 30 feet nine pairs of branches 70 feet long are taken off at right angles to each side, tapering from 10 to 6 inches in diameter. Each side branch is equipped with four clusters of sprinklers, five in each cluster. The sprinkler clusters are spaced 20 feet apart on each branch. The entire piping system for the sprinklers is supported above the water surface on concrete piers built in the pool.

Electrical equipment.—The main unit is a General Electric 12,500-kilovolt-ampere 11,500-volt 3-phase 60-cycle turbo-generator raised above the main-floor level of the plant, with the condenser installed below it. The main unit is installed in the corner of the generator room immediately adjoining the boiler house; and on the opposite side of the room from the boiler house is the double-deck switch gallery with switches and transformers for local service and exciter and field panels on the ground floor and bench board, main generator switches, and other principal equipment on the second floor, at the same level as the turbine base.

The plant is equipped with two exciters, each of sufficient capacity to excite two generators of the same capacity as the first main unit. One is a 150-kilowatt 250-volt turbine-driven unit, and the other a 170-kilowatt 250-volt motor-driven unit. The electrically controlled switches may be operated in emergency from the exciter busses but

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[9] See Moore, H. J., Midway gas-burning steam-power plant: Power, vol. 53, p. 934, June 7, 1921.

ordinarily are operated by energy supplied from a 15-kilowatt 250-volt motor-driven control generator.

Three General Electric 4,250-kilovolt-ampere 11,500-volt water-cooled transformers designed to give 69,300 volts delta or 120,000 volts with Y connections on the high-tension side are installed outside the plant, the transformers and all high-voltage equipment being of the outdoor type. A spare transformer is provided in case of emergency. High-tension busses and disconnecting switches are mounted on a steel structure in the switch and transformer area outside the plant.

BETTERAVIA PLANT.

History.—Betteravia steam plant was constructed by San Joaquin Light & Power Corporation near the small town of Betteravia, in the extreme northwestern corner of Santa Barbara County, and began operation in August, 1916. The output of the station was limited to about 1,250 kilovolt-amperes by insufficient boiler capacity from 1916 until May, 1918, when additional boilers were installed, permitting the unit to carry its full rating of 2,500-kilovolt amperes. The station was constructed to take the place of the small steam plants of Midland Counties Public Service Corporation in San Luis Obispo (shut down July 1, 1916) and in Santa Maria (shut down January 1, 1917).

Buildings.—The boilers and generating and auxiliary equipment of the Betteravia steam plant are all contained in a single building with concrete foundation, steel frame, and corrugated galvanized-iron sides and roof, close to the shore of Guadalupe Lake and directly adjoining the beet-sugar factory of the Union Sugar Co. The length of the front of the power house along the lake is 106 feet and its depth 72 feet. The roof has two longitudinal ridges, each surmounted by a ventilator running the entire length of the building. A 15-ton traveling crane commands the entire generator floor

Guadalupe Lake, from which the plant draws its condenser cooling supply, is formed by water from an artesian basin, and the plant is therefore free from many of the troubles encountered in using river or ocean water. The water is drawn in through two 14-inch pipes supported on a low dock putting out a short distance from the shore, and is discharged through a short length of 16-inch pipe emptying into the lake about 30 yards from the intake.

Fuel oil is delivered in cars on a siding near the Union Sugar Co.'s factory, several hundred feet from the plant, and thence to the steam station through a pipe line by a 6-inch Gould pump operated by a direct-connected 25-horsepower motor. The station is also equipped to use natural gas supplied from the Orcutt oil fields.

The transformer equipment, of the open-air type, with high-tension switches, and the substation supplying the Union Sugar Co.

occupy a terrace on the hill immediately behind and above the generating station.

Viewing the interior of the station from the main doorway at the center of the front (or lake side) of the building, the observer sees on his right the turbo-generator, raised above the main floor level on an arched reinforced-concrete base parallel to the end wall of the building. The condenser is supported above the floor at the side of the generator base, and the circulating pump and the engine which drive it are in a pit between the generator and the center of the room. In the center of the room and at the main floor level are the boiler-feed and fuel-oil pumps, and the feed-water heater, and beyond these the three banks of boilers occupying the entire back of the room, facing out toward the front. The motor driven exciter, the dry vacuum pump, and the remote-control switches on the generator leads are between the main unit and the front wall of the room. The switchboard is on the main floor near the front wall at the left and facing out toward the room, and beyond it in the extreme left corner near the front wall is the dressing room for the operators.

Between the back and ends of the row of boilers and the walls of the building there is a free space of about 5 feet, while between the first and second banks there is a space of 11 feet and between the second and third banks a space of 5 feet, giving ready access to all parts of the equipment.

Mechanical equipment.—Two 604-horsepower and two 350-horsepower Stirling boilers and 250-horsepower Babcock & Wilcox water-tube boilers, all operated at 180 pounds pressure and equipped to burn either fuel oil or natural gas, supply steam for the main unit and auxiliaries.

The Alberger condenser of the main unit has a cooling surface of 6,000 square feet and is supplied with cooling water by a Byron-Jackson centrifugal pump operated by a Fleming tandem compound noncondensing side-crank 9 by 17 by 12 inch engine. Dry vacuum is maintained by an Alberger rotative pump 10 by 18 by 18 inches, and condensate is handled by a vacuum pump 6 by 7¼ by 6 inches, on the main floor immediately under the condenser.

Boiler feed water may be supplied either by two duplex 7 by 4½ by 8 inch Snow pumps, or by a Platt Iron Works multistage centrifugal, designed to deliver 125 gallons per minute against a head of 460 feet and operated at 2,500 revolutions per minute by a Westinghouse steam turbine. Fuel oil pumped from the cars to the power house by a 6-inch Gould pump direct-connected to a 25-horsepower motor is delivered to the burners by two Snow duplex 4½ by 2¾ by 4 inch steam pumps from a local storage tank just back of the plant. A Cochrane feed-water heater is installed.

Electrical equipment.—The single unit now in place is a General Electric-Curtis ATB 2,500-kilovolt-ampere 2,300-volt 628-ampere 3-phase 60-cycle horizontal turbo-generator that was transferred from the Bakersfield steam plant. The unit operates at 1,800 revolutions per minute.

Excitation may be furnished either by a motor-generator set consisting of a General Electric 400-ampere 152-volt 50-kilowatt direct-current generator operated by a General Electric 75-horsepower 1,200-volt induction motor or by a Westinghouse 15-kilowatt 125-volt 120-ampere continuous-current turbo-generator operated at 1,800 revolutions per minute.

The station is fully equipped with remote control switches on both high and low tension circuits. The 6-panel switchboard controls not only the plant and outgoing transmission circuits but also the substation delivering power to the Union Sugar Co.

TRANSMISSION AND DISTRIBUTION SYSTEM.

The first transmission line of the San Joaquin Light & Power system was that constructed from the original San Joaquin plant No. 1 to Fresno, about 35 miles. This line began operation in October, 1896. The 33,000-volt extension to Hanford was completed in 1900. The distribution system in the vicinity of Fresno was gradually extended, and as the country developed agriculturally, branches were carried from the main line, and subordinate transmission feeders were constructed along the east side of San Joaquin Valley. In 1910 the system of Merced Falls Gas & Electric Co. was absorbed and a line constructed through Madera, Athlone, and Merced to Merced Falls. By that time a single line had been extended south of Hanford as far as Corcoran, and another line had been built southwest from Hanford to Coalinga. A branch from Selma east to Dinuba and Reedley, one southeast from Copper Mine substation to Kings River, and another west from Fresno to Kerman, constituted, with the original lines, the entire northern system. In the south end of its present territory the company had purchased, in July, 1910, the small plant at the mouth of Kern Canyon and the line connecting it to Bakersfield.

In the fall of 1910 refinancing gave the corporation ample funds with which to extend and consolidate its transmission system for better service of the important market for power in the oil fields on the southwest side of San Joaquin Valley and in the rapidly growing agricultural communities. Work on the new lines was begun early in 1911.

An excellent idea of the extent of the system may be obtained from the transmission map (Pl. I), and attention will here be called only to its chief features. Crane Valley, No. 3, No. 2, and No. 1–A power houses on North Fork of San Joaquin connect through San

Joaquin power house to the Copper Mine substation, which is on the edge of the valley northeast of Fresno. Between the power house and the substation are two pole lines each carrying a single 3-phase circuit of No. 1 copper wire.

Two 110,000-volt transmission lines leave the Kerckhoff power house, one running southward through the center of the 60,000-volt loop by way of Sanger, Corcoran, and Semitropic to the Buttonwillow steam plant, the other running northward to Merced, where the potential is stepped down and connection made to the 60,000-volt transmission and 10,000-volt distribution systems. Connection is made through the 60,000-volt lines at Merced to the Pacific Gas & Electric system. The Copper Mine substation is the starting point for the 60,000 and 30,000 volt transmission lines that serve a large portion of the system. The principal lines running out of Copper Mine are the 60,000-volt loop inclosing the south end of San Joaquin Valley, the 60,000-volt main line running westward through Los Banos and Livingston, and the 30,000-volt lines running south by way of Fresno to Hanford.

A very important branch from the southern loop runs westward and southwestward from Henrietta substation north of Tulare Lake by way of Coalinga, San Miguel, Paso Robles, San Luis Obispo, and Santa Maria to Los Alamos, in the northern part of Santa Barbara County. This line is operated by Midland Counties Public Service Corporation. The total length of this extension is 135 miles from Henrietta to Santa Maria.

The following standards have been used in constructing the main lines and the 10,000-volt feeders:

The 60,000-volt lines are constructed with 15 or 16 50-foot Washington fir poles to the mile, with conductors supported in an equilateral triangle 84 inches on the side by a single insulator set on the top of the pole and one at each end of a cross arm. The cross arm is fastened into a gain in the pole by a U-bolt which encircles the pole. All the insulators are supported on iron pins. Every half mile the line is guyed fore and aft by a bridle fastened to the cross arm just inside the insulator pins.

In the older parts of the 30,000-volt main lines the conductors are strung in an equilateral triangle, 60 inches on the side, with 15 or 16 40-foot round poles to the mile. In the newer standard 30,000-volt lines the three insulators are set in a row on a cross arm at the top of the pole. The lengths of spans and poles are the same as on the old lines. On some of the 30,000-volt lines one insulator has been fastened to the pole top, the second below it and in a horizontal position on one side, and the third an equal distance below the second, and on the opposite side of the pole. This method dispenses with cross arms, but probably could not be employed in a climate damper than that of southern California.

The 10,000-volt lines are 3-phase 3-wire circuits. The construction is similar to the newer type of 30,000-volt transmission, except that the cross arms carry four instead of three insulators. The poles are 35 to 40 feet long and are round. Condensed information concerning the transmission system is given in Table 90.

TABLE 90.—*High-tension transmission lines operated by San Joaquin Light & Power Corporation, 1900–1920.*

	Miles.		Miles.
1900	77.81	1911	503.25
1901	77.81	1912	606.74
1902	77.81	1913	703.94
1903	77.81	1914	703.94
1904	77.81	1915	710.44
1905	150.12	1916	729.69
1906	150.12	1917	781.19
1907	170.87	1918	[1] 740
1908	170.87	1919	742
1909	170.87	1920	[2] 840
1910	421.05		

TABLE 91.—*Transmission system (single-circuit, 3-phase) of San Joaquin Light & Power Corporation.*

From—	To—	Distance.	Wire.		Voltage.
			Size.	Material.	
		Miles.	*Gage No.*		
Copper Mine substation.	Bakersfield (via West Side).	191.95	B. C., B. S. A.	0 copper to Henrietta, 000 from Henrietta to Bakersfield.	60,000
Bakersfield	Canon power house	13.5	B. C.	No. 1	60,000
Do.	Famosa	21.47	B. C. B. S. A.	1/0 copper [a] 000 stranded aluminum.[b]	60,000 60,000
Sau Joaquin power house.	Copper Mine switching station.	20.18	1	Copper	60,000
Do.	do.	19.81	1	do.	60,000
Copper Mine substation.	Strathmore	79.00	000	Stranded aluminum	60,000
Strathmore	Famosa	43.75	000	do.	60,000
Do.	Tule power house	29.50	2	Copper	60,000
Copper Mine substation.	Madera	27.00	6	do.	60,000
Madera (Sayre's corner).	Los Banos	52.00	6	do.	60,000
Poso Junction	Mendota	16.00	6	do.	60,000
Los Banos	Livingston substation	25.00			60,000
South Dos Palos	South	5.5			60,000
Madera-Los Banos line.	Dairyland substation	9.5			60,000
Calwa	West	6.0			60,000
Power house No. 3	San Joaquin power house	8.56	6	Copper	60,000
Knowles	Power house No. 3	20.0			30,000
Copper Mine substation.	Fresno (east)	15.00	1	Copper	30,000
Do.	Fresno (west)	16.00	1	do.	30,000
Fresno	Henrietta (via Hanford)	52.08	2, 3, 4, 5, 6	do.	30,000
Hanford	Corcoran	20.75	6	do.	30,000
Henrietta	Alpaugh substation	52.0			60,000
Do.	Santa Maria	135.00	000	Stranded aluminum.	[c] 60,000
Santa Maria	Betteravia	5.5			60,000
Do.	Los Alamos	21.5			60,000

[a] 5.47 miles copper. [b] 16 miles aluminum. [c] Coast Lines Midland Counties Public Service Corporation.

[1] 29.57 miles of transmission line cut over to 10,000-volt distribution line.
[2] 61.9 miles of transmission line cut over to 10,000-volt distribution line.

TABLE 92.—*Growth in substations and miles of overhead distribution of San Joaquin Light & Power Corporation, 1900–1920.*

Year.	Number of substations.	Overhead distributing lines.	Year.	Number of substations.	Overhead distributing lines.
		Miles.			*Miles.*
1900	3	113.06	1911	21	946.30
1901	3	135.85	1912	24	1,225.94
1902	3	147.42	1913	27	1,697.10
1903	3	163.59	1914	27	1,769.87
1904	4	219.66	1915	29	1,831.24
1905	6	219.66	1916	31	2,031.59
1906	8	306.74	1917	26	2,395.67
1907	9	373.25	1918	35	2,605.00
1908	9	400.67	1919	35	2,605.00
1909	10	469.06	1920	[a] 32	2,830.00
1910	13	603.32			

[a] Some small stations abandoned and load taken over on one large one. Construction station for Kerckhoff abandoned.

TABLE 93.—*Substations and distribution lines operated by San Joaquin Light & Power Corporation.*

No.	Substation group.	Combined capacity.	Substation lines.
		Kilovolt-amperes.	*Miles.*
1	Los Banos, Mendota, Oro Loma	3,200	130.35
2	Merced, Merced Falls, Livingston	3,000	297.57
3	Madera, Dairyland	3,000	304.41
4	Raymond, Coarse Gold	975	
5	Fresno (2-kilovolt), California Avenue, Copper Mine, Kings River, Valley Ice, City Water, Kearney	20,400	524.21
6	Caruthers	1,500	200.80
7	Reedley, Stone Corral	3,000	273.23
8	Alpaugh, Corcoran, Hanford, Tulare Lake, Henrietta	6,000	263.19
9	Bakersfield, Kern Oil, Weed Patch	11,500	620.83
10	Famoso	3,750	
11	Midway, McKittrick, Carneras	10,500	233.39
		66,825	2,847.98

TABLE 94.—*Substations operated by San Joaquin Light & Power Corporation, Oct. 21, 1919.*

Substation.	Location.	Building.		Put in operation.	Voltage.				Capacity (kilovolt-amperes).	Service.
		Type.	Dimensions.		Incoming circuits.		Outgoing circuits.			
					No.	Volts.	No.	Volts.		
			Feet.							
Merced, town	Town of Merced, about 55 miles north of Fresno.	Steel and concrete, hyrib roof.	30 by 50	Aug. 1, 1910	1	10,000	1	2,000	....	Receives power at 10,000 volts from Merced substation. Serves 4,000 volts to Merced for light and power. Station contains 100-light arc tub.
Merced, new	2 miles south of town of Merced.	Reinforced concrete	18 by 42	Mar. —, 1921	1	110,000	1 6	60,000 10,000	15,000-kilowatt	Receives power at 110,000 volts from Kerckhoff transmission line. Serves 10,000 volts for the Suburban Trunk system to pumping plants in surrounding district; also serves Le Grand, Planada, and other towns.
Merced Falls	Foothills 20 miles northeast of Merced.	Corrugated iron with wooden frame.	22 by 30	Sept. 24, 1910	1	30,000	4	10,000	705-kilowatt	Receives power at 30,000 volts from Merced and delivers 10,000 volts to Merced Falls, Exchequer, Mount Gains, Hornitos, and Snelling for mining, dredging, pumping, and lighting.
Madera, town	Town of Madera, 21 miles north of Fresno.	...do	18 by 26	Apr. 30, 1911	1	30,000	3 1	10,000 4,000	....	Receives power at 10,000 volts from New Madera substation. Serves 4,000 volts for local consumption.
Madera, new	1½ miles south of town of Madera.	Corrugated iron	16 by 40	June 17, 1917	1	60,000	7	10,000	3,000-kilowatt.	Serves 10,000 volts for local distribution, mostly suburban, for pumping plants.
Los Banos	Near Los Banos	Outdoor type with switch house of corrugated iron on wooden frame and arrester house.	30 by 15 7 by 5	Oct. 17, 1911	2	60,000	4	10,000	2,000-kilowatt.	Receives at 60,000 volts from the main line out of Copper Mine substation; serves four pumping circuits of 10,000 volts and local distribution in Los Banos at 2,200 volts.
Coalinga No. 1	70 miles southwest of Fresno.	Corrugated iron with wooden frame.	15 by 43	May 14, 1913	....	60,000	4	10,000	1,500-kilowatt.	Receives 60,000 volts from Coast 60-kilovolt line from Henrietta and delivers 10,000 volts.
Mendota	2 miles west of Mendota, which is 30 miles northwest of Fresno.	Outdoor type with switch house of corrugated iron on wooden frame.	103 by 99	Oct. 17, 1911	1	30,000	2	10,000	1,200-kilowatt.	Receives at 60,000 volts from the main lines out of Copper Mine substation; serves 10,000 volts for pumping plants and also for the local distribution of light and power.

TABLE 94.—*Substations operated by San Joaquin Light & Power Corporation, Oct. 21, 1919*—Continued.

Substation.	Location.	Building.		Put in operation.	Voltage.				Capacity (kilovolt-amperes).	Service.
		Type.	Dimensions.		Incoming circuits.		Outgoing circuits.			
					No.	Volts.	No.	Volts.		
			Feet.							
Fresno steam plant and substation.	Fresno	Brick, with concrete roof on steel trusses	150 by 75	Oct. 10, 1905	2 2	30,000 10,000	3 8 1	10,000 2,300 30,000	2-kilovolt18,000 kilowatt.	Delivers 2,300 volts to Fresno for distribution of light and power, 10,000 suburban light and power for pumping plants.
Fresno Water	do	Brick, with plastered hyrib roof.	27 by 30	Aug. 14, 1911	1	30,000	8	2,300	900-kilowatt	Receives power at 30,000 volts from the 30,000 Fresno transmission line; serves power at 2,300 volts to step-down transformers for motors driving water pumps.
Kerman	2 miles south of town of Kerman, about 15 miles west of Fresno.	Corrugated iron with wooden frame.	16 by 40	Apr. 18, 1921	1	60,000	3	10,000	1,500-kilowatt.	Receives power at 60,000 volts from the substation over the Kerman transmission line; serves 10,000 volts for local distribution in Kerman: also power for suburban pumping plants.
Copper Mine	16 miles northeast of Fresno.	Corrugated iron for Sanger and Friant 10,000-volt lines. Plaster on wire mesh, double walls for east and west 60,000 loops. Corrugated-iron switch house for three 1,000-kilovolt-ampere banks	15 by 30 16 by 48 30 by 66 12 by 12	Sept. 14, 1911 July 2, 1904 Sept. 10, 1911	2	60,000	4 3 3	10,000 30,000 60,000	7,500-kilowatt.[a]	Receives at 60,000 volts from San Joaquin plant; serves 10,000-volt power to Sanger, Clovis and Friant, two 30,000-volt circuits to Fresno; 60,000 volts east and west loops to Bakersfield, also to Madera.
Kings River	Due north of Centerville.	Corrugated iron with wooden frame.	18 by 43	Sept. 26, 1912	1	60,000	3	10,000	1,500-kilowatt.	Receives power at 60,000 volts from the Copper Mine substation over the new east 60,000-volt transmise sion line; serves 10,000 volts for the local distribution for light and power and pumping plants in the immediate vicinity and 10,000 volts to the town of Sanger and Santa Fe crusher on Kings River.
Caruthers	20 miles southwest of Fresno.	do	15 by 43	May 16, 1913	1	60,000	4	10,000	1,500-kilowatt.	Receives 60,000 volts from west loop from Copper Mine and delivers 10,000 volts each to Caruthers, Raisin City, and suburban territory for pumping and lighting.

Reedley	Town of Reedley, about 23 miles southeast of Fresno.	do	35 by 18	June 16, 1906	1	10,000	1	4,000	300-kilowatt	Receives power at 10,000 volts from the new Reedley substation over the 10,000-volt distribution for suburban pumping plants and other uses; serves 4,000 volts for locals Reedley light and power.
Do	24 miles southeast of Fresno.	do	15 by 43	Oct. 10, 1912	1	60,000	4	10,000	4,500-kilowatt	Receives 60,000 volts from main line from Copper Mine and delivers 10,000 volts to old Reedley substation and to suburban pumping and lighting.
Stone Corral	In foothills 39 miles southeast of Fresno.	do	15 by 43	Sept. 27, 1912	1	60,000	4	10,000	1,500-kilowatt	Receives 60,000 volts from east 60 line from Copper Mine and delivers 10,000 volts to Woodlake, Red Banks, and for pumping and lighting in its district.
Corcoran	Town of Corcoran, about 75 miles south of Fresno.	do	26 by 18	Apr. 7, 1907	1	60,000	1	30,000	do	Receives power at 60,000 volts from the new Corcoran substation.
Lemoore	Lemoore, about 50 miles southwest of Fresno.	Building owned by city of Lemoore.	42 by 48	Apr. 30, 1909	1	10,000	1	4,000		Receives power at 10,000 volts from the Henrietta substation; serves power at 4,000 volts for the local distribution.
Hanford (substation and distribution owned by local company).	Town of Hanford, about 31 miles south of Fresno.	Brick, corrugated-iron roof.	80 by 40	Apr. 10, 1898	2	30,000	1	2,300	1,600-kilowatt	Receives power at 30,000 volts over the Hanford line from Fresno substation or from Corcoran; serves 2,300 volts for the local distribution light and power.
Bakersfield steam	Bakersfield	Reinforced concrete	82 by 140	Nov. 10, 1910	1	60,000		10,000 2,300 60,000	2-kilovolt 24,000-kilowatt, 10-kilovolt 2,499-kilowatt.	2,300 volts Bakersfield and Kern; 10,000 volts suburban; 60,000 volts Taft and McKittrick.
Midway	On west side main line about 25 miles southwest of Bakersfield.	Steel frame, hyrib walls plastered, hyrib roof.	30 by 50	Aug. 24, 1911	1	60,000	5	10,000	4,250-kilowatt	Receives power at 60,000 volts from the West Bakersfield loop; serves two 10,000-volt feeders for local distribution and for Maricopa, connecting with the 10,000-volt feeder for McKittrick.
McKittrick	On west side main line about 45 miles due west of Bakersfield.	do	30 by 50	do	1	60,000	4	10,000	3,750-kilowatt	Receives power at 60,000 volts from West Bakersfield loop; serves two 10,000-volt feeders for local distribution to Olig and for local oil leases.
Coalinga No. 2	9 miles north of town of Coalinga, about 70 miles southwest of Fresno.	Corrugated iron, wood frame.	16 by 40	Aug. 10, 1921	1	60,000	4	10,000	(b)	Receives power at 60,000 volts from the Coalinga No. 1 substation, which is on the coast 60,000-volt line; serves power at 10,000 volts to various oil leases and pumping plants, most of which lie within the suburban district surrounding Coalinga.

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a 6,000 on transmission. b No transformers; district station.

TABLE 94.—*Substations operated by San Joaquin Light & Power Corporation, Oct. 21, 1919*—Continued.

Substation.	Location.	Building.		Put in operation.	Voltage.				Capacity (kilovolt-amperes).	Service.
		Type.	Dimensions.		Incoming circuits.		Outgoing circuits.			
					No.	Volts.	No.	Volts.		
			Feet.							
Henrietta	On west side main line about halfway between Copper Mine substation and Bakersfield.	Steel frame, hyrib walls plastered, hyrib roof.	30 by 60	Aug. 24, 1911	1	60,000	2	10,000	1,500-kilowatt	Receives 60,000 volts from the main line extending from Copper Mine south to Bakersfield; serves 10,000-volt circuit leading to Lemoore and Huron.
Famoso	20 miles north of Bakersfield.	Corrugated iron, wooden frame.	15 by 43	Aug. 24, 1913	2	60,000	4	10,000	3,750-kilowatt	Delivers 10,000 volts for pumping and lighting for Famoso, Wasco, McFarland, Lerdo, and suburban country.
Sau Miguel	San Luis Obispo County, 33 miles north of San Luis Obispo.	do	15 by 43	Jan. 4, 1913	1	60,000	2	10,000	600-kilowatt	Delivers 10,000 volts for pumping and lighting to Paso Robles, San Miguel, Templeton, Santa Margarita, and suburban country.
San Luis Obispo	San Luis Obispo County.	do	15 by 43	May 23, 1913	1	60,000	3	10,000	do	Delivers 10,000 volts for pumping and lighting and for industrial services for San Luis, Arroyo Grande, and suburban.
Santa Maria	Santa Barbara County	do	15 by 43	June 13, 1913	1	60,000	3	10,000	do	Delivers 10,000 volts for pumping and lighting and industrial service, Santa Maria, Guadalupe, oil fields, and suburban territory.
Betteravia	do				1	60,000	....	10,000	do	
Los Alamos	17 miles southeast of Santa Maria.	Corrugated iron, wooden frame.	16½ by 35	May, 1918	1	60,000	4	10,000	1,500-kilowatt	Receives power at 60,000 volts from Santa Maria.
Kearney	5 miles west of Fresno.	Brick	18 by 24	June —, 1917	1	60,000	4	10,000	1,500-kilowatt	Receives power at 60,000 volts from main west 60,000-volt line. Serves power for irrigation.
Alpaugh	3 miles south of Alpaugh.	Corrugated iron	16½ by 35	Apr. —, 1918	1	60,000	4	10,000	2,000-kilowatt	Serves agricultural district.
Tulare Lake	Sec. 20, T. 22 S., R. 19 E	do	16 by 25	May —, 1918	1	60,000	2	10,000	600-kilowatt	Serves power for irrigation and local use.
Kern oil field	NW. corner sec. 6, T. 29 S., R. 28 E.	Corrugated iron, wooden frame.	18 by 26	June —, 1918	1	60,000	5	10,000	3,750-kilowatt	Serves oil fields light and power.
Bullard	SW. ¼ sec. 31, T. 12 S., R. 20 E., property of Fresno Traction Co.	Wooden frame buildings.	30 by 40	Apr. 1, 1915	1	10,000	1	2,300	375-kilowatt	Receives service from Fresno 10-kilovolt network; supplies 2,300 volts to railway company motors.

Piedra	NW. ¼ sec. 7, T. 13 S., R. 24 E.	Corrugated iron, wooden frame.	16 by 20	Feb. 7, 1911	1	10,000	1	440	225-kilowatt	Receives 10-kilovolt service from Kings River; delivers 440-kilovolt from Piedra quarries.
Oro Loma	SW. ¼ sec. 16, T. 12 S., R. 12 E.	Corrugated iron, wooden frame, switch house.	16 by 33	Aug. 17, 1916	1	60,000	2	10,000	600 kilovolt-amperes.	Receives 60,000 volts from Los Banos line; delivers 10-kilovolt suburban lighting and pumping.
Raymond	NW. ¼ sec. 22, T. 8 S., R. 19 E.	do	15 by 20	Apr. 13, 1916	1	30,000	1	10,000	600-kilowatt	Receives 30-kilovolt service from Raymond line out of power house No. 3; delivers 10 kilovolts for light and industrial service, quarries, and mining.
Coarse Gold	SW. ¼ sec. 19, T. 8 S., R. 21 E.	Outdoor installation entirely.		do	1	30,000	1	10,000	375-kilowatt	Receives 30-kilovolt service from Raymond line out of power house No. 3.
Snelling	Not a substation, bank of transmission on a dredger.								150-kilowatt	Receives service from Merced Falls; 10-kilovolt distribution.
Valley ice (extension Valley ice plant building.)	About 2 miles south of Fresno on highway.	Concrete (company owns equipment).	16 by 23⅛	June —, 1919	1	60,000	1	440	2,000-kilowatt	Served by 60,000-volt tap from west 60,000 Kearney substation.
Dairyland	Chowchilla Pacific R. R. and Tyler Road, Madera County.	Corrugated iron, wooden frame.	35 by 16½	Apr. —, 1919	1	60,000	5	10,000	3,000-kilowatt	Receives power at 60,000 volts from Madera 60,000-volt line and Copper Mine substation at Los Banos. Serves 10,000 volts for suburban trunk system and dairy farms.
Divide	Near divide on Pacific Coast R. R. to Orcutt.	do	16½ by 35	Oct. —, 1919	1	60,000	3	10,000	3,700-kilowatt	Receives power at 60,000 volts from Coast transmission line.
Livingston	15 miles west of Merced	Corrugated iron	16½ by 35	Nov. —, 1919	1	60,000	5	10,000	1,500-kilowatt	Receives 60,000 volts from extension of Los Banos and Merced. Serves power for agricultural use.
Carneras	20 miles northwest of McKittrick, T. 27 S., R. 20 E.	do	16½ by 35	July 13, 1919	1	60,000	2	10,000	do	Serves oil fields.
California Avenue	2 miles southeast of Fresno.	Corrugated iron, wooden frame.	16 by 43	Oct. 7, 1918	1	60,000	6	10,000	7,500-kilowatt	Receives power from 60,000-volt lines from Sanger to Kearney and distributes to Fresno substation for 2,000-volt distribution and to surrounding industrial and irrigation load.
San Joaquin	Sec. 13, T. 15 S., R. 16 E.	Corrugated iron	16 by 40	Mar. 25, 1921	1	60,000	4	10,000	4,500-kilowatt	Receives power from 60,000-volt line from Kerman. Serves local distribution for town of San Joaquin and suburban pumping.
Sanger	3 miles west of town of Sanger.	Reinforced concrete	18 by 42	Mar. —, 1921	1	110,000	2 3	60,000 10,000	15,000-kilowatt	Receives power from Kerckhoff-Corcoran 110,000-volt line and distributes to the 60,000-volt transmission system and to the surrounding irrigation district at 10,000 volts.
New Corcoran	75 miles south of Fresno.	do	18 by 42	Mar. 1, 1921	1	110,000	2 5	60,000 10,000	15,000-kilowatt	Receives power from Kerckhoff-Midway 110,000-volt transmission line. Serves 10,000 volts to local distribution and suburban pumping; 60,000 volts to Alpaugh, old Corcoran substation, and Henrietta.

TABLE 94.—*Substations operated by San Joaquin Light & Power Corporation, Oct. 21, 1919*—Continued.

Substation.	Location.	Building.		Put in operation.	Voltage.				Capacity (kilovolt-amperes).	Service.
		Type.	Dimensions.		Incoming circuits.		Outgoing circuits.			
					No.	Volts.	No.	Volts.		
			Feet.							
Semitropic.........	6 miles west of Wasco.	Reinforced concrete....	18 by 42	May 27, 1921	1	110,000	1 4	60,000 10,000	15,000-kilowatt	Receives power from 110,000-volt line from Midway steam plant to Corcoran and distributes to 60,000-volt system and to 10,000-volt system for the surrounding irrigation district.
Weedpatch.........	9 miles southeast of Bakersfield.	Corrugated iron, wooden frame.	16 by 40	Dec. 18, 1920	1	60,000	4	10,000	1,500-kilowatt.	Receives from the 60,000-volt line which taps from the west 60,000-volt loop from Bakersfield. Serves irrigation pumping.
Atascadero.........	Sec. 21, T. 22 S., R. 12 E.	Corrugated iron.........	16 by 40	Aug. 14, 1921	1	60,000	2	10,000	600-kilowatt...	Receives power from coast 60,000-volt line. Serves local distribution and suburban.

SOUTHERN CALIFORNIA EDISON CO.

HISTORY.

RELATIONS TO CONSTITUENT COMPANIES.

Southern California Edison Co. is the prototype in southern California of Pacific Gas & Electric Co. in northern California. Both represent complex unions of a large number of smaller companies, but the backers of the water-power company acquired control of Pacific Gas & Electric Co., whereas the steam-electric generating company acquired control of the system embodying the Southern California Edison Co. This parent company of the Edison system was a small concern—the West Side Lighting Co., which continued from 1896 till the fall of 1897, in corporate form, work begun in 1895 as a private enterprise, was consolidated in 1897 with Los Angeles Edison Electric Co. to form Edison Electric Co. of Los Angeles, was reorganized in 1902 as The Edison Electric Co. of Los Angeles, and was again reorganized July 6, 1909, as Southern California Edison Co., absorbing during each of these periods in its growth many smaller concerns. (See Table 95.) The capitalization of Southern California Edison Co. was placed at $30,000,000, divided into $4,000,000 cumulative preferred and $26,000,000 common stock. In 1917 the authorized capitalization was increased to $100,000,000, of which $4,000,000 is 5 per cent cumulative and participating first preferred, $12,500,000 is 5 per cent cumulative second preferred, and $83,500,000 is common stock.

Southern California Edison Co. has operated both gas and electric systems but has now gone out of the gas business. A good idea of the company's activities may be obtained from Table 95.

TABLE 95.—*Constituent companies of Southern California Edison Co.*

	Date of incorporation.	Control of stock obtained by successor.	Properties deeded to successor.
Southern California Edison Co.	July 6, 1909		
The Edison Electric Co. of Los Angeles	July 27, 1902		Sept. 1, 1909
Edison Electric Co. of Los Angeles (name changed from Los Angeles Edison Electric Co.)	July 9, 1894		Aug. 26, 1902
West Side Lighting Co	June 5, 1896		Dec. 1, 1897
Southern California Power Co	Apr. 18, 1897		Aug. 1, 1899
Pasadena Electric Light & Power Co	Feb. 8, 1888		Do.
Santa Ana Gas & Electric Co	June 17, 1891		Aug. 26, 1902
Santa Ana Gas Co	1886		1891
Parker Bros. & Harris electric plant			1891
Mountain Power Co. (power site, Santa Ana No. 2)	Mar. 23, 1900		Aug. 26, 1902
Southwest Gas & Electric Co	1901		
Kings River Power Co.[a]	July 12, 1902		
Redlands Electric Light & Power Co	Oct. 8, 1892		Aug. 26, 1902
Lytle Creek Light & Power Co	May 15, 1897		Nov. 7, 1903

TABLE 95.—*Constituent companies of Southern California Edison Co.*—Continued.

	Date of incorporation.	Control of stock obtained by successor.	Properties deeded to successor.
Southern California Edison Co.—Continued.			
Union Power Co. (half interest)[a]	Feb. 20, 1904		
California Power Co	Jan. 30, 1901		Aug. 26, 1902
United Electric Gas & Power Co	Feb. 13, 1900		July 2, 1903
Santa Monica Electric & Power Co	July 14, 1893		May 20, 1900
Monrovia Electric Power Co	1895		May 23, 1900
Long Beach & San Pedro Electrical Co	Mar. 20, 1896		Do.
San Pedro Terminal Gas, Electric & Power Co	Nov. 27, 1899		
Long Beach & Alamitos Gas, Electric & Power Co	Dec. 9, 1899		Apr. 5, 1901
Santa Barbara Gas Co	do		July 1, 1901
Do	July 13, 1894		Do.
Santa Barbara Consolidated Railroad Co	May 17, 1904		
Santa Barbara Consolidated Railway Co	Aug. 26, 1901		June 17, 1904
Santa Barbara Consolidated Electric Co	July 3, 1895		Aug. 19, 1901
Citizens Railway Co. of Santa Barbara	Aug. , 1887		Aug. , 1901
Santa Barbara Street Railroad Co	do		Do.
Interurban Railway Co	Aug. , 1904		
Santa Barbara Electric Light Co	Nov. 1, 1886		July 1, 1901
Santa Barbara Bath House Co	May 23, 1902		
Independent Gas & Electric Co	1903		
Pomona & Ontario Light & Fuel Co	1902		Apr. 2, 1906
Pomona Gas & Electric Light Co			
Riverside Light & Fuel Co	1901		Apr. 2, 1906
Riverside Gas & Electric Light Co			
Whittier Light & Fuel Co	1902		Apr. 2, 1906
Whittier Gas Plant			
Redlands Gas Co	1900		1905
Colton Gas Co	1903		1905
Peoples Gas Co. of Monrovia	Mar. 30, 1905		Apr. 2, 1906
Downey Light & Power Co			1914
Pacific Light & Power Corporation [b]	Jan. 12, 1910		May 27, 1917
Pacific Light & Power Co	Mar. 6, 1902		Feb. 10, 1910
San Gabriel Electric Co	May 24, 1897		Oct. 1, 1902
Sierra Power Co	1900		
San Antonio Light & Power Co	1891		
Electric Power Co. (half interest)			
Mentone Power Co	Aug. 16, 1901	Apr. 1, 1903	Nov. 27, 1911
Kern River Co	June 28, 1897		
Kern River & Los Angeles Electric Power Co	May 18, 1895	Apr. 16, 1903	1908
San Bernardino Gas & Electric Co	Dec. 21, 1900	Apr. 1, 1903	1910
San Bernardino Electric Co	1892		
Electric Power Co	Sept. 19, 1892		
Riverside Power Co	Apr. 10, 1901	1906	Nov. 27, 1911
Mammoth Power Co	1900		Feb. 10, 1910
San Joaquin & Eastern R. R. Co.[c]	Mar. 16, 1912		
Huntington Lake Hotel Co.[d]	May , 1915		
Mount Whitney Power & Electric Corporation	Oct. , 1914		
Mount Whitney Power & Electric Co	Nov. , 1909	May 27, 1917	June 15, 1920
H. G. Lacey Co	Nov. 24, 1897		Dec. 31, 1918
Ventura County Power Co	Aug. 1906		Nov. 30, 1917
Ventura Water, Light & Power Co			
Oxnard Light & Water Co			
Santa Paula Electric Co			
Santa Barbara Gas & Electric Co.[c]	Aug. , 1909		
Merchants Mutual Light & Power Co			Nov. , 1909
Santa Barbara & Suburban Ry. Co.[c]	Feb. , 1912		
Edison Securities Co.[c]	Oct. 25, 1919		
Shaver Lake Lumber Co.[c]	June , 1919		

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[a] Controlled company.
[b] Miscellaneous properties acquired by Pacific Light & Power Corporation are described on pp. 553–554.
[c] Controlled by Southern California Edison Co. through stock ownership.
[d] Controlled by San Joaquin & Eastern R. R. Co. through stock ownership.

NOTE.—The following companies included in the above list have been sold: Colton gas property Nov. 1, 1907, Redlands gas properties to Home Gas Co., Riverside Light & Fuel Co. to Southern California Gas Co., Whittier Gas properties to Southern Counties Gas Co., Monrovia Gas properties to Piedmont Gas Co., Santa Barbara Gas & Electric Co. gas properties, Long Beach gas properties.

In December, 1916, Southern California Edison Co. filed application with the Railroad Commission of California for permission to acquire the entire properties, including franchises, of Pacific Light & Power Corporation and Ventura County Power Co., and on May

22, 1917, such permission was granted by the commission. This authorization provided for the purchase of 46,175 shares of the first preferred, 96,602 shares of the second preferred, and 104,685 shares of common stock of Pacific Light & Power Corporation, together with 3,417½ shares of preferred and 7,045 shares of common stock of Ventura County Power Co., and in addition thereto $5,000,000 par value of first and refunding bonds and $1,096,048.41 notes and accounts of Pacific Light & Power Corporation, in exchange for 120,299 shares of the second preferred stock of Southern California Edison Co. and $4,000,000 in cash. The Edison company was also authorized to purchase all the properties and franchises of Pacific Light & Power Corporation for 114,218 shares of Edison common stock. On October 31, 1917, the commission authorized the Edison company to purchase 90.3 shares of preferred stock and 15.6 shares of common stock of the Ventura County Power Co. for $5,053.95. These shares constituted the entire amount of stock outstanding at that time, exclusive of that already held by the Edison company.

The properties of Pacific Light & Power Corporation were deeded to Southern California Edison Co. May 27, and those of Ventura County Power Co. November 30, 1917.

The consolidation of these systems gave Southern California Edison Co. a combined hydroelectric generating capacity of 106,100 kilowatts and a steam-generating capacity of 97,800 kilowatts, or a total of 203,900 kilowatts. Several of the small steam units included in the above total have now been retired. The acquisition of the plants of Mount Whitney Power & Electric Co. in 1920 added 9,350 kilovolt-amperes hydroelectric and 8,437 kilovolt-amperes steam-electric capacity. The installation of an additional unit in Big Creek plant No. 2 and the putting into commission of Kern River plant No. 3 and Big Creek plant No. 8 have since greatly increased the hydroelectric installed capacity, so that in October, 1921, the company's hydroelectric generating capacity was 201,350 kilovolt-amperes and its steam-electric generating capacity 110,107 kilovolt-amperes, or a grand total of 311,457 kilovolt-amperes. The transmission network covers the inhabited sections of the Santa Ana, San Gabriel, and Los Angeles river valleys from Redlands to the Pacific Ocean as far south as Capistrano, and northwestward through the coastal belt of Ventura and Santa Barbara counties to the city of Santa Barbara and San Joaquin Valley south of Fresno. The main sources of electrical energy for the system are, however, far to the north of its market, on Kern and San Joaquin rivers.

Brief histories of the principal companies now consolidated into Southern California Edison Co. are presented in the following pages.

THE EDISON ELECTRIC CO. AND ITS PREDECESSORS.

WEST SIDE LIGHTING CO.

Though not the first of the component companies to be organized, West Side Lighting Co. may well be considered out of its chronologic order, as its owners finally obtained control of the system. Its corporate existence dated from June 5, 1896, but it was the outgrowth of action which was begun early in 1895 by E. E. Peck, who applied to the Los Angeles city council for an electric franchise, but who was outbid when, in accordance with the provisions of the law, the franchise was advertised and sold. Mr. Peck's subsequent efforts to have another franchise advertised by the city were unsuccessful, but late in 1895 he obtained a franchise from the county supervisors for a small lighting district south and west of the city limits of Los Angeles. With two associates he built a small power house at Twenty-second Street and Vermont Avenue, installed a 30-light arc machine, and in December began to operate. In this undertaking he obtained the financial aid of George H. Barker, W. R. Staats, and Walter S. Wright, and Staats has continued in the directorate of the West Side and succeeding companies up to the present time.

Another unsuccessful application for franchise within the city limits of Los Angeles was made in 1896, and trouble between the association and the city authorities ensued. The electric wires of the association were run into the city over a line set on private land, were cut at the street crossings by the city authorities, and had to be replaced several times. The war was brought to a close when the association purchased a franchise that had been granted July 15, 1895, to L. F. Scott for an overhead and underground distribution system in Los Angeles. One of the provisions of the Scott franchise, however, required that the city hall should be lighted by a given date and the time for the completion of the installation had nearly expired; it was only by stringing wires along the poles of the Los Angeles Traction Co. that the new holders of the franchise were able to comply with its terms. Suit later brought to cancel the Scott franchise was decided in favor of the corporation by the Los Angeles superior court.

On June 5, 1896, the owners, who up to that date had run the business as an association, put it into corporate form under the name West Side Lighting Co., capitalized at $500,000. George H. Barker was first president; W. S. Wright, vice-president; W. R. Staats, secretary and treasurer; and these men, with E. E. Peck and E. F. Billmeyer, constituted the first board of directors. On July 6, Billmeyer and Peck were succeeded by Jason Evans and J. H. Holmes on the directorate. On September 28 of the same year a bond issue of $300,000 was authorized.

The generating capacity of the West Side system was increased by several additions during the short period of its existence. Early in 1896 machinery rated at 50 kilowatts was installed to aid the original 30-light machine in the small frame building, and in December, 1896, the plant was transferred to an old cable power house which was purchased from the street railway company. The equipment in this new plant (which is the old Los Angeles No. 1 substation of the Southern California Edison Co.) comprised in addition to the 30-light and 50-kilowatt machines a 75-kilowatt 2,000-volt alternating-current generator. In January, 1897, a 120-kilowatt alternator was added to the equipment, which was further increased shortly after by the two 120-kilowatt 2,000-volt generators and the replacement of the old arc machine by two new 80-light machines, to which was soon added another of 125-light capacity; and in the fall of 1897 two 100-kilowatt 550-volt direct-current generators were installed.

EDISON ELECTRIC CO. OF LOS ANGELES.

Early activities.—In December, 1897, West Side Lighting Co. was purchased by and consolidated with the Los Angeles Edison Electric Co., incorporated July 9, 1894, with capital stock of $500,000 (the name was later changed to Edison Electric Co. of Los Angeles); but although the West Side Co. nominally sold out, its board of directors took control of the newly formed concern and continued the business,[10] which grew rapidly. In the spring of 1898 the company completed the equipment at the steam plant by installing a 240-kilowatt 3-phase generator, furnished by the Southern California Power Co., which had already begun the construction of Santa Ana River No. 1 plant on Santa Ana River east of Redlands and the line for transmitting power from it to Los Angeles, and which had contracted for the sale of hydroelectric power from this plant to the Edison company. Before the Southern California Power Co. was in a position to supply the power it was purchased by the Edison company, was paid for in stock of the latter company, and several of its directors were placed on the Edison's board.

Other properties were rapidly acquired, and before the company was reincorporated in 1902 as The Edison Electric Co. it had absorbed properties or purchased every share of stock of Pasadena Electric Light & Power Co., Santa Ana Gas & Electric Co., Mountain Power Co., Redlands Electric Light & Power Co., Lytle Creek Light & Power Co., and California Power Co.

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[10] Much of the history of the West Side system here outlined was given by George P. Low in an article in Journal of Electricity, January, 1903. It has been checked and confirmed by the officers of the company.

Southern California Power Co.—The history of the Southern California Power Co. is very short, but the development which it projected was noteworthy in the annals of hydroelectric transmission. The company was organized by the promoters of Redlands Electric Light & Power Co. in December, 1896, and began investigations on Santa Ana River which culminated in the building of Santa Ana River No. 1 power house and an 83-mile transmission line from that point to Los Angeles. Such was the faith in the project, not only of its organizers but also of the people interested in power development in Los Angeles, that in April, 1898, Southern California Power Co. was bought out by Edison Electric Co., which completed the Santa Ana plant in December, 1898, and began to transmit power to Los Angeles over a line which was then of unprecedented length.

Pasadena Electric Light & Power Co.—Pasadena Electric Light & Power Co. (incorporated in 1888) served a local distribution system from a small steam-electric station in Pasadena. It was bought out by the Edison company in 1898, its system connected to the Edison transmission lines, and the steam station abandoned in 1907.

Santa Ana Gas & Electric Co.—Santa Ana Gas & Electric Co. was incorporated in 1891 as successor to Santa Ana Gas Co. and Parker Bros. & Harris Electric plant, and was operating a small gas and electric generating and distributing system in Santa Ana and vicinity when purchased by Edison Electric Co. in 1899. The electric generating station was closed as soon as the system was connected with the transmission lines of the Edison company.

Mountain Power Co.—Mountain Power Co., organized in 1900, filed water rights on Santa Ana River below what is now Santa Ana River plant No. 1 of Southern California Edison Co., and acquired rights of way for two projects. The upper site was acquired by Edison Electric Co. and is now occupied by Santa Ana River No. 2 plant. A right of way closely paralleling the lower site was acquired by the predecessors of Pacific Light & Power Corporation, who built the Mentone plant.

Redlands Electric Light & Power Co.—The plants constructed by Redlands Electric Light & Power Co. are among the oldest on the system now operated by Southern California Edison Co. The Redlands company was incorporated early in 1892 by local capitalists, whose plans included the use of Mill Creek for power development and resulted in the construction of the first polyphase[11] transmission line in California—Mill Creek No. 1 plant.

Mill Creek No. 1 began operation September 7, 1893, by transmitting power from its two 250-kilowatt machines over two 3-phase circuits, 7½ miles to Redlands. The power was transmitted at gen-

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[11] The Pomona plant of San Antonio Light & Power Co., which had been put in commission in 1892, was a monophase, not polyphase plant.

erator voltage of 2,400, and the line was designed to give a terminal voltage of 2,300 at Redlands. About 4½ miles from the power house the Union Ice Co.'s establishment was served under a contract which had insured the building of the generating station. The machinery installed at the ice plant consisted of a single 120-kilowatt 3-phase synchronous motor. In Redlands the distribution system was fed directly from the transmission line without the use of any substation.

In 1896, when three years of operation had proved the unqualified success of the Mill Creek project, the pipe line was extended to gain more head, and another 250-kilowatt generator was added to the equipment. In order to furnish the necessary potential for an extension of the transmission system to Riverside, three transformers, which raised the line voltage to 10,000, were installed at the power house. This line to Riverside, completed in July, 1896, was 20 miles long; its two circuits were of No. 4 copper wire carried on 30-foot poles set 120 feet apart.

A second plant—Mill Creek No. 2—went into operation in November, 1899, with two 250-kilowatt 3-phase revolving-field machines of 11,300 volts potential. This was the last hydroelectric generating plant completed (though Mill Creek No. 3 was begun) directly by the Redlands company before its absorption by Edison Electric Co. Some of the organizers of Redlands Electric Light & Power Co., however, had turned their energies in other directions, even before the completion of Mill Creek No. 2, and had incorporated Southern California Power Co. The Redlands company also held a half interest in Union Power Co. (see p. 554), controlled California Power Co. (see below), and had controlled also water rights and rights of way on Lytle Creek through Lytle Creek Light & Power Co.

Lytle Creek Light & Power Co.—When Edison Electric Co. obtained control of the Redlands Electric Light & Power Co. it also obtained the latter's rights to certain power sites and rights of way on Lytle Creek belonging to Lytle Creek Light & Power Co., but certain other properties belonging to the Lytle Creek company were not purchased, and have since been purchased by other utility companies. The present Lytle Creek plant of Southern California Edison Co., although begun by Lytle Creek Light & Power Co., was not completed until several years after the properties of the Lytle Creek Co. had been taken over by Edison Electric Co.

California Power Co.—California Power Co. was formed by the promoters of Redlands Electric Light & Power Co. to complete certain preliminary work on Kern River. It was organized in 1901 and acquired water rights filed during the year 1900. The company began some preliminary work on what is now Kern River No. 1 plant of Southern California Edison Co. In 1902 the properties of the company were completely taken over by The Edison Electric Co., which thereafter conducted the work along Kern River in its own name; operations before that date were under its control, but not under its name.

Purpose of reincorporation.—The Edison Electric Co. was formed July 27, 1902, under the laws of Wyoming, as successor to Edison Electric Co. of Los Angeles, to provide greater bonding capacity made necessary by the very rapid extensions of the system and purchase of other companies. Its authorized capitalization was $10,000,000, of which $4,000,000 was preferred stock and $6,000,000 common stock. September 1, 1902, the new company executed an indenture, known as first and refunding mortgage, under which bonds were authorized to the extent of $10,000,000.

PROPERTIES ACQUIRED FROM EDISON ELECTRIC CO. OF LOS ANGELES.

Upon its formation in 1902 The Edison Electric Co. found itself in possession of the constituent concerns described in the preceding paragraphs and a generating system consisting of the following plants:

TABLE 96.—*Generating stations owned by The Edison Electric Co. in 1902.*

Plant.	Hydro-electric.	Steam-electric.
	Kilovolt-amperes.	*Kilovolt-amperes.*
Mill Creek No. 1	750	
Mill Creek No. 2	500	
Santa Ana River No. 1	3,000	
Second Street steam station (Los Angeles No. 1)		1,250
Redlands steam plant		625
Pasadena steam plant		300
Total, 6,425 kilovolt-amperes, or 8,600 horsepower.	4,250	2,175

The most important part of the transmission system was the 33,000-volt line from Santa Ana River No. 1 to Los Angeles, to which the company proceeded to tie the Mill Creek plants. The branch of this from Shorb to Pasadena was the only other line that had so high a voltage. In the Redlands district branches operated at 10,000 potential served Highlands, Colton, San Bernardino, and Riverside. A similar line running from Pomona substation served Claremont, Lordsburg, and San Dimas. The branch to the south from Puente went only so far as Santa Ana, and from it feeders were taken off for Whittier, Fullerton, Anaheim, and Orange. No lines were maintained in the territory west of the city of Santa Ana, since this territory was, in 1902, served by United Electric Gas & Power Co.

The character of the load on the system is indicated by the following table of substations:

TABLE 97.—*Transformer capacities of substations operated by The Edison Electric Co. in 1902.*

	Kilovolt-amperes.
Redlands	1,840
Colton	300
Pomona	450
Puente	450
Santa Ana	225
Pasadena	[a] 900
Los Angeles No. 1	1,500
Los Angeles No. 2	[b] 1,240
	[c] 6,905

[a] Plus 100-light series arc.
[b] Plus motor generator and one 100-ampere 8-hour storage battery.
[c] Plus 100-light arc machine and 100-ampere 8-hour storage battery.

TABLE 98.—*Length in miles of transmission lines operated by The Edison Electric Co. in 1902.*

District.	Series arc circuit.	Series incandescent circuit.	3-phase light and power circuit.	1-phase lighting circuit.	10,000-volt line.
Los Angeles	....	....	21.2	75.7	....
Pasadena	11.2	68.0	24.7	27.0	....
Pomona	9.7	17.8	21.1	9.9	....
Santa Ana	3.3	43.2	1.5	14.2	22.3
Redlands	2.0	24.0	12.0	13.0	64.5
Whittier	....	....	....	2.5	8.5
Fullerton	....	....	....	1.2	....
Orange	....	....	....	2.3	....
Anaheim	....	....	....	.2	....
Puente	....	....	....	.4	....
	26.2	153.0	71.5	146.4	95.3

	Miles.
33,000-volt line	87.0
Los Angeles underground Edison tubes, for 110 to 220 volts	9.3
Los Angeles underground Edison tubes for 500 volts	13.3
Miles of pole line belonging to company	407.0

The chief power users in 1902 were the Union Ice Co. at Mentone (150 horsepower), San Bernardino Valley Traction Co. (243 horsepower), and the Colton cement works (180 horsepower). Pumping along the citrus belt in the San Bernardino Valley consumed a great deal of power.

ABSORPTION OF UNITED ELECTRIC GAS & POWER CO.

The first important step taken by the company after the issue of the new bonds was the purchase on May 1, 1903, of the entire capital stock of United Electric Gas & Power Co.

United Electric Gas & Power Co. had been organized in 1900, primarily to take over and consolidate the systems of some of the local gas and electric light companies then operating in the small cities and towns along the coast west of Los Angeles. In this territory it took over Santa Monica Electric & Power Co., San Pedro & Terminal Gas, Electric & Power Co., Long Beach & Alamitos Gas, Electric & Power Co., and Long Beach & San Pedro Electrical Co. After these properties were consolidated the transmission system of United Electric Gas & Power Co. extended from Santa Monica on the north to Long Beach on the south, and substations, which took the place of local steam plants, were put in operation at Long Beach, Terminal Island, San Pedro, and Redondo, and through these electricity was supplied to Ocean Park, Hermosa Beach, Redondo, Moneta, Long Beach, Miramar, Inglewood, Gardena, Terminal Island, Short Line Beach, and San Pedro. The main generating station for this system was at Santa Monica, and in 1903 the plant there was equipped with one 400-kilowatt 2,200-volt 3-phase 60-cycle alternator, direct-connected to its engine, and one 200-kilowatt alternator, with the same characteristics but driven by a belt from its engine. The main transmission line was 40 miles long and was a single 3-phase circuit of No. 6 copper, operated at 22,000 volts. In addition to its electric service the company supplied to several of the cities mentioned gas made at small local gas plants.

After building up this system in the vicinity of Santa Monica the company turned its attention to the field in and around Santa Barbara, where it acquired Santa Barbara Gas Co., Santa Barbara Electric Light Co., and Santa Barbara Consolidated Railway Co., the latter being a consolidation of Citizen's Railway Co. and Santa Barbara Street Railway Co. A central plant to supply power for the various properties in Santa Barbara was put into operation and contained in 1903 one 300-kilowatt 2,400-volt 3-phase 60-cycle direct-connected alternator, one 150-kilowatt belt-driven 3-phase 60-cycle alternator, and one 110-kilowatt belt-driven direct-current generator. The system at Santa Barbara was not connected with that in the vicinity of Santa Monica.

United Electric Gas & Power Co. also acquired Monrovia Electrical Power Co., operating a small electric system in the town of Monrovia, Los Angeles County, and this, as well as the Santa Monica and Santa Barbara systems, passed into the control of the Edison company.

INCREASES IN EQUIPMENT.

When the transmission system belonging to the United Electric Gas & Power Co. was added to the existing system of The Edison Electric Co. of Los Angeles, it brought the total length of lines, with a voltage of 33,000, 22,000, and 10,000, up to 208 miles. In the meantime, the generating capacity had been increased by the installation of Mill Creek No. 3 plant, which was put into operation

March 18, 1903, construction on it having been begun under the Redlands Electric Light & Power Co. The capacity of the plant was 3,000 kilowatts, but on its completion Mill Creek No. 2 was reduced from 500 to 250 kilowatts, so that the net gain was 2,750 kilowatts.

On September 15, 1904, the Lytle Creek power plant, housing two units with a combined capacity of 500 kilowatts was put into commission, and this was followed April 15, 1905, by Santa Ana River No. 2, with a total capacity of 1,000 kilowatts in two units, constructed on one of the sites originally held by Mountain Power Co.

On April 27, 1904, Los Angeles No. 3 was put into commission with a capacity of 2,000 kilowatts in a single turbo-generator. A duplicate machine, added in December, 1904, doubled the capacity of the plant, and in September, 1907, the installation was further increased by a 6,000-kilowatt machine, which completed the generating equipment at the station. Los Angeles No. 1, on Second Street, was put out of commission when Los Angeles No. 3 was built and since that time has served simply as a transformer station.

May 19, 1908, the company began to transmit power from the 20,000-kilovolt-ampere Kern River No. 1 plant over a tower line 115 miles long to the Los Angeles No. 3 receiving station.

MINOR PROPERTIES ACQUIRED.

In 1905 and 1906 The Edison Electric Co. purchased a number of small gas and electric companies operating in the territory south and east of Los Angeles. Among them were the following:

Independent Gas & Electric Co., organized in 1903 and purchased in 1905.

Pomona & Ontario Light & Fuel Co., organized in 1902 as successor of Pomona Gas & Electric Light Co. and purchased in 1905.

Riverside Light & Fuel Co. organized in 1901 as successor of Riverside Gas & Electric Light Co. and purchased in 1905.

Whittier Light & Fuel Co. organized in 1902 as successor of Whittier Gas Plant and purchased in 1905.

Redlands Gas Co., organized in 1905, carrying with it control of Colton Gas Co. upon its purchase in 1905.

Peoples Gas Co. of Monrovia, organized in 1905 and purchased in 1906.

HISTORY OF PACIFIC LIGHT & POWER CORPORATION AND ITS PREDECESSORS.

CORPORATE RELATIONS.

Pacific Light & Power Corporation was organized in January, 1910, to succeed Pacific Light & Power Co., which in turn had been organized March 6, 1902, to succeed San Gabriel Electric Co. San Gabriel Electric Co., which may be considered the parent company of the

Pacific Light & Power system, was incorporated May 24, 1897, and was controlled by Messrs. W. G. Kerckhoff and A. C. Balch[12] until 1902, when the close alliance that had been formed between the power interests and the electric railways in and around Los Angeles made it necessary to increase the financial resources of the San Gabriel company.

The business of San Gabriel Electric Co. was taken over by Pacific Light & Power Co. April 1, 1902, and title to its properties on October 1, 1902. According to the most authentic information available, Pacific Light & Power Co., on its organization, was controlled by Los Angeles Railway, which owned $5,050,000, and W. G. Kerckhoff, who owned $4,870,000 (par value) out of the total of $10,000,000 authorized stock. Los Angeles Railway was in turn controlled by H. E. Huntington, who is reported to have owned 55 per cent, and Southern Pacific Co., 45 per cent of the total capital stock.

Soon after its incorporation, January 12, 1910, Pacific Light & Power Corporation acquired all of the properties belonging to its predecessor. The second preferred stock of the corporation was offered for the outstanding capital stock of Pacific Light & Power Co., and the transfer was completed by the exchange of the last 523 shares of stock in April and May, 1912.

In February, 1910, the corporation acquired the large undeveloped water-power sites of Mammoth Power Co. and John S. Eastwood on San Joaquin River and on Big Creek, one of its principal tributaries. The corporation floated its first and refunding mortgage bond issue in 1911 to finance the construction on the Big Creek hydroelectric system. (See pp. 638–655.)

The holdings of the Pacific Light & Power Corporation in the stocks of various companies, as listed in this first and refunding mortgage, November 20, 1911, were as follows, all companies subject to mortgage of Pacific Light & Power Co. of September 1, 1902.

TABLE 99.—*Stocks held by Pacific Light & Power Corporation Nov. 20, 1911.*

Company.	Capital shares.	Shares outstanding.	Owned by Pacific Light & Power Co.	Per cent owned by Pacific Light & Power Co.
Pacific Light & Power Co	100,000	100,000	99,192	99.19
Southern California Gas Co	100,000	60,000	32,995	54.99
Kern River Co	100	100	94.8586	94.85
San Gabriel Electric Co	10,000	7,700	7,675	99.67
Mentone Power Co	3,000	3,000	3,000	100.00
Electric Power Co	10,000	5,100	2,500	49.01
Union Power Co	20,000	20,000	9,985	49.92
Ontario & San Antonio Heights Ry. Co	10,000	10,000	9,993	99.90

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[12] Mr. Kerckhoff was a capitalist and business man of Los Angeles. Mr. Balch had, in 1896, sold out his interest in the Union Power Co. of Portland and had moved to Los Angeles. His experience in the Union Power Co. (which generated power near the city limits of Portland in a steam plant fired with slabs from a sawmill) had convinced him of the success in store for the transmission of electric energy.

The branch railroad to Big Creek was begun in 1911, and the line was incorporated as San Joaquin & Eastern Railroad in 1912. It was of course under control of Pacific Light & Power Corporation from the outset.

Los Angeles Railway and its successor, Los Angeles Railway Corporation, continued in control of Pacific Light & Power Corporation up to 1912, when as a result of a readjustment of railway properties in Los Angeles, Pacific Electric Co. retired from operation of any of the city lines, and Los Angeles Railway Corporation, with certain exceptions, agreed to confine itself entirely to the city. Previous to this readjustment Mr. Huntington had increased his holdings in Los Angeles Railway Corporation to include all except directors' shares. In 1912 Mr. Huntington also acquired all but the directors' qualifying shares of Pacific Light & Power Corporation.

In 1913 officers of the Pacific Light & Power Corporation acquired control of Ventura County Power Co., and in 1916 this control was formally transferred to the corporation. In 1916 the corporation also acquired control of Mount Whitney Power & Electric Co. (See pp. 554–557.) The manner in which the Pacific Light & Power Corporation was merged with Southern California Edison Co. is described on pages 530–531.

SAN GABRIEL ELECTRIC CO. AND ITS ACQUIRED PROPERTIES.

Original developments.—Southern California Power Co.'s Santa Ana River plant No. 1 and San Gabriel Electric Co.'s Azusa plant were the first two hydroelectric stations in southern California to be constructed on a modern commercial basis. Their backers were not haunted by the uncertainty that had confronted the organizers of the San Antonio Light & Power Co. and the Redlands Electric Light & Power Co., with whom hydroelectric transmission was entirely an experiment whose failure might prove both costly and humiliating.

San Gabriel Electric Co. was organized in 1897 by Messrs. W. G. Kerckhoff and A. C. Balch. The newly organized company, with Mr. Balch as general manager and chief engineer, Mr. G. O. Newman in charge of hydraulic development, and Mr. R. S. Masson, electrical engineer of the Pacific Coast division of the Westinghouse Co., cooperating on the electrical installation, proceeded at once with the construction of the Azusa plant (named from the town of Azusa near which it is situated), a transmission line (23 miles long) to Los Angeles, and a steam and substation in that city. The station began to transmit power to Los Angeles June 30, 1898, and has been in operation ever since. The power house contained originally four 2-phase 50-cycle 300-kilovolt-ampere machines (later increased to five machines) and three 7½-kilowatt exciters. The power generated was stepped up from 500 to 16,500 volts by four 250-kilowatts, 400/15,000-volt transformers. The two 3-phase No. 5 copper circuits were carried on a single line of 40-foot Oregon pine poles for most of the distance and on 50-foot poles in the city, with average spans of 125 feet. The wires were spaced 24 inches in an equilateral triangle, with 5½-inch Locke glass insulators, and were transposed at 7¾ miles from the plant and again at the same distance from the substation. The present equipment of the Azusa plant is described on pages 616–620. Substation equipment for stepping down the voltage consisted of two 125-kilowatt and two 150-kilowatt 16,500/2,400-volt transformers, four 125-kilowatt 16,500/218-volt transformers, and two 125-kilowatt 16,500/360 and 460-volt transformers.

After the voltage had been reduced part of the current was delivered to rotary converters of the following capacities and potentials: One 250-kilowatt 360 and 460 alternating current to 500 direct current, two 225-kilowatt 218 alternating current to 220 or 320 direct current, and one 400-kilowatt 218 alternating current to 220 or 320 direct current.

The plant distributed (*a*) 1-phase 2-400-volt current for residences and outlying districts, (*b*) 2-phase 2,400-volt power circuit for motors, (*c*) 500-volt direct-current service for power, and (*d*) 220-volt 3-wire direct-current service for lighting.

The rectified current was distributed throughout the city by an underground system laid in creosoted lumber ducts

The steam auxiliary and its boiler plant occupied two rooms in the substation, a brick building 85 by 125 feet in plan, on the east side of Los Angeles Street near Third Street. The third room was occupied by the transformer and switching equipment. In addition to serving as a steam-electric generating and transformer station, the Third Street building was executive center for the operating department of the entire system.

The steam-electric equipment of the plant was small and when it was shut down in April, 1914, there were but two units in operation; a third was out of commission. Unit No. 3 was a Bullock 2-phase 50-cycle 1,500-kilowatt 2,400-volt 313-ampere alternator, designed for 120 revolutions per minute; unit No. 2 was a Westinghouse 2-phase 50-cycle 750-kilowatt 2,400-volt 157-ampere alternator, operating at 125 revolutions; both units were driven by McIntosh-Seymour cross-compound engines supplied with steam from eight boilers rated at 3,000 horsepower. Excitation was furnished by two continuous-current generators, each driven by a McIntosh-Seymour tandem compound horizontal engine; exciter unit No. 1 was a Bullock 110–120-volt 625-ampere continuous-current generator, operated at 275 revolutions per minute; exciter No. 2 was a Northern Electric 125-volt 480-ampere machine operated at 250 revolutions per minute

The discarded steam unit was a 300-kilowatt Westinghouse 2-phase 50-cycle 2,400-volt alternator rope driven by a 500-horsepower Corliss engine. The 7½-kilowatt 110-volt exciter was belt driven at 1,300 revolutions from the generator shaft. The boilers serving it were of the water-tube type with an aggregate capacity of 500 horsepower.

The chief addition to the generating system during the life of San Gabriel Electric Co. was Sierra Power Co., organized by the bond and stock holders of San Antonio Light & Power Co. in 1899. (See pp. 545–546.) When the Sierra plant, with a capacity of 600 kilovolt-amperes, was added to the 1,500 kilovolt-amperes in the Azusa plant, it gave a total of 2,100 kilovolt-amperes installed hydroelectric generating capacity for the entire system, in addition to the steam power in the company's Los Angeles station.

The system was again reinforced when it was connected to the generating system of the Los Angeles Railway. It was this connection which in a few years proved to be of greatest importance in the affairs of the company, leading to the reorganization of San Gabriel Electric Co. as Pacific Light & Power Co., largely as a generating system for the electric railways in and around Los Angeles.

San Antonio Light & Power Co.—The plant constructed by San Antonio Light & Power Co.—the Pomona plant—is of great interest historically, owing to the fact that it was the first hydroelectric installation for high-voltage transmission built in California.

The project was begun largely through chance. In 1890 Dr. C. G. Baldwin was made president of Pomona College, a small institution supported by the Congregational Church. Shortly after his arrival he was asked to join the town board of trade, but thinking the invitation a joke he gave it no serious consideration. The proposal was renewed, however, and he was told that if he would start any undertaking which he considered to be in the interest of the community he could count on cordial support. Still considering the proposal a jest, he said he had heard that there was water power in one of the neighboring canyons and that it might be possible to utilize it for lighting the town. His suggestion was accepted, and he was made chairman of a water-power committee. He had no training in engineering subjects and only a general knowledge of the little that had been accomplished in the way of electric transmission.

While he was still wondering what the water-power committee would do, he happened to read of a small direct-current transmission line 4 miles long, which was supplying the town of Ventura. He immediately went to Ventura and sought the president of the power company, who took him out to the plant and gave him full information as to the methods used, the success attained, and the financial questions involved.

With this information Dr. Baldwin returned to Pomona, drove out to San Antonio Canyon, and posted a water filing on what he thought was Government land; but a survey showed that his filing had been posted on lands belonging to Pomona Water & Irrigation Co. After trying in vain to get the officers of the company interested in the scheme, he purchased the land for $25,000 and proceeded to organize a company. He found this an arduous undertaking and would probably have been unsuccessful had not the promoters been able to convince Mr. Thomas Bard of the feasibility of the scheme and enlist his support and business prestige in the project. In the meantime Mr. Almerian Decker had been engaged to draw up the plans and specifications for the machinery. His designs called for single-phase alternating-current generators and for transformers connected in series to step the generator voltage of 1,000 up to a line potential of 10,000 volts.

With Mr. Decker's specifications in hand, Dr. Baldwin proceeded to Pittsburgh and placed the papers in the hands of the Westinghouse Electric Manufacturing Co., but after a short review of the scheme the engineers of the company declared the plans impracticable and refused to have anything to do with the manufacture of the machinery.

Thoroughly disheartened, Dr. Baldwin returned the papers to his trunk, gave up the power project, and proceeded to a missionary conference at Pittsfield, Mass. When leaving a meeting on the first evening, his attention was attracted by the brilliant illumination of the town. On inquiry he found that the success of the system was largely due to the efforts of a Mr. Stanley, who was at that time conducting a laboratory in Pittsfield and testing various forms of electrical machinery.

The next morning plans and specifications for the Pomona development were placed before Mr. Stanley, who, after a short examination, pronounced them entirely feasible and agreed to manufacture the machinery himself—although not in the commercial manufacturing business—if the Thomson-Houston or Westinghouse Electric Manufacturing Co. could not be induced to undertake it.

With this assurance, Dr. Baldwin visited the officers of the Thomson-Houston Manufacturing Co. and revisited the Westinghouse Co., receiving favorable consideration from both firms. The contract was finally let to the Westinghouse Co., which not only guaranteed the performance of the generating machinery but of a form of single-phase motor which was about to be put on the market. The generators were successful from the start, but the motors were not and were later replaced with another form.

Energy for commercial lighting was transmitted from the plant to Pomona November 28, 1892, and to San Bernardino December 31 of the same year. The line potential used at first was 5,000 volts, but on February 16, 1893, the potential was raised to 10,000 volts. Water was diverted from San Antonio Creek by a very simple dam into a pipe line 2,370 feet long. A short distance below the dam this pipe entered a tunnel 1,300 feet long, which cut across a loop in the stream. At the lower end of the tunnel the main drop in the pressure line began. The total head developed from water surface at the intake to nozzle at the power house was 412 feet. The pipe varied in diameter from 30 to 24 inches and in thickness of plate from No. 12 to No. 6. At the power house the line passed through a 24-inch gate valve into a receiver 20 feet long and 42 inches in inside diameter. When the generating capacity of the power house was increased the length of this receiver was increased to 48 feet.

The power house was a wooden-roofed concrete building 66 feet long by 30 feet wide. The first machine was a 120-kilovolt-ampere 1,000-volt 12-pole single-phase 60-cycle alternating-current generator with a speed of 600 revolutions per minute, direct-connected to a pair of 34-inch Pelton wheels. The exciter was a 90-ampere 125-volt type I dynamo driven by two 14-inch Pelton wheels. By connecting the primaries of the transformers across the generator poles the voltage was reduced to 500, which was stepped up to 10,000 by connecting the secondaries of the twenty 60-kilowatt transformers in series.

Power was transmitted over two single-phase circuits of No. 7 hard-drawn copper wire to a point about 8 miles from the generating station, where the lines diverged, one circuit going southward to Pomona and another turning eastward to San Bernardino. The total length of the circuit from the power house to Pomona was 13¾ miles and the length of that from the power house to San Bernardino 28¾ miles. Double-petticoat glass insulators 6 and 3½ inches in diameter were used and the line was supported on square redwood poles 25 feet long, 9 inches square at the butt and 6 inches square at the top, set 125 feet apart. The transmission loss was computed to be 5 per cent to Pomona and 10 per cent to San Bernardino. At Pomona 19 transformers and at San Bernardino 18 transformers were installed to step the potential down to 1,000 volts for local distribution. These transformers were similar to those at the power house. A test of the electrical part of the generating system gave an efficiency of 73.3 per cent.

In 1893 the capacity of the station was doubled by the addition of a second unit, and in 1894 it was again doubled by duplicating the two units already installed. At first the current was used entirely for lighting but later was used also to supply power.

Sierra Power Co.—San Antonio Light & Power Co. would probably have been successful in its undertaking had it not encountered the same trouble that from time to time has confronted all California water-power companies—the lack of water. The stream flow for 1898 and 1899 was the lowest then on record; the discharge of San Antonio Creek dwindled to about one-fourth of the flow that had been counted on, and the company was compelled to put in a steam plant at San Bernardino. The expenditure for this led to financial embarrassment and for some time the interest on the company's bonds was in default.

Late in 1899 negotiations for the sale of the property to San Gabriel Electric Co. were begun, and early in 1900 a contract was entered into between that company and Dr. Baldwin and other stock and bond holders in San Antonio Light & Power Co. Liabilities to the extent of 844 shares of stock and $75,000 par value in bonds were outstanding, and an expenditure of $35,000 was required to put the hydroelectric system in good operating condition. The San Gabriel Electric Co. agreed to purchase the hydroelectric plant and transmission system but not the steam station. In order to effect the transfer of property, Dr. Baldwin and other stockholders legally disincorporated San Antonio Light & Power Co., brought joint action of the bondholders to form a new corporation—Sierra Power Co.—with a capital stock of $75,000, and sold to it all the corporate property of the defunct company. In this new company the bondholders of the old received stock pro rata, according to their original holdings. The new corporation then issued $35,000 in 3 per cent bonds, which San Gabriel Electric Co. guaranteed should be sold at par. The $35,000 thus obtained was spent in building the present Sierra plant. The price which San Gabriel Electric Co. was to pay for the system was $75,000 to extinguish the old bonded indebtedness represented by new stock and such additional sums up to the $35,000 represented by the new bonds as should be expended on improvements on the system.

The changes contemplated by this contract were made. The pipe line was extended, the Sierra power house built, and the old Pomona plant passed into history. Its life had been short and its size insignificant, but it had started a great economic change in California. Title to the Sierra power system was acquired by Pacific Light & Power Corporation March 10, 1914, and by the Southern California Edison Co. May 22, 1917.

PACIFIC LIGHT & POWER CO.

Corporate relations.—Pacific Light & Power Co., incorporated March 6, 1902, acquired the entire stock and properties of San Gabriel Electric Co. and began the operation of the system April 1, 1902. Closer relations with the electric railway systems in Los Angeles, which had made the financing of Pacific Light & Power Co.

possible, are well shown by the marked increase in sales of railway power. Such sales amounted to 1,130,118 kilowatt-hours for the year ending March 31, 1903, the first year of the new company, but rose to 2,795,960 kilowatt-hours in the year ending March 31, 1904, the second of Pacific Light & Power Co. Its active life extended from April 1, 1902, to February 10, 1910, in which period it purchased the properties or control of most of the minor companies that were included in the system when it was merged with Southern California Edison Co. Those acquired through stock control included Mentone Power Co., Kern River Co., San Bernardino Gas & Electric Co., Ontario & San Antonio Heights Railway Co.,[13] and Ontario Domestic Water Co.; it also acquired 50 per cent of the stock of Union Power Co. and 49.5 per cent of stock of Electric Power Co.

Properties purchased by the Pacific Light & Power Co. included Sierra Power Co., acquired on a contract agreement inherited from San Gabriel Electric Co. and the plant and transmission and distribution system of Riverside Power Co. in and near Riverside.

When Pacific Light & Power Co. was succeeded by the Pacific Light & Power Corporation in 1910, formed to provide funds for the construction of the Big Creek hydroelectric system, it was operating Borel, Azusa, Sierra, Mentone, Highgrove, and Riverside hydroelectric, and Redondo, Third Street, Central Avenue,[14] and Oilwells steam-electric plants. The transmission system was much the same as it is to-day except for Big Creek tower lines and lines running out of Eagle Rock substation. The Borel, Azusa, Sierra, and Mentone hydroelectric and Redondo steam-electric plants are described in detail on later pages; the others are of historic interest only.

Mentone Power Co.—Mentone Power Co. was incorporated on August 16, 1901, under the laws of California by A. C. Balch and W. G. Kerckhoff, and other officers of San Gabriel Electric Co.

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[13] Ontario & San Antonio Heights Railway Co. and Ontario Domestic Water Co., operated only in and in the vicinity of Ontario, Los Angeles County; the first was sold to the Pacific Electric Co. in 1911 and the latter to the city of Ontario in the same year.

[14] The Central Avenue steam plant of the Pacific Electric Ry. was operated under lease by Pacific Light & Power system from August, 1908, to January, 1914. The station was a brick building 140 by 200 feet in plan, near the Southern Pacific Ry. station, Los Angeles. The equipment included five units—three Bullock 3-phase 50-cycle 1,600-kilowatt generators driven at 120 revolutions per minute, two of them by McIntosh-Seymour cross-compound engines and one by a Nordburg cross-compound engine, and each delivering 394 amperes at 2,200 volts potential; two 1,500-kilowatt capacity Stanley induction generators, driven by McIntosh-Seymour cross-compound engines and delivering 3-phase 50-cycle alternating current at 2,300 volts when operating at 120 revolutions per minute. The station also contained a Westinghouse 1,050-kilowatt 550-volt direct-current machine driven by a McIntosh-Seymour cross-compound engine and delivering 1,010 amperes and operating at 120 revolutions per minute. Two Westinghouse 125-kilowatt 125-volt direct-current generators each operated by a Fitchburg marine engine at 220 revolutions per minute furnished excitation for the plant.

Besides acting as a steam-electric generating station, the Central Avenue plant was equipped with three motor generator sets with a 550–600 volt direct-current capacity aggregating 2,600 kilowatts. The total rated capacity of the 32 Babcock & Wilcox, Stirling, and Edgemoor boilers was 10,000 horsepower.

The station was equipped with three 500-kilowatt Stanley transformers connected closed delta for each alternating-current generating unit raising the voltage to 15,000 volts for transmission.

The main purpose of the new company was the acquisition of that portion of the Santa Ana irrigation canal lying above the mouth of Santa Ana Canyon for power development.

The Santa Ana canal was originally constructed to divert the natural flow and stored waters of Santa Ana River to a large tract of land in the vicinity of Perris and Alessandro. Early in its operations the irrigation company became involved in legal and financial difficulties, and the property went into the hands of receivers. Action was brought to foreclose liens on the canal, and after litigation lasting from 1893 to 1898 the property was finally sold by the sheriff on October 11, 1898, to Charles Weir, who later transferred it to Mentone Power Co. The Mentone (now Santa Ana River No. 3) plant began operation in September, 1904, and is described on pages 596–599.

During the years through which the Santa Ana canal rights were in litigation other applicants made filings and began developments on the stream. One of these—Mountain Power Co.—whose properties were later purchased by Edison Electric Co., filed applications with the Government for two rights of way on Santa Ana River, one now occupied by Santa Ana No. 2 plant of Southern California Edison Co. and the other immediately below it and parallel and immediately adjacent to the portion of the old Santa Ana irrigation canal purchased by Mentone Power Co. Mountain Power Co. drove a short section of tunnel near the intake on this lower right of way but later abandoned this part of its enterprise.

Stock control of Mentone Power Co. was acquired by Pacific Light & Power Co. on April 1, 1903, and its properties were finally absorbed, subject to mortgage of Mentone Power Co. November 27, 1911, by Pacific Light & Power Corporation, through which they came into possession of Southern California Edison Co.

Kern River Co.—The success of the Santa Ana plant No. 1 in 1898 convinced the people of southern California that long transmissions of electrical energy were perfectly feasible. Even before that date, however, the more daring water-power promoters had looked with longing eyes on the large potential powers available on Kern River, the most accessible of the Sierra streams.

One of the earliest companies to begin the investigation of transmission from the Kern to Los Angeles was "Kern River & Los Angeles Electric Power Co.," incorporated May 18, 1895. In 1896 the company published a very complete prospectus of plans that covered what is now the Borel development, with its transmission lines 108 miles long extending to Los Angeles. The potential originally proposed was 30,000 volts.

Kern River & Los Angeles Electric Power Co. was succeeded by Kern River Co., organized under the laws of Maine June 28, 1897, with a capitalization of $2,500,000.

Stock control of Kern River Co. was acquired by Pacific Light & Power Co., April 16, 1902. The Borel canal was begun on July 31, 1902, and completed April 5, 1904; the plant went into operation December 31, 1904. The plant was completed on funds advanced by Pacific Light & Power Co. on the strength of a contract for delivery of certain quantities of power at a fixed price to the electric railway systems in and around Los Angeles. Kern River Co. never issued any bonds. In 1908 its capital stock was reduced to $10,000, of which $9,486 was listed by Pacific Light & Power Corporation under its first and refunding mortgage November 20, 1911.

San Bernardino Gas & Electric Co.—Organized December 21, 1900, under the laws of California, with a capitalization of $200,000, for the purpose of conducting a general gas and electric business in and around the city of San Bernardino, San Bernardino Gas & Electric Co. succeeded an earlier company—San Bernardino Electric Co.—which had operated the small Highgrove plant and distribution system. During its corporate life San Bernardino Gas & Electric Co. acquired several small properties located in the region. The electric properties owned by it at the time it was absorbed by Pacific Light & Power Co. included the Highgrove hydroelectric plant and a small water-power plant and 150-kilowatt steam unit at Mill Street plant in San Bernardino. The annual reports show that the first power was delivered from Mill Street station to the Pacific Light & Power system in April, 1904, and that the station was listed as hydroelectric and steam-electric until February, 1906, after which it was listed as steam only. The last power was delivered from the station in December, 1906, and in 1910 it was finally written off the books of the company.

Highgrove plant, which was constructed by Messrs. Lloyd and Sinclair, used water diverted from Warm Springs Creek, a tributary of Santa Ana River, near Highgrove, Riverside County. The station was connected to the Pacific Light & Power system in April, 1904, and delivered its last power in March, 1915; the last important delivery of power from the plant was in December, 1914. Warm Springs Creek is a short stream that is fed by seepage and spring flow from the alluvial and débris cones on the south side of the San Bernardino Mountains—probably return water from irrigation systems supplied from canyons from City Creek westward to and including Lytle Creek. The Highgrove conduit is a cement-lined canal 4 miles long and 50 second-feet in capacity, heading a short distance above the junction of Warm Creek with the Santa Ana, following down the creek to the north bank of the river, crossing to the south bank by means of a wooden flume, and continuing along the south side of the river to a point half a mile from the town of Highgrove, where a drop of 50 feet is obtained through a 6-foot pressure pipe

200 feet long. The elevation of the forebay is 940 feet. The power house was a wooden structure containing a single General Electric 150-kilowatt 3-phase 50-cycle 2,200-volt alternator, operated by two Stillwell-Bierce 15-inch turbines, at a speed of 590 revolutions per minute; the turbines were belted to the generator. The current was stepped up from 2,200 to 15,000 volts by means of two 75-kilowatt Westinghouse transformers. The station tapped in on the 15,000-volt transmission line between the Riverside plant and San Bernardino substation.

San Bernardino Gas & Electric Co. was absorbed by Pacific Light & Power Co. April 1, 1903. In 1910 its gas properties were transferred to Southern California Gas Co. and its electric properties were taken over and thereafter operated by Pacific Light & Power Corporation, the San Bernardino Gas & Electric Co. passing out of existence during the year.

Electric Power Co.—Electric Power Co. was incorporated September 19, 1892, with capitalization of $1,000,000, for the purpose of developing water power on San Gabriel River above the Azusa plant. San Gabriel Electric Co. acquired 49½ per cent of the Electric Power Co.'s capital stock, and this minority interest was transferred to Pacific Light & Power Co. and by it in turn to Pacific Light & Power Corporation. Although Pacific Light & Power Co. expended considerable money in construction on the proposed system of Electric Power Co., no plants were ever completed, and in 1913 Pacific Light & Power Corporation decided to forfeit such expenditure as it had made rather than continue with a development which, under modern conditions of transmission, promised to be unprofitable.

Riverside Power Co.—Riverside Power Co. was incorporated under the laws of California April 10, 1901, with a capitalization of $250,000. Soon after its organization the company, which was formed by local capitalists residing in Riverside and its immediate vicinity, acquired the right to use a fall on the Narrow's canal, which diverts from Santa Ana River in vicinity of Riverside. It completed the Riverside plant in 1904, and served an isolated transmission and distribution system in and around Riverside. The venture proved unsuccessful, and the system went into the hands of a receiver, from whom it was purchased by Pacific Light & Power Co. in 1906, though final title to the properties was not acquired until November 27, 1911. The first delivery of power from the plant to Pacific Light & Power system was reported in June, 1906, and the headworks were wrecked by floods in January, 1914.

The intake of Narrow's canal is in the NE. ¼ sec. 29, T. 2 S., R. 5 W., near the Los Angeles & Salt Lake Railroad bridge at Riverside. A small diversion dam, constructed of tongue-and-groove sheet piling driven in the river bed, turns the water into the canal, which follows along the south side of the river almost due west through sec. 30 of the same township and secs. 25, 36, 26–28, 33, and 32, T. 2 S., R. 6 W., to the power house. The canal is 10 feet wide on bottom, 14 wide on the surface, and about 5 feet deep. Its capacity is 100 second-feet. It is about 6 miles long and includes in its lower part two short tunnels, one about 450 feet and the other about 500 feet long. It ends in a small forebay from which two 60-inch wood-stave pipes 140 feet long lead to the upper end of the main pressure drop, where they are connected with two 36-inch lap-riveted steel-pressure pipes. The elevation at the forebay is 600 feet above sea level and that at the power house 514 feet, so that the static head is 86 feet. The concrete iron-roofed power house 60 feet long by 30 feet wide was built on the edge of Santa Ana River, so that the discharge was directly into the stream, and contained two 300-kilovolt-ampere units, each unit operated by a single 22-inch horizontal Victor turbine incased in a steel scroll and running at 500 revolutions per minute. The wheels were rated at 500 horsepower each and controlled by Lombard governors, type D. Each turbine was directly connected to a General Electric 300-kilovolt-ampere revolving-field 3-phase 50-cycle 10,500-volt generator. The two exciters were General Electric 17-kilowatt 136-ampere 125-volt machines operating at 750 revolutions per minute, and could be driven either by their separate water wheels or by an induction motor. Three 200-kilowatt 3-phase water-cooled Stanley transformers raised the potential from 10,500 to 15,000 volts for transmission. The three outgoing circuits ran to Riverside, to Corona, and to the 15,000-volt main line extending westward from the Mentone plant, tying in on this line near Ontario.

Mammoth Power Co.—The Mammoth Power Co. was a nonoperating corporation, formed to develop certain power sites on San Joaquin River. These, as well as other sites on Big Creek, held by John S. Eastwood, chief engineer of the Mammoth Power Co., were purchased by Pacific Light & Power Corporation February 10, 1910, and were combined in a project now partly completed by the construction of Huntington Lake reservoir and Big Creek plants Nos. 1, 2, and 8. (See pp. 638–655.)

San Joaquin & Eastern Railroad Co.—When Pacific Light & Power Corporation undertook its extensive developments on Big Creek, tributary to San Joaquin River, it became necessary to transport large quantities of machinery and supplies some 50 miles from what was then the nearest point on the railroad. The transportation difficulties were complicated by the fact that there was a rise of about 4,000 feet between the railroad station and the proposed site of Big Creek No. 1 power house. It was therefore decided that it would be more economical to build a railroad to the plants from El Prado, on the Fresno-Friant branch of the Southern Pacific, than to attempt to haul materials in by other means.

Construction of this line was begun in 1911, and San Joaquin & Eastern Railroad Co. was incorporated March 16, 1912, to complete and operate the road. The company operates as a common carrier.

Southern California Gas Co.—Southern California Gas Co. was incorporated October 5, 1910, with a capitalization of $6,000,000 common and $4,000,000 preferred stock, by Pacific Light & Power Corporation, to take over such gas properties as that system owned already or was about to acquire.

Among the earliest gas properties acquired by Pacific Light & Power Co. were those in and around San Bernardino which had been purchased as part of San Bernardino Gas & Electric Co. system in 1903. In 1907 Pacific Light & Power Co. acquired Domestic Gas Co. of Los Angeles, which had been incorporated in February of the same year with a capitalization of $10,000,000. In 1908 Domestic Gas Co. purchased 7,900 shares of stock and the properties of City Gas Co. of Los Angeles, which had also been incorporated in February, 1907, with an authorized capitalization of $1,000,000. For the stock and properties of City Gas Co., Domestic Gas Co. gave $1,350,000 in bonds of Pacific Light & Power Co., which were to be redeemed by an issue of $1,500,000 bonds of the Domestic Gas Co.

In the east end of the Pacific Light & Power system, San Bernardino Gas Co., incorporated May 4, 1909, with $1,500,000 authorized capital stock, absorbed Home Gas Co. of San Bernardino, Redlands Gas Co., Colton Gas Co., and certain other properties. These holdings, including the gas properties of San Bernardino Gas & Electric Co., which had been incorporated December 21, 1900, under the laws of California, with a capital stock of $200,000, and had been absorbed by Pacific Light & Power Co. April 1, 1903, were transferred to Southern California Gas Co., in 1910. Later Southern California Gas Co. acquired Riverside Light & Fuel Co. from Southern California Edison Co., and also several other small systems.

Central gas-generating stations were constructed in Los Angeles and Colton, and from these and natural gas the company supplied its distribution systems. It also wholesaled gas to Long Beach Consolidated Gas Co. and to the distribution systems in Santa Monica, Venice, and Sawtell, owned by Southern California Edison Co.

Southern California Gas Co. was financed at the outset by the proceeds resulting from the sale of the 5-year collateral trust bonds of Pacific Light & Power Corporation dated July 1, 1910. These collateral bonds were secured by the deposit of $4,000,000[15] of Southern California Gas Co.'s first mortgage bonds, dated November 1, 1910.

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[15] The total amount which might eventually be issued under this mortgage was $10,000,000, but the authorized amount was limited to $4,000,000 so long as any Pacific Light & Power bonds were outstanding.

Stock control of Southern California Gas Co. was retained by Pacific Light & Power Corporation until 1912 when it was sold.

Miscellaneous companies and properties.—Among the minor companies whose stock or properties were from time to time acquired by Pacific Light & Power system are the following:

Portions of the system of Corona Gas & Electric Co., in Corona, purchased March 30, 1911.

The distribution system of Glendale Light & Power Co. in the town of Tropico, purchased on November 27, 1912, for $5,200, the Glendale Light & Power Co. having previously sold its Glendale distribution system to the city of Glendale.

The distribution system of Eagle Rock Water Co. in Eagle Rock and the portion in Los Angeles or its immediate vicinity, purchased December 16, 1912, for the sum of $22,500, which represented a reasonable price for the physical properties as they then stood.

The electrical distribution system of Glendora Light & Power Co., in and immediately about Glendora, Los Angeles County, purchased January 15, 1914, for $10,500, which represented the estimated price of the properties as they then stood.

An electrical distribution system in and near San Fernando, Los Angeles County, purchased from John T. Wilson January 23, 1914, for $16,000, a price that represented the cost of properties less accrued depreciation. Up to the time the properties were purchased from Mr. Wilson he had secured his power from San Fernando Mission Land Co.

The electric distribution system of San Fernando Mission Land Co. in and near the city of San Fernando, purchased January 23, 1914, for $7,835.15, which represented the cost of the properties less accrued depreciation.

The electric distribution system belonging to Consolidated Utilities Co. in the town of Compton, Los Angeles County, purchased February 10, 1914, for $8,500, which represented the cost of the properties less accrued depreciation. Consolidated Utilities Co. had previous to that date purchased all its power from Pacific Light & Power Corporation.

The electric distribution system of Huntington Beach Co. in and adjacent to the city of Huntington Beach, purchased March 23, 1914, for $16,500, which was the agreed price of the property as it then stood.

That part of the electric distribution system of Southern California Edison Co. in San Fernando, Los Angeles County, was purchased July 16, 1914, for $9,488. This figure represented the price of $9,000, at which the Southern California Edison Co. had purchased the properties from the Maclay Rancho Co., plus $448 expended in addition and betterments. At the time of purchase Pacific Light & Power Corporation was serving about 85 per cent and Southern

California Edison Co. about 15 per cent of the consumers in San Fernando.

In addition to the properties actually purchased or controlled, the Pacific Light & Power Corporation owned, as of December 31, 1916, either stock or bonds of Lytle Creek Power Co., Bear Valley Water Co., Ocean View Land & Water Co., and Newport Land Co.

HISTORY OF VENTURA COUNTY POWER CO.

Ventura County Power Co. was organized in 1906 to acquire and consolidate the small local systems that had theretofore been operated by Ventura Water, Light & Power Co., Oxnard Light & Water Co., and Santa Paula Electric Co. The system operated by the company was confined almost exclusively to the valley of Santa Clara River below Castaic and to the low alluvial plain along the coast south of the mouth of the river.

In 1906 the company constructed a steam plant near the Southern Pacific Railroad station in Oxnard and completed a transmission line connecting the system with Castaic substation on the Kern River lines of Southern California Edison Co., part of the system's power supply being generated at the steam plant and part purchased from Southern California Edison Co. In 1913 stock control of Ventura County Power Co. was purchased by Mr. H. E. Huntington, who also controlled Pacific Light & Power Corporation, and October, 1915, connection was established at Saticoy with a line which the Pacific Light & Power Corporation had built westward from San Fernando Valley. The manner in which the Ventura company was merged with Southern California Edison Co. is described on page 531.

UNION POWER CO.

Union Power Co. was incorporated February 20, 1904, by Pacific Light & Power Co. and Edison Electric Co. of Los Angeles. The former acquired 49.9 per cent and the latter 50.1 per cent of the stock of the new company. The properties of Union Power Co. consist of an undeveloped power site on Santa Ana River and Bear Creek above the intake of Santa Ana No. 1 plant of Southern California Edison Co. The outstanding stock of Union Power Co. owned by Pacific Light & Power Corporation came into possession of Southern California Edison Co. when the corporations were merged in 1917. Considerable work was done on the tunnels of the proposed developments, but they were finally abandoned.

HISTORY OF MOUNT WHITNEY POWER & ELECTRIC CO.

Mount Whitney Power & Electric Co., incorporated November 8, 1909, is the direct successor of Mount Whitney Power Co., incorporated December 26, 1899, which in turn succeeded to properties that were owned in partnership by Messrs. W. H. Hammond and A. G. Wishon and that included water rights and rights of way on Kaweah River; the 1,350-kilovolt-ampere hydroelectric plant, known as Kaweah No. 1, which was begun in 1898 and had been placed in commission in June, 1899; and a transmission line to substations at Visalia, Exeter, Lindsay, Tulare, and Porterville that had been constructed with $200,000 advanced by John Hays Hammond and Leopold Hirsch of London.

On January 23, 1899, the Hammond and Wishon interests had acquired the distribution system of the Visalia Gas, Light & Heat Co. in Visalia, for which they paid $24,000 and had constructed distribution systems in Lindsay and Porterville. In the fall of 1902 the company also acquired the lighting system in Porterville belonging to the Porterville Light & Power Co., which had, up to that time, conducted a local business from a steam generating station. At Tulare power was sold on wholesale contract to a local distribution company until 1909, when Mount Whitney Power Co. purchased the system of Tulare Gas & Light Co. for $7,000. The authorized capital stock of Mount Whitney Power Co. was $300,000, of which $250,000 par value was issued.

Construction of the Kaweah No. 2 plant was begun by the company in 1904, and the plant was put into operation in February, 1905; its capacity was 1,500 kilovolt-amperes. A small steam plant also was constructed in Visalia in 1905 and 1906.

In 1904 the company purchased for $6,861.70 the stock of Globe Light & Power Co., which had been incorporated in 1902 by San Jose interests and had acquired water rights and rights of way on Tule River. The construction of what was later the Tule River plant of Mount Whitney Power & Electric Co. was begun under the name of the Globe Light & Power Co. in 1908, and the plant was completed and put into operation in September, 1909. On November 8 of that year the properties of Globe Light & Power Co. were deeded to Mount Whitney Power Co. and on same date were deeded with all other properties from Mount Whitney Power Co. to Mount Whitney Power & Electric Co., which was incorporated to accomplish more extensive financing. In May, 1913, as a result of such financing, the company had completed Kaweah plant No. 3, with a capacity of 3,500 kilovolt-amperes, and enlarged the capacity of the Visalia steam station from 937 to 6,937 kilovolt-amperes. It had also extended its transmission distribution lines so as to cover its territory more thoroughly and had done some preliminary work on Kaweah plant No. 5 and a storage reservoir on Wolverton Creek, a tributary of Marble Fork of Kaweah River.

Up to 1912 the Mount Whitney Power & Electric Co. was not subject to competition of other companies except at the extreme northern end of its system, where its territory bordered that served by San Joaquin Light & Power Corporation. In 1912, however, Tulare County Power Co. entered the field as an active competitor.

Tulare County Power Co. was incorporated under the laws of California June 10, 1910, with an authorized capitalization of $1,000,000, which was originally divided into 2,500 shares of 7 per cent cumulative preferred stock of par value of $100 and 7,500 shares of common stock. By an amendment of its articles of incorporation on July 31, 1911, 5,500 shares of the common stock were designated as "Consumer's common stock" which the company proposed to sell to prospective power users; the purchaser of one share of "Consumer's common stock" was, according to this plan, to receive the right to one horsepower of electric energy at the actual cost of production (originally estimated at $36 but later raised to $42).

Between November 7, 1911, and March 22, 1912, Tulare County Power Co. procured franchises for the transmission and distribution of power in Tulare County, and in the cities of Lindsay, Tulare, and Exeter, all of which were for the term of 50 years and all of which provided for the usual payment of 2 per cent of the gross receipts under the law.

The company planned upon its formation to construct a hydroelectric plant on Tule River below the Tule River plant of the Mount Whitney Power & Electric Co., and also a steam-electric generating station of 1,500 kilovolt-amperes capacity in Tulare. The construction of the latter was completed and the delivery of power began on April 17, 1912. Owing to financial difficulties in which the company became involved almost from the day it began operations, the hydroelectric plant on Tule River was never completed. Such power as the company did not generate at the Tulare steam plant, it purchased from San Joaquin Light & Power Corporation through Strathmore substation. The financial difficulties, due largely to lack of provision for long-time financing and to the unsatisfactory terms of the contract which it entered into with San Joaquin Light & Power Corporation, finally forced the sale of the properties to the Mount Whitney Power & Electric Co. Under the terms of the agreement dated June 30, 1915, the latter company agreed to pay to the Tulare company or its creditors the sum of $550,000 for the generating, transmission, and distribution system, on which it was claimed the sum of $475,283.63 had been expended for physical properties and $119,395.03 in developing the business.

The properties of all the foregoing systems were merged with that operated by Mount Whitney Power & Electric Co. From the date of its incorporation until 1914 Mount Whitney Power & Electric

Co. was an independent operating corporation controlled through stock ownership by John Hays Hammond. In October, 1914, however, Mount Whitney Power & Electric Corporation was organized under the laws of New York and control of Mount Whitney Power & Electric Co. was transferred to it by Mr. Hammond, who acquired in return the entire capital stock except directors' qualifying shares of the new holding company. The assets of the holding company consisted only of cash and of the stock of Mount Whitney Power & Electric Co. Stock control of the Mount Whitney Corporation (of New York) was acquired by Southern California Edison Co. May 22, 1917.

On June 14, 1920, Mount Whitney Power & Electric Co. was granted permission by the California Railroad Commission to sell all its properties to Southern California Edison Co. Proceedings in the case showed that all the preferred stock of Mount Whitney Power & Electric Co. then outstanding and all the common stock except the shares necessary to qualify directors were owned by Mount Whitney Power & Electric Corporation; and the entire outstanding stock of Mount Whitney Power & Electric Corporation was owned by Southern California Edison Co. The properties were transferred by deed to Southern California Edison Co. June 15, 1920, and the systems were combined for operation July 1, 1920.

PROPERTIES CONTROLLED THROUGH STOCK OWNERSHIP.

Santa Barbara Gas & Electric Co.[15a]—Santa Barbara Gas & Electric Co. is controlled by Southern California Edison Co. through ownership of 4,000 shares of preferred and 3,374 shares of its common stock (Dec. 31, 1918). The company was formed in 1910 to acquire the gas and electric properties owned by Southern California Edison Co. in Santa Barbara together with the properties owned by the Merchants Mutual Light & Power Co. of the same place. There was no connection between the transmission systems of the Santa Barbara Gas & Electric Co. and Southern California Edison Co. until January, 1918, Santa Barbara being served with electricity entirely from the isolated steam-electric plant in Santa Barbara. The entire operating revenues of the company are derived from the gas and electric operations in and around Santa Barbara.

Santa Barbara steam-electric plant operated one 220, three 300, and one 1,000 kilovolt-ampere generators, giving a total plant capacity of 2,120 kilovolt-amperes. In 1914 the power generated amounted to 3,671,215 kilowatt-hours, in 1915 to 4,470,318, in 1916 to 5,040,004, in 1917 to 5,906,596, in 1918 to 3,866,000 kilowatt-hours in addition to 4,190,000 received from the Edison Co. over the new tie line, in 1919 to 809,688 generated and 7,835,877 received

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[15a] Properties finally sold to Southern California Edison Co. by permission of California Railroad Commission dated November 17, 1922.

from the Edison Co., and in 1920 to 815,628 generated and 9,615,573 received from the Edison Co.

The Santa Barbara distribution system is served from the steam plant and a 3,000 kilowatt substation aside from which the company operated only four substations of 450 kilowatt capacity at Montecito, 300 kilowatts at Summerland, 150 kilowatts at Goleta, and 200 kilowatts at Carpinteria. The company owns 18.9 miles of transmission line and 370 miles of primary and 220 miles of secondary overhead-distribution line.

Santa Barbara & Suburban Railway Co.—Santa Barbara & Suburban Railway Co., controlled by Southern California Edison Co. through ownership (Dec. 31, 1920) of its $500,000 capital stock, now owns all the railway properties in the Santa Barbara district, having acquired a franchise and constructed an entirely new road in place of that operated by Santa Barbara Consolidated Railroad Co., whose franchise had expired and whose road was abandoned. Through its purchase of United Electric Gas & Power Co. in 1903 The Edison Electric Co. of Los Angeles acquired stock control of Santa Barbara Consolidated Railway Co., which had been incorporated in 1901 and which had upon its incorporation acquired the properties of Citizen's Railway Co. and Santa Barbara Street Railroad Co., both incorporated in 1887. As the roads of these early companies were intended for the operation of horse cars and were very lightly built, they went to pieces rapidly when electric operation was installed. The resulting poor service and other causes rendered the system financially unsuccessful, and the payment of interest on the bonds was finally discontinued. When the franchise expired local capitalists at Santa Barbara, believing that a well-equipped railway system was necessary for the prosperity of the town, organized Santa Barbara & Suburban Railway Co., just before the passage of the public-utilities act, and issued all its capital stock to R. H. Gaud, secretary of the organization committee. The company then authorized two bond issues—one of $500,000, dated March 15, 1912, due March 15, 1937; the other of $163,000, dated March 15, 1912, due March 15, 1942. The first of these issues was to be sold for cash to provide for future equipment; the last was to be issued to holders of the bonds of Santa Barbara Consolidated Electric Co. and Santa Barbara Consolidated Railway Co., in exchange for their old bonds. Southern California Edison Co. guaranteed the interest on the bond issue of $163,000 for five years and acquired the total outstanding capital stock of the railway company with the exception of directors' qualifying shares.

Mount Whitney Power & Electric Co.—Stock control of the Mount Whitney Power & Electric Corporation, which controls the operating concern, Mount Whitney Power & Electric Co., was acquired by Southern California Edison Co. with the other properties and franchises of the Pacific Light & Power Corporation May 22, 1917. The history of the Mount Whitney system is related on pages 554–557.

PROPERTIES SOLD.

In accordance with its general policy of discontinuing the gas business, Southern California Edison Co. has now sold all the gas properties of many of the companies which it acquired from The Edison Electric Co. Among the properties sold may be mentioned the following:

Colton Gas property to Seth Hartley November 1, 1907.

Redlands Gas properties to Home Gas Co. in Redlands in exchange for its electrical properties in 1909.

Riverside Light & Fuel Co. to Southern California Gas Co. in January, 1911.

Whittier Gas properties to Southern Counties Gas Co. in 1911.

Monrovia Gas properties to Piedmont Gas Co. in 1910.

The gas and electric properties in Santa Barbara acquired from United Electric Gas & Power Co. were sold in 1909 to Santa Barbara Gas & Electric Co., which at the same time acquired Merchants Mutual Light & Power Co. In 1918 Santa Barbara Gas & Electric Co. transferred the gas properties to Southern Counties Gas Co.

Gas properties in Long Beach were sold to Long Beach Consolidated Gas Co., which at the same time acquired Long Beach Inner Harbor Gas Co., a combination of Inner Harbor Gas Co. and Long Beach Gas Co. The operations of the Long Beach company were confined exclusively to the production and distribution of gas in Long Beach and wholesale delivery of gas to Southern California Edison Co. for distribution on its San Pedro and Wilmington distribution systems. The system of the Long Beach Co. proper began with 80 miles of main line and less than 8,000 consumers in 1910 and grew to 155 miles of main line and 12,867 consumers in 1915. In 1916 all these properties were sold to Southern Counties Gas Co.

MARKET.

AREA AND POPULATION.

At the end of 1920 Southern California Edison Co. was delivering power in ten counties shown in Table 100. The physical characteristics and population of these counties are given on pages 448–453.

TABLE 100.—*Area and population of counties supplied by Southern California Edison Co.*

County.	Area.	Population.			
		1890	1900	1910	1920
	Square miles.				
Fresno	5,950		37,866	75,657	128,779
Kern [a]	8,003	9,808	16,480	37,715	54,843
Kings	1,159		9,872	16,230	22,031
Los Angeles	4,067	101,454	170,298	504,131	936,455
Orange	780			34,436	61,375
Riverside	7,240		17,897	34,696	50,297
San Bernardino	20,157	25,497	27,929	56,706	73,401
Santa Barbara [b]	2,740	15,754	18,934	27,738	41,097
Tulare	4,856		18,325	35,440	59,031
Ventura	1,878	10,071	14,367	18,347	28,724
	56,845		351,668	841,096	1,456,018

[a] In Kern County the company delivers to several small mines in the vicinity of Borel and makes wholesale deliveries to San Joaquin Light & Power Co.

[b] The city of Santa Barbara and vicinity are served by Southern California Edison Co. through Santa Barbara Electric Co. The north end of the county is reached by the lines of the Midland Counties Public Service Corporation, served by San Joaquin Light & Power Corporation.

The incorporated and unincorporated places on the system are as follows:

TABLE 101.—*Incorporated communities served by Southern California Edison Co.*

City or town.	County.	Population.			
		1890	1900	1910	1920
Alhambra	Los Angeles			5,021	9,096
Anaheim	Orange			2,628	5,526
Arcadia	Los Angeles			696	2,239
Azusa	do		863	1,477	2,460
Beaumont	Riverside				857
Beverly Hills	Los Angeles				674
Brea	Orange				1,037
Burbank	Los Angeles				2,913
Chino	San Bernardino			1,444	2,132
Claremont	Los Angeles			1,114	1,728
Colton	San Bernardino	1,315	1,285	3,980	4,282
Compton	Los Angeles			922	1,478
Corona	Riverside		1,434	3,540	4,129
Covina	Los Angeles			1,652	1,999
Culver City	do				503
Delano	Kern				805
Eagle Rock	Los Angeles				2,256
El Monte	do				1,283
El Segundo	do				1,563
Exeter	Tulare				1,852
Fillmore	Ventura				1,597
Fullerton	Orange			1,725	4,415
Glendale	Los Angeles			2,746	13,536
Glendora	do				2,028
Hanford	Kings		2,929	4,829	5,888
Hermosa Beach	Los Angeles			679	2,327
Huntington Beach	Orange			815	1,687
Huntington Park	Los Angeles			1,299	4,513
Inglewood	do			1,536	3,286
La Verne	do			954	1,698
Lindsay	Tulare			1,814	2,576
Long Beach	Los Angeles	564	2,252	17,809	55,593
Los Angeles	do	50,395	102,479	319,198	576,673
Manhattan Beach	do				859
Monrovia	do	907	1,205	3,576	5,480
Monterey Park	do				4,108
Newport Beach	Orange			445	894
Ontario	San Bernardino			4,274	7,280
Orange	Orange	866	1,216	2,920	4,887
Oxnard	Ventura			2,555	4,414

TABLE 101.—*Incorporated communities served by Southern California Edison Co.*—Continued.

City or town.	County.	Population.			
		1890	1900	1910	1920
Pasadena	Los Angeles	4,882	9,117	30,291	45,354
Pomona	....do	3,634	5,526	10,207	13,505
Porterville	Tulare			2,696	4,097
Redlands	San Bernardino	1,904	4,797	10,449	9,571
Redondo Beach	Los Angeles	603	855	2,935	4,913
Rialto	San Bernardino				961
Riverside	Riverside	4,683	7,973	15,212	19,341
San Bernardino	San Bernardino	4,012	6,150	12,779	18,721
San Fernando	Los Angeles				3,204
San Gabriel	....do				2,640
San Marino	....do				584
Santa Ana	Orange	3,628	4,933	8,429	15,485
Santa Barbara	Santa Barbara			11,659	19,441
Santa Monica	Los Angeles	1,580	3,057	7,847	15,252
Santa Paula	Ventura			2,216	3,967
Seal Beach	Orange				669
Sierra Madre	Los Angeles			1,303	2,026
South Pasadena	....do	623	1,001	4,649	7,652
Stanton	Santa Ana				695
Tehachapi	Kern			385	458
Tulare	Tulare		2,216	2,758	3,539
Upland	San Bernardino			2,384	2,912
Venice	Los Angeles			3,219	10,385
Ventura	Ventura				4,342
Vernon	Los Angeles			772	1,005
Visalia	Tulare		3,085	4,550	5,753
Watts	Los Angeles			1,922	4,529
Whittier	....do	585	1,590	4,550	7,997

TABLE 102.—*Unincorporated communities served by Southern California Edison Co.*

Alamitos Bay.
Alexis.
Almond.
Altadena.
Anaheim Landing.
Annandale.
Antelope Valley.
Armona.
Arrowhead.
Artesia.
Athens-on-Hill.
Auberry.
Balboa Beach.
Baldwin Park.
Banning.
Barsdale.
Bassett.
Bell.
Bellflower.
Belmont.
Belvedere.
Belvidere.
Benedict Canyon.
Bixby.
Bloomington.
Bolsa Chica.
Bouquet Canyon.
Brentwood Park.
Brighton Beach.
Brookhurst.
Bryn Mawr.
Buena Park.
Burnett.
Burler.
Calabasas.
Camarillo.
Carmenita.
Carpinteria.
Casa Loma.
Cerritos.
Chatsworth.
Clearwater.
Clifton-by-the-Sea.
Clink.
Coldwater Canyon.
Crafton.
Crestmore.
Cudahy.
Cypress.
Declez.
Del Rosa.
Devils Gate.
Downey.
Ducor.
Duarte.
Earlimart.
East Highlands.
East San Pedro.
Edgewood Park.
El Camino.
El Modino.
El Molino.
El Rio.
Etiwanda.
Farmersville.
Firth Tract.
Floral Park.
Florence.
Florencita Park.
Fontana.
Freemont.
Garden Grove.
Gardena.
Glenney.
Goleta.
Goshen.
Graham.
Granada Park.
Green Meadows.
Greenwood.
Guasti.
Harbor City.
Hawthorne.
Highgrove.
Highlands.
Hillside.
Hoffman.
Homewood.
Horseshoe Bend.
Hueneme.
Hyde Park.
Hynes.
Inceville.
Ingledale.
Irvine.
Ivey Station.
Jasmine.
Kesterjet.
La Borde.

TABLE 102.—*Unincorporated communities served by Southern California Edison Co.*—Continued.

La Brea.
La Canada.
La Crescenta.
La Fetra.
La Habra.
La Miranda.
La Ramasa.
Laguna Beach.
Laguna Bell.
Lamanda Park.
Lancaster.
Lang.
Lankershim.
Las Lomas.
Laurel Canyon.
Lawndale.
Lemon Cove.
Lennox.
Linda Vista.
Little Lands.
Loma Linda.
Lomita.
Los Alamitos.
Los Cerritos.
Los Nietos.
Los Nogales.
McFarland.
McNeil.
Mentone.
Merriman.
Mint Canyon.
Modjeska.
Mojave.
Moneta.
Monolith.
Montalvo.
Montana.
Montebello.
Montecito.
Monte Vista.
Montrose.
Moorpark.
Naples.
Newhall.
Newkirk.
Newmark.
Nordhoff.
Northam.
Norwalk.
Oak Crest.
Oak Knoll.
Ocean Park Heights.
Ojai.
Olinda.
Olive.
Orangehurst.
Owensmouth.
Packwood.
Palmdale.
Palms.
Palosverdes.
Pasadena Glen.
Pattenton.
Piru.
Pixley.
Placentia.
Playa del Rey.
Plummers.
Point Fermin.
Lynwood.
Lytle Creek.
Poplar.
Providencia.
Puente.
Puente Largo.
Rancho.
Ramona Acres.
Redhill.
Richfield.
Richgrove.
Rivera.
Roscoe.
Roseboro.
Rosecrans.
Rosemead.
Rosena.
Rubio.
San Dimas.
San Pedro.
San Rafael Heights.
Santa Anita Canyon.
Santa Anita Park.
Santa Fe Springs.
Santa Susana.
Saticoy.
Saugus.
Savana.
Sawtelle.
Seaside.
Sepulveda.
Signal Hill.
Simi.
Solano.
Soldiers Home.
Soledad Canyon.
Somis.
Southgate Terrace.
Spadra.
Springville.
Stone Canyon.
Strathmore.
Strawberry Park.
Studebaker.
Success.
Summerland.
Sunland.
Sunnyside.
Sunnyslope.
Terra Bella.
Tipton.
Torrance.
Tropico.
Tustin.
Universal City.
Van Nuys.
Venice Hill.
Verdugo Park.
Wallace.
Walnut.
Walnut Park.
Wauhena.
Westgate.
Westminster.
Willowbrook.
Willowville.
Wilmington.
Wineville.
Winona.
Wiseburn.
Woodlake.
Woodville.
Wyndotte.
Yorba Linda.
Yucaipa.

The territory formerly served by Mount Whitney Power & Electric Co. is on the main transmission lines of Southern California Edison Co. but is remote from the territory covered by its main distribution network. The territory and load conditions of Mount Whitney Power & Electric system prior to its acquisition by Southern California Edison Co. are shown in the following paragraphs.

Except at the ends of two distribution lines that barely reach Kings and Kern counties, the San Joaquin Valley system acquired from Mount Whitney Power & Electric Co. operates entirely in Tulare County in the territory lying along the west slope of the

Sierra foothills from Seville on the north to McFarland on the south. This territory, with an extent north and south of about 50 miles and east and west of about 20 miles, is almost entirely surrounded by the main loop of the system, except for outlying territory originally served by lines of the Tulare County Power Co., added to the system in 1915. On the west side of the loop are the towns of Visalia, Tulare, Tipton, Pixley, Earlimart, and Delano, and on the east side, along the base of the foothills, are Richgrove, Ducor, Terra Bella, Porterville, Strathmore, Lindsay, Orangehurst, and Exeter. A branch line from the Delano substation runs south to McFarland and another from the loop runs north to Venice Hill. The system is supplied with power from the south by the transmission line from the Tule River plant, and from the north by the line from the plants on the Kaweah and by the Visalia and Tulare steam plants. It is also connected to the San Joaquin Light & Power system, through a substation at Strathmore, and was permanently connected at the end of 1919 to the Big Creek lines of Southern California Edison Co., through a substation at Richgrove, a temporary connection having been made at that point earlier in the year.

The population of the incorporated communities served up to the time the system was taken over is shown in Table 103.

TABLE 103.—*Incorporated places served by Mount Whitney Power & Electric Co.*

City or town.	Population.			
	1890	1900	1910	1920
Delano				805
Exeter				1,852
Lindsay			1,814	2,576
Porterville			2,696	4,097
Tulare	2,697	2,216	2,758	3,539
Visalia	2,885	3,085	4,550	5,753
	5,582	5,301	11,818	18,622

The unincorporated places listed below are also served:

Badger.
Richgrove.
Venice Hill.
Lemon Cove.
Tipton.
Plano.
Ducor.
Strathmore.
Springville.
Woodlake.
Earlimart.
Farmersville.
Goshen.
Terra Bella.
Success.
Poplar.
Klink.

LOAD.

Power generated at steam and hydroelectric stations operated by Southern California Edison Co. from 1904 to 1920 and power purchased from other companies are given in Table 104. The large increase in 1917 over 1916 is due to the acquisition of Pacific Light & Power Corporation May 31, 1917. Power generated and purchased by Pacific Light & Power Corporation prior to May 31, 1917, is shown separately in Table 105.

The mean monthly loads and monthly load factors of the Edison system alone from 1905 to May 31, 1917, are shown in figure 25, and similar information for Pacific Light & Power Corporation up to May 31, 1917, in Plate L. A combination of the mean monthly loads obtained by consolidating figure 25 and Plate L is given in Plate LII, but in that plate it has been possible to show combined monthly load factors only for the period June, 1917, to the end of the record, when the properties were operated as a single system.

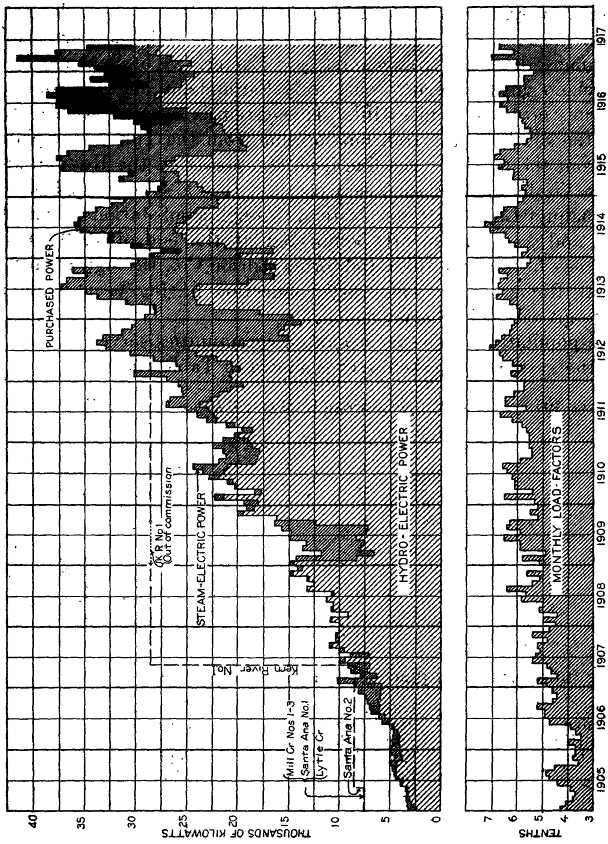
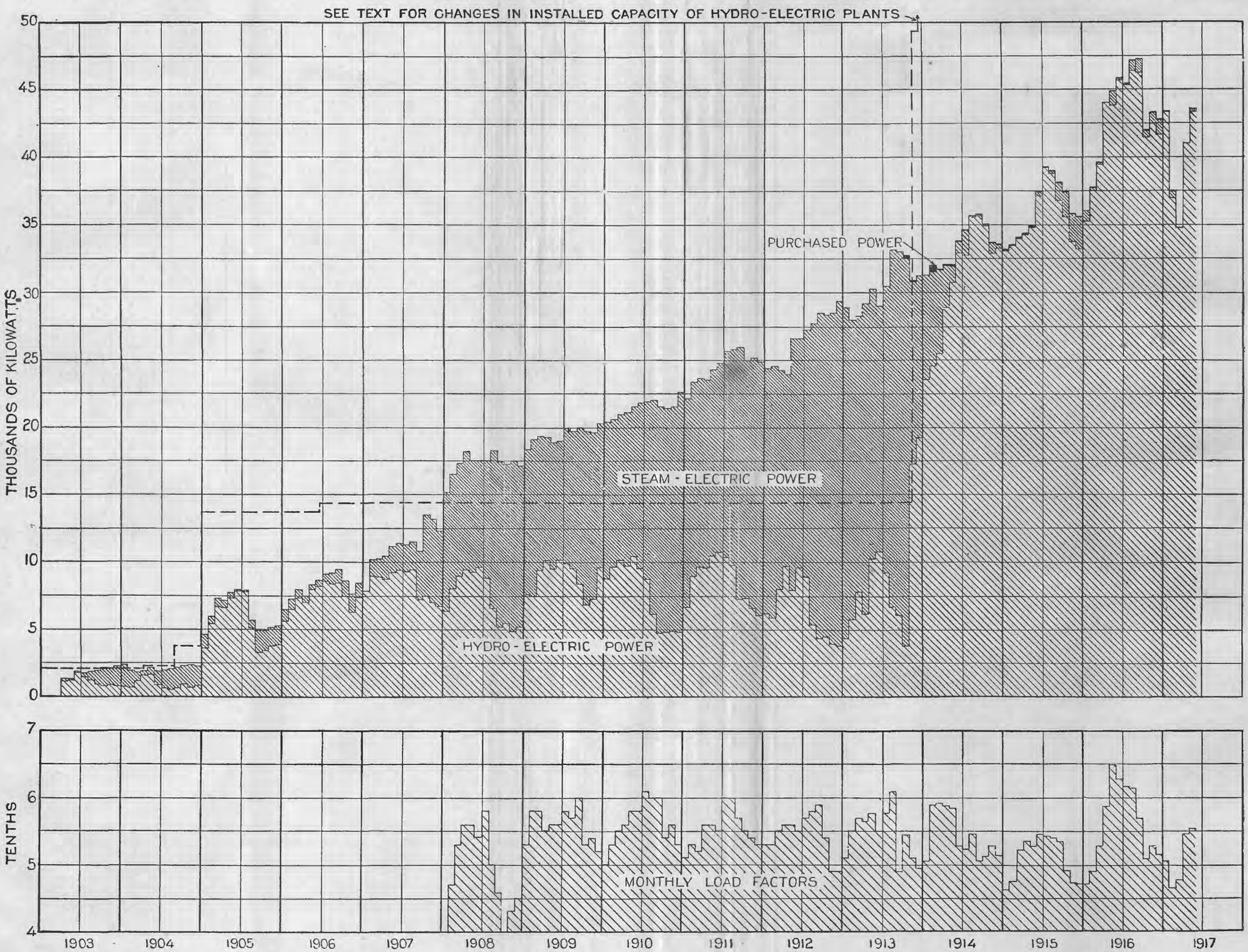
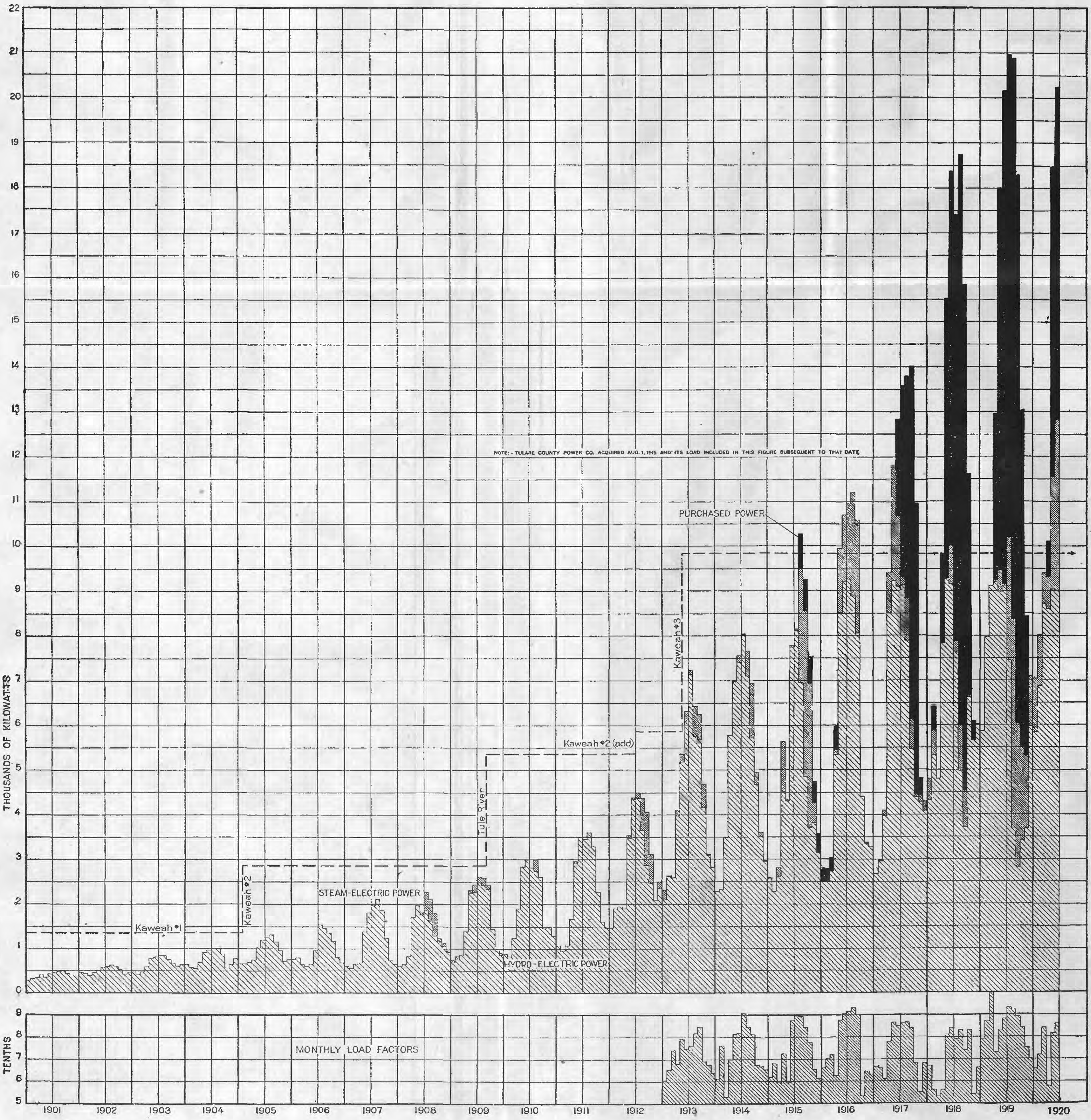


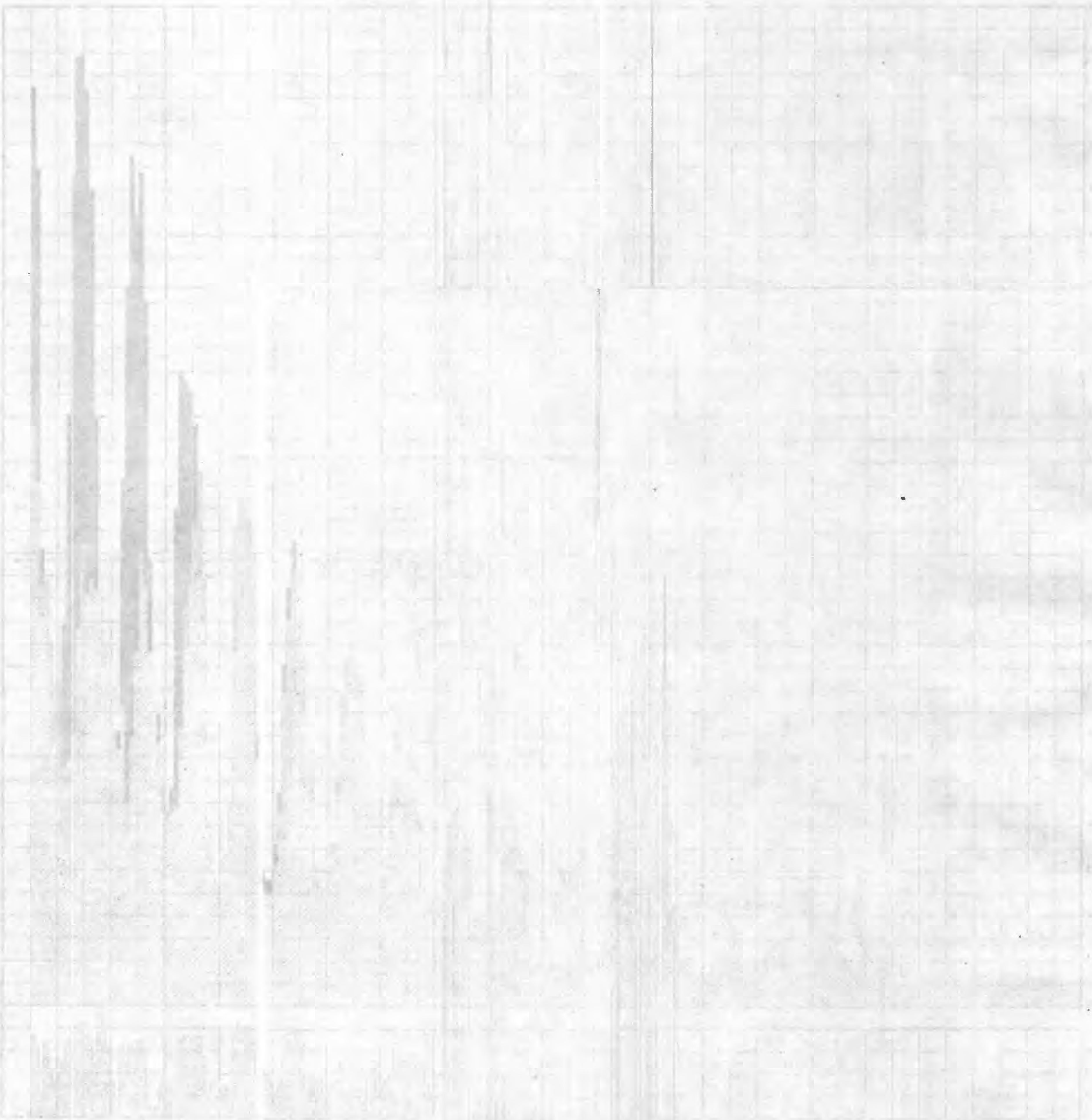
FIGURE 25.—Southern California Edison Co., mean monthly loads and load factors, 1905-1917.

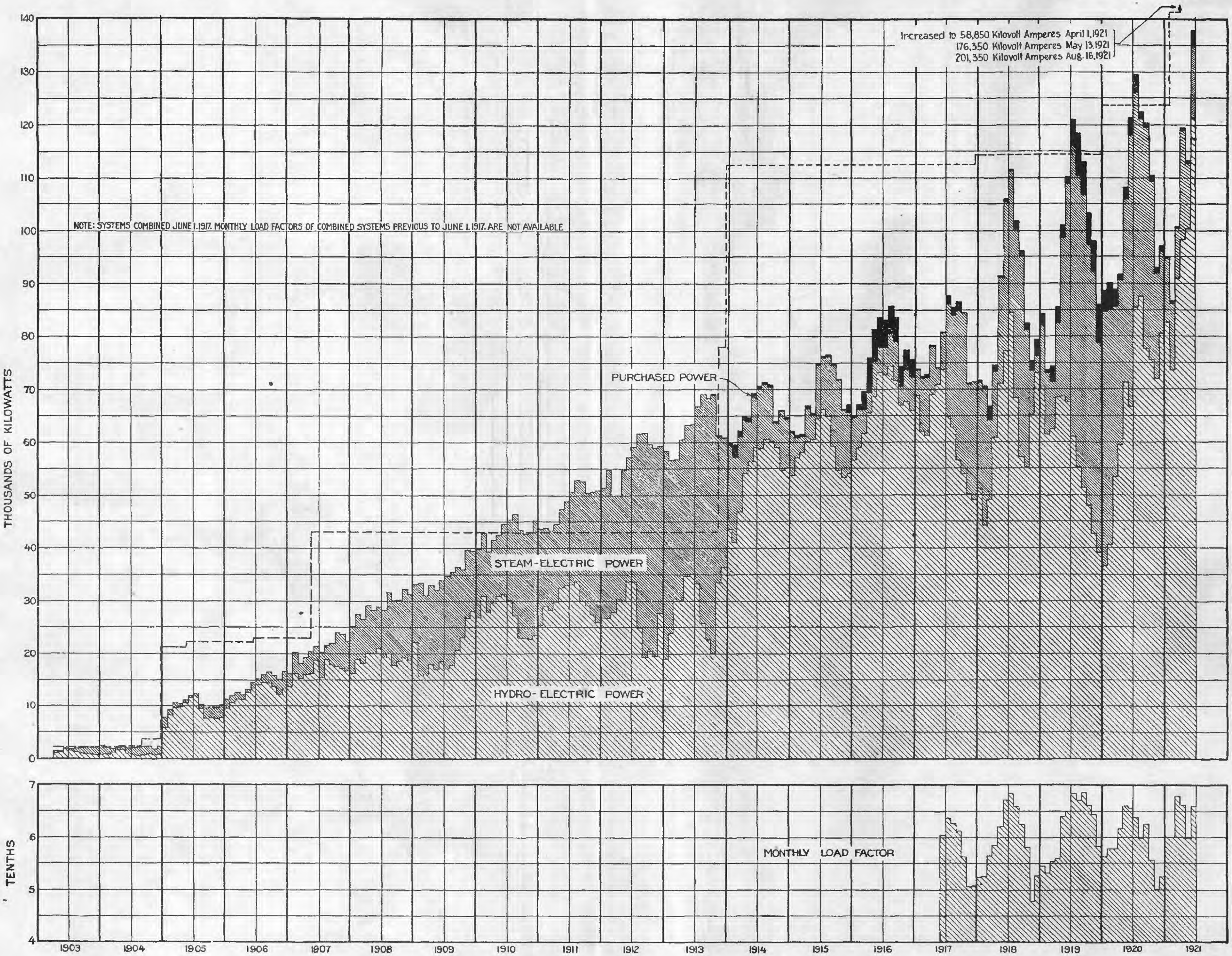


PACIFIC LIGHT & POWER SYSTEM, MEAN MONTHLY LOADS AND LOAD FACTORS FROM 1903 TO DATE OF CONSOLIDATION WITH SOUTHERN CALIFORNIA EDISON CO.



MOUNT WHITNEY POWER & ELECTRIC CO., MEAN MONTHLY LOADS AND LOAD FACTORS FROM 1901 TO DATE OF CONSOLIDATION WITH SOUTHERN CALIFORNIA EDISON CO.





SOUTHERN CALIFORNIA EDISON CO., MEAN MONTHLY LOADS AND LOAD FACTORS, 1903–1921, INCLUDING LOADS OF FORMER PACIFIC LIGHT & POWER CORPORATION.

Table 104.—*Power generated and purchased by Southern California Edison Co., 1904–1920.*

Year.	Generated (kilowatt-hours).			Purchased (kilowatt-hours).	Total system (kilowatt-hours).	Horsepower.		Load factor (per cent).
	Hydro-electric.	Steam.	Total.			Mean.	Peak.	
1904	19,957,913	6,274,065	26,231,978	415,947	26,647,925	4,076	13,333	30.5
1905	31,353,460	4,896,626	36,250,086	85,862	36,335,948	5,558	17,171	32.3
1906	45,026,250	9,243,086	54,269,336	108,116	54,377,452	8,318	23,100	36.0
1907	73,252,122	11,564,992	84,817,114	....	84,817,114	12,974	28,847	45.0
1908	101,701,170	1,020,216	102,721,386	....	102,721,386	15,713	37,327	42.1
1909	97,679,255	29,243,662	126,922,917	7,269,738	134,192,655	20,527	48,627	42.2
1910	170,425,054	13,813,030	184,238,084	2,291,358	186,529,442	28,533	55,027	51.8
1911	183,970,603	20,650,413	204,621,016	479,566	205,100,582	31,375	60,293	52.0
1912	169,242,163	88,761,047	258,003,210	1,756,474	259,759,684	39,735	66,167	61.0
1913	172,916,514	110,009,323	282,925,837	829,772	283,755,609	43,406	73,338	59.2
1914	202,704,746	78,965,090	281,669,836	4,264,900	285,934,736	43,739	72,139	60.6
1915	205,925,749	77,582,511	283,508,260	2,489,664	285,997,924	43,749	75,880	57.7
1916	217,570,155	45,494,892	263,064,047	35,784,766	298,849,813	45,715	81,650	56.0
1917	397,846,525	138,109,588	[a]535,956,113	6,073,374	542,029,487	....	....	......
1918	554,235,214	186,698,288	740,933,502	10,802,478	751,735,980	114,993	218,590	52.6
1919	508,246,941	310,257,206	818,504,147	[b] 5,992,093	812,512,054	124,290	237,314	52.4
1920	592,187,331	311,974,024	904,161,355	22,012,248	926,173,603	141,677	284,600	49.8

[a] Includes outputs of plants acquired with Pacific Light & Power Co. for June 1 to Dec. 31 only.
[b] Net kilowatt-hours from exchange of power.

Table 105.—*Power generated and purchased by Pacific Light & Power Corporation from 1907 to date of its acquisition by Southern California Edison Co.*

Year.	Generated (kilowatt-hours).			Purchased (kilowatt-hours).	Total system (kilowatt-hours).	Horsepower		Load factor (per cent).
	Hydro-electric.	Steam.	Total.			Mean.	Peak.	
1907	74,568,695	25,227,234	99,795,929	....	99,795,929	15,266	31,500	48.5
1908	62,433,117	83,626,548	146,059,665	....	146,059,665	22,343	47,700	46.8
1909	79,151,416	86,792,479	165,943,895	....	165,943,895	25,384	52,100	48.7
1910	65,896,655	108,147,321	174,043,976	16,195,341	190,239,317	29,101	60,200	48.3
1911	75,444,196	139,394,048	214,838,244	1,199,371	216,037,615	33,047	62,800	52.6
1912	56,918,677	177,336,170	234,254,847	1,049,267	235,304,114	35,994	79,500	45.3
1913	81,600,262	183,460,551	265,060,813	259,290	265,320,103	40,586	84,400	48.1
1914	271,620,766	21,219,288	292,840,054	710,301	293,550,355	44,904	94,600	47.5
1915	310,074,494	6,023,695	316,098,189	162,147	316,260,336	48,378	101,700	47.6
1916	371,585,131	4,723,600	376,308,731	184,450	376,493,181	57,592	111,000	51.9
1917 [a]	144,802,292	529,692	145,331,984	[b] 1,945,247	143,386,737	....	....	......

[a] Jan. 1 to May 31, when the system was taken over by Southern California Edison Co.
[b] Net kilowatt-hours from exchange of power.

Table 106.—*Power generated and purchased by Mount Whitney Power & Electric Co.*

Year.	Generated (kilowatt-hours).			Purchased (kilowatt-hours).	Total system (kilowatt-hours).	Horsepower.		Load factor (per cent).
	Hydro-electric.	Steam.	Total.			Mean.	Peak.	
1901	3,412,000	....	3,412,000	None.	3,412,000	520	....	......
1902	4,384,000	....	4,384,000	None.	4,384,000	670	....	......
1903	5,605,000	....	5,605,000	None.	5,605,000	860	....	......
1904	6,675,000	....	6,675,000	None.	6,675,000	1,020	....	......
1905	8,092,000	....	8,092,000	None.	8,092,000	1,240	....	......
1906	8,252,000	....	8,252,000	None.	8,252,000	1,260	....	......
1907	10,394,268	18,355	10,412,623	None.	10,412,623	1,590	....	......
1908	11,441,000	1,227,770	12,668,770	None.	12,668,770	1,940	....	......
1909	13,837,000	363,600	14,200,600	None.	14,200,600	2,170	....	......
1910	16,737,300	217,910	16,955,210	None.	16,955,210	2,590	....	......
1911	19,749,147	47,630	19,796,777	None.	19,796,777	3,030	....	......
1912	23,926,200	2,164,796	26,090,996	None.	26,090,996	3,990	7,437	53.6
1913	36,994,370	2,385,700	39,380,070	None.	39,380,070	6,030	12,258	49.2
1914	44,005,600	1,682,100	45,687,700	None.	45,687,700	6,990	12,405	56.3
1915	39,928,200	8,430,700	48,358,900	2,100,800	50,459,700	7,720	14,950	51.6
1916	49,883,500	7,064,300	56,947,800	971,200	57,919,000	8,860	16,220	54.6
1917	52,523,900	5,385,700	57,909,600	19,257,375	77,166,975	11,800	22,330	52.9
1918	55,064,900	2,947,600	58,012,500	40,759,446	98,771,946	15,120	30,070	50.4
1919	56,740,823	11,796,400	68,537,223	44,318,040	112,855,263	17,270	32,600	53.3
1920[a]	35,057,890	7,348,600	42,406,490	6,969,899	49,376,389	....	....	......

[a] Combined with Southern California Edison Co. July 1, 1920.

Mean monthly loads on the system of Ventura County Power Co. (acquired November 30, 1917), computed from kilowatt-hours generated at the Oxnard steam plant, purchased from Southern California Edison Co. through Castaic substation, and purchased from Pacific Light & Power Corporation through Saticoy substation, are shown in figure 26. The large seasonal variations show the relative importance of the agricultural uses on the system. The purchased power shown in figure 26 also shows in figure 25 and Plates LII and L, monthly loads of Southern California Edison Co. and Pacific Light & Power Corporation.

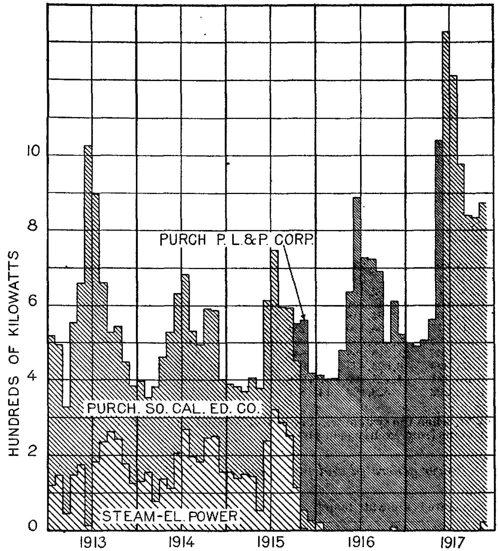


FIGURE 26.—Ventura County Power Co., mean monthly loads from 1913 to date of absorption by Southern California Edison Co.

Monthly load factors on the Edison system during five years prior to acquisition of Pacific Light & Power ranged from a minimum of 54 per cent in the lowest winter month to a maximum of 73 per cent in one of the most favorable summer months Monthly load factors on on the old Pacific Light & Power system for the same period range from a minimum of 43.5 per cent to a maximum of 64.9 per cent. Since the consolidation of the two systems monthly load factors have varied from a minimum of 48 per cent in November, 1918, to a maximum of 82.9 per cent in July, 1921.

The daily load curves of Pacific Light & Power system for February 18, 1914, and August 19, 1914, shown in figure 27, and the mean monthly system loads for 1913 and 1914, shown in Plate L, give a graphic history of the substitution of water power for steam power that resulted from the installation of the Big Creek hydroelectric system, and show conclusively the results that may be attained in cutting down the use of fuel oil by an adequate hydro-electric construction program.

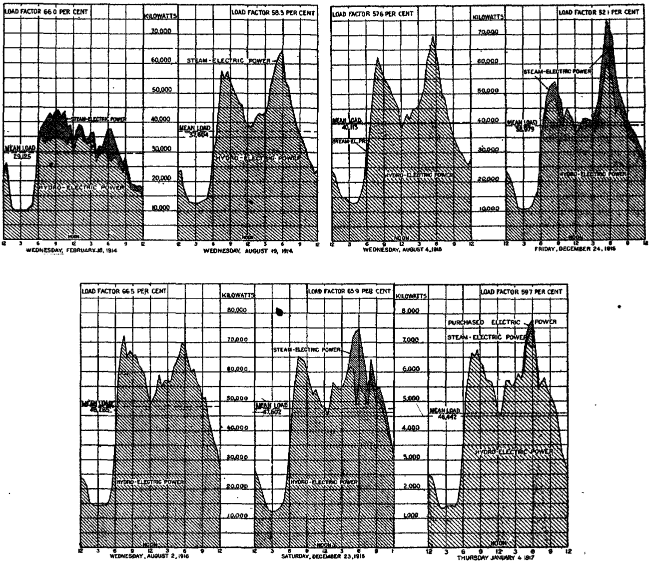


FIGURE 27.—Southern California Edison Co. (Pacific Light & Power system), daily load curves 1914–1917.

The following interesting table shows the variation in the available capacity of plants that are dependent upon the natural flow of the streams. The plants carry practically full load during certain months of each year, but the full-load period varies greatly with the year, and the yearly capacity ranged from 61.7 per cent of the installed capacity in 1912 to 91.6 per cent in 1916; the average for 11 years was 74.7 per cent.

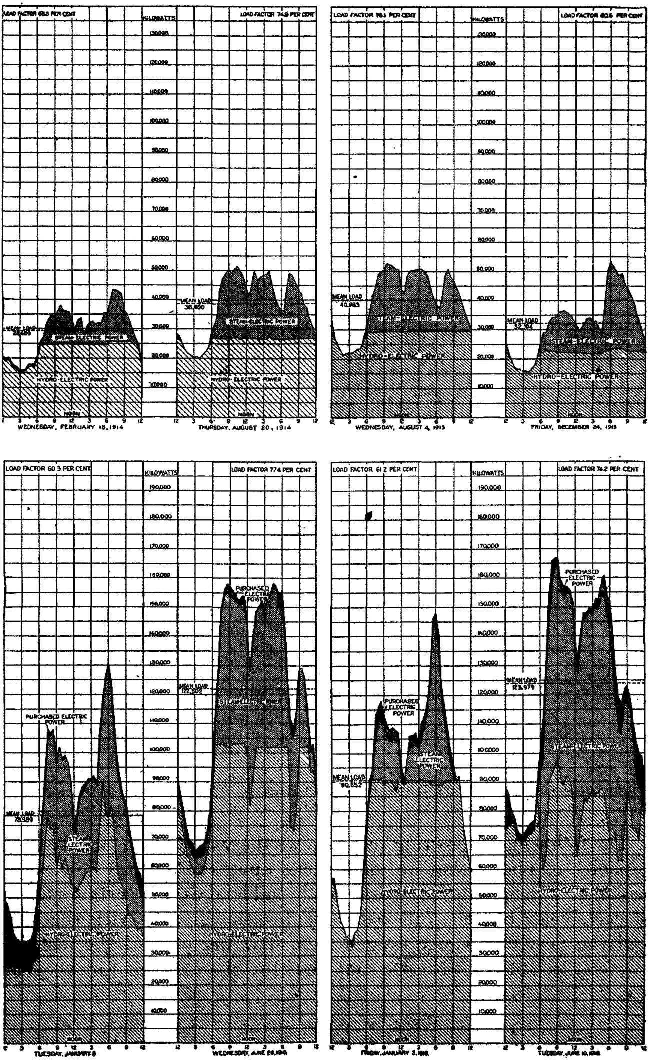
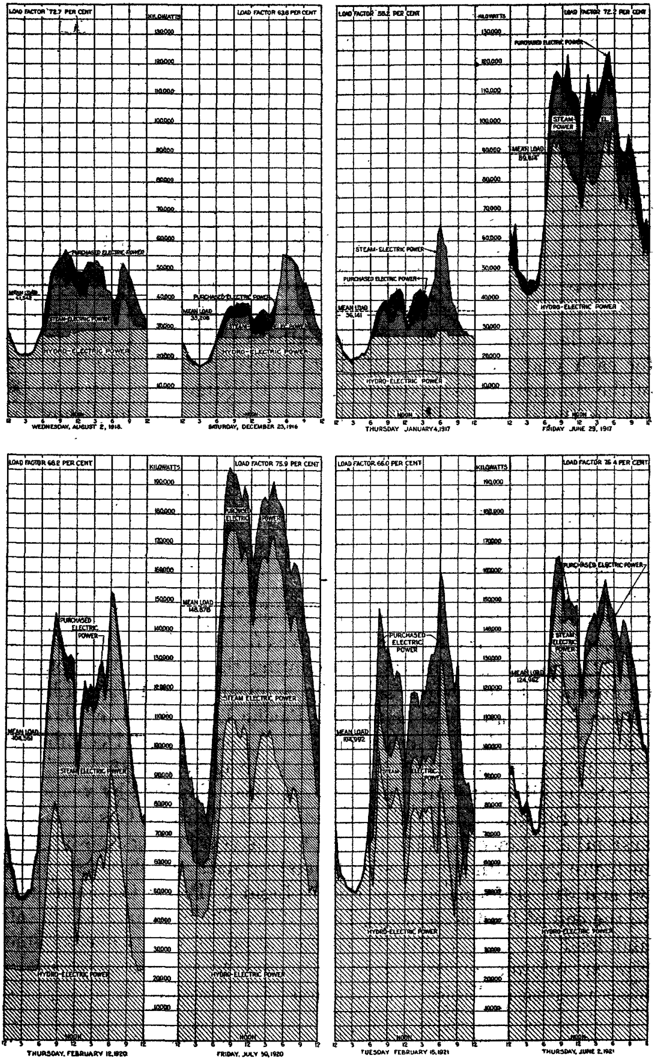


FIGURE 28.—Southern California Edison Co.,



daily load curves, 1914–1921.

TABLE 107.—*Percentage of developed water power actually flowing in streams at plants of Southern California Edison Co.*

[Based on present installed capacity (83,905 kilowatts, October, 1921) and exclusive of Big Creek plants, which are all supplied with storage.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1910	94.9	92.6	98.3	99.6	99.2	97.0	90.1	69.6	58.5	59.7	55.5	54.9	80.8
1911	66.5	84.7	92.5	98.7	99.5	99.2	97.9	88.9	70.5	66.7	59.7	60.0	82.1
1912	59.7	57.4	57.8	82.4	95.3	94.3	82.4	51.2	39.2	40.2	41.5	39.7	61.7
1913	40.8	50.0	57.2	87.1	94.0	91.6	81.2	58.9	59.7	41.0	48.4	47.6	63.1
1914	75.9	88.5	97.7	99.7	99.4	99.2	97.6	90.0	71.5	63.3	54.2	55.4	82.7
1915	59.5	73.0	86.2	97.2	99.0	99.3	98.0	72.7	56.5	48.6	49.2	54.8	74.5
1916	84.9	97.3	99.4	99.9	99.6	99.3	99.3	97.6	82.7	91.7	76.9	72.2	91.6
1917	79.1	87.0	96.0	95.9	96.8	94.8	92.6	88.0	63.1	51.3	49.3	47.4	78.4
1918	46.8	51.9	84.8	82.3	94.4	93.5	85.9	59.2	66.3	75.3	60.9	61.4	71.8
1919	51.6	68.6	75.3	92.4	93.0	92.1	83.3	47.4	38.2	42.9	39.0	48.0	64.3
1920	46.5	54.9	73.6	95.6	97.0	96.6	89.1	68.0	49.3	51.6	55.7	58.1	69.7
Average	64.2	73.5	83.6	93.8	97.0	96.1	90.7	71.9	59.6	57.5	53.6	54.5	74.7

Two daily load curves for the Southern California Edison system for each year from 1914 to 1921 are shown in figure 28. The form of the summer curves is determined by the large irrigation load carried by the system. The large difference between the load shown on the curve of January 4, 1917, and June 29, 1917, is due to acquisition of Pacific Light & Power system on May 31, 1917. The load factors for the particular days shown range from a minimum of 55.2 per cent for January 4, 1917, to a maximum of 77.4 per cent June 26, 1918, during the height of the pumping season.

The form of the Pacific Light & Power curves, shown in figure 27, was determined largely by the heavy electric-railway load in and around Los Angeles, and the size of this load was such that it has marked effect on the form of the curves from June 29, 1917, to June 2, 1921, shown in figure 28, representing the load on the Southern California Edison system since the acquisition of Pacific Light & Power. The daily load factors for Pacific Light & Power shown in figure 27 range from a minimum of 52.1 per cent for December 24, 1915, to a maximum of 66.5 per cent for August 2, 1916.

Sales in kilowatt-hours and connected load classified by years from 1913 to 1920 for Edison system (and Santa Barbara Gas & Electric system) are shown in Table 108 and for the year ending June 30, 1915, in figure 29. Other interesting operating data are shown in figures 30 and 31. Information for Pacific Light & Power Corporation up to the end of 1916 is shown in Table 109. The large increase in sales and load for 1917 is due to consolidation of the two companies. Similar information concerning revenues from various classes of loads is given in Tables 251, 253, and 257, Appendix A.

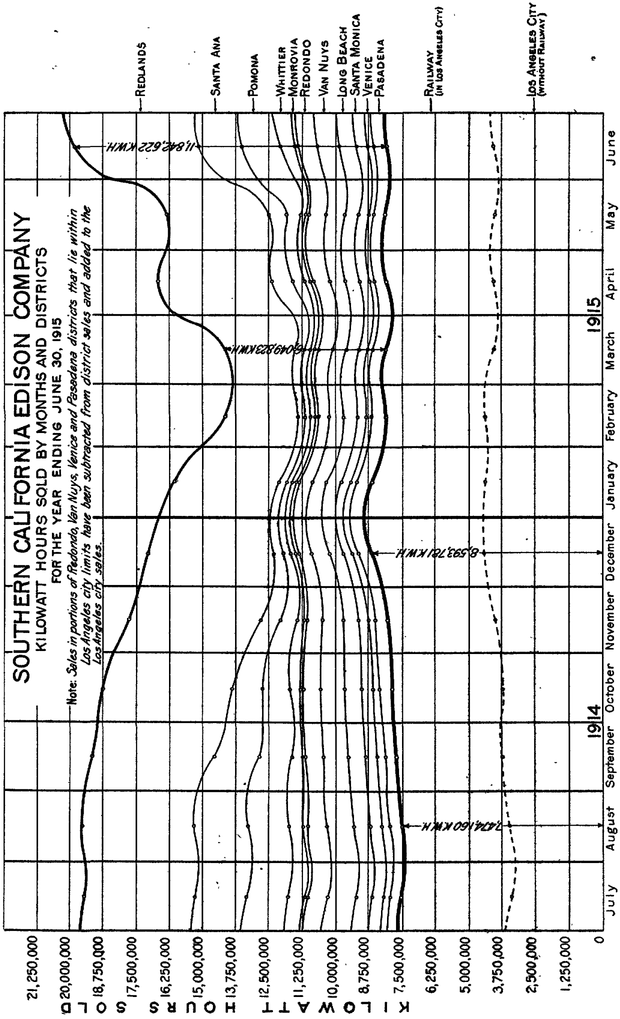


FIGURE 29.—Southern California Edison Co., sales in kilowatt-hours, by months and districts, for year ending June 30, 1915.

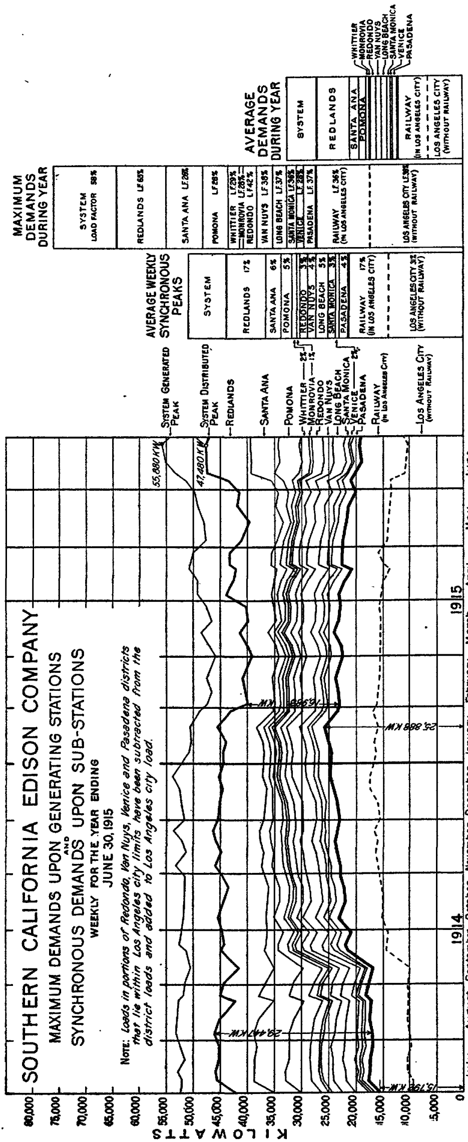


FIGURE 30.—Southern California Edison Co., maximum demand on generating stations and synchronous demands on substations weekly for year ending June 30, 1915.

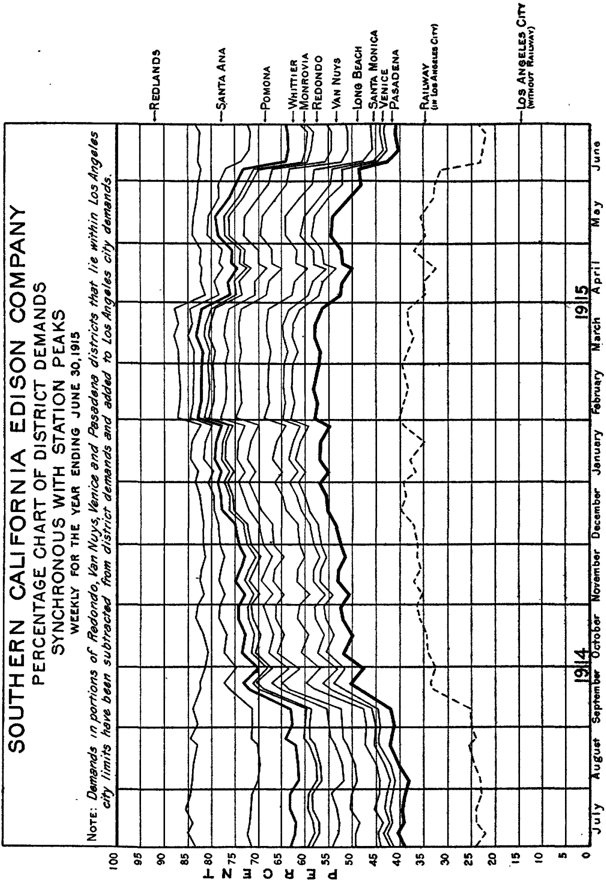


FIGURE 31.—Southern California Edison Co., percentage chart of district demands synchronous with station peaks weekly for year ending June 30, 1915.

Sales in kilowatt-hours and connected load on the Ventura County Power Co.'s system up to 1917, the year it was absorbed, are given in Table 110.

The growth of load on the Southern California system from 1913 to 1920 is given in Table 111, and similar information for Pacific Light & Power Corporation from 1900 to 1916 in Table 112.

TABLE 108.—*Sales and connected load, Southern California Edison system, 1913–1920.*

Southern California Edison system.

Class of load.	1913				1914			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	34,420,953	15.9	81,533	47.5	39,312,465	18.7	89,401	46.5
Commercial								
Municipal	3,291,221	1.5	1,145	.7	4,257,574	2.0	1,512	.8
Power:								
Industrial	109,442,435	50.6	....	....	98,569,386	46.9	....	....
Agricultural								
Municipal	....	....	1,552	.9	....	....	2,309	1.2
All other	69,350,427	32.0	87,398	50.9	68,158,917	32.4	98,781	51.5
Miscellaneous [a]	....	....	....	....	....	....	....	....
	216,505,036	100.0	171,628	100.0	210,298,342	100.0	192,003	100.0

Class of load.	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	42,108,510	19.9	95,524	46.6	44,832,401	20.3	102,901	45.4
Commercial								
Municipal	4,775,508	2.3	1,670	.8	5,194,713	2.3		
Power:								
Industrial	96,608,238	45.7	....	....	100,994,722	45.8	123,921	54.6
Agricultural								
Municipal	....	....	3,658	1.8	4,794,111	2.2		
All other	66,953,983	31.6	104,097	50.8	63,420,517	28.9		
Miscellaneous	[b] 1,035,659	.5	....	....	1,162,590	.5		
	211,481,898	100.0	204,949	100.0	220,399,054	100.0	226,822	100.0

Class of load.	1917				1918			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Municipal—								
Street	5,045,000	1.2	2,081	0.7	5,365,000	0.9	2,318	0.7
Miscellaneous	409,000	.1	693	.2	417,000	.1	685	.2
Commercial	31,477,000	7.2	60,594	20.5	23,485,000	3.8	63,258	19.7
Used by company	636,000	.1	....	....	366,000	.1	....	....
Power:								
Municipal	7,846,000	1.8	7,169	2.4	9,157,000	1.5	7,105	2.2
Commercial—								
Industrial	140,777,000	32.3	65,934	22.3	155,999,000	25.4	48,615	15.1
Agricultural			54,498	18.4			57,697	18.0
Other commercial power			29,672	10.1			17,857	5.6
Railway	178,060,000	40.9	65,881	22.3	268,522,000	43.7	73,111	22.8
Used by company	3,067,000	.7	....	....	3,919,000	.6	....	....
Other electrical corporations	68,197,000	15.7	9,129	3.1	146,670,000	23.9	50,592	15.7
	435,514,000	100.0	295,651	100.0	613,900,000	100.0	321,238	100.0

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[a] Used by company.
[b] Lighting, 649,063 kilowatt-hours; power, 386,596 kilowatt-hours; used by company.

TABLE 108.—*Sales and connected load, Southern California Edison system, 1913–1920*—Continued.

Class of load.	1919				1920			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Municipal—								
Street	5,312,000	0.8	2,309	0.7	5,944,000	0.8	2,628	0.7
Miscellaneous	645,000	.1	719	.2	582,000	.1	945	.2
Commercial	26,589,000	4.0	67,886	20.1	36,709,000	4.9	82,352	20.9
Used by company	406,000	.1	....	....	394,000	.1	....	....
Power:								
Municipal	11,923,000	1.8	5,653	1.7	14,818,000	2.0	7,066	1.8
Commercial—								
Industrial	192,227,000	28.8	49,832	14.7	289,927,000	38.6	64,619	16.4
Agricultural			66,709	19.7			101,240	25.7
Other commercial power			18,224	5.4			20,090	5.1
Railway	252,351,000	37.8	72,367	21.4	276,897,000	36.9	74,313	18.8
Used by company	7,725,000	1.2	....	....	509,000	.1	....	....
Other electrical corporations	169,691,000	25.4	54,257	16.1	124,530,000	16.5	40,943	10.4
	666,869,000	100.0	337,956	100.0	750,310,000	100.0	394,196	100.0

Santa Barbara Gas & Electric Co.

Class of load.	1913				1914			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	1,180,749	44.8	3,698	72.6				
Commercial					1,299,370	41.9	4,156	68.5
Municipal	246,661	9.4			275,342	8.8	90	1.8
Used by company	....	....						
Power:								
Used by company	....	....	1,395	27.4				
Railway	544,736	20.6			744,780	24.0		
Municipal	9,097	.3			12,968	.4	37	.6
All other power	655,572	24.9			772,391	24.9	1,774	29.1
	2,636,815	100.0	5,093	100.0	3,104,851	100.0	6,057	100.0

Class of load.	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	1,515,036	43.9	4,607	67.7	1,769,636	44.9	5,027	64.7
Commercial								
Municipal	263,404	7.6	94	1.3	312,094	7.9		
Used by company	15,713	.4	....	....	18,226	.5		
Power:								
Used by company	31,905	.9	....	....	33,899	.9	2,748	35.3
Railway	827,180	23.9	....	....	802,050	20.3		
Municipal	14,250	.5	38	.5	17,329	.4		
All other power	788,114	22.8	2,086	30.5	988,576	25.1		
	3,455,602	100.0	6,825	100.0	3,941,810	100.0	7,775	100.0

TABLE 108.—*Sales and connected load, Southern California Edison system, 1913–1920*—Continued.

Class of load.	1917				1918			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilo-watts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilo-watts.	Per cent of total.
Lighting:								
Municipal—								
Street	316,000	6.6	113	1.2	310,000	5.6	117	1.1
Miscellaneous	26,000	.5	71	.8	39,000	.7	86	.8
Commercial	1,920,000	40.4	5,310	56.7	1,788,000	32.6	5,624	54.3
Used by company	30,000	.6	....	....	31,000	.6	....	....
Power:								
Municipal	29,000	.6	92	1.0	171,000	3.1	114	1.1
Commercial	1,527,000	32.1	3,463	37.0	2,161,000	39.4	4,115	39.8
Used by company	17,000	.4	....	....	9,000	.2	....	....
Railway	891,000	18.8	310	3.3	973,000	17.8	298	2.9
	4,756,000	100.0	9,359	100.0	5,482,000	100.0	10,354	100.0

TABLE 109.—*Sales and connected load, Pacific Light & Power Corporation, 1901–1916.*

Class of load.	Sales (kilowatt-hours).					
	1901–2[a]	1902–3[a]	1903–4[a]	1904–5[a]	1905[b]	1906
Lighting:						
Municipal, street—						
Arc	1,556,190	2,015,831	1,909,852	2,035,960	1,786,084	7,854,238
Incandescent						
Commercial	42,862	79,485	2,679,579	3,250,810	2,812,268	....
Power:						
Commercial	4,013,231	5,029,165	5,523,725	8,415,790	7,599,955	10,240,659
Railway	1,281,923	1,130,118	2,795,958	8,698,159	25,490,777	48,363,664
Gross sales	6,894,206	8,254,599	12,909,114	22,400,719	37,689,084	66,458,561

Class of load.	Sales (kilowatt-hours).					
	1907	1908	1909	1910	1911	1912
Lighting:						
Municipal, street—						
Arc	9,173,441	9,613,616	4,206,246	4,616,252	5,092,362	5,666,306
Incandescent			347,527	328,852	267,324	291,249
Commercial	....	....	7,205,936	7,601,841	9,321,087	10,332,323
Power:						
Commercial	6,785,621	7,291,643	12,409,339	16,013,825	19,356,609	25,831,838
Railway	64,104,544	116,235,609	129,127,256	145,429,067	160,957,745	169,584,905
Gross sales	80,063,606	133,140,868	153,296,404	173,989,837	194,995,127	211,706,621

[a] Year beginning Apr. 1 and ending Mar. 31.

[b] Apr. 1 to Dec. 31.

NOTE.—Connected load not segregated, 1901–1913.

TABLE 109.—*Sales and connected load, Pacific Light & Power Corporation, 1901–1916*—Continued.

Class of load.	1913				1914			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Municipal, street—								
Arc	7,056,445	3.0	2,182	4.1	7,611,868	3.3	2,329	2.0
Incandescent								
Commercial	11,494,580	4.8	26,649	50.2	12,615,129	5.4	32,220	28.1
Power:								
Commercial	25,438,202	10.7	24,310	45.7	24,018,595	10.3	80,125	69.9
Railway	185,894,589	78.2			186,315,445	79.9		
Other electrical corporations	7,734,932	3.3			2,561,194	1.1		
Gross sales	237,618,748	100.0	53,141	100.0	233,122,231	100.0	114,674	100.0

Class of load.	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Municipal, street—								
Arc	8,136,116	3.2	2,925	2.3	8,541,743	2.9	735	0.5
Incandescent								
Commercial	14,789,434	5.8	32,852	25.6	17,279,752	5.8	39,648	30.2
Power:								
Commercial	228,356,892	91.0	92,564	72.1	272,290,592	91.3	90,961	69.3
Railway								
Other electrical corporations								
Gross sales	251,282,442	100.0	128,341	100.0	298,112,087	100.0	131,344	100.0

TABLE 110.—*Sales and connected load, Ventura County Power Co., 1913–1916.*

Class of load.	1913 [a]		1914			
	Sales.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:						
Residence	420,695	15.6	395,525	13.4	....	....
Commercial	311,715	11.5	370,627	12.5	....	....
Municipal	84,488	3.1	82,447	2.8	22.9	0.8
All other	1,728	.1	24,694	.8	....	....
Power:						
Industrial	477,139	17.7	812,691	27.5	1,203.2	41.4
Agricultural	1,086,740	40.2	635,745	21.5	1,519.9	51.0
All other power	319,266	11.8	636,095	21.5	233.1	6.8
	2,701,771	100.0	2,957,824	100.0	2,979.1	100.0

[a] "Kilowatts connected" not segregated in 1913.

TABLE 110.—*Sales and connected load, Ventura County Power Co., 1913–1916*—Con.

Class of load.	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Commercial	811,131	36.4	....	....	916,021	32.3	1,648	31.7
Municipal	84,004	3.8	31.5	1.1	83,591	2.9	26	.5
Power:								
Industrial	....	....	1,361.3	49.2	....	....	....	....
Agricultural	....	....	1,051.9	38.0	....	....	....	....
Municipal	....	....	324.5	11.7	....	....	....	....
Commercial	33,248	1.5	....	....	....	....	....	....
All other power	1,299,365	58.3	....	....	1,835,281	64.8	3,522	67.8
	2,227,748	100.0	2,769.2	100.0	2,834,893	100.0	5,196	100.0

TABLE 111.—*Growth of load on lines of Southern California Edison Co., 1904–1920.*

Year.	Number of consumers.	Number of street lamps.		Capacity of motors.	Connected load.
		Arc.	Incandescent.[a]		
				Horsepower.	*Horsepower.*
1904	19,713	1,319	351,334	7,803	32,017
1905	25,321	2,225	460,791	13,605	45,659
1906	32,764	2,740	586,105	19,662	60,380
1907	39,606	3,479	701,095	31,132	79,959
1908	42,234	3,486	781,557	41,368	95,563
1909	44,445	3,193	867,142	48,298	108,023
1910	55,191	2,770	992,567	61,649	124,815
1911	66,398	2,649	1,240,861	72,441	156,754
1912	80,995	2,496	1,436,617	97,478	194,750
1913	96,851	2,162	1,634,185	118,610	228,853
1914	108,839	2,056	1,799,762	136,284	257,502
1915	116,768	1,959	1,925,445	143,695	274,631
1916	121,019	1,868	2,040,779	165,430	304,041
1917	195,321	5,414	2,549,364	340,848	550,926
1918	201,129	4,396	2,775,532	383,821	602,932
1919	214,528	5,531	2,851,224	413,920	644,194
1920	238,269	5,517	3,144,526	474,943	722,679

[a] 50-watt equivalent.

TABLE 112.—*Growth of load on lines of Pacific Light & Power Corporation, 1900–1916.*

Year.	Number of consumers.	Number of street lamps.		Motors.		Connected load.
		Arc.	Incandescent.	Number.	Capacity.	
					Horsepower.	*Horsepower.*
1900 [a]	....	516	24,179	102	1,630	....
1901 [a]	....	1,289	20,981	121	1,791	....
1902 [a]	....	1,482	32,035	174	2,638	....
1903 [a]	....	1,737	41,507	418	4,497	....
1904 [a]	....	2,043	73,393	640	7,307	....
1905 [a]	....	2,275	97,058	683	8,369	....
1905	....	2,648	112,264	....	....	....
1906	....	3,024	154,717	796	8,525	....
1907	....	3,791	180,818	890	10,373	....
1908	....	3,927	202,646	953	11,654	....
1909	11,176	4,026	238,648	1,055	12,774	76,731
1910	13,471	4,289	281,083	1,274	16,409	88,059
1911	15,728	4,781	332,774	1,603	20,854	102,884
1912	19,136	4,989	393,099	1,948	26,242	117,112
1913	24,112	4,424	511,307	2,423	32,560	136,400
1914	30,281	4,965	623,915	3,093	38,928	152,878
1915	34,457	4,874	677,751	3,612	46,923	172,000
1916	38,429	4,545	731,478	4,323	53,097	176,000

[a] Year ending Mar. 31; all others end Dec. 31.

Until the Southern California Edison and Pacific Light & Power corporations entered into contract with the city of Los Angeles to sell their distribution systems within the city limits, the city was the most important load center of both companies. When the contract for sale was completed an operating agreement was entered into by which Southern California Edison Co. operates (December, 1921) its local distribution system in the city for the account of the city, distributing power generated by the city at its municipal plants and supplying a large amount of additional power at wholesale. Wholesale deliveries to street-railway companies are also continued.

A classification of sales in kilowatt-hours and connected load, by districts, for the year 1920, shows the following as their relative importance:

The largest sales for municipal street lighting were in Santa Monica, 860,000 kilowatt-hours with 315 kilowatts connected; Long Beach, 703,000 kilowatt-hours with 495 kilowatts connected; Redondo, 561,000 kilowatt-hours with 193 kilowatts connected; Santa Ana, 504,000 kilowatt-hours with 140 kilowatts connected; Pomona, 497,000 kilowatt-hours with 134 kilowatts connected; and Venice, 355,000 kilowatt-hours with 78 kilowatts connected.

Commercial lighting of business establishments and residences combined form a very important class of load, the largest sales being in Long Beach district, 6,538,000 kilowatt-hours, with 12,324 kilowatts connected; Pasadena, 3,478,000 kilowatt-hours, with 5,874 kilowatts connected; Santa Ana, 3,400,000 kilowatt-hours, with 8,209 kilowatts connected; Santa Monica, 2,520,000 kilowatt-hours, with 6,995 kilowatts connected; and Vernon, 2,423,000 kilowatt-hours, with 4,033 kilowatts connected. Under lighting was reported 394,000 kilowatt-hours used by the company.

The relative amounts of energy sold for lighting and for power by the Edison company prior to 1913 were:

TABLE 113.—*Sales of energy for light and power, Southern California Edison Co., 1908–1912.*

Year.	Light.	Power.	Total.
	Kilowatt-hours.	*Kilowatt-hours.*	*Kilowatt-hours.*
1908	18,175,437	57,135,563	75,311,000
1909	20,973,363	76,204,870	97,178,233
1910	22,896,720	114,588,285	137,485,005
1911	27,361,906	122,088,826	149,450,732
1912	31,948,773	161,438,178	193,386,951

The largest deliveries of energy for municipal power were in Long Beach district, 3,411,000 kilowatt-hours with 828 kilowatts connected; Santa Monica, 2,768,000 kilowatt-hours with 770 kilowatts connected; Monrovia, 2,067,000 kilowatt-hours with 622 kilowatts connected; Redlands, 1,457,000 kilowatt-hours with 1,175 kilowatts connected; and San Bernardino, 1,220,000 kilowatt-hours with 578 kilowatts connected.

Under sales of commercial power, the company grouped both industrial and agricultural uses but segregated connected load to industrial, agricultural, and "other." The largest deliveries were on wholesale contracts, 53,657,000 kilowatt-hours with 10,968 kilowatts industrial connected; Santa Ana, 28,362,000 kilowatt-hours with 17,515 kilowatts agricultural, 3,418 kilowatts industrial, and 1,984 kilowatts "other" power connected; Vernon, 26,942,000 kilowatt-hours with 13,764 kilowatts industrial, 2,876 agricultural, and 394 kilowatts "other" power connected; Redondo 22,894,000 kilowatt-hours with 7,839 kilowatts industrial, 3,209 kilowatts agricultural, and 853 kilowatts "other" power connected; Porterville, 20,455,000 kilowatt-hours with 984 kilowatts industrial, 11,262 kilowatts agricultural, and 1,498 kilowatts "other" power connected; and Pomona, 17,220,000 kilowatt-hours with 1,456 kilowatts industrial, 11,719 kilowatts agricultural and 1,452 kilowatts "other" power connected. Company uses of power aggregated 509,000 kilowatt-hours.

Pumping water for irrigation is one of the most important loads on the company's system, forming about 26 per cent of the connected load for retail power. Although power for agricultural pumping is sold in every district, 80 per cent of the total connected irrigation load is in the territory surrounding the cities of San Bernardino, Santa Ana, Redlands, Monrovia, Fullerton, Pomona, and Whittier, in southern California, and Delano, Lindsay, Tulare, Porterville, and Visalia, in the San Joaquin Valley territory, acquired with the Mount Whitney Power & Electric system.

The principal crops raised in the southern California district are citrus fruits, and in the San Joaquin Valley district citrus fruits and alfalfa. The company estimates that the total irrigated area is about 600,000 acres and is being constantly increased. The normal pumping season starts April 1 and ends October 31, and during the height of this season many pumping plants operate continuously day and night and produce a very marked effect on the monthly load factor of the entire system. For example, during 1921 the load factor for the system for January was 55 per cent, and those for July and August were 74 and 76 per cent respectively. The annual load factor for 1920 was 58 per cent.

The very heavy railway load on the system is shown by wholesale deliveries in 1918 (chiefly to Pacific Electric Railway and Los Angeles Railway Corporation) of 267,277,000 kilowatt-hours, with 71,243 kilowatts connected. The remaining railway loads were in Redlands district, 840,000 kilowatt-hours, with 438 kilowatts connected; Pasadena, 405,000 kilowatt-hours, with 694 kilowatts connected; while in San Bernardino no sales were reported but 736 kilowatts were given as connected.[16] During 1920 sales to electric railways (principally to Los Angeles Railway and Pacific Electric Railway) amounted to 276,046,000 kilowatt-hours, or 34 per cent of the total output of all substations.

Wholesale deliveries to other electric corporations connected to the system[17] amounted in 1920 to 101,778,000 kilowatt-hours, with 36,816 kilowatts connected; in addition to which 9,494,000 kilowatt-hours were delivered to such corporations in Redlands district, 6,857,000 kilowatt-hours in the Van Nuys, 3,139,000 kilowatt-hours, with 373 kilowatts connected, in the Pomona district, 1,506,000 kilowatt-hours in Santa Ana district, and 961,000 kilowatt-hours in Monrovia. Wholesale deliveries for resale, principally to municipalities, for the year 1920 amounted to 125,000,000 kilowatt-hours, of which 87,000,000 was furnished to the city of Los Angeles.

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[16] The railway load of the Edison company before it absorbed Pacific Light & Power Corporation was relatively unimportant. The Edison company entered into a contract to furnish power to the Los Angeles Pacific Railway before the absorption of that company by the Pacific Electric Co. Under this contract the company could be called upon to furnish up to 9,333 horsepower; and under the terms of the contract the Vineyard steam plant, belonging to the railway, was operated by the Edison company from 1909 to 1913. The average railway load, 1910 to 1913, in kilowatts, was: 1910, 3,430; 1911, 3,380; 1912, 5,558; 1913, 5,535.

[17] In October, 1915, Pacific Light & Power Corporation began delivering power on a wholesale contract to Ventura County Power Co. The load was, however, of only minor importance, as will be seen by a glance at Table 110.

During the dry season of the summer of 1913 Pacific Light & Power Corporation began power deliveries to San Joaquin Light & Power Corporation through a roundabout transfer. This was accomplished by delivering power to Southern California Edison Co. in Los Angeles, in return for which Southern California Edison Co. connected one of the 5,000-kilovolt-ampere units of the Kern River plant to a line constructed up Kern Canyon from the plant of San Joaquin Light & Power Corporation. This unit was operated exclusively on the San Joaquin load and was speeded up to give 60 cycles per second, although the machine was originally designed for the 50 cycles in use on the Southern California Edison system. Direct delivery of power to the San Joaquin Corporation from its Big Creek system would have necessitated construction of new lines to the Big Creek plants or the installation of expensive transformer equipment for reducing the 104,000 volts potential on the Big Creek lines to 60,000 volts on the San Joaquin lines.

During 1918 and 1919 Southern California Edison Co. again furnished power to San Joaquin Light & Power Corporation and also made deliveries to Mount Whitney Power & Electric Co., which had not then been purchased. This power was delivered by operating a portion of one of the 150,000-volt Big Creek lines at 60,000 volts, energized by one or more of the units at Kern River No. 1 power house or by a single unit at Big Creek No. 1 power house running overspeed to deliver 60 cycles. When the Vestal substation was installed, connecting Kern River No. 3 with the Big Creek transmission line, provision was made for permanent connection for power exchange with the San Joaquin Light & Power system and with the Mount Whitney system, which had been purchased by Southern California Edison Co. This connection consists of 34,500 kilowatts of transformer capacity, with a ratio of 150,000/60,000 volts, and 13,500 kilowatts of capacity in frequency changers receiving 50-cycle and delivering 60-cycle alternating current.

Municipalities also purchased in 1920 for their own use for light and power 21,000,000 kilowatt-hours.

Total sales and connected load in 1920 showed the following distribution by most important districts: Wholesale deliveries totaled 431,481,000 kilowatt-hours, with 120,519 kilowatts connected; Santa Ana district, 34,445,000 kilowatt-hours with 32,406 kilowatts connected; Vernon district, 29,833,000 kilowatt-hours with 21,514 kilowatts connected; Redondo district, 25,980,000 kilowatt-hours with 16,403 kilowatts connected; Pomona district, 23,061,000 kilowatt-hours with 19,117 kilowatts connected; Redlands, 21,910,000 kilowatt-hours with 12,672 kilowatts connected; and Porterville, 21,577,000 kilowatt-hours with 16,733 kilowatts connected.

The following paragraphs relate to the Mount Whitney Power & Electric system. The figures refer to 1919 (the last full year it was operated independently) except as noted.

Lighting and domestic uses on the system consumed 5.1 per cent of the kilowatt-hours output and yielded 18.4 per cent of total electric revenues. The principal load centers for lighting and heating were Visalia, Porterville, and Tulare.

Power was supplied to the Visalia Electric Railway, which operates both freight and passenger service from Visalia and Exeter northeastward to Lemon Cove. The total capacity of the railway converting machinery is 1,080 horsepower; energy was delivered at the Exeter substation. The revenues from railway power amount to only 1.2 per cent of gross electric revenues for the system.

Pumping in the citrus belt extending along the foothills, from Lemon Cove at the north to McFarland at the south end of the Mount Whitney system, always consumed a large part of the total power output.

In the hearings before the Railroad Commission, in the general readjustment of rates during the last part of 1916, the company reported that of all the electric energy sold for power, 81.8 per cent was used for pumping water for irrigation; 4.3 per cent was used for domestic plants, most of which were on farms; 9.5 per cent for industrial, 2.1 per cent for railroad, and 2.3 per cent for miscellaneous power uses. About 86 per cent of all the electric energy sold for power was therefore used for pumping or in connection with agriculture.

In the same case [18] the company reported that irrigation plants which it supplied with power were irrigating 67,481 acres, planted to the following crops:

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[18] Railroad Commission of California, Decision No. 3242.

TABLE 114.—*Classification of crops irrigated by power from Mount Whitney system, 1915.*

Crop.	Acreage.	Per cent of total acreage.
Citrus orchards:		
Bearing	13.498	
Nonbearing	14,272	
	27,770	41.2
Olive orchards:		
Bearing	392	
Nonbearing	2,641	
	3,033	4.5
Alfalfa	28,891	42.8
Miscellaneous orchards	1,156	1.7
Peaches	1,155	1.7
Vineyards	1,018	1.5
Miscellaneous field crops	4,458	6.6
Total acreage	67,481	

The length of the irrigation season is usually seven months, during which time the ratio of the average demand to the rated capacity of motors is 94.3 per cent. The company's records show that the annual consumption per horsepower of installed capacity of motors is 3,595 kilowatt-hours for motors operating irrigating pumps. In connection with these figures the following table is of interest, as giving not only the number, horsepower, and agricultural load but also a means of comparing it with other classes of load on the system.

TABLE 115.—*Segregation of motors operated with power from Mount Whitney Power & Electric system.*

Class.	Number of motors.	Per cent of total number.	Total horsepower.	Per cent of total horsepower.
Agricultural	1,666	66.5	14,316	81.8
Domestic	495	19.8	758	4.3
Industrial	298	11.9	1,654	9.5
Railroad	2	....	375	2.1
Miscellaneous	44	1.8	397	2.3

The above table supplements Table 116, which gives classified or segregated loads on the system and may be used also in connection with Table 262 (Appendix A, which segregates earnings from various types of load.

Power generated and purchased, system peaks, and system load factors are given in Table 106. Connected load, number of electric consumers, and arc and incandescent lamps are given in Table 117. These tables show that in 1903 the average load generated on the system was 860 horsepower, the total connected load 1,587 horsepower, and number of consumers 710. At the end of 1919 these figures had increased to average system load 17,270 horsepower, total connected load 51,363 horsepower, and number of consumers 12,781.

TABLE 116.—*Sales and connected load, Mount Whitney Power & Electric Co., 1913–1920.*

Class of load.	1913				1914		
	Sales.		Connected load.		Sales (kilowatt-hours).	Connected load.	
	Amount.	Per cent of total.	Kilowatts.	Per cent of total.		Kilowatts.	Per cent of total.
Lighting:							
Residence	$41,795	7.5	1,847.9	13.7	491,488	1,942.8	12.9
Commercial	59,396	10.7	913.8	6.8	580,669	869.4	5.6
Municipal	12,878	2.3	91.0	.7	(b)	103.0	.8
All other	3,813	.7	162.0	1.2	59,447	200.5	1.4
Power:							
Industrial	25,289	4.5	724.4	5.4	(b)	1,143.7	7.6
Agricultural	322,501	58.0	7,631.0	56.5	(b)	8,310.6	55.2
All other	90,830	16.3	2,111.9	15.7	(b)	2,493.3	16.5
	556,502	100.0	[c] 13,482.0	100.0	1,131,604	[c] 15,063.2	100.0

Class of load.	1915			1916		
	Sales (kilowatt-hours).	Connected load.		Sales (kilowatt-hours).	Connected load.[a]	
		Kilowatts.	Per cent of total.		Kilowatts.	Per cent of total.
Lighting:						
Residence	553,907	2,394.1	12.7	960,661	2,592.8	12.8
Commercial	611,067	1,037.2	5.5	777,101	1,050.8	5.2
Municipal	(b)	115.3	.6	(b)	204.4	1.0
All other	71,596	262.0	1.4	91,866	266.0	1.3
Power:						
Industrial	2,132,776	1,458.2	7.8	1,770,210	2,280.8	11.2
Agricultural	4,780,893	10,506.1	56.0	4,628,384	11,011.2	54.3
All other	1,258,331	3,000.8	16.0	1,136,847	2,879.5	14.2
	9,408,570	[c] 18,773.7	100.0	9,095,069	20,285.5	100.0

[a] Connected load of Aug. 31, 1916, irregular season.

[b] Part or all of this class of load is flat rate for which there are no measurements or estimates of kilowatt-hours.

[c] In addition to total kilowatts reported, there was in 1913 Visalia Electric R. R., 325 horsepower, increased in 1914 to 900 kilowatts, in 1915 decreased to 805.7 kilowatts; also, in 1914, 542 kilowatts miscellaneous and unclassified, which is not included in the total.

NOTE.—No detailed figures for sales in kilowatt-hours for Tulare County Power Co. are available. As of Dec. 31, 1914 (8 months prior to its absorption by Mount Whitney Power & Electric Co.), the Tulare County Power Co. had a connected load of 3,318 kilowatts, of which 90 per cent was agricultural power.

TABLE 116.—*Sales and connected load, Mount Whitney Power & Electric Co., 1913–1920*—Continued.

Class of load.	1917		1918			
	Connected load.		Sales.		Connected load.	
	Kilowatts.	Per cent of total.	Kilowatt-hours).	Per cent of total.	Kilo-watts.	Per cent of total.
Lighting:						
Municipal—						
Street	[a] 150.34	0.6	558,000	0.80	142	0.4
Miscellaneous	93.57	....	57,000	.08	120	.4
Commercial—						
Business	1,587.10	6.8	2,304,000	3.25	5,202	17.1
Residence	2,872.47	11.4				
Power:						
Municipal	569.38	2.3	1,014,000	1.43	576	1.9
Commercial—						
Industrial	2,106.68	8.4	65,438,000	92.43	2,277	7.5
Agricultural	14,209.93	56.8			18,085	59.5
Other	2,593.06	10.4			3,104	10.3
Other electrical corporations	830.29	3.3	1,080,000	1.53	891	2.9
Used by company	....	....	[b] 318,000	.48	....	....
	25,012.82	100.0	70,769,000	100.00	30,397	100.0

Class of load.	1919				1920 (Jan. 1 to June 30).			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilo-watts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilo-watts.	Per cent of total
Lighting:								
Residence	(c)	....	(c)	(c)	(c)	....	(c)	....
Municipal	932,000	1.1	390	1.0	466,978	1.3	393	0.9
Commercial	[d] 3,394,000	4.0	7,620	19.9	2,183,300	6.3	8,035	18.3
Power:								
Industrial	[e] 79,752,000	92.3	3,781	9.9	29,913,543	86.0	3,807	8.6
Agricultural			21,035	54.9			25,128	57.2
Municipal	1,136,000	1.3	718	1.8	538,463	1.5	778	1.8
Railway	1,144,000	1.3	891	2.3	577,385	1.7	910	2.1
Other	....	....	3,896	10.2	1,112,330	3.2	4,867	11.1
	86,358,000	100.0	38,331	100.0	34,791,999	100.0	43,918	100.0

[a] Kilowatt of motors given as of Aug. 31, 1917, when maximum load is connected due to seasonal contracts. All other data as of Dec. 31, 1917.

[b] Includes 89,000 kilowatt-hours of lighting and 229,000 kilowatt-hours of power used by company.

[c] Included with "Commercial."

[d] Includes 68,000 kilowatt-hours used by company.

[e] Includes 114,000 kilowatt-hours used by company.

NOTE.—Sales in kilowatt-hours not reported for 1917.

TABLE 117.—*Growth of load on lines of Mount Whitney Power & Electric Co., 1900–1919.*

Year.	Number of consumers.	Number of street lamps.		Connected load.
		Arc.	Incandescent.	
				Kilowatts.
1900	....	....	....	750
1901	....	....	....	870
1902	....	....	....	1,150
1903	710	....	....	1,587
1904	820	....	....	1,917
1905	990	....	....	2,388
1906	1,297	58	53	2,657
1907	1,438	57	40	3,325
1908	2,056	59	58	4,731
1909	2,850	61	62	6,136
1910	3,367	65	96	8,353
1911	3,886	68	81	10,458
1912	4,464	107	89	12,982
1913	5,851	120	92	18,066
1914	5,811	156	108	20,918
1915	7,124	169	165	26,250
1916	7,356	175	294	27,200
1917	9,241	....	....	33,516
1918	9,228	....	....	40,732
1919	12,781	....	....	51,382

The mean monthly loads on the system, reduced from kilowatt-hours output of hydroelectric and steam-electric plants, and power purchased 1901 to June 30, 1920, are shown graphically in Plate LI (p. 564), which shows not only the power delivered to consumers but also that lost in the transmission and distribution systems. Monthly load factors prior to 1913 are not available. Figure 32 shows output of Tulare County Power Co. for the years 1913 to 1915, computed from the power purchased from San Joaquin Light & Power Corporation at Strathmore substation and the output of Tulare steam plant.

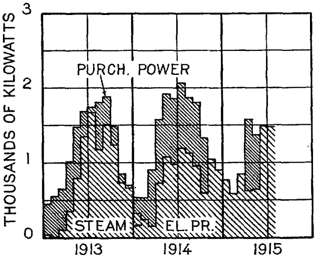


FIGURE 32.—Tulare County Power Co., mean monthly loads from 1913 to date of absorption by Mount Whitney Power & Electric Co.

Mean monthly loads in Plate LI show that the winter demand for power is but a fraction of that during the irrigation season in midsummer. The financial salvation of the company lay in the fact that the maximum demand for power coincides to a considerable extent with the maximum supply of water in Kaweah and Tule rivers, used in operation of the hydroelectric plants. It was therefore necessary to generate a comparatively small part of the total output at the company's steam plants. Most of the steam power was generated, as is indicated by the monthly mean load diagrams during the last part of the summer. Had the Mount Whitney company been able to complete its proposed Wolverton reservoir in Kaweah basin, it would probably have been able to dispense almost entirely with the operation of its steam plant. Power shown as purchased during the latter part of 1915 was received from the San Joaquin Light & Power Corporation on the contract assumed with the system of Tulare County Power Co.

Daily load curves for Mount Whitney Power & Electric system are presented in figure 33. The daily load factors are extremely high, ranging from 71.5 to 94.6 per cent, but on account of extreme seasonal variation in the loads the annual load factors are much smaller, being in the neighborhood of 55 per cent.

ELECTRIC SYSTEM.

ORDER OF PRESENTATION.

For convenience in description the electric system of Southern California Edison Co. may be divided into seven sections: (1) The hydroelectric plants in the San Bernardino and San Gabriel mountains east of Los Angeles, comprising the plants on Santa Ana River (known as Santa Ana Nos. 1, 2, and 3), the plants on Mill Creek (known as Mill Creek Nos. 3, 2, and 1), the plants on Lytle Creek (known as Lytle Creek and Fontana), the Sierra plant on San Antonio Creek, and the Azusa plant on SanGabriel River; (2) the plants on Kern River, including Borel and Kern River Nos. 1 and 3; (3) the plants in the San Joaquin basin (known as Big Creek plants Nos. 1, 2, and 8); (4) the plants on Kaweah River, including Kaweah plants 3, 2, and 1; (5) the plant on Tule River; (6) the steam-electric stations, including Long Beach, Los Angeles No. 3, and Redondo and Oxnard; and (7) the transmission and distribution system.

SANTA ANA RIVER PLANTS.

SOURCE OF WATER SUPPLY.

The part of the Santa Ana River basin contributing water used in operating Santa Ana plants Nos. 1 and 2 and the Mentone plant is a roughly rectangular area, 166 square miles in extent, in the San Bernardino Mountains northeast of Redlands, in San Bernardino County (Pl. LV, p. 592). From its source Santa Ana River flows westward, and at the point of diversion for Santa Ana No. 1 it is joined by Bear Creek, its principal tributary. Bear Creek rises northwest of Sugarloaf Mountain at an elevation of 8,000 feet and flows northwesterly and westerly through Bear Valley, parallel to Santa Ana Canyon, but below Bear Valley dam the stream turns and flows nearly due south to its junction with the main river. On the north border of Bear Valley the ridges rise to elevations ranging from 6,500

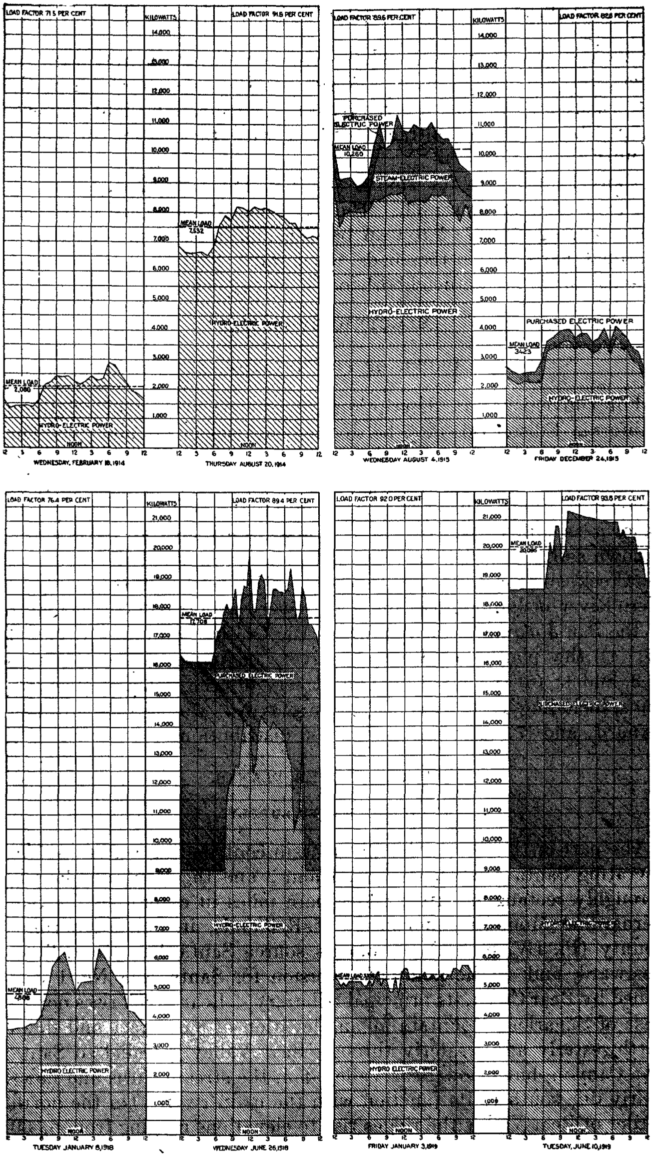
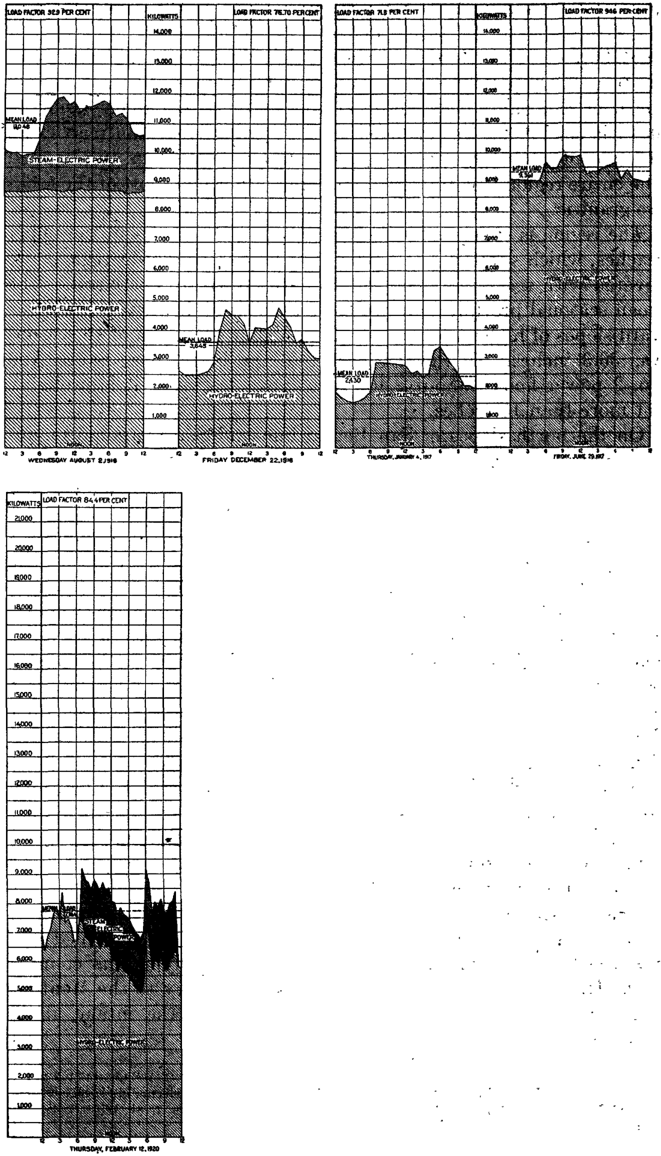


FIGURE 33.—Southern California Edison Co. (Mount Whitney



Power & Electric system), daily load curves, 1914-1920.

to 8,000 feet. On the ridge between the two streams the elevations are from 7,000 to 9,000 feet. The highest mountains in the basin are south of the Santa Ana, most of the southern boundary rising to elevations of 9,000 feet or more; San Gorgonio Mountain reaches an altitude of 11,485 feet and San Bernardino Mountain 10,630 feet. The entire region is very rugged and precipitous and most of the rocks are granitic.

The region is sparsely forested except in a few places in the upper reaches, which support a fair growth of pine. The lower regions are covered with scattered trees and a dense growth of chaparral. The mean seasonal precipitation probably exceeds 40 inches on the westward slopes of highest peaks. In Bear Valley the mean of 16 seasons was 33.3 inches. In the lower part of the basin, near Santa Ana No. 2 power house, about 2,400 feet above sea level, it is probably not more than 15 inches.

On the north slopes of San Bernardino and San Gorgonio mountains very small patches of snow sometimes remain throughout the year, but during the later summer months so little is left that its influence on the stream flow [19] is probably not appreciable.

The area tributary to the head of Santa Ana No. 1 canal comprises 145 square miles and the elevation of the intake is 3,517 feet. The area tributary to Santa Ana No. 2 canal contains in addition the area along Santa Ana Canyon between No. 1 intake and No. 1 power house. A supplementary supply was originally brought into the No. 2 conduit through siphons from intakes on Alder and Keller creeks, tributaries to the opposite side of the Santa Ana. Both of these siphons were washed out, however, in or prior to 1911, and the Alder Creek siphon has never been rebuilt. In 1919 a new intake was constructed on Keller Creek, and the water was diverted through a gravity line of 8-inch galvanized pipe approximately 1,170 feet long into the tailrace of Santa Ana No. 1 plant, thus making the supply available for diversion directly into the No. 2 main intake. The approximate elevation of its intake is 2,750 feet. At Santa Ana No. 2 power house the water is again diverted, through the head of the old Santa Ana canal to the Mentone power house at the mouth of main Santa Ana Canyon, and then passes across the river bed and into the head of high-line irrigation ditches supplying the country about Highlands. The total area of basin tributary to the Mentone plant is 166 square miles and the elevation of the intake about 2,250 feet.

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[19] For records of discharge of this part of Santa Ana River see U. S. Geol. Survey Water-Supply papers as follows: 300, pp. 550-580, 639 (up to June 30, 1912); 331, pp. 53-58 (1911-12); 361, pp. 76-81 (1912-13); 391, pp. 71-82, 325 (1913-14); 411, pp. 92-97 (1914-15); 441, pp. 60-66 (1915-16); 461, pp. 37-41 (1916-17); 481, pp. 36-41 (1917-18).

RESERVOIR.

The only artificial storage in the Santa Ana basin is that provided by Bear Valley reservoir, the use of which for power development is only incidental to its use for irrigation. The reservoir is in the lower end of Bear Valley (from which it takes its name) and was noteworthy on account of the bold design of its dam—a single arch with a very light section, built in 1884.

In 1910 and 1911 the water level in the reservoir was raised to a maximum of 19 feet over the old level by a multiple-arch dam [20] which was built in the canyon below the old dam.

The area of the old reservoir was 1,859 acres and its capacity 26,463 acre-feet, with a maximum depth of 53 feet. The new reservoir has an area of 3,005 acres, a capacity of 72,000 acre-feet, and a maximum depth of 72 feet. The stored waters are liberated to supply the needs of the citrus groves in the east end of San Bernardino Valley, and on their way to the heading of the irrigation canal pass successively through Santa Ana No. 1, Santa Ana No. 2, and Santa Ana No. 3 (Mentone) power plants.

SANTA ANA PLANT NO. 1.

Location.—The power house for Santa Ana No. 1 plant is in sec. 26, T. 1 N., R. 2 W.

Construction was begun by Southern California Power Co., but before the work was completed the plant passed into the hands of Edison Electric Co. of Los Angeles. The transmission from the power house to Los Angeles was begun in December, 1898. Its entire length of 82 miles was at the time exceptional.

Conduit.—The conduit for the Santa Ana No. 1 has two intakes, both in sec. 19, T. 1 N., R. 1 W., one on Bear Creek and the other on Santa Ana River just above the junction of these two streams, at an elevation of about 3,517 feet above sea level. The conduit follows down the north and northwest sides of Santa Ana River traversing secs. 23, 24, 25, and 26, T. 1 N., R. 2 W., from the Bear Creek dam, and therefore the water diverted from the Santa Ana is brought through the point between the two streams and emptied into the pond above the Bear Creek dam.

About November, 1912, the company replaced the old wooden sand box which was between tunnels Nos. 3 and 4 with a concrete structure forming a dam across the canyon in which the old sand box was built, thus making a small receiving chamber that serves as a sand box. The dam is provided with four sluice gates and six overfall weirs.

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[20] Designed by Mr. John S. Eastwood, under whose supervision it was constructed.

The entire conduit consists of flumes and tunnels, the lengths of which, from measurements made early in 1912, are given in the following table:

TABLE 118.—*Tunnels and flumes on conduit of Santa Ana plant No. 1.*

Tunnels.			Flume between tunnels.	
No.	Length.	Concrete lining.	No.	Length.
	Feet.			*Feet.*
			Dam and No. 1	[a] 400
1	246.0	Floor only part concrete	1 and 2-3	177.70
2-3	1,139.8			
4	488.3	Whole section	2-3 and 4	86.1
5-6	885.7	do	4 and 5-6	965.8
7	885.7	do	5-6 and 7	124.4
8	2,073.7	do	7 and 8	75.1
9	785.0	do	8 and 9	127.7
10	835.4	do	9 and 10	95.6
11	588.5	do	10 and 11	46.8
12	790.5	do	11 and 12	194.4
13	190.9	do	12 and 13	293.3
14	507.9	do	13 and 14	60.7
15	212.8	do	14 and 15	53.3
16	730.2	do	15 and 16	107.5
17	555.6	do	16 and 17	115.3
18 or forebay [b]	849.0	do	17 and 18	173.9
	11,765.0			2,697.6

[a] Estimated.

[b] 107 feet of abandoned tunnel at lower end of No. 18. The length given for tunnel No. 18 (or forebay) s to the beginning of the pressure pipe.

The tunnels are 5 feet wide by 6.5 feet high and the flumes are 5 feet high by 5.5 feet wide. The elevation at the headworks is 3,517 feet, that at the forebay 3,491 feet, and the grade 9.5 feet per mile. The carrying capacity is 120 second-feet.

Originally the plant had a small forebay reservoir, but this was destroyed by a landslide or slip, and at present the only forebay is the lower end of tunnel 18.

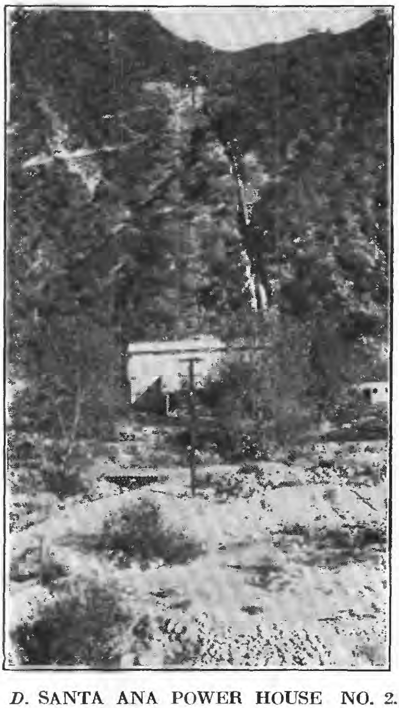
From a point near the lower end of tunnel 18 a 44-inch pipe, three-sixteenths of an inch thick, extends a distance of 851 feet to the old forebay site at which point the 44-inch pipe is joined by a Y to two 30-inch pressure pipes that lead down the hill to the power house, a total distance of 2,262 feet. These pressure pipes, which are of steel, are No. 10 (British wire gage) at the top, and nine-sixteenths of an inch thick at the bottom, and terminate in a $\frac{9}{16}$-inch lap-welded steel header 30 inches in diameter, from which the supply lines are led to the water wheels. The pressure pipe is laid in a trench and covered with earth. From the header the water is distributed by branch pipes to the wheels. Each branch tapers from 10 inches in diameter at the header to 6 inches at the nozzle connection. The static head at the power house, which is about 2,765 feet above sea level, is 726 feet.

Power house.—The power house (Pl. LIII, *C*) is a concrete building 36 feet 6 inches wide by 126 feet long, with a corrugated-iron roof

A. AZUSA POWER HOUSE.

B. MENTONE POWER HOUSE.

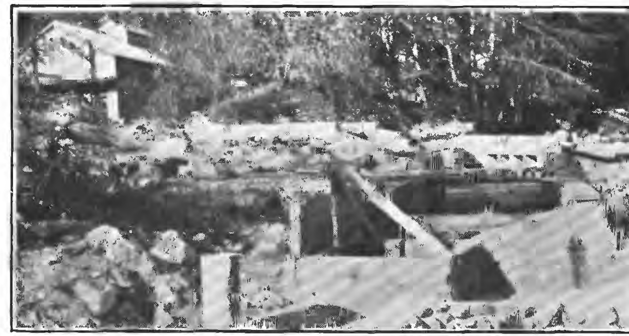
C. SANTA ANA POWER HOUSE NO. 1.



D. SANTA ANA POWER HOUSE NO. 2.

HYDROELECTRIC SYSTEM OF SOUTHERN CALIFORNIA EDISON CO.

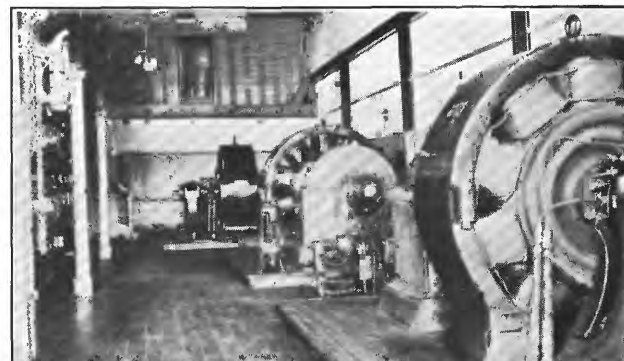
A. OLD POMONA PLANT, THE FIRST LONG-DISTANCE HYDROELECTRIC TRANSMISSION PLANT IN CALIFORNIA.



B. SIERRA POWER HOUSE AND INTAKE OF ONTARIO PLANT NO. 1.

Showing the close succession in developments typical on streams in southern California.

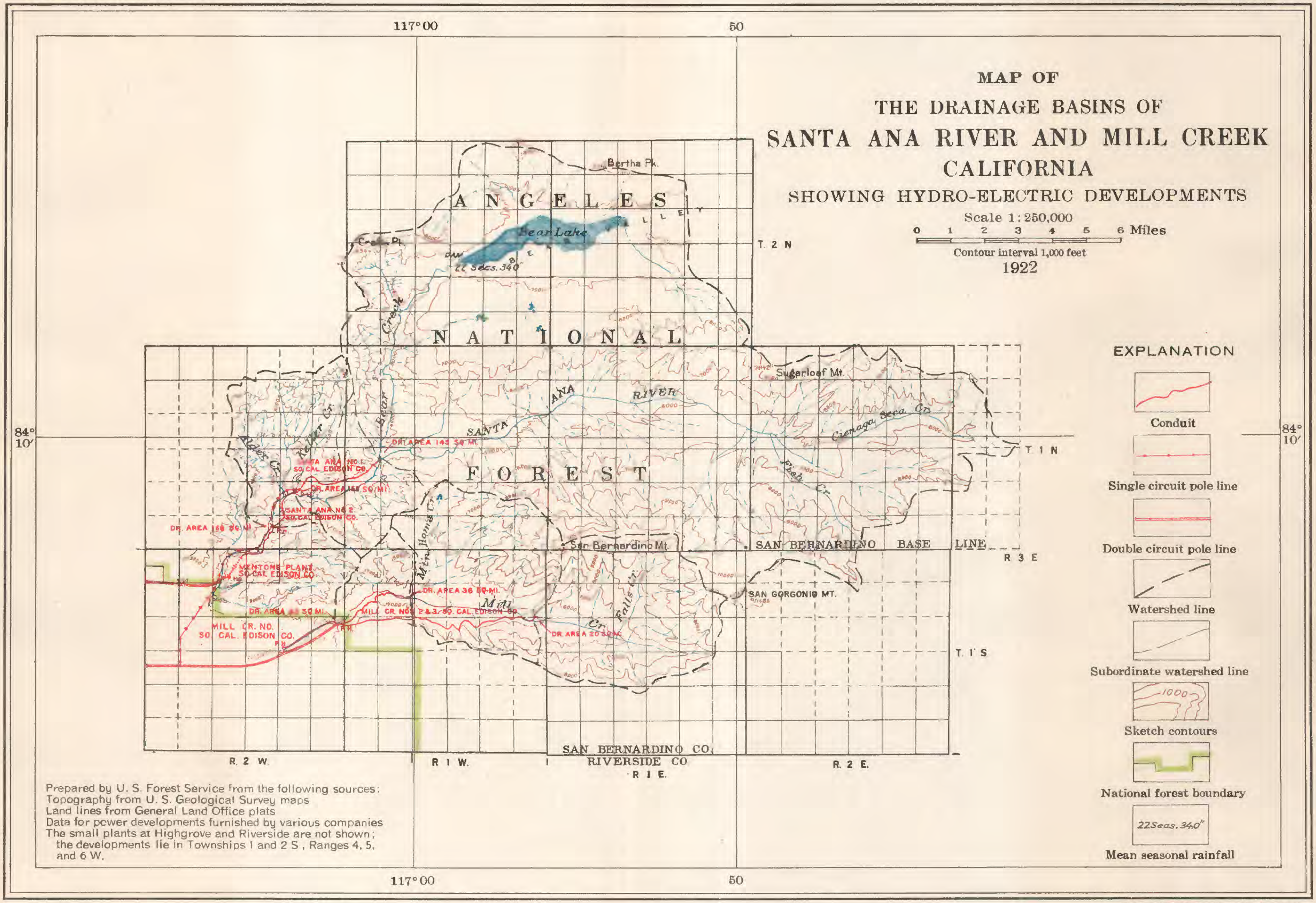
C. RECEIVER AND MANIFOLD, AZUSA POWER HOUSE.

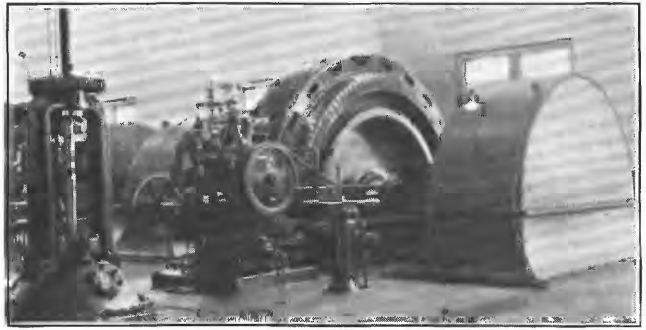


D. GENERATOR ROOM, MILL CREEK POWER HOUSE NO. 1.

The three generators shown, the first polyphase machines for high-tension transmission, were installed in 1893 and are still in use.

HYDROELECTRIC SYSTEM OF SOUTHERN CALIFORNIA EDISON CO.


MAP OF
THE DRAINAGE BASINS OF
SANTA ANA RIVER AND MILL CREEK
CALIFORNIA
SHOWING HYDRO-ELECTRIC DEVELOPMENTS
Scale 1:250,000
0 1 2 3 4 5 6 Miles
Contour interval 1,000 feet
1922
117°00
50
84°10′
ANGELES NATIONAL FOREST
Bear Lake
22 Secs. 340
Bertha Pk.
Sugarloaf Mt.
SANTA ANA RIVER
Cienaga Seca Cr.
Fish Cr.
Bear Creek
Keller Cr.
Alder Cr.
Mill Cr.
Falls Cr.
San Bernardino Mt.
SAN BERNARDINO BASE LINE
SAN GORGONIO MT.
DR. AREA 145 SQ. MI.
SANTA ANA NO. 1 SO. CAL. EDISON CO.
SANTA ANA NO. 2 SO. CAL. EDISON CO.
MENTONE PLANT SO. CAL. EDISON CO.
DR. AREA 36 SQ. MI.
MILL CR. NOS. 2 & 3 SO. CAL. EDISON CO.
MILL CR. NO. SO. CAL. EDISON CO.
DR. AREA 20 SQ. MI.
T. 2 N
T. 1 N
T. 1 S
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E
SAN BERNARDINO CO.
RIVERSIDE CO.
EXPLANATION
Conduit
Single circuit pole line
Double circuit pole line
Watershed line
Subordinate watershed line
Sketch contours
National forest boundary
22 Seas. 34.0″
Mean seasonal rainfall
Prepared by U. S. Forest Service from the following sources:
Topography from U. S. Geological Survey maps
Land lines from General Land Office plats
Data for power developments furnished by various companies
The small plants at Highgrove and Riverside are not shown; the developments lie in Townships 1 and 2 S., Ranges 4, 5, and 6 W.
ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

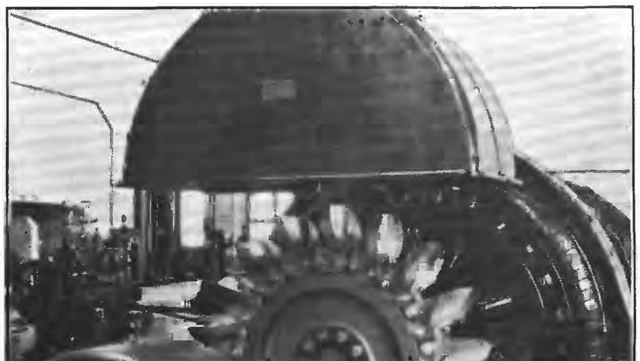


A. 5,000-KILOVOLT-AMPERE UNIT, KERN RIVER POWER HOUSE NO. 1.

Showing gate valves, governor, and double overhung impulse wheel.

B. FOREBAY, KERN RIVER PLANT NO. 1.

Last tunnel discharges into forebay in lower left corner of view. Photograph by H. W. Dennis.



C. IMPULSE WHEEL, KERN RIVER POWER HOUSE NO. 1.

Wheel housing lifted to show buckets of impulse wheel. Photograph by L. A. Schuetze.

D. INTERIOR OF SANTA ANA POWER HOUSE NO. 1.

Showing original switchboard.

HYDROELECTRIC SYSTEM OF SOUTHERN CALIFORNIA EDISON CO.

supported on steel trusses. The walls are not reinforced. The runway for the 20-ton crane is carried on steel supports that are set out from the wall on one side and on a ledge on the wall at the other side of the generator room. The runways are 26 feet 6 inches apart. The building houses four units that are arranged with their shafts parallel to its long axis close to its back wall.

From the header at the back of the building the supply pipe for each wheel is carried through the back wall under the floor to a needle nozzle operating the single impulse wheel of each unit. After leaving the wheel the water is discharged against a double baffle plate placed in a long narrow wasteway running in the direction of the stream. These plates are so arranged that the first deflects the stream through nearly 90° down against the other, which in turn deflects it through the same angle in the opposite direction, to flow away in the bottom of the channel. The four waste tunnels tail into a single channel which cuts across their ends parallel to the lower side of the power house and about 30 feet from it. From this cross-channel the water flows through a short canal into the inlet chamber at the head of the siphon passing under the river to Santa Ana No. 2 conduit.

Hydraulic equipment.—Three of the four 1,000-horsepower impulse wheels are of Pelton manufacture, with 21 buckets each and a $4\frac{13}{16}$-inch needle nozzle. The fourth is a Doble wheel with 21 buckets and a 5-inch needle nozzle. Each unit is governed by a Lombard governor, type F. The wheels have a pitch diameter of 74 inches.

Generators.—The station is equipped with four General Electric 750-kilovolt-ampere 20-pole revolving-field generators (Pl. LVI, *D*) designed to operate at 300 revolutions per minute and produce 3-phase 50-cycle alternating current at 750 volts. The shafts are supported in ring-lubricated bearings, one at each end and one between the field and the impulse-wheel housing. The bearings rest on and are bolted to the cast bed of the unit.

Exciters.—Excitation is furnished by three General Electric 30-kilowatt 4-pole 125-volt continuous-current generators, each driven by a 75-horsepower Pelton wheel.

Transformers.—The current is stepped up from the 750 volts potential of the generators to 33,000-line voltage by means of two banks of transformers. Each bank consists of three General Electric single-phase water-cooled 50-cycle 500-kilowatt transformers.

Wiring.—The original layout which, when completed, was considered first class, was reconstructed in 1914, by installing new switchboard, oil switches, and wiring. The switchboard contains sixteen 24 by 48 inch panels, consisting of 4 generator panels, 4 field panels, 2 instrument panels, 1 station light-and-power panel, and 3 exciter panels, and contains also two 750-volt busses with a set of measuring instruments in each bus, so located as to measure power transmitted to the lines through the two banks of three 500-kilowatt single-phase transformers.

The generator leads, beginning at the generator, go through an automatic oil switch equipped with two current transformers and an ammeter to a dividing point which leads to either of the two busses through a set of selecting switches for each bus.

The transformers are connected delta on the low side and Y grounded neutral on the high (33,000 volts). The low side (750 volts) taps off of the bus in the same manner as the generator leads but passes through a nonautomatic oil switch to the transformers, each transformer circuit being equipped with an ammeter in one leg only and connected by means of a current transformer.

Each high-tension (33,000-volt) transformer circuit goes through an oil switch and then connects to a common point. From this point a single circuit leads out of the station and forms the transmission line. The 33,000-volt oil switches are all equipped with disconnecting switches on each side.

The line is protected with one General Electric aluminum-cell lightning arrester (outdoor type), which is just outside the lower side of the station.

SANTA ANA PLANT NO. 2.

Location.—The power house of Santa Ana No. 2 plant is in sec. 34, T. 1 N., R. 2 W. The conduit heads in sec. 26 and traverses secs. 26, 34, and 35, T. 1 N., R. 2 W. The plant was constructed entirely under The Edison Electric Co. and began operation May 20, 1905.

Conduit.—The conduit (Pl. LV) for Santa Ana No. 2 is supplied with water through the tailrace of Santa Ana No. 1. The discharge from the various units of the latter plant finally collects in a common channel and passes to a concrete-lined inlet chamber, 25 feet square by 5 feet 7¼ inches deep, on the bank of Santa Ana River. From this chamber the water is admitted to the main conduit line to Santa Ana No. 2 by a 40-inch steel siphon, about 433 feet long, which passes under the river bed to the opposite wall of the canyon and joins the main conduit at the sand box below tunnel No. 1. Tunnel No. 1 heads on the river just above Santa Ana No. 1 power house and is designed simply as an emergency intake to be used only when water must be admitted directly from the stream.

The sand box has two hoppers, 30 feet long by 9 feet wide, with bottoms sloping toward one end, so that the depth in each varies from 4 feet to 8 feet 6 inches.

Within the first half mile of the line two small branch siphons, each 10 inches in diameter, originally joined the conduit from streams on the opposite side of the river. The first, 895 feet long, was from Keller Creek and the second, 857 feet long, from Alder Creek. These siphons were destroyed by flood and were not replaced.

The total length of the main conduit (excluding Alder and Keller Creek feeders) supplying Santa Ana No. 2 plant is 8,560 feet, of which 433 feet at the head is in the 40-inch siphon and 201 feet in another siphon 44 inches in diameter, 7,571 feet is in 12 tunnels, and 265 feet is in one flume. The average grade of the conduit is 7.92 feet per mile.

The tunnels are concrete lined except in an unarched section 1,120 feet long, and measure 6.5 feet high to the crown of the arch, with a waterway 4 feet deep by 4.5 feet wide. The capacity of the conduit is 100 second-feet.

The small concrete-box forebay is furnished with sluice gates to aid in the removal of sediment. A wooden box waste-flume runs from it down to the side of the power house and empties into the tailrace.

A single lap-riveted pressure pipe 36 inches in diameter and 644 feet long serves the power house. The site is such as to offer an excellent alinement for the pipe—straight horizontally and with very slight bends in profile. At the power-house wall the pipe is provided with a 36-inch gate, and beyond this gate a curved Y, with branches 20 inches in diameter, laid under the floor, serves the two units; there is an additional gate valve in each branch of the Y within the power house. The main pipe line is buried. The static head obtained is 305 feet.

Power house.—Santa Ana No. 2 power house (Pl. LIII, *D*) is a concrete structure with a corrugated galvanized roof supported by steel trusses. The main building is 33 feet 3 inches wide by 64 feet 3 inches long, but on the side opposite the pressure main a projection 24 feet 8 inches long stands out 15 feet 2 inches from the side of the building and forms a bay in the side of the generator room. This bay contains the switchboard with most of the wiring behind it. The two units are set in the ends of the generator room with shafts at right angles to its long axis. The transformers are next to the front wall of the generator room on one side and the exciters in a similar position on the other side of the switchboard bay.

The pressure main enters under the floor of the building, at the center of the back, or side opposite the switchboard. The branches of the Y turn the streams through the full right angles in opposite direction so the discharges are toward the ends of the building.

Hydraulic equipment.—Each unit is operated by one 800-horsepower Doble impulse wheel, which is fitted with 18 buckets, and is 84 inches in diameter on the center line of buckets. The units are of the 3-bearing type, both impulse wheel and generator being between bearings which are supported on cast-iron bed plates. Water is delivered to each wheel through a single 7½-inch deflecting needle-nozzle regulated by a Lombard governor, type F. Either unit may be shut down by means of a hand-operated gate valve in its branch pipe just inside the outer wall of the building.

Generators.—The two generators are General Electric 500 kilovolt-ampere 34-pole revolving-field 750-volt 3-phase 50-cycle machines, operating at a speed of 176 revolutions per minute.

Exciters.—Excitation is provided by two General Electric 17-kilowatt 4-pole 40-horsepower 125-volt continuous-current generators, each driven by a Doble wheel regulated by a Replogle governor.

Transformers.—Six General Electric 175-kilowatt air-cooled 50-cycle single-phase transformers, form B 1, arranged in two banks, step the current up from 750 to 33,000 volts.

Wiring.—The switchboard is composed of one exciter, two generators, one main line, one transformer, and one local circuit panel. Above the 750-volt board is the 33,000-volt board with open-cell switch compartments.

There are single 750-volt and 33,000-volt busses, the latter being sectionized by air switches. The circuit from each generator is carried to a triple-pole oil switch which serves to connect the machine to the 750-volt bus. Similar switches connect each of the two transformer circuits to the 750-volt bus. A short branch line passing through an oil switch in the power house taps in on the main line from Santa Ana No. 1 plant to Los Angeles.

There are no lightning arresters.

Water level in No. 2 forebay and disconnection of generating equipment from line in case of short circuit or troubles of similar nature, either inside or outside the power house, are now controlled semiautomatically.

SANTA ANA PLANT No. 3.

Location.—The Santa Ana plant No. 3, which before its acquisition by Southern California Edison Co. was called the Mentone plant, was put into operation in September, 1904, by Mentone Power Co. and with other plants owned by Pacific Light & Power Corporation became the property of Southern California Edison Co. May 27, 1917.

The intake for the plant is in sec. 34, T. 1 N., R. 2 W.; the conduit traverses sec. 34, T. 1 N., R. 2 W., and secs. 3 and 4, T. 1 S., R. 2 W. The power house is in sec. 4, T. 1 S., R. 2 W.

Conduit.—The plant utilizes the upper part of the old Santa Ana irrigation canal, which diverts from the river at a point exactly opposite Santa Ana plant No. 2 at an elevation about 2,350 feet above sea level.

Water was originally diverted by a small dam, which was constructed partly of concrete and partly of boulders set in concrete and sunk in the bed of the stream, and which crossed the channel diagonally downstream from the north to the south bank. Just above the inlet on the south bank the dam was pierced by two sets of sluice gates that were used to clear the intake pool of sediment, and a short distance from the intake the conduit entered a U-shaped sand box which was provided with small timber inlet and outlet gates at the ends of the legs, and with four sluicing gates in the loop of the U, through which the sediment was shot into the stream bed. Changes in the channel formed such a mass of débris around this box that most of the sand had to be removed at two larger boxes just below tunnel No. 1. About 250 feet below the first sand box the tailrace of the Santa Ana No. 2 plant discharged into the conduit, which almost immediately passed into tunnel No. 1.

The diversion dam, sand box, and short length of canal above the head of tunnel No. 1, as well as a short length of conduit and one of the two sand boxes immediately below the tunnel, were washed out by a severe flood in January, 1916. A temporary dam of loose rocks and sand thrown across the stream bed about 40 feet below the remains of the original dam diverts the water for the plant into a shallow channel about 250 feet long, excavated in the river bed on the south side of the main channel. At the end of this channel there is a low dam of cobblestones laid in mortar, which turns the flow through a concrete gateway fitted with stop planks into a ditch about 175 feet long, 9 feet wide at the top, 5.5 feet wide at the bottom, and 4 feet deep, lined with cobblestones laid in mortar. At the lower end of this lined ditch there is an emergency spillway over the downstream side of the channel and an inclined trash rack through which the water flows into a wooden flume approximately 120 feet long that ends at the head of the first tunnel. The wooden flume has a semicircular bottom 6 feet in diameter with a 2-foot vertical rise above the semicircle at each side. Where the flume joins the tunnel there is a cylindrical steel screen across its channel. A semicircular steel flume about 100 feet long, roofed with plank and protected on the side toward the stream by a masonry wall about 6 feet high connects the tailrace outlet of Santa Ana No. 2 plant with the head of tunnel No. 1. Flow of water into the tunnel is controlled by two wooden gates raised vertically by racks and gears, one gate being at the tunnel portal and one just below the cylindrical screen in the wooden flume. The No. 1 tunnel now in use is not that which originally formed the head of the Santa Ana canal but is an old tunnel started by Mountain Power Co. to parallel the Santa Ana canal in contest for power rights of way on the stream. Since the two tunnels were practically at the same elevation and within a short distance of each other, the Pacific Light & Power Co. purchased from Southern California Edison Co. the old Mountain Power Co. tunnel, cleared it out, and put it in use to replace the old Mentone No. 1 tunnel after the flood of 1916.

The total length of the conduit is about 2.7 miles, and the line includes seven tunnels (below that at the intake), of approximately the following lengths: No. 2, 1,478 feet; No. 3, 270 feet; No. 4, 270 feet; No. 5, 90 feet; No. 6, 1,525 feet; No. 7, 1,695 feet; and No. 8, 115 feet. It also includes an inverted siphon about 551 feet long, which is made of two 52-inch pipes and which carries the conduit over the bed of a side stream. The capacity of this part of the Santa Ana canal was 240 second-feet, but only 80 second-feet is used by Mentone plant. The grade in the canal is approximately 10 feet per mile.

Pressure pipe.—A lap-riveted steel pressure pipe 40 inches in diameter leaves the main canal just where the latter begins to wind around the point at the mouth of Santa Ana Canyon and head toward Mill Creek. At this point there is a small concrete box forebay, and at the head of the short tunnel above the box there is an emergency spill which discharges down the mountain side back of the point above the power house into a concrete-lined ditch that comes around the base of the point and discharges into the tailrace. The pipe is buried for only a part of its length, the upper and lower ends being exposed. Its horizontal alinement is straight and in profile it descends very rapidly for slightly more than half of its length, and then at a more moderate rate until it reaches the power house. The total length of the pipe from forebay to power house is 696 feet and the static head is 352 feet.

Power house.—The power house (Pl. LIII, *B*) is a single monolithic concrete building 41 feet long by 31 feet wide on the outside, with a corrugated-iron roof supported on a steel frame and a small lean-to for transformers at its south end. Originally the transformers occupied an 8 by 14 foot compartment in the southeast corner of the ground floor of the main building, under the present switch gallery, but in 1911 they were moved to their present position. The generator room now occupies the entire interior of the power house. The main entrance is a large sliding door in the front wall of the power house at the southwest corner, and there is also a broad opening from the generator room to the transformer compartment and swinging doors opening outside from the latter.

The single unit is set parallel to and close to the front wall of the generator room to the left of the main doorway, with its wheel housing toward the center of the room. The exciters and governors are between the unit and the back wall of the building, so that the southwest end of the room, from the main doorway to the back wall is left free. The switchboard is against the back wall opposite the doorway, and the switches are in a gallery above it. The lightning arresters are mounted on a concrete footing outside the building, just back of the switchboard. Two 15,000-volt circuits leave the building through inclined tile-pipe outlets running from the switch gallery through the end wall of the power house, just above the transformer compartment.

Hydraulic equipment.—The pressure pipe enters the back of the building above the floor line, and after passing through a large gate valve branches to two stationary nozzles, each fitted with a hand-operated needle. In addition to the needle regulation, each stream is further controlled by a hood deflector operated by a Lombard governor, type B. The unit is of the three-bearing type, with both impulse-wheel rotors covered by a single hood and carried between bearings. The rated capacity of the two is 2,600 horsepower. Each rotor is fitted with 16 buckets and measures 54 inches in diameter on the center line of buckets. The rotors are mounted upon the same shaft with the revolving field of the generator.

Generator.—The single generator is a Westinghouse revolving-field 1,500-kilovolt-ampere 2,200-volt 2-phase 50-cycle alternating-current machine, operating at 300 revolutions per minute.

Exciters.—There are two exciter sets. The first set to which a Doble impulse wheel is attached consists of a Westinghouse 22.5-kilowatt 125-volt 180-ampere direct-current generator, operating at 975 revolutions per minute, and a Westinghouse CCL 40-horsepower 2,200-volt 78-ampere 2-phase 50-cycle induction motor. The second exciter is a direct-current generator arranged to be belted to the main generator shaft instead of being run by a separate motor or by an impulse wheel; it is a General Electric 65-kilowatt 4-pole 125-volt 520-ampere continuous-current generator, type MP, operating at 875 revolutions per minute.

Transformers.—The two Stanley SKC 3,000 shell type 750-kilowatt 2,000/17,500-volt water-cooled transformers originally installed are still in use.

Wiring.—The generator is connected to the transformers through air disconnecting switches. Transformation is made from 2-phase to 3-phase alternating current by the Scott system of wiring. On the 15,000-volt side the transformers may be connected to either the north or the south line busses through single-phase oil switches. The two outgoing lines are connected to their respective busses through oil switches, but with the present system of wiring can not be thrown from one bus to the other. The change of output from the north to the south bus, therefore, has to be made by the transformer switches. The station transmits at 15,000 volts over a double circuit line running westward through San Bernardino Valley and tying into the main line at the North Ontario substation.

MILL CREEK PLANTS.

SOURCE OF WATER SUPPLY.

Mill Creek, one of the principal tributaries of Santa Ana River, joins that stream through a broad wash northeast of Redlands. The course of the stream above the mouth of the main canyon is very nearly due west. The part of the basin (Pl. LV) that contributes the water used in power development is about 4 miles broad north and south by 9 miles long, and is directly south of the headwaters of the Santa Ana, from which it is separated by San Bernardino and San Gorgonio mountains and the high ridge between and west of them. The water is used by three power plants, but development progressed upstream instead of down as on Santa Ana River. Mill Creek No. 1 plant, since the extension of its conduit, diverts its supply at the mouth of the main canyon, where the stream flows out over the broad débris fan between the Crafton Hills and the foot of the San Bernardino Mountains. On the south side of the mouth of the canyon, directly opposite No. 1 intake, stands the power house for plants Nos. 2 and 3. The conduit for No. 2 heads about 3 miles farther up the canyon and that for No. 3 somewhat more than 2 miles above headworks of No. 2.

The elevation at the mouth of the canyon is about 3,000 feet, and the area of the basin above that point is 43 square miles. Of this area 38 square miles is above the intake of Mill Creek No. 2, which is 3,650 feet above sea level, and 20 square miles is above Mill Creek No. 3 intake, which is about 5,000 feet above sea level. Elevations within the area above the plants range from 3,000 feet at the lowest intake to 11,485 feet at the crest of San Gorgonio Mountain, to 10,630 feet at the crest of San Bernardino Mountain, and to 10,000 feet or more along nearly all the 5 miles of ridge separating the two peaks. At no point along the boundaries of the upper half of the basin is the elevation less than 8,300 feet.

Some of the higher mountain ridges support a fair growth of pines, but by far the greater part of the region above the plants is covered only with brush or very scattering and scrubby trees. Most of the rugged ridges are barren and rocky, exposing the granite that forms the predominating rock of the region.

Record of precipitation are meager, but those available indicate that the mean seasonal rainfall in the part of the basin under consideration ranges from 15 inches in the lower altitudes to about 40 inches well up on the shoulders of the highest peaks. The flow in the last part of the dry season is derived largely from percolation from the upper regions, as no snow lingers on the south slopes of San Gorgonio and San Bernardino mountains.

There are no storage reservoirs on Mill Creek and therefore no means of augmenting the low flow.[21]

MILL CREEK PLANTS NOS. 2 AND 3.

Location.—The intake for Mill Creek plant No. 2 is in sec. 8, T. 1 S., R. 1 W., the conduit traverses secs. 8, 7, and 18 of the same township and sec. 13, T. 1 S., R. 2 W., and the combined Nos. 2 and 3 power house is in sec. 13, T. 1 S., R. 2 W.

The plant was begun October 24, 1898, by Redlands Electric Light & Power Co., completed September 1, 1899, and put into operation November, 1899. When Mill Creek No. 3 was built, Mill Creek No. 2 was deprived of part of the drainage area originally tributary to it (see p. 600), and has consequently become subordinate to the higher-head plant; it now contains only half the generator equipment installed when it was built.

The intake of Mill Creek No. 3 is in sec. 13, T. 1 S., R. 1 W. The conduit traverses secs. 13, 14, 15, 16, 17, and 18 of that township and sec. 13, T. 1 S., R. 2 W. The construction of the plant was begun by Edison Electric Co. of Los Angeles, the successor to Redlands Electric Light & Power Co., in the fall of 1899. Work was carried on slowly until July, 1901, and then more vigorously until March 18, 1903, when the plant went into operation.

Conduit of plant No. 3.—The intake dam of Mill Creek No. 3 plant is at an elevation of about 5,000 feet above sea level. The entire length of the conduit line from intake to forebay is very nearly 28,190 feet.

The dam is founded in the gravel of the stream bed and consists simply of a concrete wall crossing the stream diagonally and serving to deflect its flow toward the tunnel headgates on the north bank. Near the headgates the wall has an ogee section that forms a spillway. At the north end of the spillway water is admitted through a screen to a concrete headgate box, which is provided with a waste gate and with a headgate that admits the water through another screen to the head of the first tunnel of the conduit. All the gates at the head works are constructed of timber, slide in vertical grooves, and are operated by hand winches.

From the headgate the water drops into a tunnel that goes under a small point of rock putting out from the wall of the canyon and terminates in a flume, 125 feet long and 3 by 4 feet in section, which discharges into a concrete sand box 102 feet long by 52 feet wide, divided into eight sections, each 12½ by 52 feet, by seven transverse walls that cross the main box. The floor of each section is depressed

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[21] For discharge records for Mill Creek see U. S. Geol. Survey Water-Supply Papers as follows: 300, pp. 587-598 (up to December, 1911); 331, pp. 58-59 (1911-12); 361, pp. 82-83 (1912-13); 391, pp. 76-77 (1913-14); 411, pp. 97-98 (1914-15); 441, pp. 67-68 (1915-16); 202-203 (miscellaneous measurements); 461, pp. 42-43 (1916-17); 481, pp. 41-42 (1917-18). Most of these records are furnished by Southern California Edison Co.

along its long axis, and slopes 2½ feet in the first 10 feet and then at the rate of 5½ feet in 50 to the outer wall. These slopes are sufficient to discharge all collected sediment when the gates on the lower side of the compartments are opened. At its shallowest part, along the upper side wall, the box is 2½ feet deep; the deepest point of each section, along the lower side wall, is 9½ feet. All the transverse or section walls except the center one rise within 2½ feet of the top of the main walls; the center wall rises to the full height and is provided at the middle of its crest with a weir 10 feet long and 1 foot deep.

Except where five steel siphons cross branch canyons the entire line from the sandbox to the forebay consists of concrete pipe 3 inches in shell thickness and 31½ inches inside diameter laid on a hydraulic grade of 0.002 (2 feet per thousand). The aggregate length of the concrete pipes is 25,190 feet and the capacity is 20 second-feet.

The steel siphons in the line range in length from 116 to 2,151 feet, as shown by the following table:

TABLE 119.—*Dimensions of siphons in conduit of Mill Creek plant No. 3.*

Siphon No.	Length.	Diameter.	Thickness of plates.
	Feet.	*Inches.*	*No.*
1	848	30	12
2	339	22	14
3	116	30	12
4	153	30	12
5	2,151	22	14

Equal capacities for the different diameters of siphons are obtained by varying the heads. All the siphon pipes are carried in trenches and buried to a depth of several feet.

Part of the concrete pipe line is laid in trench and is covered, and the rest is carried in 3 by 6 feet tunnels which were driven through mountain spurs to improve the alinement. The following table shows the ranges in tunnel lengths:

TABLE 120.—*Lengths of tunnels on conduit of Mill Creek plant No. 3.*

Tunnel No.:	Feet.	Tunnel No.:	Feet.
1	263.89	11	501.85
2	546.22	12	910.02
3	171.70	13	228.80
4	328.19	14	420.35
5	98.82	15	185.45
6	379.58	16	151.12
7	388.63	17	1,068.35
8	183.39	18	135.80
9	142.37	19	256.17
10	603.16		

At the lower end of the last tunnel the conduit discharges into a forebay having a capacity of about 216,000 cubic feet. This equalizing reservoir is formed by a small earth dam, with concrete core wall, placed across a hollow. A box-flume spillway carries any surplus water from the reservoir down the hill toward the power house and into the flume leading to Mill Creek No. 2 forebay.

The pressure pipe is 8,120 feet long, from forebay to power house, and varies in diameter from 26 inches at the top of the main pipe to 24 inches where it first branches, and to a minimum of 13 inches where, after a second branching, the pipes reach their respective units. The upper end of the line 26 inches in diameter is constructed of No. 14 riveted steel; the lower end of the line is lap-welded pipe three-fourths of an inch thick and 24 inches in diameter. The branches to the four water wheels consist of 114 feet of 16¼-inch pipe five-eighths of an inch thick and 277 feet of 13-inch pipe one-half of an inch thick. The branches from the 24-inch to the two 16-inch and from each of these 16-inch to two 13-inch pipes are made through steel Y's. The lower, or lap-welded part of the line, has flanged unions. The faces of these flanges are planed and in them is cut a circular groove. In the groove is inserted a rubber gasket which gives tightness and which can not be blown out on account of the smooth surfaces of the adjoining flanges being drawn into close contact. Protection against water hammer in the line is provided by automatic blow-offs and by five air chambers distributed at various points down the mountain side. The material used in the entire pipe line is open-hearth box-annealed steel, with tensile strength of 60,000 pounds per square inch.

The pipe follows down the profile of the point at the south side of the mouth of Mill Creek canyon, making a long, gentle bend to the north. The profile is in general convex, with several breaks in grade. The total static head is 1,905 feet and is noteworthy as the next to the highest in the State, being exceeded only by that at Big Creek plant No. 1, which has a maximum static head of 2,131 feet.

Conduit of plant No. 2.—The intake dam of Mill Creek plant No. 2 lies at an elevation of about 3,650 feet, and the headgates closely resemble those of Mill Creek No. 3 (p. 601). As the intake was originally constructed water was admitted to the head of tunnel No. 1, which passed below the natural bed of the stream. This tunnel was timber lined, and, having caved in, was abandoned prior to 1906 and replaced by a wooden flume which in 1916 was replaced by concrete pipe. At the lower end of the line is a sand box, of the same design as that on Mill Creek No. 3 line (pp. 601-602), but measuring only 52 feet 2 inches by 22 feet. The box is divided into five compartments, each of which varies in depth between 5 and 8 feet.

The conduit consists of 11,334.2 feet of concrete pipe laid in trench and covered, 1,692.7 feet of concrete pipe laid through tunnels, 1,971.1 feet of wooden flume, 226.5 feet of open ditch, and a sand box 52.2 feet long, or a total of 15,276.7 feet. The wooden flumes measure 2 feet by 2 feet 6 inches inside. Both flumes and pipe are laid on a grade 0.002 and are designed to carry 10 second-feet.

The forebay is a small concrete box, measuring 18 by 8 feet in plan and varying between 5 and 10 feet in depth. A sliding gate admits water to the pressure line, which is a single 18-inch lap-riveted pipe; at its lower end it branches into two 13-inch pipes leading to the two generators and one 6-inch pipe feeding the exciters. The main pressure line from forebay to power house is 1,411 feet long and the static head developed is 627 feet. The general profile of the pressure line is very abrupt and the convex point of the hill which it follows gives an economical location.

Power house.—Mill Creek No. 2 power house was extended at the north end when Mill Creek No. 3 was built, and so, although the installations bear separate designations they are under the same roof.

The power house is a monolithic concrete structure 121 feet 8 inches long by 37 feet 8 inches wide, with a corrugated-iron roof carried on steel trusses. The older part of the building—that housing Mill Creek No. 2—was completed September 1, 1899, and the addition housing Mill Creek No. 3 on March 18, 1903.

The five units of the two installations (4 in No. 3 and 1 in No. 2) are placed in line parallel to the back of the building. On the opposite side, set out in the generator room and parallel to the wall, are the 750-volt and 33,000-volt switchboards. Back of the 33,000-volt board are the transformers. Directly across the room from Mill Creek No. 2 generator are the two exciter units. A hand-operated crane, spanning the room, runs on rails laid on a ledge in each side wall.

The branch pipe to each one of the five units enters directly through the rear wall of the building. There is no receiver, and the gate valve in each pipe is just outside the wall; the valve is operated from within the house by a handwheel working through a beveled gear. After leaving the wheel each stream is intercepted by double baffle plates and passes through its own tailrace to the main discharge channel, which runs about 30 feet from and parallel to the power house and which discharges through a long flume into the head of the conduit of Mill Creek plant No. 1.

Hydraulic equipment.—Each unit is operated by a single impulse wheel which is set between bearings and is run by a single jet controlled by a Lombard governor, type F. The wheels of the Mill Creek plant No. 2 and of the unit No. 1 of Mill Creek plant No. 3 are of Pelton and Nos. 2, 3, and 4 units Mill Creek plant No. 3 are of Doble design. The Mill Creek No. 2 wheel is 60 inches in diameter and is rated at 350 horsepower, and each of the Mill Creek No. 3

wheels is 84 inches in diameter and is rated at 1,300 horsepower. The Mill Creek No. 2 wheel carries 20 buckets and operates at 375 revolutions per minute. The Mill Creek No. 3 Pelton wheel carries 28 buckets, is 88 inches in diameter, and operates at 430 revolutions per minute. Each of the three Doble wheels carries 30 buckets, is 84 inches pitch diameter, and is operated at 430 revolutions per minute. Water is supplied to Mill Creek No. 2 wheel through a 3-inch nozzle, to the Pelton wheel in Mill Creek No. 3 through a $2\frac{3}{4}$-inch needle deflecting nozzle, and to each of the Doble wheels in Mill Creek No. 3 through a $2\frac{9}{16}$-inch deflecting needle nozzle.

Generators.—The one generator now left in Mill Creek No. 2 installation is a 250-kilovolt-ampere machine; each of the four in Mill Creek No. 3 is of 750-kilovolt-ampere capacity. The voltage of all these machines is 750, and all are of the revolving-field type, manufactured by General Electric Co. The Mill Creek No. 2 unit operates at 375 and the Mill Creek No. 3 units at 430 revolutions per minute. As in all the Southern California Edison stations, the alternating-current machinery is of 3-phase 50-cycle design. The main units of both plants are of the 3-bearing type—one bearing on each end of the shaft and one between the wheel housing and the generator, all resting on a cast-iron base to which they are bolted.

Exciters.—Excitation is furnished by two General Electric type MP 4-pole 30-kilowatt 125-volt continuous-current generators, each of which is driven by a 24-inch Pelton wheel operated by a single jet, fed through the branch from Mill Creek No. 2 pressure pipe.

Transformers.—The entire output of the combined power house is stepped up from the generator voltage of 750 to a line voltage of 33,000 by four General Electric 3-phase 50-cycle air-cooled transformers of 750-kilovolt-ampere capacity and three single-phase Westinghouse 335-kilovolt-ampere 50-cycle water-cooled transformers. The high-tension side of this equipment is Y-connected with grounded neutral.

Wiring.—Mill Creek Nos. 2 and 3 are wired as a single station. The switchboard contains four generator, two exciter, one output, and two transformer panels. The three leads from each generator are carried through expulsion fuses to three single-pole quick-break double-throw knife switches, by means of which each machine may be connected to either of the 750-volt generator busses. Each bank of the transformers may be connected to either of the 750-volt generator busses by sets of similar switches. From the 750-volt busses power for the transformer blowers is supplied through one bank of three 15-kilowatt transformers which also supplies station light and power.

The high-tension side of each bank of transformers connects to the 33,000-volt double-line bus through double-throw disconnecting switches. Each 33,000-volt bus is sectionized so that the two outgoing lines may be worked separately from either bank of transformers or in parallel. The 33,000-volt switches are above and at one end of the 750-volt bus and board. The high-tension wires are supported by insulators in the lower chord of the roof trusses, the two circuits pass out the side of building through General Electric K–22 oil switches of the outdoor type.

Each line is equipped with electrolytic lightning arresters manufactured by General Electric Co. A double 3-phase circuit of No. 4 copper wire runs from the power house past Mill Creek of No. 1 to the Redlands substation, about 10 miles distant.

MILL CREEK PLANT NO. 1.

Location.—The intake for Mill Creek plant No. 1 is in sec. 13; the conduit traverses secs. 13 and 14, and the power house is in sec. 14, T. 1 S., R. 2 W. The plant is distinguished as the first polyphase alternating-current station in California, and the second in the United States. It was put into operation by Redlands Electric Light & Power Co. September 7, 1893, and in its earlier years served Redlands, 7½ miles distant, over two 3-phase circuits operated at 2,400 volts. In 1896 the transmission was extended to Riverside and the potential raised to 10,000 volts. The potential is now 33,000 volts.

Conduit.—Mill Creek No. 1 plant diverts water at the mouth of the main canyon at an elevation about 3,000 feet above sea level. The waters discharged from plants Nos. 2 and 3 are combined with the supply diverted by a small dam that intercepts any additional water which may have entered the stream below the Mill Creek No. 2 headworks.

From the intake the supply line runs southwestward along the north bank of Mill Creek and terminates at the power house on the northwest side of the stream, about 2,500 feet above sea level. The entire conduit is composed of 30-inch lap-riveted steel pipe, working under pressure. As originally constructed the line was about 3,000 feet shorter than at present, but before plant No. 2 was built the line was extended to a total length of 10,415 feet, in order to gain additional head. The storm of January, 1916, made it necessary to relocate some parts of the line, which is now (1921) 10,715 feet long. The pipe is laid in a trench in the alluvial fan below the mouth of the main canyon and is buried for practically its entire length. The static head now developed is 510 feet.

There is no forebay reservoir at the intake dam. An equalizing reservoir below power house No. 1 receives the flow passing through the three plants, and by preventing fluctuation that might otherwise be caused by the unequal discharge of waters stored in the forebay of Mill Creek No. 3 maintains a constant flow in the irrigation canals below the power houses.

Power house.—The lower part of power house No. 1 is made of concrete, and is roofed with galvanized iron on wooden trusses; the upper part is a frame structure with rustic finish. The building contains three units, two of which are placed parallel to the back wall, and the other across the end of the generator room. (See Pl. LIV, *D*, p. 592.) On the side of the room opposite the first two generators is the switchboard, and in the frame addition at the upper end (and at an elevation slightly higher than that of the generator floor) are the transformers.

The power house stands on slightly sloping ground, with its long axis parallel to the general course of the stream and also to the pressure pipe, which runs along the back of the house and branches to the various units.

Hydraulic equipment.—The prime mover of each unit is a single Pelton wheel, mounted between bearings on the same shaft with the armature of the generator. One wheel is supplied by a set of 2-inch deflecting nozzles, and the other two are supplied by 3¾-inch needle nozzles with deflectors. Operation is regulated by a Lombard governor, type F.

Generators.—The generators are all General Electric 250-kilovolt-ampere machines, operating at 600 revolutions per minute, and giving 2,500-volt 3-phase 50-cycle alternating current. All three are of the old revolving-armature type, and are carried on three bearings set on a cast bedplate.

Exciters.—Two Thomson-Houston 7½-kilowatt 110-volt continuous-current generators, operated by direct-connected Pelton wheels at 1,600 revolutions per minute, furnish excitation.

Transformers.—Three Wagner 250-kilowatt transformers are Y-connected on the high-tension side to step up from 2,500 to 33,000 volts, at which potential energy is delivered to the main transmission line.

Wiring.—The leads from each generator pass through automatic 2,400-volt oil switches and thence to the low-tension bus, which is connected to the transformers through another oil switch. The high-tension side of the transformers can be connected to either the south or north line through an oil switch and pole-top switches. The lines are short taps which connect (near the power house) to the two 3-phase circuits of No. 4 copper running from the Mill Creek 2–3 plant to Redlands substation.

Water level in Mill Creek No. 1 plant forebay and disconnection of the generating equipment from the line in case of short circuit or troubles of similar nature, either inside or outside the power house are now controlled semiautomatically.

LYTLE CREEK PLANTS.

SOURCE OF WATER SUPPLY.

Lytle Creek emerges from Cucamonga Mountains near the mouth of Cajon Pass, flows southeast, and joins Santa Ana River near San Bernardino. (See Pl. LX, p. 616.) At the end of 1921 two power plants were in operation on the stream—Lytle Creek plant of Southern California Edison Co., diverting at an elevation of 2,708 feet above sea level with a tributary drainage of 41.6 square miles, and Fontana plant, diverting near the mouth of the main canyon at an elevation of approximately 2,225 feet above sea level with a tributary drainage of 47.8 square miles. The drainage basin above the mouth of the canyon is on the south slope of San Antonio Peak and ranges in elevation from 2,225 feet at the lower intake to 10,080 feet at the summit of the peak. Cucamonga Peak, on the southwest border of the basin, is 8,911 feet above sea level. The North Fork, Middle Fork, and South Fork of the stream unite a short distance above the Lytle Creek intake. The region drained by the Middle Fork of the stream is precipitously rugged and by far the greater part is rocky and covered only with brush and a slight forestation. The upper ridges, however, support a fair growth of pine.

Below the intake of Lytle Creek plant but above the mouth of the canyon the stream spreads out over a broad wash of boulders and gravel, in which the Fontana Union Water Co. has sunk a number of lined and unlined shafts in addition to driving several tunnels or collecting galleries. During floods the water is spread over the gravel beds and is turned into shafts, in order to replenish underground storage instead of allowing the water to waste down the main channel. Water is discharged from the galleries and diverted from surface flow. Fontana plant receives the discharge from Lytle Creek power house directly through an inverted siphon which crosses from the north to the south side of the stream and empties into a sunken concrete sand rack and division box.

The mean seasonal precipitation probably does not greatly exceed 40 inches at any point in the basin and in by far the larger part is 25 inches or less. Most of the low flow comes from the higher slopes of Cucamonga and San Antonio peaks and Pine Mountain. There are no artificial or natural lakes in the drainage basin.[22]

LYTLE CREEK PLANT.

Location.—Lytle Creek power house is on the northeast side of Lytle Creek canyon in sec. 6, T. 1 N., R. 5 W., at an altitude 2,225 feet above sea level. The intake is in sec. 26, T. 2 N., R. 6 W., and

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[22] For records of flow of Lytle Creek see U. S. Geol. Survey Water-Supply Papers as follows: 300, pp. 605-617 (up to June 30, 1912); 331, pp. 62-63 (1911-12); 361, pp. 86-87 (1912-13); 391, pp. 80-81 (1913-14); 411, pp. 99-100 (1914-15); 441, pp. 68-70, 312 (1915-16); 461, pp. 43-44 (1916-17); 481, pp. 43-44 (1917-18).

the conduit traverses secs. 25, 26, and 36 of that township, sec. 31, T. 2 N., R. 5 W., and sec. 6, T. 1 N., R. 5 W. The plant was built by The Edison Electric Co. of Los Angeles and began operation September 15, 1904.

Conduit.—Water is diverted into the first flume of the conduit by means of a small concrete dam, 151.5 feet long, 11 feet in maximum height, 14 inches wide on top, and 15.5 feet thick through the base, with a wing wall 13 feet long. The dam is provided with two sliding sluice gates for the purpose of cleaning out the sediment collecting above it.

The total length of Lytle Creek conduit is 21,723 feet from dam to forebay, divided as follows:

	Feet.
Flume	817
Sand box	70
Concrete pipe	17,111
Canal	1,137
Siphons 1–5	822
Pressure pipe	1,766
	21,723

The flume at the head is 3 feet 6 inches in cross-section and extends from the intake to the sand box at the edge of the canyon and at the head of the first tunnel. This flume is double, one compartment being carried below the stream bed to catch underflow and the other along the surface to catch the surface flow. No. 1 flume is 297.5 feet long; No. 2, 206 feet.

The sand box is made of concrete, is 79 by 36 feet inside, and is divided into five 30 by 14 foot chambers, each varying in depth from 3 feet 5 inches at its shallowest part to 8 feet 2 inches at its deepest. There is a gate in the flume for each compartment in the sand box. As in the Mill Creek sand boxes, only the middle cross wall is carried up to the upper edge of the box. On the crest of this wall there is a 12 by 1 foot weir. At the lower end of the box the discharge passes over a weir 8 feet long and 2 feet 2 inches deep into a bay 8 by 20 feet and from this into the head of the first tunnel through a 48-inch gate.

The 13 tunnels along the Lytle Creek line, aggregating 3,093 feet, are 2 feet 8 inches by 6 feet 3 inches in section and range in length from 91 feet to 580 feet, as shown by the following table:

TABLE 121.—*Length of tunnels on Lytle Creek conduit.*

No.	Feet.	No.	Feet.
1	237	9	277
2	223	10	178
3	169	11	91
4	102	12	310
5	132	13	580
6	223		
7	336		3,092
8	234		

The concrete pipe that forms most of the conduit is 36 inches inside diameter and is laid in sections 30 inches long. The pipe is carried directly through all the tunnels. Outside of the tunnels it is laid in trench and is covered to a depth of about 3 feet. The total length of pipe is 17,656 feet, not including pipe in tunnels.

The five siphons scattered along the line are 36 inches in diameter and are constructed of lap-riveted steel. No. 1 is 162.77 feet long; No. 2, 240.8 feet; No. 3, 142.56 feet; No. 4, 118.42 feet; and No. 5, 155.5 feet. There is also a siphon 903.5 feet long that carries the water discharged from the power house under the bed of Lytle Creek and delivers it to the intake of Fontana Union Water Co.

Near the head of the conduit there is a stretch of open canal 1,137 feet long, 3 feet wide at a point 6 inches above the rounded bottom, 6 feet wide on the surface, and about 2½ feet deep from surface to bottom. This canal is lined with rock which is laid in mortar and faced with concrete.

At the lower end of the conduit the water discharges into a very small forebay—a concrete box 10 by 20 feet inside measurements, the bottom sloping to give a depth varying from 5 feet 6 inches to 10 feet 6 inches. The carrying capacity of the conduit is 24 second-feet.

The length of the pressure pipe from forebay to power house (including branches) is 1,565 feet. The first 20 feet of pipe tapers from 30 to 26 inches in diameter. This section is followed by a single lap-riveted 26-inch continuous riveted line, varying in thickness from No. 12 to one-half inch. At the end of the 26-inch line is a 4-branch cast-steel Y, connecting to three 15-inch generator pipes, each 45 feet long, and one 8-inch exciter pipe 39 feet long. Only two of the generator branches are used. From the forebay there is also a wooden flume spill, 1,506 feet long and 1 foot 7 inches by 2 feet interior dimensions, which empties into the tailrace near the power house to prevent waste of water above the head of the irrigation intake if the plant is suddenly shut down. The pressure pipe has one moderate bend in horizontal alinement and is convex in general profile. The static head is 483 feet.

Power house.—Lytle Creek power house is constructed of concrete and has a corrugated-iron roof carried on steel trusses. The building measures in plan 28 by 52 feet.

The back of the power house is toward the mountain and its long axis is therefore at right angles to the line of the pressure pipe. The branch to each generator is made outside of the power house and enters under the floor through the rear wall. The discharge from the wheels is collected in a general channel at one side of the power house and flows into the siphon which discharges into the head of Fontana conduit.

Hydraulic equipment.—Each unit is operated by a single Pelton impulse wheel rated at 400 horsepower, regulated by a Lombard governor, type F, and operated at a speed of 375 revolutions per minute. Each wheel carries 16 buckets, is 42 inches in diameter on bucket centers, and is operated by a single 5-inch deflecting needle nozzle.

Generators.—The power house is equipped with two General Electric 250-kilovolt-ampere 16-pole generators, operating at 375 revolutions per minute and producing 50-cycle 3-phase alternating current at a potential of 11,500 volts. The units are of the 3-bearing type, with heavy bedplate castings.

Exciters.—The two exciters are General Electric 10-kilowatt 4-pole continuous-current generators, type MP, operated at 650 revolutions per minute, and each supplies 143 amperes at 70 volts with no load or with full load. They are operated by hand-regulated Pelton wheels.

Transformers.—This station transmits directly from the generator at 11,500 volts and is provided with no transformers in the main circuit, the only equipment of this kind in station being two 5-kilowatt units to step the potential down for use at the station.

Wiring.—The switchboard consists of four panels—one exciter, two generators and one general output panel. The lead from each generator passes through an 11,500-volt oil switch to a single bus, from which it is carried directly to the two circuits of the Lytle Creek-Colton line, passing out of the power house through tile pipes. On each 11,500-volt line there is a horn disconnecting switch.

Just below the outlets for the two lines the General Electric aluminum-cell lightning arresters are connected to the circuits.

Water level in Lytle Creek forebay and disconnection of the generating equipment from the line in case of short circuit or troubles of similar nature, either inside or outside the power house, are now controlled semiautomatically.

FONTANA POWER PLANT.

Location.—Fontana power plant was constructed by Fontana Power Co. during 1917 to utilize a fall in the ditch system of the Fontana Union Water Co., and is operated under a 30-year contract by Southern California Edison Co. The plant went into commission December 22, 1917.

The intake is in the N.W. ¼ sec. 6, T. 1 N., R. 5 W. The pressure pipe traverses secs. 6, 7, 8, 16, 17, 21, and 22 of the same township, and the power house is in the SW. ¼ sec. 22.

Conduit.—The division or sand box at the head of the Fontana pipe line originally delivered water to two ditches running in a southeasterly direction down the Lytle Creek débris cone to the upper edge of the lands controlled by the Fontana Co. When the power plant was constructed a concrete channel 10 feet deep, 12 feet wide, and 130 feet long was built from the lower end of this division box to the point selected for the head of the pressure pipe, where a sand box and trash racks were installed. From this sand box a single steel pressure pipe 22,566.6 feet long extends southeast down the débris cone to the power house. The dimensions of the pipe are as follows:

TABLE 122.—*Dimensions of pressure pipe, Fontana plant.*

Type of pipe.	Length of section.	Diameter.	Plate thickness.
		Inches.	*Inches.*
Lap-riveted	5,166.65	42	5/32
Do	1,200.00	42	11/64
Do	700.00	42	3/16
Do	700.00	42	13/64
Do	600.00	36	3/16
Do	700.00	36	13/64
Do	500.00	36	7/32
Do	1,500.00	36	1/4
Do	3,200.00	36	5/16
Do	3,000.00	36	3/8
Do	3,000.00	36	7/16
Do	1,800.00	36	15/32
Do	1,000.00	36	1/2
Do	500.00	36	1/2
	23,566.65		

The pipe is laid in a trench and covered with earth. The line was designed to deliver 50 second-feet. The slope of the débris cone is very uniform. Twenty-five feet from the back wall of the power house the pressure pipe connects through a casting with two main branches three-eighths of an inch thick and 22 inches in diameter, to two curved riveted steel lines of the same diameter, running to the main units. An 8-inch intermediate branch runs from the casting direct to the exciter wheels. At the main units the 22-inch pipes connect to Y castings, 21 feet apart, branching to the double overhung impulse wheels, flow through each branch being controlled by a hand-operated valve. Water discharges from the wheels into a system of sand and division boxes immediately outside the power house and at the head of the Fontana irrigation system. Near the exciters there is an upturn in their 8-inch supply line, raising it above the floor level to a Y, serving both units, which are placed wheel to wheel. A hand-operated gate valve is installed in each branch line.

Elevation of water surface in the intake chamber at the head of the pipe is 2,234.5 feet and elevation of nozzle centers at the power house 1,576 feet above sea level, giving a static head of 658.5 feet.

Power house.—Fontana power house is a single reinforced-concrete building 45 feet 9 inches long by 35 feet 8 inches wide, outside measurements, with flat-sloped reinforced-concrete roof. The outside height from ground to parapet is 26 feet 6 inches. A single generator room with balcony at its back occupies the entire interior of the building. The room is 15 feet 9¼ inches high to the base of the crane rail and 21 feet high to the lower chord of the roof trusses. The switchboard is under the central portion of the gallery, facing out between the two main units and the office and lavatory under the left end of the gallery. The generator room proper is 43 feet 9 inches long by 25 feet wide; the space occupied by the gallery is 43 feet 9 inches long by 7 feet 6 inches wide, and the gallery floor is 8 feet 10 inches above the main floor.

Hydraulic equipment.—Each main unit is operated by double-overhung Pelton impulse wheels, and there is a hand-operated gate valve in the branch lines supplying each wheel. The diameter of the jets is 3½ inches and the units are regulated by sleeve-type jet deflectors, operated by Pelton 0–3 oil-pressure governors. The wheels are rated at 800 horsepower each and are 52 inches in diameter on pitch line, and the speed of the units is 375 revolutions per minute.

The two main units are placed with shafts in line parallel to and 13 feet 2 inches from the front wall of the generator room. The exciters are similarly arranged in line 3 feet 6 inches from the front wall. The main shaft of each unit is supported on two pedestal bearings designed for oil-ring lubrication, and set on the concrete generator foundation.

Each exciter is operated by a single overhung impulse wheel, 28 inches in diameter on pitch line, supplied through a 1⅛-inch hand-regulated needle nozzle.

Generators.—The two generators are Westinghouse 1,200-kilovolt-ampere 11,000-volt 63-ampere 3-phase 50-cycle alternating-current machines giving a total installed capacity of 2,400-kilovolt-amperes, or 3,216 horsepower for the station.

Exciters.—The two exciter sets are identical in design, each set consisting of a Westinghouse 45-kilowatt 125-volt 360-ampere continuous-current generator operated at 700 revolutions per minute by a Pelton impulse wheel mounted on the main shaft.

Wiring.—Fontana power house, like the Lytle Creek station, is operated without step-up transformers transmitting at the generator potential of 11,000 volts to Colton.

SAN ANTONIO CREEK PLANTS.

SOURCE OF WATER SUPPLY.

San Antonio Creek heads between San Antonio and Telegraph peaks in the Cucamonga Mountains, at an elevation of about 7,700 feet, and flows southward through a rugged canyon from which it emerges and spreads over an alluvial cone, losing such flow as is not diverted in the coarse gravels of its broad wash. Its tributaries in the canyon are very short and of heavy gradient. At the end of 1921 there were three power developments utilizing the fall in the stream between an elevation of 4,100 feet at the upper diversion and 2,400 feet at the lower power house near the mouth of the canyon. These were, in order downstream, Ontario plant No. 2, of Ontario Power Co., diverting at an elevation of 4,100 feet with a tributary drainage of 11.2 square miles; Sierra plant of Southern California Edison Co., diverting at an elevation of 3,790 feet with a tributary drainage of 15.1 square miles; Ontario plant No. 1 of Ontario Power Co., diverting at an elevation of 3,148 feet with a tributary drainage of 18 square miles. (See Pl. LX, p. 616.)

Elevations within the drainage basin range up to 10,080 feet at the crest of San Antonio Peak, and the general altitude along much of the eastern and northeastern boundaries is about 8,000 feet.

The lower parts of the basin are covered with brush and a sparse growth of trees and the upper ridges support a medium growth of pines, but at no place in the drainage is the forest cover heavy. The rocks are granitic and the topography is extremely rugged and precipitous, especially among the higher peaks.

The mean monthly rainfall does not exceed 40 inches in any part of the basin. The low flow [23] of the stream is derived almost entirely from precipitation on the slopes of San Antonio Peak.

There are no artificial reservoirs in the drainage basin.

SIERRA PLANT.

LOCATION.

The Sierra plant, which was put into operation February 14, 1901, by Sierra Power Co., is on the site of the old Pomona plant of San Antonio Light & Power Co., the first alternating-current long-distance transmission plant in the State of California and the second in the United States. (See pp. 543–545.) The old power house (Pl. LIV, *A*, p. 592) is about half a mile above the Sierra power house and is entirely dismantled, but around it are still to be found many parts of the original transformer equipment, which consisted of some twenty units, connected in series to give the desired 10,000 volts used in the single-phase transmission to Pomona and San Bernardino.

The intake is in sec. 25, T. 2 N., R. 8 W., San Bernardino base and meridian, and the conduit traverses secs. 25 and 36 of the same township. The power house is in sec. 36, T. 2 N., R. 8 W., on the west bank of San Antonio Creek at an altitude of 3,164.4 feet above sea level.

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[23] For records of discharge of San Antonio Creek see U. S. Geol. Survey Water-Supply Papers as follows: 300, pp. 618–622 (up to June 30, 1912); 331, pp. 65–72 (1911–12); 391, pp. 81–82 (1913–14); 411, pp. 100–102 (1914–15); 441, pp. 75–76 (1915–16); 461, pp. 48–51 (1916–17); 481, pp. 46–49 (1917–18).

CONDUIT.

The intake of the Sierra conduit is a small concrete weir pierced by two sluice gates. Wing walls that lead upstream from its end form a box settling pool from which water is drawn through a gate chamber on the west bank. The elevation of the intake is about 3,792.4 feet above sea level. There is no open conduit, as the pressure pipe begins at the intake. For about one-fourth of a mile below the headgates the pipe follows the side of the canyon, then passes through a tunnel (about one-fourth of a mile long) driven through a point on the west side of the canyon, around which the creek flows in a loop. From the mouth of this tunnel the pipe drops more rapidly, and follows down along the west side of the canyon to the power house. The entire length of the pressure line is approximately 6,940 feet. It is constructed of lap-riveted steel pipe, laid in a trench and covered. In diameter the pipe varies from 32 to 20 inches. The capacity of the line is 20 second-feet and the total static head developed is 628 feet.

GENERATING STATION.

Power house.—The power house (Pl. LIV, *B*) is a concrete building 52.5 feet long by 22 feet wide with corrugated-iron roof. The long axis of the building is parallel to the stream, and the pressure pipe passes along its east side to two impulse wheels set under iron hoods in a common wheel pit and tailrace which runs along the side of the foundations. The shaft from each of these wheels passes through the wall of the building to its generator. The switchboard is on the side of the room opposite the generator. The building contains but a single room, with the main doorway at the downstream end and a bank of transformers on each side of the doorway. The high-tension wiring passes from the transformers to oil switches in a gallery above them and thence to the lines through tile outlets in the end wall.

Hydraulic equipment.—Each unit is operated by a 500-horsepower 54-inch 18-bucket Pelton wheel which receives water from a single plain deflecting nozzle, controlled by a Lombard governor, type F. The rotor of the impulse wheel is mounted between bearings, and the wheel and generator shafts are connected by a flexible leather-link coupling. A flywheel is mounted on the wheel shaft just inside the wall of the building.

Generators.—The generators are Westinghouse 300-kilovolt-ampere revolving-armature 500-volt 300-ampere 2-phase machines, operating at 430 revolutions per minute. The lower half of the generator frame, the base of the machine, and the main bearings are cast in one piece.

Exciters.—Each main generator is excited by a Westinghouse 7.5-kilowatt bipolar 125-volt continuous-current exciter, which is belted to its armature shaft.

Transformers.—The four transformers are arranged in two banks. The first bank contains two Westinghouse 250-kilowatt water-cooled single-phase transformers, stepping up from 500 to 17,500 volts. The second bank is of the same type as the first, but each transformer has a capacity of 200 kilowatts and steps up from 500 to 17,110 volts. Both banks are Scott connected, so that the 2-phase generator current is changed to 3-phase current for transmission.

Wiring.—The station is provided with a very simple 2-panel switchboard, which is fitted with 500-volt 4-pole single-throw knife switches. From the board the circuits run to the transformers and thence up to twelve 15,000-volt single-pole high-tension oil switches in the gallery over the transformers. Through these switches each bank of the transformers may be connected to either outgoing line.

General Electric electrolytic lightning arresters were installed in 1916 on a concrete pedestal just west of the main entrance to the power house, replacing two sets of 18,000-volt Westinghouse low-equivalent lightning arresters which were mounted in the opposite end of the generator room from the transformers.

AZUSA PLANT.

LOCATION.

Azusa power house (Pl. LIII, *A*, p. 592) is in sec. 22, T. 1 N., R. 10 W., on the east side of the mouth of San Gabriel Canyon, about 750 feet above sea level. The intake is in sec. 31, T. 2 N., R. 9 W., San Bernardino base and meridian; the conduit traverses sec. 31, T. 2 N., R. 9 W., secs. 5, 6, 7, 18, T. 1 N., R. 9 W., and secs. 13, 23, and 24, T. 1 N., R. 10 W.

The plant was put into service June 30, 1898, by San Gabriel Electric Co., and became the property of Southern California Edison Co. in 1917, through the purchase of Pacific Light & Power system.

SOURCE OF WATER SUPPLY.

The Azusa plant is operated with water from San Gabriel River, whose drainage area above the intake—about 5 miles above the mouth of the canyon—embraces 202 square miles of territory in the San Gabriel Mountains. No storage reservoir is used.

The main San Gabriel River is formed about 2 miles above the intake by the junction of two forks, one coming from the east and the other from the west. Most of the smaller tributaries of these two forks flow from the high mountains to the north. The drainage basin is fairly regular in outline, is about 10 miles wide north and south and 20 miles long east and west, and its slopes are very irregular and precipitous. (See Pl. LX.)

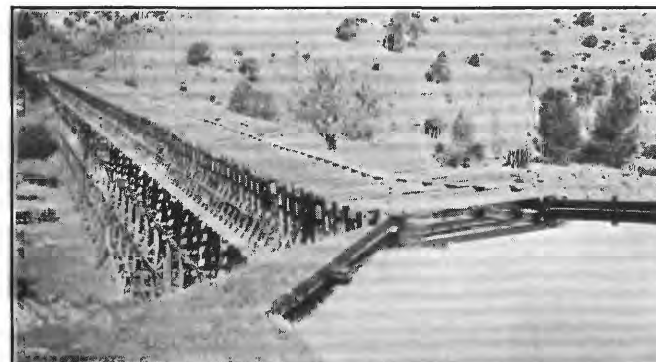
Elevations in the area above the intake range from 1,210 feet above sea level to 10,080 feet at the summit of San Antonio Peak. North

A. CONDUIT OF KAWEAH PLANT NO. 2, JUNCTION OF FLUME TO DITCH.

B. CONCRETE FLUME, CONDUIT OF KAWEAH PLANT NO. 3.

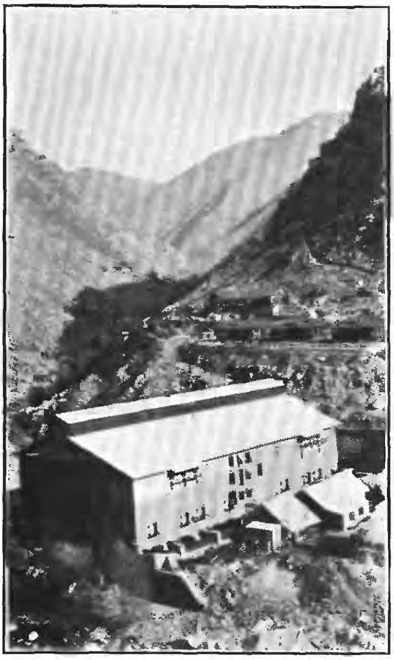
Photograph by H. A. Kluegel.

C. BOREL CANAL, IN UPPER END OF HOT SPRINGS VALLEY.



D. BODFISH FLUME, BOREL CONDUIT.

HYDROELECTRIC SYSTEM OF SOUTHERN CALIFORNIA EDISON CO.



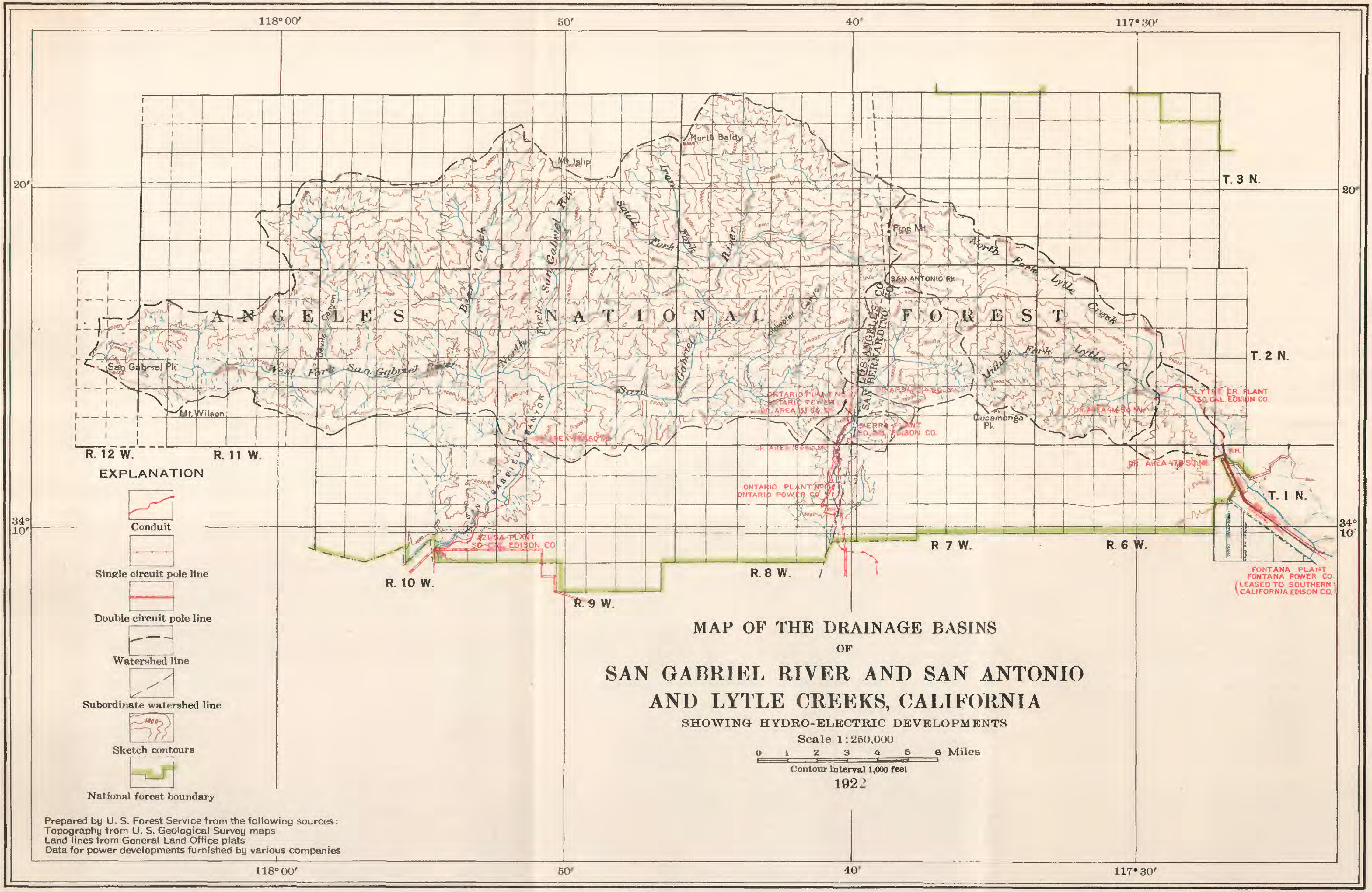
A. KERN RIVER POWER HOUSE NO. 1, SOUTHERN CALIFORNIA EDISON CO.

B. INTAKE DAM, KERN RIVER PLANT NO. 3, SOUTHERN CALIFORNIA EDISON CO.

Photograph by J. C. Dort.

C. TRANSFORMERS AT BISHOP CREEK PLANT NO. 6, SOUTHERN SIERRAS POWER CO.

D. COTTONWOOD POWER HOUSE, CITY OF LOS ANGELES BUREAU OF POWER AND LIGHT.


MAP OF THE DRAINAGE BASINS
OF
SAN GABRIEL RIVER AND SAN ANTONIO
AND LYTLE CREEKS, CALIFORNIA
SHOWING HYDRO-ELECTRIC DEVELOPMENTS
Scale 1:250,000
0 1 2 3 4 5 6 Miles
Contour interval 1,000 feet
1922
EXPLANATION
Conduit
Single circuit pole line
Double circuit pole line
Watershed line
Subordinate watershed line
Sketch contours
National forest boundary
Prepared by U. S. Forest Service from the following sources:
Topography from U. S. Geological Survey maps
Land lines from General Land Office plats
Data for power developments furnished by various companies
ANGELES NATIONAL FOREST
118° 00′
50′
40′
117° 30′
20′
34° 10′
T. 3 N.
T. 2 N.
T. 1 N.
R. 12 W.
R. 11 W.
R. 10 W.
R. 9 W.
R. 8 W.
R. 7 W.
R. 6 W.
North Baldy
Mt. Islip
Pine Mt.
San Antonio Pk.
San Gabriel Pk.
Mt. Wilson
Cucamonga Pk.
West Fork San Gabriel River
North Fork San Gabriel Riv.
South Fork
Iron Fork
San Gabriel River
North Fork Lytle Creek
Middle Fork Lytle Cr.
Bear Creek
Coldwater Canyon
San Gabriel Canyon
LOS ANGELES CO.
SAN BERNARDINO CO.
LYTLE CR. PLANT SO. CAL. EDISON CO.
ONTARIO PLANT NO. 1 ONTARIO POWER CO.
ONTARIO PLANT NO. 2 ONTARIO POWER CO.
SIERRA PLANT SO. CAL. EDISON CO.
AZUSA PLANT SO. CAL. EDISON CO.
FONTANA PLANT FONTANA POWER CO. (LEASED TO SOUTHERN CALIFORNIA EDISON CO.)
DR. AREA 47.8 SQ. MI.
ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

Baldy and Pine Mountain on the northeast boundary rise more than 9,000 feet, and Islip Mountain reaches an elevation exceeding 8,000 feet. On the extreme west are Mount Wilson and Mount Markham and San Gabriel peaks which, although lower, reach noteworthy altitudes. Although the East and West forks occupy depressions that lie almost due east and west, the main stream formed by them immediately turns nearly due south and flows through a deep canyon until it emerges into San Gabriel Valley.

Granitic rocks poorly covered with soil make up a large part of the drainage basin above the Azusa intake. The mean rainfall in this area probably ranges from about 20 inches in the lower hills to 40 inches well up on the higher mountains. Owing to the poor soil and the relatively low precipitation the forest cover consists chiefly of brush and a very sparse growth of timber. In some favored places on the higher ridges, however, the forest cover is fair. Much of the early summer flow of San Gabriel River, like that of Mill Creek and Santa Ana River, comes from snows that have lingered through the spring in the deep canyons in the upper mountains. Late in the fall, however, the snow wholly disappears, and the stream flow dwindles to the small supply derived from seepage and small springs. There are neither natural nor artificial lakes in the basin, and the power plant and irrigation systems below it depend wholly on the natural flow of the stream.[24]

CONDUIT.

The intake of the Azusa conduit is a submerged concrete dam 325 feet long and 60 feet in maximum height, constructed in the gravels of the stream bed at the upper end of an "oxbow" in the canyon. The water diverted immediately drops 20 feet into the head of tunnel No. 1. The conduit consists largely of tunnels through the sharp spurs of the southeast side of the canyon. At the mouth of the last tunnel the water flows into a small concrete-box forebay.

The latest available measurements show that 22,828 feet is in tunnels provided with an 8-inch lining and having a net section of 4 feet 4 inches by 6 feet (excavated section 5 feet 8 inches by 7 feet 4 inches); 3,876 feet is in cyclopean concrete flume 4 feet 9 inches wide by 6 feet high; 541 feet is in open masonry flume 5 feet wide and of varying depths (217 feet 4 feet deep, 150 feet 6 feet deep, and 174 feet 10 feet 6 inches deep); a section 6 feet long is in concrete flume 5 feet wide by 10 feet deep; 2,530 feet consists of stave pipe 4 feet in diameter and 2 inches thick with a concrete casing 1 foot thick; and 1,636 feet is of concrete pipe 26 inches in diameter and 4 inches

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[24] For records of discharge of San Gabriel River see U. S. Geol. Survey Water-Supply Papers as follows: 300, pp. 641-683 (up to June 30, 1912); 331, pp. 73-78, 416 (1911-12); 361, pp. 87-93 (1912-13); 391, pp. 83-87 1913-14); 411, pp. 102-105 (1914-15); 441, pp. 77-81 (1915-16); 461, pp. 53-57 (1916-17); 481, pp. 50-55 (1917-18).

thick. The total length of the conduit is 31,217 feet. The longest tunnel on the line is 1,610 feet. The finished width of the tunnels is 4 feet 4 inches and the height to crown of arch is 6 feet. The grade in the tunnels is 1 foot per 1,000, and in the pipes 2.06 feet per 1,000. The average grade for the entire line is 1.36 feet per 1,000 feet. The capacity of the conduit is 80 second-feet.

From the forebay, which is lined with concrete 2 feet thick, is 40 by 30 feet and 8 feet deep, and is fitted with sluice gates for the removal of sediment, the water passes through a set of trash screens into the head of the pressure pipe. All waste flow is carried around the point of a small hill into a wooden waste flume and thence into an irrigating ditch at the tailrace of the power house. The pressure line, a lap-welded 36-inch steel pipe 827 feet long, varying in plate thickness from one-eighth to three-eighths of an inch, follows down the crest of a mountain spur a short distance southeast of the power house. The upper half of its length is anchored to masonry bedrock and the lower half is buried in a trench. In the lower half of its course it turns through an angle of approximately 30° and then runs to a sharp bend of 90° with 50-foot radius and a tapered joint 5 feet long to the receiver, which lies along the west side of the power house. At the forebay water enters the pipe through 45 feet of 48-inch pipe and a joint tapering from 48 to 36 inches in diameter. The branches to the wheels are taken from the receiver (Pl. LIV, *C*, p. 592), which is 48 inches in diameter and constructed of ½-inch plates. The static head developed is 401 feet.

GENERATING STATION.

Power house.—The Azusa power house (Pl. LIV, *C*) consists of two buildings, a generating station and a switch house. The former is a monolithic concrete building, 73 feet long and 23 feet 10 inches wide; the switch house is similar in construction and is 93 feet long by 16 feet 6 inches wide. The generating station has a corrugated-iron roof on a steel frame and is divided by a longitudinal wall into two rooms, one for the generators and the other for the transformer equipment. The generator room is about twice the width of the transformer compartment and is spanned by a traveling crane which runs on tracks laid along shoulders in its walls. The five units are arranged along the west wall of the building, with their shafts connecting to the wheels through apertures in the wall. The water wheels are outside of the building and between it and the header (Pl. LIV, *C*) on the end of the pressure pipe. The wheel casings are protected from the weather by an extension or lean-to roof. The switchboard is opposite the row of generators, parallel to and close beside the central longitudinal wall.

The high-tension switch house is back of and above the main building.

Hydraulic equipment.—Each water wheel is operated through a separate branch from the header and as the discharge from the nozzles is parallel to the receiver each of the streams turns through two full right angles in passing from the pressure pipe to the wheel.

The prime movers attached to the five units are impulse wheels with two rotors to the unit, with a combined rated capacity of 480 horsepower for the pair and a speed of 430 revolutions per minute. No. 1 unit is operated by a double Pelton wheel which is hand-governed by a hood deflector over the jets; its operation is steadied also by a heavy flywheel mounted on the shaft between the wheel housing and the side of the generator room. Units Nos. 2 and 3 are operated by double Doble wheels governed by jet deflectors which are put in operation by Lombard governors, type F. Units Nos. 4 and 5 are also double Doble wheels operated by stationary hand-regulated needle nozzles, governed by jet deflectors controlled by Lombard governors, type F.

Generators.—The station is equipped with five Westinghouse 300-kilovolt-ampere 300-ampere 500-volt stationary-field 2-phase 50-cycle generators, operating at 430 revolutions per minute. The bearings and connections between wheel and generator are of the same type as at Sierra power house.

Exciters.—The five exciters are Westinghouse 5-kilowatt 4-pole 125-volt machines operated at 1,300 revolutions per minute by belts from the generator shafts.

Transformers.—The generator potential is stepped up to the 17,500 volts of the main transmission line by eight Westinghouse 200-kilowatt and two Westinghouse 250-kilowatt 50-cycle transformers, all of which are water cooled. The transformers are connected by the Scott method in order to change 2-phase to 3-phase current.

Wiring.—The switchboard has eight panels, upon which are painted wiring diagrams for the apparatus. Panel 1, which feeds the North and South Azusa lines, has two Wagner alternating-current ammeters and panel No. 2 feeds the Canyon and Covina lines and is equipped like No. 1. Panels 3 to 7, inclusive, are generator panels; each is equipped with 1 Wagner alternating-current ammeter, 1 Westinghouse indicating ammeter, 1 Wagner indicating wattmeter, 1 combination exciter and generator field rheostat wheel, 1 remote-control lever for generator switch, and an exciter switch. Panel 8 feeds the North and South Sierra lines, and has two Wagner alternating-current ammeters. On a bracket attached to panel 1 there is a Weston voltmeter, and similar brackets on panel 8 contain a Lincoln synchronizer and two Westinghouse alternating-current voltmeters.

All the switching is done on the high-tension side of the transformers. The high-tension connections from each bank of transformers run to the switch house, where they connect to either north or south bus through pneumatic remote-control 3-phase oil switches. The outgoing lines are arranged so that they can be connected to either bus through similar sets of oil switches. The entire switching equipment is of the Kellman type. The power house is on the 15,000-volt main transmission line running east and west through the San Bernardino citrus belt.

General Electric electrolytic lightning arresters were installed in 1916 on a concrete base near the eastern end of the generator building, replacing two sets of Westinghouse low-equivalent 18,000-volt lightning arresters that were mounted on the wall in the end of the transformer room.

KERN RIVER PLANTS.

SOURCE OF WATER SUPPLY.

Kern River is the most southern of the great streams that flow westward from the crest of the Sierra Nevada. The part of its basin (Pl. LVII, in pocket) that furnishes water used in power development lies entirely above the mouth of the main canyon, which is at a point 18 miles east of Bakersfield, and embraces 2,300 square miles in eastern Kern and Tulare counties. The basin extends almost due north and south 90 miles, and its maximum width east and west is about 30 miles.

The northern part of the area is divided into two drainage basins by a high and rugged central ridge that runs nearly due south from the main divide at Cottonwood Pass and terminates north of South Fork Valley, just east of Kernville. The western basin is drained by North Fork and its main tributary, Little Kern; the eastern basin by South Fork. The eastern boundary of the basin runs south from Mount Whitney and is formed by the main backbone of the Sierra; the western boundary is formed by the secondary and parallel ridge of the Great Western Divide and by its extension, Greenhorn Mountains. The northern boundary lies on the crest of the tremendous amphitheater formed by the junction of the Great Western and Main divides, and the southern along the terminal ridges of the Sierra, where they join the Tehachapi.

The main or North Fork of the Kern heads in the extreme north end of the basin in the Mount Whitney region—one of the highest and roughest in the Sierra. The river flows due south 72 miles in an air line (about 84 miles along its bed) to its junction with South Fork, 3 miles below Kernville. From this point the course of the main river is southwest for 23 miles in an air line (30 along its bed) to the point where the last power diversion is made by the San Joaquin Light & Power Corporation, just opposite Kern River No. 1 power house of the Southern California Edison Co., and 17 miles southwest of Borel power house. At a point 27 miles from its head North Fork flows through Kern Lake and at 45 miles it is joined from the west by the Little Kern, whose general course in the 21 miles from its headwaters to the junction is nearly southeast. From Junction Meadow to Kern Lake North Fork flows through Kern Canyon proper. The gorge in this section of the river is from 1,500 to 2,000 feet deep and its width at the top is about a mile. Below the lake the canyon broadens out somewhat but is deep and rugged to within a few miles of Kernville. The area drained by North Fork above Kern River No. 3 intake comprises 845 square miles, and the area above the Borel intake 1,020 square miles.

South Fork, which drains the eastern part of Kern River basin, flows southward parallel to the eastern boundary and then turns nearly due west to join the main stream. The entire length of this branch is 83 miles. South Fork basin is somewhat less rugged than that of the other branch of the river. In general the basin is rather flat and it abounds in meadows lying among irregular chains of hills.

Elevations within the basin range from slightly less than 1,000 feet above sea level at the intake of San Joaquin Light & Power Corporation's canal up to the highest elevation in the United States—the crest of Mount Whitney—14,501 feet above sea level, and at least six peaks near Mount Whitney exceed 14,000 feet. By far the greater part of the boundary of the basin lies well above 7,000 feet, and much of it above 10,000 feet. The elevations along the central ridge between North and South Fork basins range from 8,000 to 9,000 feet, the highest point along this ridge being Kern Peak—11,493 feet.

The extreme altitudes are characterized by tremendous granite domes and peaks. Indeed, the rocks of most of the region are granitic, but the granitic formation is most noticeable in the barren and arid ridges of the southern part of the basin and in the glaciated higher peaks.

The southern and eastern parts of the basin are sparsely covered with juniper and chaparral, and are more like the arid mountains of Southern California than the true Sierran regions. Above Kernville, however, the growth improves generally, and at some points the forest cover is excellent; especially near the crest of Greenhorn Mountains and along Kern Canyon above Fairview.

Records of precipitation in the basin are meager. The mean for 17 seasons at Kernville was 10.3 inches and for 11 seasons at Isabella 11.2 inches. Both of these points are at relatively low altitudes in the southern part of the area. Studies by C. H. Lee[25] show a mean rainfall in the northern (and higher) half of the basin ranging from 20 to 30 inches.

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[25] Lee, C. H., An intensive study of the water resources of a part of Owens Valley, Calif. U: S. Geol. Survey Water-Supply Paper 294, pl. 7, 1912.

The low flow of Kern River[26] comes almost entirely from the high country on the headwaters of North Fork and Little Kern. The waters of South Fork are often completely used up by the irrigators along its valley, so that only return seepage enters the main stream. At present, because of legal obstacles, there is no feasible way to increase the low flow by storage on the upper river, for not only is the low flow diverted through canals but the flood flow of the stream has been appropriated for storage in the San Joaquin Valley, where the flood waters are run into Buena Vista Lake. This appropriation of the flood at the extreme lower end of the river is unusual in California, as most of the storage in the State is on the headwaters of the streams. As yet no satisfactory agreement has been possible by which the waters can be stored in the mountains (where losses due to seepage and evaporation may be minimized) and used not only by the present appropriators but also by the power companies during the season of low flow.

Four hydroelectric plants had been completed on Kern River up to the end of 1921. In order downstream, these are Kern River No. 3 and Borel plants of Southern California Edison Co., both diverting from North Fork; Kern River No. 1 plant of the same company and Kern Canyon plant of San Joaquin Light & Power Corporation, both diverting from the main river.

KERN RIVER PLANT NO. 3.

LOCATION.

Kern River plant No. 3 is the largest generating station on the river and is also the farthest upstream, being on North Fork, above Kernville. It was constructed entirely by the engineers of Southern California Edison Co. The work extended over more than a decade, but construction on a large scale was not undertaken until after the war. The first unit began to operate on April 1 and the second on May 13, 1921.

The intake dam is in the SE. ¼ NE. ¼ sec. 12, T. 23 S., R. 32 E. The conduit traverses secs. 12, 13, 24, and 25 of that township; secs. 30, 31, and 32, T. 23 S., R. 33 E.; secs. 5, 8, 9, 16, 17, 20, 29, 32, and 33, T. 24 S., R. 33 E.; and secs. 3, 4, and 9, T. 25 S., R. 33 E. The power house is in the NE. ¼ NE. ¼ sec. 9, T. 25 S., R. 33 E.

CONDUIT.

The ogee gravity-type diversion dam, with a straight crest 240 feet long, is 60 feet in maximum height from the original stream

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[26] For records of flow of Kern River see U. S. Geol. Survey Water-Supply Papers as follows: 299, pp. 37-38, 71-103, 411-412 (up to June 30, 1912); 331, pp. 115-124, 418 (1911-12); 361, pp. 116-125, 503 (1912-13); 391 pp. 118-125, 327 (1913-14); 411, p. 332 (1914-15); 441. pp. 101-104 (1915-16); 461. pp. 101-104 (1916-17) and 481, pp. 104-107 (1917-18).

bed to the crest, which is 3,632 feet above sea level. A fish ladder is installed at the west end of the dam, and the intake structure is at the east end. The intake, containing eight inlet openings 6 feet 6 inches wide by 3 feet 6 inches deep, submerged 4 feet below the minimum water surface, runs upstream at right angles to the east end of the dam. (See Pl. LIX, *B*.) A trash rack of flat steel bars covers the stream face of the intake structure, and two undersluices pierce the dam at the inlet, one in front of and one immediately behind the inlet screen and gates. A motor-driven rake is installed to remove trash from the front of the screen. The width of the intake chamber between the line of gates and the east abutment of the dam increases gradually from 8 feet opposite the three upstream gates to 18 feet 6 inches opposite the lower end of the set, or the axis of the dam. At this point two sliding gates 8 feet wide by 8 feet deep with motor drive are installed. About 420 feet of reinforced-concrete flume, most of which is set on piers, connects these gates to a very large reinforced-concrete sand box. In the first 75 feet below the headgates the flume narrows to an inside width of 9 feet 6 inches; the outside wall forms a spillway for 150 feet below the gates.

The similarity of the sand box to a reinforced-concrete barge or ship with stream-line prow and stern, built on the shore and ready for launching, is certain to impress all observers. Immediately above the sand box the flume widens and is divided by a central pier into two channels, each provided with a single sliding steel gate. Each gate controls the flow of water into the compartment of the sand box on its side of the structure.

The sand box is 448.3 feet long from the gates at its upper end to those at its lower end and is divided into two longitudinal compartments practically symmetrical with respect to the central division wall. Either of the compartments may be emptied and cleaned while the other is still in use. The box widens on stream-line curves for the first 50 feet below its head to an interior width of 82 feet, and its bottom drops 7.5 feet (from an elevation of 3,622.16 feet to 3,614.66 feet). Seven division walls in each of these flaring channels divide the flow into eight equal streams (16 in all). An adjustable vertical vane or rudder on the upstream end of each guide wall permits sufficient adjustment to compensate for any difference in velocity in different parts of the approaching stream.

The double box is 82 feet wide for 250 feet and then narrows gradually to the gates at its lower end, at the head of the short flume connecting to the upper end of tunnel No. 1. The floor of the main box slopes from the ends toward its center, the drop being 2 feet. Undersluices are provided at the lowest point, permitting the separate discharge of sediment from either compartment into the stream. The main part of the box is 18 feet deep at the ends and 20 feet deep at the center.

Except for short reinforced flumes (chiefly of the bench type), connecting the ends of tunnels, and one long steel siphon, the entire conduit is a series of tunnels. The floor and sides of the tunnels are lined with concrete throughout the conduit, but the top of the tunnel is lined only where the rock showed signs of being unstable. The first 9 miles of tunnel below the headworks has a finished width of 8.5 feet, with side walls 8 feet high, though water is carried only to a depth of 7.5 feet; the grade in this section is 2 feet per thousand. The remaining tunnels are 9.5 feet in clear width and carry water to the same depth but have a lighter grade (1.5 feet per thousand), giving the same maximum capacity, 600 second-feet.

TABLE 122a.—*Tunnel and flume lengths, Kern River plant No. 3.*

	Feet.
Transition flume	95.95
Flume	336.93
Sand box	442.77
Flume	159.74
Tunnel No. 1	4,064.65
Tunnel No. 4 (Nos. 2 and 3 eliminated by consolidation)	6,197.35
Tunnel No. 5	350.00
Tunnel No. 6	3,911.20
Tunnel No. 7–A	1,430.00
Tunnel No. 7–B	600.00
Tunnel No. 8–A	566.00
Flume	1,032.70
Tunnel No. 8–B	1,486.54
Tunnel No. 9–A	892.00
Tunnel No. 9–B	1,809.80
Tunnel No. 10	663.40
Tunnel No. 11	582.04
Tunnel No. 12	2,658.88
Tunnel No. 13	1,897.07
Tunnel No. 14	2,866.40
Tunnel No. 15	1,711.70
Tunnel No. 16	872.87
Tunnel No. 17	4,053.12
Flume	1,712.24
Tunnel No. 18	5,209.40
Tunnel No. 19	1,251.00
Tunnel No. 20	6,509.10
Tunnel No. 21	7,132.00
Tunnel No. 22	2,445.00
Siphon spillway	45.08
Siphon	924.87
Tunnel No. 23	3,246.80
Pressure flume	1,139.78
Forebay	61.00
	68,357.38

The inverted siphon is at the Brush Creek crossing, about a mile above the forebay. The span between portals is 958 feet, and the difference in elevation from the portal to the lowest point in the siphon 327 feet. The siphon is 1,170 feet long; its diameter ranges from 9 feet 6 inches at the tunnel portals to 8 feet at the lowest point, and the plate thickness from three-eighths inch at the highest to three-fourths inch at the lowest point. The siphon is of riveted steel construction throughout, is supported on concrete piers at the field joints, and is provided with anchors and expansion joints.

The downstream end of the siphon connects to a tunnel, which in turn connects with a reinforced-concrete pipe 9.5 feet in diameter, extending to the reinforced-concrete box forebay.

Flow from the forebay into the two pressure pipes is controlled by two 8 by 8 foot cast-iron gates. Water may be wasted through a cylindrical spillway valve at the forebay, remotely controlled from the power house, when the plant is shut down.

The two penstocks are 2,520 feet long. The first 795 feet of each line below the forebay is riveted steel pipe, and the rest of the pipe to the power house is lap-welded pipe. The riveted pipe ranges from 84 inches in diameter and three-eighths inch in plate thickness at the top to 72 inches in diameter and seven-sixteenths inch in plate thickness where it joins the welded section. The welded pipe reduces immediately from 72 to 66 inches in diameter and gradually to 60 inches at the Venturi meter back of the power house, continuing at that diameter from the lower end of the meter. Anchors are installed at bends in the lines, with expansion joints midway between, and both lines are supported on concrete piers. Flow in the Venturi meter is recorded by instruments installed in the power house.

GENERATING STATION.

Power house.—The power house is on the east side of North Fork 6 miles north of Kernville and 48 miles by road from Caliente, the nearest point on the main line of the Southern Pacific Railroad. The building is a reinforced-concrete structure, with concrete-slab roof of very flat pitch, supported on a steel-truss roof system. The building (Pl. LXVII, *D*, p. 746) is 130 feet long by 88 feet 6 inches deep and fronts directly on the river; a low extension 24 feet long by 18 feet deep in plan at the downstream end of the main building houses the station service pumps.

A generator room 105 feet long by 47 feet deep in the clear, 39.5 feet high from the main floor to the crane rail, and 49 feet high to the lower chord of the roof trusses, occupies the downstream front of the interior. The upstream front is occupied by a compartment 18.75 feet wide by 34 feet deep, containing the low-tension switch cells, rheostats, spare exciter, and station auxiliaries. A 65-ton electric crane commands the generator room.

A row of transformer cells 15 feet deep and 35 feet high extends nearly the full length of the back of the generator room. The three transformers that form the bank for one generator are in a single bay directly behind it, a single spare transformer in a small bay between the banks, and two 3-phase local-service transformers in separate bays in the upstream end of the transformer area.

Two bus and switch rooms, one above the other, about 19 feet deep and 91 feet long, occupy the space between the transformer bays and the back wall of the power house; curtain walls divide each room into seven switch cells.

The second floor and the basement are reached from the main floor by stairways at either end of the generator room or by an elevator at the upstream end of the transformer area.

The two vertical units are set in line 24 feet from the front wall of the generator room; unit No. 1 is 36 feet from the downstream end of the room, and the units are spaced 36 feet on centers. The governor for each unit is behind it, and duplicate motor-driven governor oil pumps are centered between the two units and close to the front wall of the room. A Pelton wheel is mounted between these oil pumps and may be connected to either in case of emergency. Lubricating-oil pumps, sump pumps, and a spare exciter are also arranged along the front wall. Under normal operation, however, each unit is excited by a direct-current generator mounted on the upper end of its main shaft.

A basement with several floor levels under the generator room contains the Larner-Johnson valves at the end of the main lines, the turbines, relief valves, and miscellaneous hydraulic equipment, and the oil-sump tanks. Special provision is made for changing the runners of the turbines so that they may be operated at either 50 or 60 cycles. The elbows of the draft tubes are cast in the concrete of the foundations. A humidifier is installed in the upstream end of the basement.

Elevations on the pressure line are as follows:

	Feet.
Water surface in the forebay	3,504.5
Center line of turbines	2,694.0
Maximum tail-water level	2,698.0
Mean tail-water level	2,683.0
Minimum tail-water level	2,678.0

The static head therefore ranges from 826.5 to 806.5 feet, with a mean of 821.5; the turbines are designed for a net head of 800 feet.

Elevations at the power house are as follows:

	Feet.
Parapet top	2,764.0
Upper bus-room floor level	2,732.0
Top of crane rail	2,746.0
Main or generator floor level	2,706.5
Basement floor level	2,694.0
Subbasement floor level	2,684.0

Hydraulic equipment.—At the power house the pressure pipes connect to Larner-Johnson valves with 60-inch inlets and 52-inch outlets, equipped for remote hydraulic control from the switchboard. Above the valve a branch in each line leads to a bursting plug, and below the valve a branch leads to a relief valve.

The two turbines, identical in design, are Allis-Chalmers vertical-shaft Francis type units, designed to operate under a net head of 800 feet, at either 500 or 600 revolutions per minute, the speed depending upon which of the two interchangeable runners is in use. Each turbine is rated at 22,500 horsepower. The upper end of the draft tube is of cast iron and so arranged that the section can be readily removed to permit changing the turbine runner. The inlet of the turbine casing is 48 inches in diameter; the runners used when operating at 50 cycles are 68¾ inches and those used when operating at 60 cycles are 64 inches in diameter.

The center line of the runner inlet is 16 feet above low tail water, but in order to permit changing the runners at high water it was necessary to provide slots for sliding steel gates at the outlet of the draft tubes.

The governor is on the main floor near its unit, is belted to the main shaft, and controls a relay valve supplying oil at 200 pounds pressure per square inch to the two servomotor cylinders 25 inches in diameter connected to the turbine operating ring.

The turbine is so designed that hydraulic uplift will balance most of the weight of the rotating parts. A water-cooled spring-type thrust bearing at the top of the generator will carry any unbalanced weight.

A relief valve is connected to the operating ring in such manner as to open when the wicket gates close, and it may be connected through a dashpot so as to close slowly.

The guaranteed efficiency of the turbines at either 500 or 600 revolutions per minute is 86 per cent for full and 90 per cent for three-fourths load.

Generators.—The generators of the two vertical units that comprise the ultimate equipment of the station are General Electric 17,500-kilovolt-ampere 11,000-volt alternators, designed for normal operation at 500 revolutions per minute, producing 50-cycle alternating current but to be operated at times at a higher speed to turn out 60-cycle current.

Exciters.—A compound-wound exciter rated at 95 kilowatts, 250 volts, at 500 to 600 revolutions per minute, is mounted on the upper end of the main shaft of each unit, and there is a spare motor-driven exciter of sufficient capacity to excite the fields of both main generators.

Transformers.—Each generator connects directly to a bank of three single-phase General Electric 5,833-kilovolt-ampere water-cooled transformers, with a ratio of 10,000 volts delta on the low-tension to 75,000 volts Y on the high-tension side. A spare transformer is provided for connection to either bank in case of emergency.

Wiring.—The high-tension side of each bank of transformers connects to either of two high-tension busses through General Electric 300-ampere 70,000-volt disconnecting switches and General Electric FK-36 400-ampere 70,000-volt oil switches; there is no disconnecting switch between the oil switch and the bus. The two busses may be connected to either of the outgoing lines in the same manner. The busses may be disconnected at the center, and the station operated in two sections, one at 50 and the other at 60 cycles. The high-tension connections are carried through porcelain bushings in the roof to a steel rack to which the transmission lines connect. A General Electric aluminum lightning arrester for each line is installed on the roof.

The main switchboard is on the second floor at the upstream side of the generator room, and the storage battery supplied by a motor-generator charging set is on the third floor, above the switchboard. The board is equipped to control not only the switches and other equipment in the plant but the gates at the forebay.

Two circuits of 4/0 stranded copper conductor, carried on a single steel-tower line, run almost due west about 45 miles and connect to the Big Creek lines through the Vestal substation in San Joaquin Valley. A $\frac{7}{16}$-inch stranded steel ground line is strung on the peaks of the towers for the full length of this line. The two circuits are ordinarily operated in parallel but may be operated separately.

BOREL PLANT.

Location.—The Borel plant was put into operation December 31, 1904, by Kern River Co., which was organized for that purpose and controlled through stock ownership by Pacific Light & Power Corporation.

The intake is on North Fork of Kern River in the outskirts of the town of Kernville, in sec. 33, T. 25 S., R. 33 E., Mount Diablo base and meridian. The conduit traverses secs. 4, 5, 8, 17, 19, 20, 30, 31, 32, T. 26 S., R. 33 E., secs. 6 and 7, T. 27 S., R. 33 E., and secs. 10, 11, and 12, T. 27 S., R. 32 E.; the power house is in sec. 10, T. 27 S., R. 32 E., on the bank of Kern River, in the canyon below Hot Springs Valley.

Conduit.—In the center of the river at the point now occupied by the Borel intake there was originally a small island which divided the stream into an east and west channel. Under the plan of development adopted, a diversion weir was thrown across the east channel, and intake gates admitting water to a settling basin above the head of the canal were placed in the west channel. An earth embankment was thrown up between the two channels downstream from the island and riprapped on the river side. This embankment formed a settling basin along the old course of the west channel, which when first constructed, had a depth of 10 feet, a width of 200 feet half a mile above the headgate, an area of 19 acres, a capacity of 4,000,000 cubic feet, and a length of 0.6 mile. These dimensions have been somewhat changed by silting, but there is still a capacious basin above the canal heading. A timber overflow dam was placed in the embankment about halfway between the intake and the canal heading so that water not needed for power might be wasted back into the river.

The main diversion weir, across the east channel, is of the timber-frame type and is founded on piles driven in three parallel rows 11 feet 6 inches apart. A shallow concrete cut-off wall and a row of sheet piling extend along the upper row of piles, and between the rows and for a few feet down the stream from the lower there is a concrete apron that extends entirely across the river. The open timber framework of the dam is bolted to the heads of the piles (which are flush with the apron) and is fitted to receive stop planks that may be removed during high water and thus provide practically a free channel to pass the floods. The maximum height of the diverting weir above the apron is but slightly over 4 feet. The elevation of the United States Geological Survey bench mark in Kernville is 2,569 feet above sea level.

The structure across the west channel at the head dam is of the same type as the diversion dam, but instead of being fitted with stop planks, it has ten inclined 6 by 6 foot timber gates which are operated by rack and pinion. The tops of these gates are on the same level as the crest of the intake dam.

The regulator that spills surplus water from the settling basin back into the river is similar in structure to the diversion dam. It consists of two sections, the one upstream being 104 feet and that downstream 120 feet long. The structure is founded on four rows of 15-inch piles spaced 11 feet between rows, and has a concrete apron, a cut-off, and a row of sheet piling similar to those at the intake. The apron of the upstream section of the escape is 1 foot higher than that of the downstream section. The top of the structure is 1.4 feet above the crest of the head dam, the water surface is 1 foot below the crest of the head dam, and the depth of water on the two levels of the apron is therefore 7.5 feet on one and 8.5 feet on the other. Outlet is provided through three timber gates, one 2.83 by 8.5 feet and two 5.2 by 8.5 feet, operated by rack and pinion.

Water is discharged from the settling basin into the head of the canal, through a set of gates flanked by concrete wing walls. Immediately above these is a set of scouring sluices that discharge through the embankment into the river channel and are designed to remove silt that may be deposited in front of the canal heading.

The canal is provided with six headgates each 5 feet wide, similar in general features to the inlet gates at the head of the settling basin. On the river side of the canal intake are nine sluices that are divided into two sets of four large gates by a small gate in the center, with which sluicing operations are started. The width of the set of canal gates is 30 feet and that of the sluice gates 38 feet. The bottom of the canal at its head is 9.6 feet below the top of the head dam and 8.5 feet below water surface; the bottoms of the sluices just above the canal gates are 3 feet below the canal grade.

The canal follows down the west side of North Fork for about 3 miles to the junction of the two forks, where it crosses the main river by an 8 by 10 foot timber flume 1,835 feet long. Directly over the stream the flume is carried on a 4-span truss bridge, 464 feet long, set on five concrete piers. The high trestle approach to the bridge has four vertical and two batter posts per bent. The main trestle bents are spaced 15 feet apart.

After crossing to the west bank of the river, the canal traverses the comparatively level country at the lower end of Hot Springs Valley (Pl. LVIII, *C*, p. 616) for about 4 miles, then crosses Erskine Creek, follows around the point of a hill, reaches another large flume across Bodfish Creek (Pl. LVIII, *D*), and thence to the power house traverses very rugged country in the upper part of the lower Kern Canyon. In this section of the conduit are several tunnels. The total length of the conduit is 59,350 feet (11.24 miles), of which 5,572 feet is in 14 flumes, 1,943 feet in 4 concrete-lined tunnels, and the remainder in open, concrete-lined conduit.

Because of the different grades and sections used the conduit may be considered as naturally divided into two parts, the division coming about 8 miles from the head.

On the upper stretch the canal has a grade of 1 in 5,000 and the flumes 1 in 1,000. The bottom width of the concrete-lined canal in this section is 23 feet, the top width 49 feet, the total depth 9 feet, the depth of water 7.5 feet, and the width at water surface 44.5 feet. The flumes in this section are 16 feet wide by 8 feet deep, and have the same grade as the canal except on the bridge at the river crossing, where the flume cross section is 10 by 8 feet and the grade is 1 in 1,000.

On the lower part of the conduit the grade is 2 in 5,000 for the canal and flumes and 1 in 1,000 in the tunnels. In the rugged country of this section the bottom width of the canal is reduced 15 feet and the side slopes are 1 to 1 instead of 1½ to 1, thus giving a top width of 33 feet and a width at the water surface of 30 feet. The flumes are 14 feet wide instead of 16 feet, but their depth is the same, 8 feet. The tunnel section is 10 by 12 feet, but the depth of water is usually only 8 feet. The difference in elevation between water surface at the intake and water surface in the forebay is 25.5 feet. The capacity of the conduit is 590 second-feet.

Forebay.—The forebay is merely an enlargement of the conduit made by excavating into the hillside near its end. A continuation of the forebay past the penstock forms a wasteway through which surplus water may be turned into a small canyon and discharged into the river below the power house. Inclined trash racks cover the gate opening at the head of the pipes.

Pressure pipes.—Five 60-inch lap-riveted steel pressure pipes, averaging 594 feet long, extend from the forebay to the power house. These pipes are straight in horizontal alinement but their profile is broken by five bends at various points. The pipes are made secure by heavy concrete anchorages, are laid above ground, and are uncovered. The effective head to the floor of the power house is 236 feet. By means of draft tubes the working head is increased to 260 feet. At the power house the pipe lines are embedded in concrete anchor blocks and each line turns through nearly a right angle to its respective unit.

Power house.—The Borel power house is a reinforced-concrete building, 168 feet 3 inches long by 63 feet 10 inches wide outside, with corrugated-iron roof on steel trusses. It is set with its long axis at a very slight angle to the direction of the pipe lines, so that they approach almost parallel to the downstream side of the station. The five units are arranged along the downstream side of the generator room, which is 42 feet wide and extends the full length of the building. The shafts of the units are at right angles to the major axis of the room, the turbines being next to the wall and the generators set out toward the center of the room.

The transformer room runs the full length of the upstream side of the building, 168 feet, and is 18 feet wide. A thick wall separates it from the generator room, and the switchboard is carried in a recessed balcony against this wall, facing out into the center of the generator room.

Hydraulic equipment.—Each pipe line passes from the concrete terminal anchorage outside the building through the wall just above the floor and supplies a single unit. Just inside the power house each line passes through a hydraulically operated gate valve to the turbine that operates the unit. The original installation consisted of five Girard turbines, but after several years of operation the turbine of unit No. 5 was replaced by a 3,600-horsepower Doble impulse wheel with two 57-inch rotors each operated by a double nozzle, and in 1913 the turbines of the other units were replaced by 4,000-horsepower turbines of the Pelton-Francis type. Unit No. 5 was turned at the time it was replaced, so that its shaft is now parallel to the length of the power house. The Lombard governors, type B, installed with the original turbines are still in use.

Generators.—The station is equipped with five Bullock 2,000-kilovolt-ampere 2,200-volt 525-ampere 3-phase 50-cycle revolving-field generators designed to operate at 231 revolutions per minute. The generator rotors are mounted on the same shaft with the turbine runners.

Exciters.—The exciter equipment consists of two Westinghouse multipolar 125-volt 150-kilowatt continuous-current generators, driven by Victor turbines controlled by Lombard governors, type F.

Transformers.—Fifteen General Electric 750-kilowatt water-cooled single-phase transformers step up the potential from 2,200 volts to 57,000 volts, with Y connection and grounded neutral.

Wiring.—The switchboard is in a gallery recess in the side of the generator room toward the transformer cells. Each generator is connected directly to its bank of transformers and also to the 2,400-volt bus through an oil switch, the 2,400-volt switchboard being used for synchronizing the generators and 2,400-volt distribution.

Each bank of transformers connects to either or both of the two high-tension busses through Kellman oil switches. Each of the two outgoing transmission lines is connected to one of the high-tension busses. The generators may be synchronized directly to the high-tension busses through their respective transformers. The high-tension oil switches are designed for electropneumatic control from the operating bench board and direct control from the operating gallery.

The transmission line running south from the power house to Los Angeles is described on pages 695–696 and its route is shown on Plate I (in pocket).

Lightning protection is afforded by General Electric aluminum lightning arresters installed in a separate building near the river end of the main power house.

KERN RIVER PLANT NO. 1.

Location.—The intake of Kern River plant No. 1 is in sec. 5, T. 28 S., R. 31 E.; the conduit traverses secs. 5, 6, and 7, T. 28 S., R. 31 E.; secs. 12, 13, 22, 23, 24, 26, 27, 28, 29, and 32, T. 28 S., R. 30 E.; the power house is in sec. 29, T. 28 S., R. 30 E. Mount Diablo meridian, on a narrow point in a bend of the Kern.

The construction of the plant was begun by California Power Co. in January, 1902, and completed by The Edison Electric Co. of Los Angeles. The plant began to transmit power on May 19, 1907.

Conduit.—The intake dam of the conduit of Kern River No. 1 is a massive ogee concrete structure, with a maximum height of 30 feet above the bed of the river (the foundation being carried to bedrock) and a crest length of 208 feet. The elevation of its crest, reckoned according to the company's assumed datum (which is slightly lower than the datum of the United States Geological Survey), is 2,008 feet. The water surface in the head of the canal, referred to the same datum, is 2,006.5 feet, and the water surface in the forebay 1,937 or 1,939 feet, the elevation depending on the number of flashboards in use; the elevation in the center of the nozzles in the power house is 1,062 feet. According to these figures the total drop in the canal is 67.5 feet, and the static head at the power house is 877 feet. Losses due to friction reduce this to an effective head of 865 feet when the plant is working at its rated capacity. The canyon at the dam is so narrow that the entire flood of the river—which has attained within the period covered by records a maximum exceeding 13,100 second-feet—must be passed over the crest or through the canal gates.

The two headgates of the canal, each giving a clear opening of 7 feet by 6 feet 7¾ inches, are placed side by side. The entire width of the canal at the gates is 16 feet and at its center there is a grooved pier 2 feet 8 inches wide, which divides it into the two gateways. The gates have steel I-beam frames covered by sheet-steel skins and operate in vertical grooves, faced with steel angles which are set into the concrete. Motive power is applied through pistons operated in two vertical oil cylinders by pressure pumps. Two similar gates are placed with their operating cylinders at a low level in the gate house and serve an undersluice designed to carry away accumulated deposits of silt.

The head of the canal contracts from a width of 16 feet at the headgates to 8 feet at a point 50 feet below them and at the entrance of the first tunnel; in this distance the grade of the bottom has a total uniform drop amounting to 1 foot 3 inches in order to provide for the acceleration of the water to the usual velocity of flow in the canal.

At the mouth of the first tunnel the conduit empties into a concrete sand box 104 feet long and 20 feet wide, varying in depth from 8 feet 8 inches at the ends, where it is shallowest, to 21 feet just above the lower end, where it is deepest. Two round undersluices, which are 3 feet in diameter and are slit longitudinally along their tops, are laid side by side across and under this deepest point in the box. At the outer end of each of these sluices is a 24-inch cast-iron pipe, fitted with a gate valve that can be operated by a handwheel from a balcony built even with the upper edge of the box. The floor of the box slopes gradually downward from the mouth of the first tunnel to the undersluices, a distance of some 80 feet, and then rises abruptly to the level of the floor of the first flume in a distance of 13 feet. This arrangement tends to keep sand from washing past the slots in the upper part of the undersluices. A curve arching toward the discharge side of the box also tends to force the deposited material toward the side gates.

The total length of the conduit is 44,789 feet from the intake to the forebay; of this 42,884 feet is in 19 tunnels, ranging in length from 496 to 4,374 feet, as shown by Table 123, 1,294 feet is in flume, and 611 feet in arched concrete conduit. The longest flume is just below the sand box at the canal head and is 904 feet long.

TABLE 123.—*Length of tunnels on conduit of Kern River plant No. 1.*

No.	Length.	Concrete arched lining.	Not arched.
	Feet.	*Feet.*	*Feet.*
19	750	750	....
18	2,134	2,134	....
17	1,898	1,708	190
16	1,499	812	687
15	3,767	[a] 610	3,157
14	4,374	[a] 217	4,157
13	2,335	900	1,435
12	2,170	35	2,135
11	2,587	2,243	344
10	3,015	569	2,446
9	2,070	43	2,027
8	3,842	1,078	2,764
7	824	726	98
6	1,805	387	1,418
5	1,523	748	775
4	496	110	386
3	4,050	168	2,882
2	3,150	3,150	....
1	595	595	....
	42,884	16,983	25,901

[a] Made up of 4 or 5 arches.

The lined sections of the tunnels and the full section of the flume are uniformly 8 feet wide and 7 feet deep. In the tunnels not wholly arched with concrete the lining is carried up 6 inches thick to 7 feet above the floor. The uniform grade from the dam to the forebay is 7.92 feet per mile. The maximum depth of water for which the conduit was designed is 6.5 feet, which gives a stream cross section of 52 square feet. The mean velocity with this depth has been measured as 8.93 feet per second, giving a discharge of 464.5 second-feet.

Forebay.—As the side of the canyon above the power house offered no site for a regulating reservoir, the forebay consists simply of a concrete box (Pl. LVI, *B*, p. 592) between 9 and 10 feet deep and about 29 by 42 feet. Inside of the main forebay is an interior box around which the water spreads as it flows out of the tunnel. The head of the pressure main opens through the floor of the interior forebay, and water is admitted to the pressure main through gates placed in the walls of the box.. At one side of the main forebay box a spillway is provided, water flowing over the top of a partition wall into the head of a chamber leading to a timber chute. This chute runs down the side of the hill to the river above the power house.

Pressure pipes.—The single pressure main, as originally designed, was a 7.5-foot pipe of $\frac{3}{16}$-inch plate, laid in an inclined shaft and backed with concrete. The shaft passed down through solid rock for about 250 feet on a grade of 130.3 per cent and then for about 1,030 feet on a grade of 85.4 per cent to the level of the power house; it then turned and ran horizontally 420 feet to the retaining wall at the upper end of the building. About 150 feet from the upper end of its horizontal course the line passed out of solid rock into a timbered tunnel running through the talus and loose material at the foot of the mountain. The 7.5-foot pipe was diminished to 5.25 feet by a 20-foot tapering joint just before the line left bedrock; the 5.25-foot section was 252 feet long and extended through the tunnel from the end of the solid rock to the header at the power house; plates $1\frac{3}{8}$ inches thick were used in this section.

The theory upon which the pressure main was designed was that the $\frac{3}{16}$-inch lining would prevent percolation and that the concrete backing would transmit all pressure direct to the solid rock walls of the shaft. Either from outside hydrostatic pressure or from a yielding of the backing under the normal outward pressure in the pipe, these thin plates failed in several places and had to be replaced with a pipe about 6 feet in diameter and of a thickness proportioned to take the full pressure without relying on backing.

This reinforcement was started at the center of the taper joint between 7.5-foot and 5.25-foot pipes and laid upward through the former, 1,176 feet to the forebay. The uniform inside diameter in this new section is about 6 feet and plates vary in thickness from $\frac{3}{8}$ to 1 inch by steps of one-sixteenth inch. The dimensions of the reinforced line from the retaining wall at the end of the power house to the forebay are shown by the following table:

TABLE 124.—*Dimensions of pressure line, Kern River plant No. 1.*

Length.		Thickness.	Course.	Diameter.	Maximum head.
Ft.	*in.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
252		$1\frac{3}{8}$	....	[a] 63	874
10		$1\frac{3}{8}$	....	Taper joint.	874
[b] 222	$9\frac{5}{8}$	1 plate.	5	[c] $74\frac{1}{8}$	874
102		$\frac{15}{16}$	6	[c] $74\frac{1}{8}$	826
102		$\frac{7}{8}$	6	[c] $74\frac{1}{8}$	759
102		$\frac{13}{16}$	6	[c] $74\frac{1}{8}$	692
104		$\frac{3}{4}$	8	[c] $74\frac{1}{8}$	626
104		$\frac{11}{16}$	8	[c] $74\frac{1}{8}$	559
104		$\frac{5}{8}$	8	[c] $74\frac{1}{8}$	492
104		$\frac{9}{16}$	8	[c] $74\frac{1}{8}$	424
104		$\frac{1}{2}$	8	[c] $74\frac{1}{8}$	357
104		$\frac{7}{16}$	8	[c] $74\frac{1}{8}$	290
40		$\frac{3}{8}$	8	[c] $74\frac{1}{8}$	229
221	$2\frac{3}{8}$	$\frac{5}{16}$	5	[d] 72	191
1,676					

[a] Inside diameter.
[b] 135 feet horizontal at bottom of line.
[c] Outside dlameter.
[d] Mean diameter.

At the outlet of the tunnel the pressure pipe is continued by a header lying parallel to the downstream side of the power house. As successive branches are taken from the header to feed the eight main and two exciter streams, its diameter is reduced by taper pieces to 4.75, 4.25, 3.75, 3.00, and 2.33 feet. Each branch curves to a right angle with the main header and just before passing through the wall of the power house is fitted with a gate valve. In addition to this valve there is another within the power house, close up to the deflecting nozzle.

Power house.—The site for Kern River No. 1 power house is partly natural and partly blasted from the face of the hill. The long axis of the building (Pl. LIX, *A*, p. 616) is at right angles to the general trend of the stream, and is parallel to the axis of the pressure main which emerges from the tunnel in the center of the retaining wall to the right of the power house.

The building, which measures 168 by 70 feet outside and 164 long by 48 feet 3 inches inside, is of very heavy reinforced concrete, with steel roof frame covered with galvanized roofing. The entire generating, transforming, and switching equipment is the one main building. The generator room is in part separated from the switching apparatus, wiring ducts, and line cells by a wall running the length of the building. The transformers are set in alcoves cut through the partition wall and facing out into the generator room.

The four units are arranged in a line on the discharge side of the power house, with their shafts parallel to and 12 feet from the wall. The shafts are therefore parallel to the long axis of the building. The generators by their arrangement fall into two groups of two, each of which is placed as close as possible to its own end of the building. In the space between the two groups and on a line with the machines are the exciters, each one beside its pair of generators; the door on the discharge side of the building is between the exciters.

On the opposite or intake side of the power house are the transformer compartments, and behind the curtain wall the line and bus cells, built into the recesses between and back of the transformer compartments. The switchboard is in a balcony at the center of this side of the room, and all high and low tension wiring is carried through ducts or cells under, between, or back of the transformers. None of it is exposed in the main room except the high-tension disconnecting switches, which are visible through apertures in the curtain walls between the transformer banks. A 50-ton traveling crane spans the generator room.

All bends in the supply pipes leading to the impulse wheels are made outside of the building, and the pipes running under the transformer compartments and main floor to each wheel are straight. Each stream, after impinging on the water wheel, strikes against a curved baffle plate, which deflects it down against another below the water surface in the tailrace. The water then discharges into the stilling pool of the weir on the upstream or discharge side of the power house.

Hydraulic equipment.—Each of the four units is of the double overhung type, having a single impulse wheel on each end of the generator shaft. The impulse-wheel runners are cast steel, 6 feet

8 inches in diameter; each carries 18 bronze ellipsoidal divided buckets measuring 27 by 23½ inches, bolted to the runners. The runners are bolted to flanges formed on the ends of the generator shaft. Each unit is supplied by two deflecting-needle nozzles, raised and lowered by governor, and the position of the needle is controlled by hand. The moving portions of the nozzles are supported in trunnions with ball-joint connection. The nozzle castings are bifurcated to allow center control of the needle, and the weight of the nozzle is supported by a balance piston. In 1921 the old buckets on the No. 3 unit were replaced by buckets of a different design, and its needle nozzles and shape of tip changed, by the Allis-Chalmers Co., to obtain a higher efficiency.

Generators.—The power house is equipped with four General Electric ATB 5,000-kilovolt-ampere 24-pole generators (see Pl. LVI, *A*, p. 592, photograph taken before forced ventilation was installed), giving 1,260-ampere 2,300-volt 3-phase 50-cycle alternating current at 250 revolutions per minute. All main bearings in each unit are furnished with both forced and ring lubrication and are water cooled. The generators are delta connected to the low-tension busses.

In 1914 the generators were entirely inclosed and ventilation was provided by forced circulation of precooled air. For cooling the air two humidifiers were installed. These humidifiers, one for each pair of generators, are over the tailrace on the upstream side of the building.

Exciters.—The two exciter sets, identical in type and capacity, are General Electric 8-pole 225-kilowatt machines, designed to give 1,800 amperes at 125 volts with 430 revolutions per minute. The generator of each exciter set is mounted in the center of the unit, the impulse wheel furnishing motive power is at one end and a large flywheel is at the other end of the main shaft. Each exciter also is furnished with a governor, which acts on a deflector turning down over the jet instead of deflecting the nozzle.

Transformers.—The station contains thirteen 1,667-kilowatt 50-cycle single-phase transformers, arranged in four banks of three each, with a spare that can be connected to any bank. The transformers are connected delta on the low and Y on the high tension side, and are tapped to step up the 2,300-generator voltage to 18,750, 56,250, or 75,000 Y; the equipment is normally connected to give 75,000 volts. They are of the oil-cooled type, the oil being pumped out into a set of coils on the discharge side of the building just above the weir box, where a sprinkling device supplied from the exciter tailrace plays upon the pipe coils.

Wiring.—The generator leads are carried through three separate 4-inch bituminous-fiber ducts under the floor of the power house to the low-tension transfer bus. This 2,300-volt bus is cut into four segments by three oil switches. From each generator segment a lead is carried up through a cell in the wall back of the transformer compartment and out to the low-tension side of the transformers. In this lead there is a double-throw disconnecting switch that can pass the current to the transformer either directly or through an oil switch. The high-tension leads from the transformers are carried through disconnecting switches at the back of the compartment to the high-tension busses running the length of the building, in concrete ducts under the transformer bays. The high-tension busses are sectionized in the middle by oil switches, and from the center of each segment lines are carried up through cells to the high-tension oil switches. All oil switches in station, except low-tension sectionizing bus switches, whether high or low tension can be isolated by disconnecting switches placed on either side. The lines pass from the building through 36-inch square openings placed just below the broad eaves.

The two outgoing circuits on the Los Angeles tower line are equipped with General Electric aluminum-cell lightning arresters which are mounted outside the power house on its downstream side.

The plant is also connected to the San Joaquin Light & Power system through a single-circuit pole line, and one generator operated at 60 cycles supplies power to this line.

BIG CREEK PLANTS.

PLAN OF DEVELOPMENT.

The Big Creek system was designed by Pacific Light & Power Corporation as a progressive development to utilize the power resources of the main San Joaquin between a proposed reservoir at Mammoth Pool and the San Joaquin plant of San Joaquin Light & Power Corporation, and the fall in Big Creek between Big Creek basin (now Huntington Lake) and the river. The development originally contemplated two storage reservoirs and four power plants, of which Big Creek No. 1 and Big Creek No. 2 plants are complete and the power houses contain about half the machinery with which they will finally be equipped; the reservoir on Big Creek has been developed to three-fourths of its ultimate capacity. The rest of the original progressive development remains for future construction, and seven reservoirs and five power houses within the San Joaquin basin have been added to the scheme. Only one of these newer plants, Big Creek No. 8, has been constructed (to part of its final capacity), but work has started on another, plant No. 3. Plant 8 and plant 3 in its present location utilize the head that it was proposed to utilize by the construction of a similar plant, original No. 3.

SOURCE OF WATER SUPPLY.

The drainage basin (Pl. LXIX, in pocket) that supplies the water used by the Big Creek plants lies about 70 miles east of Fresno, in Fresno County, and includes the high-lying mountain basin that extends about 14 miles almost due west from the head of Big Creek to the point where the stream begins its rapid drop into the main canyon of San Joaquin River.

Huntington Lake reservoir floods portions of secs. 11, 12, 13, 14, 15, and 16, T. 8 S., R. 25 E., and secs. 7, 8, 17, and 18, T. 8 S., R. 26 E. The intake of No. 1 conduit is at the reservoir in sec. 14 and the conduit traverses secs. 14, 15, 22, 21, and 28, T. 8 S., R. 25 E.; the power house is in NE. ¼ SE. ¼ sec. 28. Intake for plant No. 2 is in sec. 28, and conduit traverses secs. 28, 33, 32, and 31, T. 8 S., R. 25 E., sec. 6, T. 9 S., R. 25 E., and secs. 36 and 25, T. 8 S., R. 24 E.; power house No. 2 being in SW. ¼ SW. ¼ sec. 25.

The average width of Big Creek basin above plant No. 1 is about 6 miles, and the total area above the storage dams 79.5 square miles. Elevations within this area range from 6,800 to 10,650 feet and the general elevation of the ridge encircling the headwaters at the east is about 10,000 feet. Up to about 8,000 feet above the sea level the basin is well forested, but at higher levels the rocks are generally bare.

No extended records of precipitation are available, and the entire development is a preeminent example of the value of storage. The stream dwindles to such small proportions late in the summer and early in the fall that without storage it would be worthless for power development. There is, however, a high peak to the flood from April to June, owing to the melting of snow in the higher parts of the basin, and with the excellent facilities for storage the flow of the stream can be equalized to give a well-maintained discharge throughout the dry season. The lowest water known during the period of record, which extends from January, 1910, to December, 1918, was for January, 1913, during which the mean monthly flow of Big Creek was 6.9 second-feet. With the 50,000 acre-feet storage of the initial development and a period of draft beginning July 1, 1912, and continuing until April 1, 1913, a flow of 108 second-feet could have been maintained. With the full storage of 103,250 acre-feet storage there would have been draft on storage from July 31, 1911, to April 1, 1913, and a uniform flow of 157 second-feet could have been maintained during this period of severe drought.[27]

At Big Creek plant No. 2, which diverts immediately below plant No. 1, the drainage basin supplying water includes also the 24.8

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[27] For records of discharge of Big Creek below the mouth of Pitman Creek see U. S. Geol. Survey Water-Supply Papers as follows: 331, pp. 159-161 (up to Sept. 20, 1912) ;361, pp. 159-160 (1912-13); 391, pp. 145-146 (1913-14); 411, pp. 143-144 (1914-15).

square miles drained by Pitman Creek. Altitudes in the Pitman Creek basin range from about 5,000 to 9,500 feet, but most of the area is below 8,500 feet. The basin contains a few small lakes, but most of the reservoir sites shown on the topographic maps are so high that they could impound but a small part of the run-off. The basin is similar to that of Big Creek. From April to June the run-off is comparatively large, the monthly mean for June, 1911, for example, amounting to 674 second-feet. Late in the fall and early in the winter the flow dwindles to almost nothing, and the stream would be wholly useless for power if it were not used in connection with the Big Creek storage. Any water from Pitman Creek that can be used through plant No. 2 (and through plants that may be constructed later) adds appreciably to the power available and postpones the date at which the Big Creek storage must be used.

Subsequent to the construction of plants 1 and 2 the Southern California Edison Co. acquired from a lumber company water rights and the storage site at Shaver Lake, about 4 miles southwest of Big Creek No. 2 plant, and early in 1921 it completed a tunnel from Shaver Lake to connect with Big Creek No. 2 conduit. The drainage area of Stevenson Creek above Shaver Lake is 31 square miles, and the basin ranges in elevation from 5,270 feet at the dam site to a maximum of about 7,900 feet at the northwestern boundary. The topography of this part of the Shaver Lake basin is much less rugged than that of Big and Pitman Creek canyons. The drainage basin was originally well forested, but much timber has been cut, giving place to scattered second growth and brush.

The Edison Co. plans to construct a dam at the outlet of Shaver Lake with a total height of 173 feet. A spillway level of 5,370 feet above sea level will give a capacity of 138,570 acre-feet. The present capacity of Shaver Lake is small, the reservoir having been constructed merely as a log pond for a sawmill.

RESERVOIRS.

The Big Creek reservoir, now called Huntington Lake, is at the head of the Big Creek No. 1 conduit and almost at the head of the main pressure drop. There were three gaps in the rim of the basin, which necessitated building three dams to form the reservoir. The largest dam, or No. 1, is on the stream itself, and Nos. 2 and 3 are west of it. The dams were constructed for Pacific Light & Power Corporation in 1912–13 by Stone & Webster to raise the water surface to 6,915 feet above sea level. The dams are all constructed of concrete and are all curved or arched in plan.

The work of raising the dams to increase the water-surface elevation from 6,915 to 6,950 feet above sea level was begun September 1, 1916, and completed October 28, 1917. The area and capacity of the reservoir are shown in figure 34, from which will be noted that the capacity of the reservoir has been increased from 52,000 to 88,700 acre-feet. The dimensions of the enlarged dams are given in Table 125. The table shows that the crest elevation of dam No. 2 is now 6,953.50 feet and that of dam No. 3 is 6,952.50 feet, and that a small dam, designated No. 3a, with a crest elevation of 6,953.50

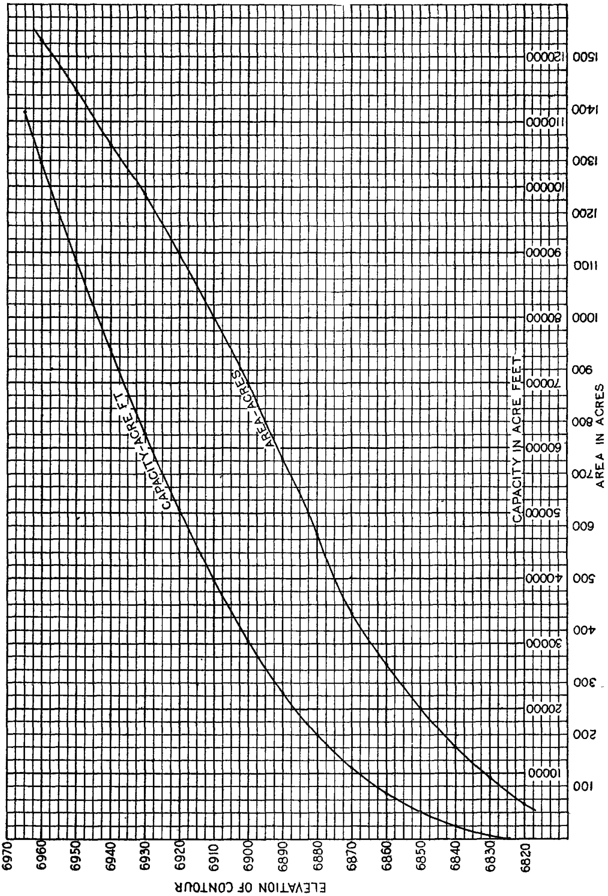


FIGURE 34.—Southern California Edison Co., capacity and area curves of Huntington Lake (Big Creek) reservoir.

feet, has been added to the three that formed the original reservoir. This dam closes a small gap in the hills west of dam No. 3, which was above the original water surface of the reservoir. No spillways or waste pipes are provided in dams Nos. 2, 3, or 3a; all provision for discharging water from the reservoir is at dam No. 1. The crest elevation of dam No. 1 varies. Near the center of the dam there are two spillways lips—one 353 feet and the other 292 feet long. The 42 feet of crest between the spillways rises to an elevation of 6,952.33 feet and forms an operating platform from which the slide gates over the heads of the three 42-inch outlet pipes are controlled. This operating platform is reached by a bridge over the spillway section at the west side of the dam, the bridge itself and the crest elevation of the dam between the end of the spillway and the abutment being at an elevation of 6,955.50 feet. The crest elevation between the eastern spillway and the east abutment of the dam is 6,951 feet, except for a short section directly at the abutment, which rises to an elevation of 6,952.50 feet. At the extreme west end of the dam there is also a set of siphon spillways through which flow will begin when the water level in the reservoir rises to 6,950 feet. The downstream faces of all the present dams are stepped in the same manner as in the original dams, to secure good bond when their height is still further increased. Bond between the old and new parts of the present structure is secured by steel rails sunk in the angle between the rise and tread of each of the steps of the original dam and extending out into the new concrete. A 4-inch vitrified drain was laid along every alternate step of the old structure before the addition was started, and from these drains waste pipes of the same material lead out through the downstream face of the addition, thus relieving any water pressure due to leakage into the joint between the old and new parts of the dam.

TABLE 125.—*Dimensions of dams (in feet), Huntington Lake reservoir.*

Dam.	Elevation of crest.	Elevation of spillway.	Elevation of base.	Maximum height.		Crest length.	Thickness.		Type of structure.
				To crest.	To spillway.		Base.	Top.	
No. 1	6,951–6,955	6,950	6,786	169.0	[a]164	1,219.8	102.5	6	Center curved on radius of 954.33 feet, central angle 35° 58′. Ends straight. Concrete.
No. 2	6,953.50	(b)	6,850	103.5	....	1,871.0	57.8	6	Single concrete arch; radius 800 feet.
No. 3	6,952.50	(b)	6,805	147.5	....	675.5	74.9	6	Single concrete arch; radius 625.1 feet.
No. 3-A	6,953.50	(b)	[c]6,925	28.5	....	272.0	24.0	3	Straight gravity dam.

[a] Seven siphon spillways in addition to two spillway notches totaling 645 feet long.
[b] No spillway.
[c] Bottom of cut-off wall.

BIG CREEK PLANT NO. 1.

Location.—Big Creek No. 1 power house is on the north side of Big Creek immediately below the mouth of Pitman Creek. The plant and Huntington Lake reservoir were constructed in 1912 and 1913, and the first two of the four units eventually to be installed in the power house went into operation November 8, 1913.

Conduit.—The conduit is operated on the closed system, the entire line being in steel pipe or in tunnel driven through solid rock. Water is admitted to the head of the first tunnel at the west end of dam No. 1 (Pl. LXI, *A*) through three screen sections in the upstream face of a gate tower, 20 feet inside diameter and 104 feet high. These screens, each of which measures 7 feet 6 inches by 104 feet, are kept clear of drift by motor-driven rakes. Flow from the tower into the tunnel is controlled by a 9-foot gate valve. When the maximum water surface in the reservoir is raised to 9,965 feet, the gate will operate under head of 140.5 feet and will then be motor driven. There is a 24-inch by-pass from the reservoir to a 36-inch inspection shaft, which runs from the top of the tower down to the top of the tunnel. In addition to the outlet through the tower into the tunnel there are three 42-inch sluice pipes which pierce the base of the dam and discharge into the stream bed below it and through which flow is controlled by a sliding hand-operated sluice gate in each.

The tunnel is 3,880 feet long, 12 feet in diameter, and has a grade of 2 feet per thousand. Four hundred feet from its lower end there is a concrete bulkhead through which connection is made with a steel pipe 108 inches in diameter, which extends to the lower portal of the tunnel. The tunnel below the bulkhead is lined with concrete and there is ample space for inspectors to enter alongside the pipe. At the lower end of the tunnel there is a riveted steel Y, one branch of which is dead ended and the other connected to an 84-inch riveted steel pipe that is laid on a light grade around the southeast slope of the mountain to the head of the pressure drop. The pipe is laid in a trench, is supported by concrete piers at intervals of 35 feet, and has double-riveted longitudinal and single-riveted circular joints. At angles it is anchored by concrete block anchors and the trench is back filled and the pipe covered to a depth of 1 foot. Manholes are about 2,000 feet apart. At its lower end there is a 4-branch Y, each branch being 44 inches in diameter and containing a 42-inch hand or motor controlled gate valve. The motors have remote control from the power house. In each line just below the valves there is a 24-inch standpipe. The standpipes extend up the hillside 425 feet and end in vertical surge tanks 36 inches in diameter and 35 feet high, which rise to an elevation of 6,990 feet. The gates are sheltered by a gatehouse. With the present installation only two of the four branches at the manifold are in use, as only two of the four lines below the manifold were required by the first installation. These extend the greater part of the distance to the power house, each finally branching into two pipes that serve the wheels of one of the units. The dimensions and general characteristics of the pressure pipes are given in Table 126.

TABLE 126.—*Details of pressure lines, Big Creek plant No. 1.*

Length of section.	Number of pipes.	Diameter of pipes.	Type of section.	Thickness of plate.
Feet.		*Inches.*		*Inches.*
35	1	84-44	Reducer.......	$\frac{3}{8}$
103	2	44	Lap welded....	$\frac{3}{8}$
445	2	42	.....do.........	$\frac{3}{8}$
126	2	42	.....do.........	$\frac{7}{16}$
130	2	42	.....do.........	$\frac{1}{2}$
129	2	42	.....do.........	$\frac{9}{16}$
147	2	42	.....do.........	$\frac{5}{8}$
152	2	42	.....do.........	$\frac{11}{16}$
141	2	42	.....do.........	$\frac{3}{4}$
149	2	42	.....do.........	$\frac{13}{16}$
149	2	42	.....do.........	$\frac{7}{8}$
162	2	42	.....do.........	$\frac{15}{16}$
167	2	42	.....do.........	1
179	2	42	.....do.........	$1\frac{1}{16}$
158	2	40	.....do.........	$1\frac{1}{16}$
228	2	40	.....do.........	$1\frac{1}{8}$
249	2	38	.....do.........	$1\frac{1}{8}$
149	2	36	.....do.........	$1\frac{1}{8}$
147	2	36	.....do.........	$1\frac{3}{16}$
450	2	36	.....do.........	$1\frac{1}{4}$
259	4	26	.....do.........	$\frac{15}{16}$
441	4	26	.....do.........	1
[a]117	4	26	.....do.........	$1\frac{1}{16}$
50	4	24	.....do.........	1
4,462				

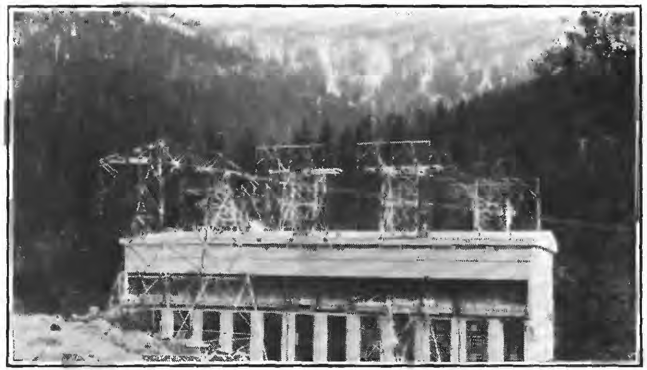
[a] In power house.

The elevation of spillway lip at Huntington Lake is now (1921) 6,950 feet and the elevation of the outlet 6,810 feet; the elevation of nozzle centers at the power house is 4,819 feet, and the plant operates under gross heads ranging from 2,024 to 2,131 feet. The maximum head for the ultimate development will be 2,146 feet. Expanded, riveted joints are used for heads of 1,460 feet or less and flanged joints, bolted, for higher heads.

Power house.—Big Creek No. 1 power house (Pl. LXIV) is built of reinforced concrete and steel and has a frontage of 171 feet along the stream and a depth of 85 feet; its height to the top of the roof is 104 feet, but the total height of the structure is increased to 138 feet by a steel horn-gap frame. The east end wall of the power house is so constructed that the building may be extended to a total length of 213 feet when the ultimate development is made. The present building contains two 17,500-kilovolt-ampere generators and the third unit can be installed without extending the building.

The generator room (Pl. LXI, *C*, *D*) occupies the entire length of the front of the building but does not extend the whole height.

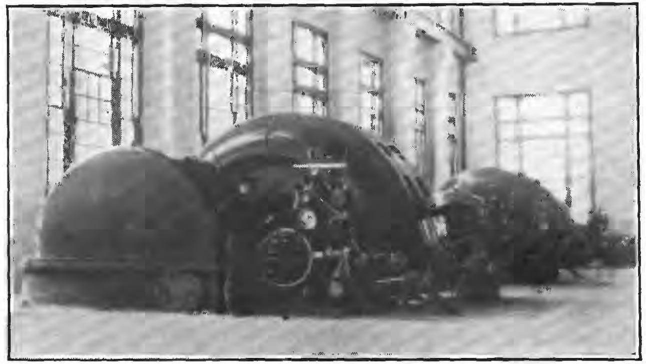
A. DAM NO. 1, HUNTINGTON LAKE.



B. TRANSMISSION-LINE OUTLETS, BIG CREEK POWER HOUSE NO. 1.

C. GENERATOR ROOM, BIG CREEK POWER HOUSE NO. 1, DURING CONSTRUCTION.

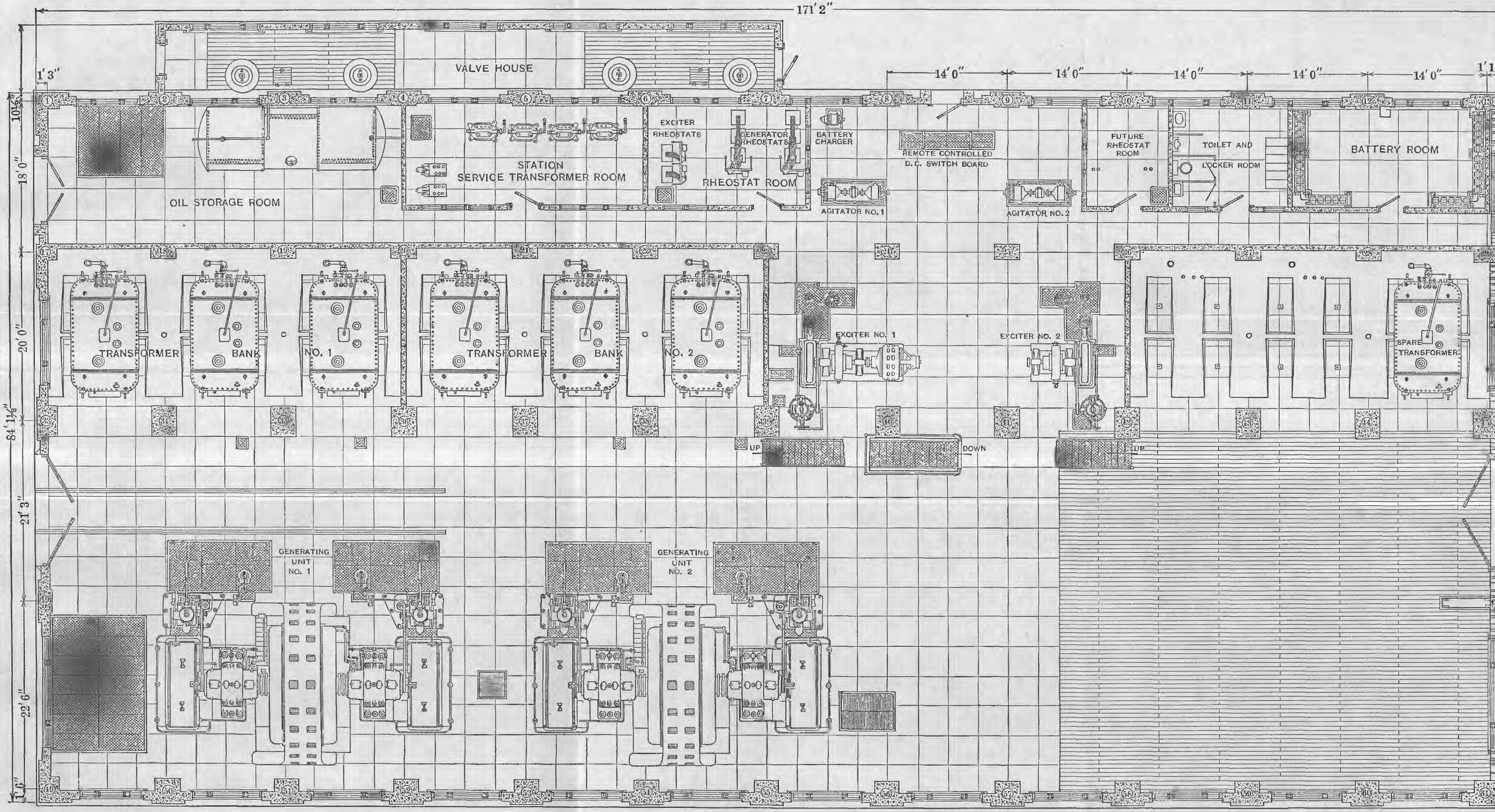
Photograph by J. L. Mathias.



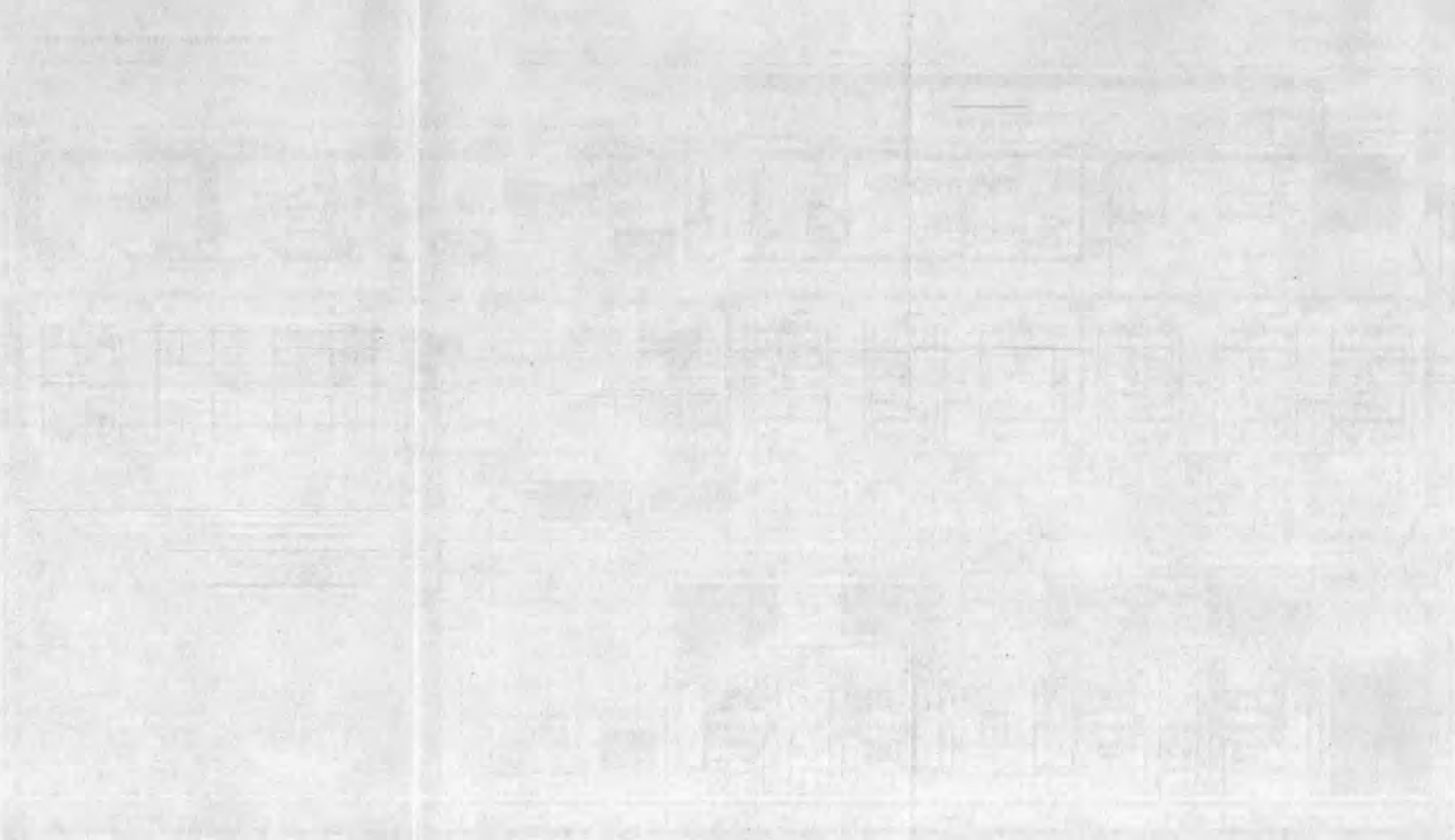
D. GENERATOR ROOM, BIG CREEK POWER HOUSE NO. 1.

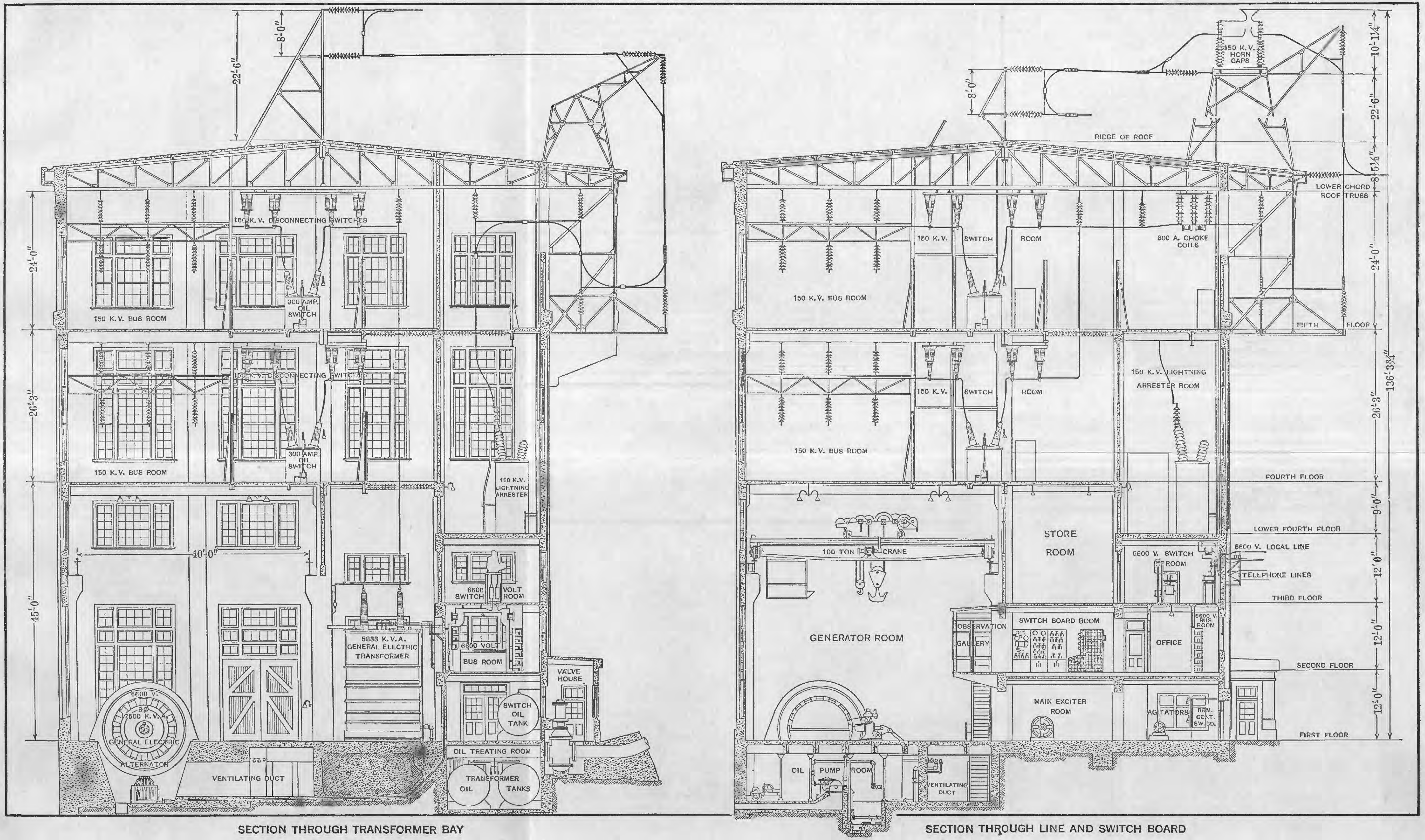
Photographs *A*, *B*, and *D* by the company.

HYDROELECTRIC SYSTEM OF SOUTHERN CALIFORNIA EDISON CO.



BIG CREEK POWER HOUSE NO. 1, SOUTHERN CALIFORNIA EDISON CO., FIRST-FLOOR PLAN.





SECTION THROUGH TRANSFORMER BAY

SECTION THROUGH LINE AND SWITCH BOARD

BIG CREEK POWER HOUSE NO. 1, SOUTHERN CALIFORNIA EDISON CO., CROSS SECTIONS.

BIG CREEK POWER HOUSE NO. 1 AND PRESSURE PIPES, SOUTHERN CALIFORNIA EDISON CO.

Photograph by the company.

Directly back of the generator room are the transformers with the auxiliary bus room behind them. The high-tension leads pass directly up from the transformers to the 150,000-volt switch and bus rooms above the transformer space and the generator room. The two 150,000-volt bus systems are carried on two floors, one above the other. The outgoing lines are supported from the steel roof system by suspension insulators and bushings into an overhang or hood at the back of the power house, turn vertically downward back of the upper part of a curtain wall, and then run out at right angles through an opening. The system, seemingly complex, is very simple, as is shown on the cross section of the power house in Plate LXIII.

Hydraulic equipment.—At the back wall of the building each of the four 24-inch pressure pipes passes through a 24-inch motor-operated gate valve, the valves for the four pipes being sheltered in a valve house built against the back of the power house. (See Pl. LXII.) After passing through the gate valves each line runs directly to its wheel. The nozzles are of the stationary, needle type, are of 5.2 inches bore, and were constructed by Allis-Chalmers Co. The flow is regulated just back of the nozzles by means of a relief which is operated in conjunction with the nozzles by an automatic pressure regulator. The relief discharges into the main tailrace.

The units are of the double overhung type, with one 10,000-horsepower wheel on each end of the main shaft. The wheels are 94 inches in diameter on the pitch line, and each one carries 19 cast-steel buckets. The shafts of the units are hollow forgings, 28 feet 11 inches long, 20 inches in diameter at the bearings, and 27 inches in diameter at the rotor of the generator. The bearings are of the self-alining type, with a ring-oiling and a water-cooling system. Each bearing is 60 inches long. The generator is provided with a heavy cast base bolted to the concrete foundations, and the bearing pedestals are bolted to this base. The wheel housings have cast-iron bases reaching up to the center of the bearings, and the hood above this is constructed of steel plate. On each wheel of each unit is a governor, and one wheel may be shut off entirely when operating at part load. The units are arranged for electric speed control from the switchboard.

Generators.—The two generators are General Electric 17,500-kilovolt-ampere 3-phase 50-cycle 6,600-volt alternators, operated at 375 revolutions per minute and designed to carry an overload up to 21,000-kilovolt-amperes for 1 minute and 25,000-kilovolt-amperes for momentary peaks.

Exciters.—Two of the three main exciters called for by the designs have been installed. Both are of the interpole type with compound windings; one is driven by an impulse wheel and the other is a motor generator set with impulse wheel connected. The exciter wheels are 47 inches in diameter and have 24 buckets. Water is served to them from a general 8-inch header and 6-inch supply pipes through $1\frac{5}{16}$-inch nozzles regulated by hood jet deflectors. Each of the main exciters has a rated capacity of 150 kilowatts and potential of 250 volts when operated at 750 revolutions per minute. Each main exciter may itself receive excitation from a pair of secondary exciters so arranged electrically as to give a wide range of control.

Transformers.—Two main banks of transformers with a spare can be connected into either bank. The transformers are General Electric 5,833-kilovolt-ampere 1-phase 50-cycle water-cooled type, with a ratio of 6,600/86,700 volts. The connections are delta on the low-tension side and Y with grounded neutral on the high-tension side to give 150,000 volts. The grounding is through a current transformer, which is connected to an alarm system. The insulation is designed for 150,000 volts. Each transformer weighs 90,000 pounds and contains 68,000 pounds of oil, giving a total of 158,000 pounds.

Wiring.—The leads from the generator run directly to the 6,600-volt generator bus, which can be connected through either of two H–3 remote-control electrically operated nonautomatic switches to either of the two 6,600-volt transfer busses. (See Pl. LXIII.) Each 6,600-volt oil switch can be isolated by disconnecting switches. Each transfer bus connects through duplicate switching apparatus of the same type to a short 6,600-volt transformer bus, to which the low-tension side of the transformers is connected. The 6,600-volt busses are contained in horizontal concrete cells.

The high-tension leads from the transformers may be connected through either of the two General Electric electrically operated remote-control oil switches (type K–21) to either of the 150,000-volt busses, and the busses through similar switches to the short line busses. Each of the 150,000-volt switches is separated from its neighbor by a concrete curtain wall, and the switches are also separated from the high-tension bus room by a concrete curtain reaching about 12 feet from the floor. The low-tension busses are constructed of flat-bar copper, the high-tension busses of 2-inch wrought-iron pipe, and the high-tension transformer leads of $1\frac{1}{4}$-inch wrought-iron pipe. The high-tension leads are supported, through the bends necessary in their course, by 150,000-volt insulators attached to the framework of the plant.

Both the main and the exciter switchboards are operated by remote control. The main board is in a gallery opposite the central part of the generator room and is of the bench-board type. The board controls the leads from the exciters to the generator field, generators, transformers, and exciter motors. The exciter fields are controlled from the exciter switchboard, which is on the main floor in the exciter bay next to the back wall of the station. Station auxiliaries are controlled from an upright board near the main switchboard. Trouble in any particular part of the power house is reported by an alarm system that lights a lamp in the switchboard room.

The two outgoing lines run nearly due north, past No. 2 power house, then turn to the west and south and run just east of Bakersfield and over the Tehachapi Mountains and terminate at the Eagle Rock substation, about 9 miles northeast of Los Angeles. The total length of these two tower lines, each of which carries a single circuit, is about 242 miles. (See description of transmission system, pp. 692–695.)

Each of the two outgoing lines is equipped with a set of General Electric electrolytic lightning arresters with choke coils. The arresters are at the back of the power house in the room above the 6,600-volt switch room. The horn gaps are on a framework on the roof.

BIG CREEK PLANT NO. 2.

Location.—Big Creek No. 2 diversion dam is immediately below Big Creek No. 1 power house. The plant was constructed, as was Big Creek No. 1, for Pacific Light & Power Corporation by Stone & Webster during the years 1912 and 1913, and went into operation December 18, 1913.

Conduit.—The diversion dam of Big Creek No. 2 plant, or, as it is designated by the company, dam No. 4, is 73 feet high, 288 feet long on the crest, and arched on a radius of 150 feet. The dam is built of concrete and has a section somewhat lighter than a full gravity section. Through its base is a sluiceway controlled by a 72-inch gate valve, and its crest can be fitted with flashboards rising 5 feet above the main structure, which has a crest elevation of 4,805 feet. No. 2 intake is directly upstream from the south end of the dam, and water is admitted to the tunnel through a system of screens supported by buttressed concrete headworks built against the face of the rock.

The conduit for plant No. 2 is entirely in tunnel from the intake to the point where the pressure pipes, after leaving the surge tank, come out on the face of the hill above the power house. The tunnel, 12 feet in diameter, has a grade of 3.2 feet per thousand and is unlined, being driven through firm granite bedrock the entire distance, which is 21,289 feet from the intake to the surge chamber, near the head of the pressure drop.

The surge chamber is excavated down through rock to the level of the tunnel in the same manner as the tank of the San Francisquito plant No. 1 of the Los Angeles Bureau of Power and Light. (See p. 746.) The chamber is, however, of cylindrical instead of conical section, 30 feet in diameter and 120 feet deep, and is lined with concrete. At the base of the tank water is admitted through a gate into a pipe 108 inches in diameter and 252 feet long, connecting through a 108–44-inch reducer 50 feet long with a manifold having two 44-inch branches at the point where the line finally emerges from the face of the hill and the pressure pipes begin. There is a 42-inch gate in each of the 44-inch branches of the manifold. In each pipe line, below the gate, there is a vertical standpipe, the top elevation of which is 4,830.8 feet. The sections of pressure pipe range in length from 50 to 835 feet and in diameter from 24 to 108 inches, as shown by Table 127.

The elevation of the top of flashboards at the intake is 4,810 feet and at the center of nozzles at the power house 2,952 feet above sea level, giving a maximum static head of 1,858 feet.

TABLE 127.—*Details of pressure lines, Big Creek plant No. 2.*

Length of section.	Number of pipes.	Diameter.	Type of section.	Thickness of plate.
Feet.		*Inches.*		*Inches.*
252	1	108	Riveted........	$\frac{1}{2}$
50	1	108–44	Reducer........	$\frac{1}{2}$
620	2	44	Riveted........	$\frac{3}{8}$
835	2	42	Lap-welded....	$\frac{3}{8}$
151	2	42	.....do.........	$\frac{7}{16}$
148	2	42	.....do.........	$\frac{1}{2}$
148	2	42	.....do.........	$\frac{9}{16}$
150	2	42	.....do.........	$\frac{5}{8}$
173	2	42	.....do.........	$\frac{11}{16}$
401	2	42	.....do.........	$\frac{3}{4}$
225	2	42	.....do.........	$\frac{13}{16}$
193	2	42	.....do.........	$\frac{7}{8}$
279	2	42	.....do.........	$\frac{15}{16}$
195	2	42	.....do.........	1
163	2	42	.....do.........	$1\frac{1}{16}$
118	2	40	.....do.........	$1\frac{1}{16}$
130	2	40	.....do.........	$1\frac{1}{8}$
160	2	38	.....do.........	$1\frac{1}{8}$
212	2	36	.....do.........	$1\frac{1}{8}$
183	2	36	.....do.........	$1\frac{3}{16}$
[a]116	4	26	.....do.........	$\frac{15}{16}$
50	4	24	.....do.........	$\frac{15}{16}$

[a] In power house.

In February, 1921, a third unit was added in power house No. 2 and an additional penstock of riveted steel and lap-welded pipe was constructed from a steel tee below the forebay to a Johnson valve in the power house. This pipe is supported on concrete piers and anchors. Its thickness ranges from $\frac{3}{8}$ inch to $1\frac{7}{16}$ inches, and its sectional lengths are as follows:

	Feet.
Riveted steel pipe 44 to 36 inches in diameter....................	2,433
Lap-welded pipe 36 inches in diameter..........................	2,178
Reducers and 26-inch pipe....................................	121
	4,732

In May, 1921, a tunnel was completed from the mill pond at Shaver Lake to the head of the pressure system at power house No. 2. The difference in height between the lower portal of the tunnel and the original No. 2 conduit is, however, not utilized at present. The elevation of the top of the present Shaver dam is approximately 5,275 feet, and the capacity of the lake below elevation 5,273 feet is 5,690 acre-feet. The elevation of the outlet into the temporary flume leading to the tunnel is 5,237.4 feet, which renders available for diversion practically the entire storage of the reservoir. The reservoir is ultimately to be greatly enlarged.

Power house.—Power house No. 2 is the same size as No. 1; that is, 85 feet wide by 171 feet long, 104 feet high to the top of the roof, and 138 feet to the top of the horngap framework. The general arrangement and structural details of the station are almost identical with those at power house No. 1. (See pp. 644–645.) Three of the four units for which the power house is designed have been installed.

Hydraulic equipment.—The gate valves, the type of nozzles and wheels, and the speed and power of the wheels for units 1 and 2 are the same for the No. 2 as for the No. 1 plant, but on account of the lower head under which they are operating, the wheels are provided with 17 instead of 19 buckets and use more water. Each of the double overhung impulse wheels on units 1 and 2 is 94 inches in diameter and rated at 10,000 horsepower. The double overhung Pelton impulse wheels on unit No. 3 are 92 inches in diameter and are designed to operate under 1,780-foot head at 375 revolutions per minute, with a rated capacity of 11,250 horsepower each, or 22,500 horsepower for the pair.

Generators.—The first two units installed are Westinghouse 17,500-kilovolt-ampere 6,600-volt 3-phase 50-cycle alternators, operated at 375 revolutions per minute. Their bearings are of the same general type as those in use in No. 1 plant, but the weight of the units (without wheels) is somewhat less—240,900 pounds as against 292,250 pounds for the units at No. 1 plant. Generator No. 3 is practically identical with Nos. 1 and 2.

Exciters.—There are two main exciters, each exciter generator being a Westinghouse 200-kilowatt 250-volt direct-current generator, operating at 750 revolutions per minute. They are not of the interpole type, like those of plant No. 1, but are compound-wound with 2-shunt windings on the same poles. In operating they are usually not used with series windings, but for hand regulation these can be switched into circuit from the remote-control exciter board. One of the windings is connected across the armature (without rheostat in series) for self-excitation; the other is excited from a storage battery and is controlled by a Tirrell regulator.

Transformers.—Transformer equipment consists of three banks and a spare, Westinghouse oil-insulated water-cooled 5,833-kilovolt-ampere 6,600/86,700 volt 1-phase transformers, connected delta on the low-tension side and Y with grounded neutral on the high-tension side to give a line potential of 150,000 volts.

Wiring.—The general features of the No. 2 wiring system are the same as those for the No. 1 power house. The switches, however, are of Westinghouse manufacture, as is the other electric equipment. The low-tension switches are 6,600-volt type C and the high-tension switches 150,000-volt type GA. The weight of the three phases of the high-tension switches is 24,000 pounds without or 36,000 pounds with oil. The space occupied by each is 19 feet 6 inches by 7 feet 9 inches by 16 feet. The outgoing lines from the power house connect through a short stub, to the main lines from plant No. 1 to Los Angeles. The No. 3 unit may be connected to either the 6,600-volt bus through an oil circuit breaker, or directly to a bank of 150,000/6,600-volt transformers, which in turn can be connected to either high-tension bus through oil circuit breakers.

BIG CREEK PLANT NO. 8.

LOCATION.

The entire fall on Big Creek between Huntington Lake reservoir and the junction of the stream with San Joaquin River, as well as the fall in the main river immediately below Big Creek, was originally to have been developed by Big Creek plants Nos. 1, 2, and 3; but, owing to a revision of this scheme, original site No. 3 has been developed by two plants, of which the lower retains the original numerical designation, and the upper, which develops the entire head between power house No. 2 and the main river, is numbered 8 (plants 5 to 7 having been tentatively outlined for the upper drainage basin of the San Joaquin). Plant 8 is therefore the third to be constructed on Big Creek. The plant was built by the company and began commercial operation August 16, 1921.

The intake dam is on Big Creek 1,000 feet below Big Creek power house No. 2, in the SW. ¼ SW. ¼ sec. 25 and SE. ¼ SE. ¼ sec. 26, T. 8 S., R. 24 E. The conduit, which, except for the pressure pipe, is entirely in tunnel, traverses secs. 26 and 27 of the same township to the power house, on the south bank of Big Creek at its junction with San Joaquin River, in the NE. ¼ NE. ¼ sec. 27.

CONDUIT.

The intake dam is of the same type as that at the head of the Big Creek No. 2 conduit—a concrete arch of somewhat lighter than gravity cross section. The upstream face of the dam is arched on a radius of 150 feet, the crest length is 220 feet, and the maximum height is 60 feet. Nineteen spillway openings, 10.5 feet deep by 7 feet wide, in the crest of the dam are provided with flashboard slots. A steel gallows frame along the crest of the dam over these slots permits the easy removal of the stop logs. The elevation of the top of the logs or flashboards is 2,945 feet above sea level. The thickness of the top of the dam is 7.5 feet. Sliding gates operated from the crest of the dam cover the upper ends of the two 72-inch undersluices.

The intake at the upper end of the tunnel is of the same general type as that at the intake of plant No. 2 but has submerged inlets designed to give siphon action. It has three openings, each 8 feet wide by 11 feet high, with bottoms 2,910 feet above sea level. The top of the structure is 2,950 feet above sea level, or 5 feet above the top of the flashboards in the dam. The inlet passages run horizontally for 4.5 feet at the same size as at the entrance, and then the bottom rises 6 feet in a horizontal distance of 30 feet, each channel narrowing in the same distance to a width of 5 feet but increasing in height to 22 feet. An inclined trash rack of flat steel bars extends down from the top of the intake to the floor level of the entrance, 18 feet in front of the opening.

The tunnel from intake to forebay is nearly square, 20 by 20 feet in cross section, and about 5,570 feet long; it was driven through solid granite, and although it is operated under pressure no lining has been found necessary. The tunnel grade is 4 feet per thousand and its estimated capacity 1,800 second-feet.

A short section of riveted steel pipe 18 feet in diameter connects the lower end of the tunnel to a steel forebay or surge chamber, 35 feet in diameter and 90 feet high. The floor of the surge chamber is about 5 feet below the floor of the lower end of the tunnel, and the top is 35 feet above the high-water level at the intake, so that there will be no overflow even if the plant is suddenly shut down when operating at full load. Three penstock outlets are provided at the base of the tank, one 8 feet in diameter for the present unit, and two, each 10 feet in diameter, for the two future units which will complete the installation. The second and third openings are now closed by bulkheads.

A by-pass, carried around the base of the tank to the first pressure pipe, permitted the company to put the plant into operation several weeks earlier than would otherwise have been possible, as there was a delay in the completion of the surge chamber.

A gate valve is installed at the head of the pressure pipe, inside the surge chamber, and a 3-foot air-vent pipe connects to the pressure pipe outside the surge chamber and rises beside it and to its full height, being fastened to the main tower. A 20-inch by-pass pipe, connecting the surge tower to the pressure pipe just below the air vent, permits filling the pipe before opening the main valve.

The single pressure pipe now installed is laid above ground, in an open trench or on the surface, supported on concrete piers, and held by five concrete anchors of gravity section; expansion joints are installed between the anchors. The upper end of the line is lap-riveted, and the lower end lap-welded. The inside diameter ranges from 8 feet at the top to 6 feet at the bottom, and the plate thickness from 3/8 inch at the top to 1 1/8 inches at the bottom. The total length of the line is 2,592 feet, of which the first 506 feet is riveted and the last 2,086 feet welded. The details of the line are as follows:

TABLE 127a.—*Details of pressure pipe, Big Creek plant No. 8.*

Type of pipe.	Length.		Inside diameter.	Thickness.	Type of pipe.	Length.		Inside diameter.	Thickness.
	Ft.	*in.*	*Feet.*	*Inch.*		*Ft.*	*in.*	*Feet.*	*Inch.*
Double-riveted lap	385		8.0	3/8	Lap-welded	191	8	6.0	5/8
Do	60		7.5	3/8	Do	192		6.0	11/16
Do	24	5	7.0	3/8	Do	144	1	6.0	3/4
Triple-riveted lap	36	7	7.0	3/8	Do	192	6	6.0	13/16
Lap-welded	60	6	7.0	3/8	Do	173		6.0	7/8
Do	58	9	7.0	7/16	Do	96	4	6.0	15/16
Do	57	3	6.5	3/8	Do	96	3	6.0	1
Do	153		6.5	7/16	Do	33		6.0	1 1/16
Do	19	4	6.5	1/2	Do	86	4	6.0	1 1/8
Do	76	6	6.0	7/16		2,592		....	....
Do	231	4	6.0	1/2					
Do	224	4	6.0	9/16					

The following are the elevations of the principal points on the pressure system:

	Feet.
Top of intake dam	2,950.0
Top of flashboards	2,945.0
Spillway lip	2,939.0
Center line of undersluices through dam	2,898.0
Invert of tunnel at intake	2,916.0
Invert of pipe connecting lower end of tunnel to surge chamber	2,895.0
Floor of surge tank	2,890.0
Top of surge tank	2,980.0
Center line of pressure pipe at tank	2,898.0
Center line of turbine	2,230.0
High-water level in tailrace	2,245.0
Normal water level in tailrace	2,215.0
Floor of tailrace	2,206.5

The static head therefore ranges from 700 feet between the top of the flashboards and high water in the tailrace to 730 feet between the top of the flashboards and normal water level in the tailrace. High-water level in the tailrace depends upon the flood stage of the main San Joaquin River; normal or low-water level is fixed by a permanent concrete weir across Big Creek just downstream from the draft-tube outlets.

GENERATING STATION.

Power house.—The two buildings forming Big Creek generating station are on the east bank of San Joaquin River just south of the mouth of Big Creek. The generator building, facing northeast directly on Big Creek, is 100.5 feet long by 57 feet deep outside foundations; the transformer and switch house, directly behind and attached to the generator house, is 66 feet long by 96 feet deep outside.

The generator room, which rises the full height from floor level to roof, occupies the east end of the generator building. That part of the generator building between the west wall of the generator room and the west end of the plant is divided into three floors, housing auxiliary apparatus and the switchboard. This space measures about 23 feet long (on the main axis of the building) by 55 feet deep, but the back part is occupied by stairways, leaving 39 feet in depth for the switchboard and other rooms. The elevation of the main floor in the generator building is 2,250 feet above sea level, and a basement (or turbine) floor extends under the entire building at the 2,230-foot level.

The generator room is 55 feet wide inside the walls and 50 feet in the clear inside the columns of the crane runways. It measures 35 feet high from the main floor to the crane rail, 47 feet 3 inches to the lower chord of the roof trusses, and 56 feet 9 inches to the peak of the roof. The room is 66 feet long. The single vertical generator is set back 28 feet from the front wall and 36 feet 6 inches from the east end of the room.

Duplicate oil pumps, normally motor-driven but with an impulse wheel mounted between them for emergency use, are near the front and in the east end of the generator room. The station generator, driven by an impulse wheel supplied through a branch taken from the main pressure pipe above the Johnson valve, is near the front wall in the west end of the room.

The entire generator floor is commanded by a 150-ton electric crane.

A humidifier with a capacity of 70,000 cubic feet of air per minute is installed in the west end of the basement, and space has been provided for another, to be installed when the second and third units are added.

The transformers are in the front of the transformer house in cells opening into the back of the generator room; the high-tension leads rise vertically above the transformers through a space 20.5 feet deep in the clear and extending the full length and height from the main floor level to roof truss 2343 of the transformer house.

Immediately behind this transformer and high-tension space are two high-tension switch rooms 35.5 feet deep in the clear, extending the full length of the building, one above the other. The floor level of the lower is 2,275 feet above sea level and that of the upper 2,309.5 feet.

Between the switch rooms and the back wall of the building are two similarly arranged high-tension bus rooms 37.25 feet deep in the clear. The floor level of the lower bus room is 2,291 feet above sea level and that of the upper is 2,318 feet.

The parapet of the transformer house is 2,331 feet above sea level, or 101 feet above the main generator and transformer floor level. The nearly flat concrete-slab roof slopes toward the back of the building.

Hydraulic equipment.—At the power house the pressure line connects through a cast-steel elbow to a 72-inch Larner-Johnson balanced plunger valve with hydraulic control. The valve in turn connects to a vertical Francis turbine with a 77-inch runner, rated at 30,000 horsepower. The turbine was manufactured by the I. P. Morris department of the William Cramp & Sons Ship & Engine Building Co. The turbine operates at 428 revolutions per minute, and its speed is controlled by an I. P. Morris standard governor, operating through oil under pressure supplied through gear pumps that are ordinarily operated by motors but are so designed as to be operated by a small impulse wheel in case of emergency.

A relief valve with capacity equal to the maximum discharge through the turbine is connected to the turbine gates, and a dashpot on the relief valve may be adjusted to give any desired time of closing.

A 250-horsepower Allis-Chalmers impulse wheel operates a generator furnishing station light and power. Water for this wheel, for the impulse wheel on the governor oil pump, and for the operation of the Johnson valve is supplied from the main pipe line through a branch taken off above the Johnson valve.

Generator.—The main generator is a General Electric 25,000-kilovolt-ampere 3-phase 50-cycle 11,000-volt alternator direct-connected to the turbine and operated at 428 revolutions per minute. It is designed for an efficiency of 96.5 per cent at full load, 95.5 per cent at three-fourths load, and 93.8 per cent at one-half load—all efficiencies computed at a power factor of 0.9.

Exciters.—A General Electric compound-wound direct-current generator of the interpole type mounted on the upper end of the shaft of the main unit furnishes exciting current under ordinary operation. This exciter is rated at 165 kilowatts, 250 volts.

Transformers.—A bank of three General Electric oil-insulated water-cooled 50-cycle single-phase transformers with a rated capacity of 8,333 kilowatts each and a ratio of 11,000/86,700 or 127,000 volts are in use, and a fourth transformer is installed for emergencies. The bank is connected delta on the low and Y with grounded neutral on the high tension side. The bank is grounded through a current transformer with secondary winding connected to a curve-tracing ammeter and alarm system. Each transformer weighs 50,000 pounds without oil, or 95,000 pounds with oil.

The generator is connected to the bank of transformers through a low-tension oil switch, and the high-tension side of the transformers to each high-tension bus through an oil circuit breaker. The circuits are so arranged that the low-tension oil switches may be shunted and thus taken off the line for inspection and repair.

The high-tension leads from the transformers to the oil circuit breakers are 1¼-inch standard iron pipe, except the direct connections to the circuit breaker, where bare copper cable of 1,000,000 circular mils cross section is used. The busses are 2½-inch standard iron pipe. A disconnecting switch is installed on each side of the circuit breaker.

The low-tension oil switches are of the General Electric 11,000-volt 2,000-ampere H6 tandem type, and the high-tension circuit breakers are 220,000-volt 400-ampere type FK 36.

The short stub line connecting to the main transmission tower line has been operated at 150,000 volts but is designed for 220,000 volts.

KAWEAH RIVER PLANTS.

SOURCE OF WATER SUPPLY.

The parts of the Kaweah River basin (Pl. LVII, in pocket) that furnish water for use in the development of power comprise 165 square miles on the Middle Fork of Kaweah River (above the point where the Sequoia National Park line crosses the stream) and 85 square miles lying wholly on East Fork. The area is entirely in Tulare County, about 28 miles northeast of Visalia.

Middle Fork and its principal tributary, Marble Fork, drain a rectangular area 15 miles long east and west by 10 miles wide north and south. East Fork drains a mountain basin 14 miles long east and west by 8 miles wide north and south. Elevations within the basin range from about 1,400 feet at the intake of Kaweah plant No. 2 to 12,651 feet at the top of Triple Divide Peak, the northern and eastern boundaries including many peaks exceeding 11,000 feet and the greater part of the basin being between 5,000 and 10,000 feet above sea level.

From its headwaters to the intake of Kaweah plant No. 2, Middle Fork flows nearly southwest, and in the first 10 miles below its head it receives several tributaries that drain the western slope of the Great Western Divide. About 2 miles above the intake of plant No. 2 it is joined by Marble Fork, which is formed by the junction of several small streams that drain the southern slope of the ridge between Silliman Crest and Tableland. The general course of Marble Fork from its headwaters to the head of Deep Canyon is southwest, but below that point its direction is almost due south.

East Fork of Kaweah River rises in Monarch, Lady Franklin, and other small lakes between Sawtooth and Florence peaks, on the north slope of the Great Western Divide, at elevations between 10,500 and 11,000 feet, and flows almost due west to its junction with the Middle Fork, about 4 miles below the intake of Kaweah plant No. 1. Its principal tributary is Horse Creek, which drains the southeastern part of the basin; the tributaries that join the river from the north are unimportant.

The headwater region is very rugged and the rocks granitic and almost wholly destitute of soil. The western half of the basin of East Fork has a fair covering of soil, though the basic structure is the same. The ridges in the lower country support a good forest cover which becomes more sparse down in the canyons and finally gives way to chaparral and a scattered growth of oaks along the slopes immediately above the stream. The principal part of the Sequoia National Park, with its groves of giant trees, is in the basin of Marble Fork.

The stream flow in the low season [28] is derived chiefly from melting snows in the upper mountain region and from small lakes and springs. The flow of short rivers in this region, like the Kaweah and the Tule, is decidedly flashy, owing to the extremely steep gradients, the relatively small drainage areas, and the predominant granitic formations.

RESERVOIRS.

On the headwaters of East Fork are four small storage reservoirs that were formed by constructing dams at the outlets of small natural lakes and that are used primarily for power development.

At Lady Franklin Lake a masonry dam 400 feet long on the crest and 12 feet in maximum height impounds 530 acre-feet.

Silver Lake is controlled by a masonry dam 93 feet long on the crest and 16 feet in maximum height. The estimated storage is 100 acre-feet.

Eagle Lake dam is 300 feet long and 4 feet high. The estimated storage is 260 acre-feet.

Monarch Lake dam is 375 feet long and 10 feet high. The estimated storage is 400 acre-feet.

All these lakes except Monarch Lake, which is just north of Silver Lake, are shown by name on Plate LVII.

The high mountains of the eastern part of the basin of Middle Fork contain numerous small lakes, but none of these are controlled.

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[28] For records of discharge of Middle, Marble, and East forks of Kaweah River, see U. S. Geol. Survey Water-Supply Papers as follows: 299, pp. 414, 415; 361, pp. 142-147; 391, pp. 133, 134, 327. These records consist chiefly of miscellaneous measurements.

Stream-flow records for the main stream have been published in Water-Supply Papers as follows: 299, pp. 141-142 (1903 to June 30, 1912); 331, pp. 146-148 (1911-12); 361, pp. 143-145 (1912-13); 391, pp. 132-133 (1913-14); 411, pp. 129-133 (1914-15); 441, pp. 113-114 (1915-16); 461, pp. 112-113 (1916-17); 481, pp. 110-113 (1917-18).

Some work was done by the company on a dam at the Wolverton reservoir site, on Wolverton Creek, but only preliminary construction was completed.

KAWEAH PLANT NO. 3.

Location.—Kaweah No. 3 plant was constructed by the Mount Whitney Power & Electric Co. during 1912–13 and was put into operation in May, 1913.[29]

It is the last of the series of plants on Kaweah River built by the company up to the end of its separate existence. The intakes for Kaweah No. 3 are in secs. 23 and 26, T. 16 S., R. 29 E.; the conduit traverses secs. 23, 26, 27, 33, and 34, T. 16 S., R. 29 E.; the power house is in sec. 33, T. 16 S., R. 29 E., on the left bank of Middle Fork of Kaweah River, just above the diversion dam of Kaweah No. 2 plant.

Conduit.—Both the Marble Fork and the Middle Fork diversion dams of the Kaweah No. 3 plant are low concrete structures. From the diversion dam on Middle Fork to the point where it is joined by Marble Fork siphon the Middle Fork conduit consists of approximately 3,300 feet of concrete flume, 3 feet deep and 6 feet wide (see Pl. LVIII, *B*, p. 616), constructed on a grade of 2 feet in 1,000. The conduit from the Marble Fork diversion dam to the upper end of the siphon across Middle Fork and from the lower end of the siphon to the head of the pressure-pipe line is constructed on a grade of 0.001 (1 foot per 1,000). About 6,000 feet is in concrete-lined ditch 6 feet wide on the bottom and 4 feet deep, with side slopes of 1 to 1; and the remaining 15,700 feet is made by what is termed slab-bench construction. Of this length approximately 12,700 feet is single-slab and 3,000 feet is double-slab construction.

The single-slab conduit is 4 feet deep and 8 feet wide on the bottom, and was constructed by excavating a bench along the hillside, with an uphill slope of 1 to 1. A reinforced-concrete slab was then placed in position to form a vertical wall on the outer or downhill side of the bench, the slabs being made in a central yard and transported to place. A concrete lining 3 inches thick was then placed on the uphill slope of the bench and about halfway across the bottom, from which point to the junction with the slab it was increased in thickness and reinforced.

The double-slab conduit, which is 4 feet deep by 9 feet 6 inches wide (inside dimensions), was constructed by excavating the uphill slope perpendicularly for the depth of the conduit and placing a vertical slab on the uphill (inner) side as well as the downhill (outer), tying in the concrete bottom in a similar manner to that used on the single-slab conduit.

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[29] The writer is indebted to Mr. H. A. Kluegel, former chief engineer of Mount Whitney Power & Electric Co., for the description of Kaweah No. 3 plant.

The siphon that carries the Marble Fork supply across Middle Fork to the main conduit consists of 1,085 feet of 48-inch steel pipe one-fourth inch thick and operates under a maximum static head of 125 feet. At the river crossing the siphon is covered with solid concrete, and in order to provide for the future doubling of the conduit capacity, a second pipe is also embedded in this concrete block at the river crossing. Outlet valves for draining and cleansing the siphon are installed at the lowest point.

A regulating reservoir 315 feet long, 15 to 70 feet wide, and 7 to 22 feet deep, with a capacity of approximately 11 acre-feet, was completed and put into service in September, 1913.

The first 243 feet of the pressure pipe below the regulating reservoir is laid nearly horizontally on a bench along the hillside and terminates at a standpipe 27.40 feet high, 42 inches in diameter, and three-sixteenths of an inch thick, beyond which the line turns and drops down the hill. The pressure line is made up as follows:

TABLE 128.—*Dimensions of pressure pipe of Kaweah plant No. 3.*

Length.	Diameter.	Thickness.	Length.	Diameter.	Thickness.
Feet.	*Inches.*	*Inches.*	*Feet.*	*Inches.*	*Inches.*
1,395.70	42	$\frac{3}{16}$	309,65	36	$\frac{1}{2}$
223.30	42	$\frac{1}{4}$	126.30	36	$\frac{1}{2}$
447.43	40	$\frac{5}{16}$			
407.34	40	$\frac{3}{8}$	3,151.07		
262.25	38	$\frac{7}{16}$			

The lower end of the pressure pipe is connected in the power house with a cast-steel Y and is embedded in a massive block of concrete carried down to bedrock; and at practically all angles and places where advantageous anchorage may be had the pipe is anchored by being embedded in solid concrete. Manholes are provided at suitable intervals along the pipe line.

The static head at nozzle centers is about 775 feet.

Power house.—The power house is a reinforced-concrete building 50 by 50 feet inside. The generator room is 50 feet by 34 feet 4 inches and extends across the back of the building, on the side where the pipe line enters. A solid concrete wall 8 inches thick, with sliding doors, forms a partition across the building and separates the generator room from the transformer and switch room, telephone booth, and storeroom. The building is of fireproof construction, all trimmings, doors, and windows being made of metal.

Hydraulic equipment.—The pipe-line enters the back of the power house and there terminates in a Y, the branches of which run to the two units. Each unit is operated by a Pelton-Doble 77-inch single overhung impulse wheel, having a maximum rating of 3,000 horsepower and developing 2,000 to 2,500 horsepower at best efficiency with normal load and running at 300 revolutions per minute. Each impulse wheel is controlled by a Pelton automatic oil-pressure governor operating a main needle valve; an auxiliary needle valve is also provided. As an additional safeguard, a Lombard relief valve is also installed in the pipe-line just outside the power house. The main gate valves are operated hydraulically.

Generators.—The two generators are Westinghouse 1,750-kilovolt-ampere 2,300-volt 3-phase 60-cycle machines, direct-connected to the impulse wheels and operated at 300 revolutions per minute.

Exciters.—Two 55-kilowatt exciters are installed in the station. One is driven by a Pelton water wheel and the other by an 82-horse-power 2,300-volt 8-phase induction motor. Each exciter has sufficient capacity to excite both generators.

Transformers.—Four 1,250-kilovolt-ampere single-phase transformers are installed—one bank and a spare. They are oil insulated and water cooled, water for this purpose being pumped from the tailrace into a tank on the hillside above the power house. The transformers are connected to step up from 2,300 volts delta to 35,000 volts Y with grounded neutral.

Wiring.—The switching apparatus is very complete, oil switches being used, with hand control from the switchboard, where a full set of measuring instruments is installed, together with voltage regulator and auxiliary apparatus. All wiring from generators to switchboard and from switchboard to transformer room is insulated cable in iron conduit. In the transformer room the wiring is composed of copper tubing carried on insulators supported on a pipe framework.

A main high-tension 300-ampere 3-phase single-throw 35,000-volt Westinghouse type E oil circuit breaker is installed in the switch room, and an air-break high-tension switch is installed on a concrete-pole framework outside the building.

The switchboard, consisting of five panels finished in natural black slate, is erected 7 feet from the wall separating generator and switch rooms, and is on the floor at one side of the generator room.

The switchboard is made up as follows:

Panel No. 1: Exciter panel, controlling the two 55-kilowatt exciters and containing two ammeters, one voltmeter, three 2-phase single-throw knife switches and rheostat handles.

Panel No. 2: Tirrill regulator and induction motor control, containing TA 125 form F-5 regulator, handle for remote control type Q auto starter switch, and ammeter and watthour meter for measuring input to motor.

Panels Nos. 3 and 4: Generator panels, controlling the two 1,750-kilovolt-ampere 2,300-volt generators, and each containing voltmeter, power-factor meter, ammeter, field ammeter, indicating wattmeter, three ammeter receptacles, one 8-point voltmeter receptacle, one 6-point synchronizing receptacle, field discharge switch, handle and face plate for remote control, type D, oil switch, governor-control switch, and field rheostat handle. A 3-phase type C watt-hour meter is mounted on rear of panels.

Panel No. 5: Load panel, controlling three 1,250-kilovolt-ampere transformers and containing one 6,000-kilowatt 3-phase graphic indicating wattmeter, handle, and face plate for remote control type B breaker, two type B ITL relays, and a 3-phase type C watt-hour meter on rear of panel.

Bracket: A swinging bracket holds a type SI synchroscope. The bracket is at the left side of the switchboard (when facing the front of board) and is next to panel No. 5.

The original wooden pole line 2½ miles long connecting Kaweah No. 3 power house with the main line at Kaweah No. 1 power house has been replaced by a new pole line with steel wishbone cross arms, designed for operation at 60,000 volts but now insulated for 30,000 volts. The conductors are No. 2 copper wire.

A 3-tank type A Westinghouse electrolytic lightning arrester is installed on the roof of the power house.

KAWEAH PLANT NO. 2.

Location.—Kaweah No. 2 plant was constructed by Mount Whitney Power Co. in 1904–5 and put into operation in February, 1905. The intake is in sec. 33, T. 16 S., R. 29 E.; the conduit traverses sec. 33, T. 16 S., R. 29 E.; secs. 4, 5, 7, and 8, T. 17 S., R. 29 E., and secs. 12 and 13, T. 17 S., R. 28 E. The power house is in sec. 7, T. 17 S., R. 29 E.

Conduit.—The diversion dam for Kaweah plant No. 2 is on Middle Fork, a mile above its junction with East Fork, and about 1,400 feet above sea level. The dam is a low masonry structure 161 feet long and averaging 7 feet high, and the masonry intake of the conduit is at its northwest end. Flow through this intake is controlled by four timber headgates, 2 feet 5½ inches wide by 6 feet 6 inches high, which slide vertically in a wooden guide frame bolted to the masonry. Below the dam there is a short wing wall with masonry spillway in the outer bank of the conduit, and at the lower end of its spillway there is an inclined trash rack of flat steel bars across the conduit.

The conduit consists of 3.17 miles of concrete-lined ditch, 5 feet wide on the bottom, 12 to 13 feet wide and 3.5 feet deep at water surface, constructed on a grade of 0.001 (1 foot per 1,000), and 0.86 mile of redwood flume 5 feet wide and 4 feet deep, built with a grade of 0.002 (2 feet per 1,000). The flume box is built of 1½-inch lumber; the side posts and caps of the belt courses are 4 by 4 inches; the cross beams and stringers of the belt courses and the trestle posts are 4 by 6 inches (Pl. LVIII, *A*, p. 616). The rated capacity of the conduit is between 75 and 80 second-feet.

The forebay is a concrete-lined enlargement of the lower end of the ditch. It is in two sections, one 24 feet long, 5 feet deep, and 12 feet wide; the other 263 feet long, 9 feet deep, and 14½ feet wide. The masonry side walls are 18 inches thick, and the floor 12 inches thick. At the lower end of the forebay a set of five sliding gates admits water to the head of the pressure pipe.

A single lap-riveted steel pipe 1,011.5 feet long, reduced from 60 to 40 inches in diameter in the first 50 feet, continues at that uniform diameter to a receiver approximately 44 feet long and tapering from 40 to 34 inches in diameter along the downstream face of the power house.

Branches were made from the receiver to the three units that constituted the original equipment. Between the second and third branches the diameter of the main pipe is reduced from 40 to 34 inches, and below this taper the branch to the third unit and smaller branches to the two exciter sets are made. Only these latter branches are now used except in emergencies. The static head developed is 369 feet, of which 351 feet is above center of wheels and 18 feet is draft head.

Power house.—The power house is a wooden-frame building covered with corrugated iron and is 62 feet long by 34 feet wide outside, with concrete floor, walls, and footings. One end of the house is toward the stream and the other toward the forebay, so that the pressure pipe is parallel to the side and not the end of the building. The station was formerly equipped with three 500-kilowatt units, but two of these have been replaced by a single 1,500-kilovolt-ampere machine. The units are placed with their shafts parallel and across the generator room, with the turbines near the downstream wall. The turbines discharge back through the wall into a tailrace directly under the lower end of the pressure pipe, along the downstream side of the building. This tailrace passes along the side of the foundation and curves downstream from the station to a junction with the river. On the opposite (upstream) side of the room is the switchboard, set out far enough from the wall so that both low-tension and high-tension switches are accommodated behind it. Directly upstream from the power house and separated from it by a narrow court is the concrete transformer house. Each transformer is in a separate cell. The swinging doors of the transformer cells open toward the power house, and any transformer can be run out into the court on a small track if repairs are necessary.

Hydraulic equipment.—The new turbine is of the horizontal Francis type, is rated at 1,690 normal and 2,250 maximum horsepower, and is direct-connected to the generator and controlled by a Lombard type E governor. The runner is 32 inches in diameter and has 18 vanes and 18 guide vanes. Two Lombard 8-inch relief valves are installed to prevent dangerous rises in pressure. The one old 500-kilovolt-ampere unit out of the three that constituted the original equipment of the power house is operated by a 39-inch 1,000-horsepower Victor Girard type turbine manufactured by the Platt Iron Works. The two 30-kilowatt exciters are operated by 16-inch Victor Girard type turbines manufactured by the same company.

Generators.—The old units, one of which is left in place for use in emergencies, were General Electric ATB 16-pole 500-kilovolt-ampere 126-ampere 2,300-volt 3-phase 60-cycle alternators, operated at 450 revolutions per minute. The new generator, which in normal operation now carries the entire load, is a General Electric ATB form S 10-pole 377-ampere 2,300-volt 3-phase 60-cycle alternator operated at 720 revolutions per minute. The machine is rated at 1,500 kilovolt-amperes (or 1,200 kilowatts at 0.8 power factor).

Exciters.—The exciter equipment consists of two General Electric 4-pole 30-kilowatt 125-volt 240-ampere direct-current generators, each operated at 1,050 revolutions per minute by a small Girard turbine.

Transformers.—The seven transformers are single-phase 350-kilowatt Stanley 1400 shell type, with a ratio of 2,300 to 34,000. The connections used are delta on the low and Y with grounded neutral on the high tension side. The equipment is connected in two banks with a spare.

Wiring.—The 6-panel switchboard contains three generator panels, one exciter panel, and two feeder panels; the equipment is designed for a double bus. The frequency indicator and a synchronoscope are mounted on a bracket at the end of the board.

The switching equipment as originally installed consisted of ten General Electric 3-phase type F 2,300-volt oil switches and three single-phase Stanley oil-tank 35,000-volt switches. The latter are placed directly back of the switchboard, on the side of the generator room toward the transformer house.

A single 3-phase circuit of No. 2 copper, operated at 34,000 volts, connects the plant to the main line running from Kaweah No. 1 to the valley. This branch line is about half a mile long.

One General Electric aluminum type form C–2 32,000–37,900-volt 3-tank lightning arrester is in use at the power house.

KAWEAH PLANT NO. 1.

Location.—Kaweah No. 1, the oldest hydroelectric plant on the system formerly owned by the Mount Whitney Power & Electric Co., was put into operation in June, 1899, by W. H. Hammond, who then transferred it to Mount Whitney Power Co.

The power house is in sec. 8, T. 17 S., R. 29 E., on the south bank of Kaweah River, about 2 miles below the junction of East and Middle forks, at an elevation of 1,138 feet above sea level. The intake is in sec. 13, T. 17 S., R. 29 E.; the conduit traverses secs. 8, 9, 13, 14, 15, and 16 of the same township and range.

Conduit.—The conduit of Kaweah No. 1 plant heads on East Fork of Kaweah River at an elevation of 2,600 feet, in a natural basin that has been formed in the granite by stream erosion.

From the intake an unlined tunnel 3 feet wide, 6 feet high, and 50 feet long was driven through a point of rock on the south bank of the stream, and at the lower portal of this tunnel the flume begins. The flume, which is 30,723 feet long, is constructed along the precipitous slopes on the south side of the canyon and around the point above the junction of East and Middle forks of the Kaweah. The entire conduit is redwood flume, 3 feet wide and 2 feet deep inside, built of 1½ by 12 inch planks battened with 1 by 4 inch strips. The timbers of the trestle are 4 by 4 inches, and the box bents are spaced 4 feet apart. A 12-inch footboard is supported on the caps. Sand traps are provided at frequent intervals along the line. The uniform grade of the flume is 0.004 (4 feet per 1,000), and the carrying capacity is 23.5 second-feet. At its lower end the flume discharges into a timber sand box 20 feet long, 13 feet wide, and 6 feet deep, provided with an apron spillway over which water passes into a wooden forebay 240 feet long, 10 feet wide, and 10 feet deep. Water is supplied to a steel standpipe constructed of $\frac{3}{16}$-inch plates, 6 feet in diameter and 16 feet high, installed at the head of the pressure pipe line, either through a short sheet-iron trough leading from the flume or through a 2-foot riveted steel pipe 26 feet long leading from the sand box.

The pressure pipe, a single line 3,300 feet long, runs to the power house without lateral bends. The steepest part of the line is inclined 45°, but the slopes along the line vary and there are many breaks in grade. The line is laid in a trench and is covered for nearly all its length, being exposed only in a few places. For a distance of 400 feet from the power house it is laid in concrete, and farther up the hill it is anchored to bedrock at frequent intervals. The characteristics of the pipe are given in Table 129.

TABLE 129.—*Type and dimensions of pressure pipe of Kaweah plant No. 1.*

Type of pipe.	Length.	Inside diameter.	Thickness.
	Feet.	*Inches.*	*Gage.*
Riveted steel	50	[a] 48 to 24	12
Do	290	24	12
Do	200	24	11
Do	200	24	10
Do	100	23	10
Do	180	23	8
Do	160	23	7
Do	160	22	5
Do	180	22	3
Do	340	21	1
Do	280	20	1
Lap-welded	540	19	5/16
Do	200	19	11/32
Do	320	19	3/8
Do	80	19	7/16
Do	20	19	1/2
	3,300	....	....

[a] Taper joint.

A receiver 35 feet long and averaging 14 inches in diameter lies along the upstream side of the power house.

The elevation of water surface in the forebay is 2,425.9 feet above sea level, and the elevation of the nozzles at the power house 1,138.2 feet, giving a static head of 1,287.7 feet. The company estimates the loss in head due to friction at 46 feet.

A tailrace 54 feet long, 3½ feet wide, and 8 feet in average depth extends from the power house to the stream. The tailrace floor is concrete, the walls and roof for the first 36 feet are concrete, and the remainder is built of rough redwood.

Power house.—The generating station is a wooden-frame building with corrugated-iron covering, 20 feet high to the eaves, 33 feet 2 inches by 55 feet in plan. A 12 by 12 foot addition on one side of the main house contains part of the switching equipment and just outside of this addition are four small concrete transformer houses 12 by 12 feet, 9 feet 6 inches high, with 18-inch concrete walls, and a corrugated-iron lightning arrester and high-tension switch house 17 by 20 feet. The three units are placed along one wall of the main building with their shafts across the generator room and their water wheels next to the wall. On the opposite side of the room is the switchboard and auxiliary apparatus.

At the upstream side of the power house the pressure main terminates in a steel casting, from which branches are carried through the wall to the wheels at intervals of 10 feet. In each of these branches is a gate valve, and at the extreme lower end of the pipe, beyond all the wheels, outside the power house, there was formerly a blow-off nozzle controlled by a hand-operated gate valve at the power-house wall. This has been taken out. As the receiver runs along the side of the power house and the units are placed with their wheels close inside the wall, the branches to the wheels are very short. The branches bend in a gentle reverse curve, so that on leaving the wheels the water is discharged into a tunnel tailrace running along under the foundations parallel to the wall of the building. All three wheels are in line, so that the stream for the first and second wheels when deflected strikes a baffle and discharges under the next succeeding wheel.

Hydraulic equipment.—Each of the units is operated by a single 50-inch Doble overhung wheel equipped with 20 double ellipsoidal buckets. One unit is provided with a needle nozzle and the other two are governed by deflecting hoods over the streams. The operation of these hoods is controlled from the switchboard by hand wheels on the ends of long rods that turn beveled gears at the units.

Generators.—The three generators are Westinghouse stationary-field 450-kilovolt-ampere 440-volt 590-ampere 3-phase 60-cycle machines, operating at 515 revolutions per minute. Originally each shaft carried a 4,000-pound flywheel, but these wheels have been removed.

Exciters.—One Westinghouse multipolar 15-kilowatt 125-volt continuous-current machine driven at 1,050 revolutions per minute by belt from the generator shaft furnishes excitation. This exciter was designed to carry all three generators. A motor-generator exciter set, installed in 1919, contains an Allis-Chalmers induction motor which is direct-connected to and mounted on the same bedplate with a direct-current generator. The induction motor is a 40-horsepower 3-phase 60-cycle 440-volt machine, operated at 1,160 revolutions per minute, and the exciter is a 30-kilowatt 125-volt compound-wound generator.

Transformers.—The plant is equipped with four Allis-Chalmers outdoor-type 500-kilovolt-ampere oil-insulated transformers, arranged for circulation of the oil through cooling coils. The voltage of these transformers is 440 to 40,415/38,105/21,632/19,052. They are connected delta on the low-tension and Y on the high-tension side to give a line potential of 33,000 volts.

Wiring.—The low-tension switching apparatus comprises three 3-phase General Electric type F form K-2 oil switches. There are three Stanley oil-tank single-phase high-tension switches.

Section 1 of the 6-panel switchboard contains the voltage regulator and exciter control; section 2 is the exciter panel; sections 3, 4, and 5 are generator panels; and section 6 the feeder panel.

The outgoing line is a single 3-phase circuit of No. 2-0 (Brown & Sharpe gage) medium-drawn copper. The poles are sawed redwood 36 to 40 feet long and 5 by 5 inches at the top; the 40-foot poles are 10 by 10 inches at the butt. The average span used is 120 feet. The line runs to the Exeter, Porterville, and Visalia substations, about 28 miles, by way of Lemon Cove, and receives en route a branch from Kaweah plant No. 2.

TULE RIVER PLANT.

LOCATION.

The Tule River power house is in sec. 6, T. 21 S., R. 30 E., on Middle Fork of Tule River. The intake is in sec. 26, T. 20 S., R. 30 E; the conduit traverses secs. 26, 27, 28, 29, 30, and 31, T. 20 S., R. 30 E.; sec. 36, T. 20 S., R. 29 E.; and sec. 6, T. 21 S., R. 30 E.

The plant was constructed by Globe Light & Power Co. in 1908 and 1909 and began generation of power in September, 1909.

SOURCE OF WATER SUPPLY.

The Tule River plant is operated with water furnished by North and South forks of Middle Fork of Tule River, the total drainage area above the intake comprising 86.5 square miles. The drainage basin (see Pl. LVII, in pocket) is on the west slope of the ridge that separates the Kern River basin from the San Joaquin Valley, is 18 miles east of Porterville, and is entirely in Tulare County.

North Fork of Middle Fork rises in some small lakes on the western slope of Sheep Mountain, about 9,300 feet above sea level, and flows southward to its junction with South Fork of Middle Fork. Its tributaries, without exception, rise on the ridge between the Tule and Kern basins, and therefore enter the stream from the east. South Fork of Middle Fork rises on this same ridge at an elevation of about 8,500 feet, and flows almost due west to its junction with the North Fork of Middle Fork. Both the North and South forks and the Middle Fork below their junction have very steep gradients.

The rocks of the region above the plant are largely granitic. Many of the mountains are bald granite knobs, but below their caps are covered with moderate growths of pine and oak and on their lower slopes and in the canyons are sparsely forested. A large part of the basin is densely covered with chaparral and scrub oak.

Elevations within the basin above the plant range from 2,500 feet at the intake to 10,000 feet at several points along the northeastern boundary of the Middle Fork basin. It is in this region that few small lakes are found. The equalizing effect of these lakes on the flow of the stream is almost negligible.[30] The low flow comes chiefly from springs and seepage in the upper mountain regions, as the elevations are too low to permit snow to remain until the end of the warm season.

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[30] For records of discharge of Tule River, see U. S. Geol. Survey Water-Supply Papers as follows: 299, p. 414 (miscellaneous measurements of Middle Fork); 331, pp. 136-142; 361, pp. 136-137; the records published in Nos. 331 and 361 show the flow of North and South forks of Middle Fork of Tule. No further records for these two branches have been published.

CONDUIT.

The conduit has two small concrete intake dams, one 44.75 feet long on North Fork and the other 123.75 feet long on South Fork of Middle Fork, immediately above their junction. The length of the conduit from the intake to the head of the pressure pipes is 35,927 feet, divided as follows:

TABLE 130.—*Conduit of Tule River plant.*

	Feet.
Wooden flume	23, 513
Concrete-lined ditch	10, 803
Concrete flume	228
Sand boxes	202
Inverted siphon	879
Regulating reservoir	302
	35, 927

These figures include the North Fork branch flume, 377 feet, and South Fork branch flume, 673 feet in length.

The wooden flume is 4 feet wide and 3 feet deep, is constructed of pine, and on a grade of 0.002 (2 feet per 1,000). The concrete-lined ditch is 4.5 feet wide on the bottom, 10.5 feet on the top, and 3 feet deep, with a grade of 0.001 (1 foot per 1,000). The concrete lining is 2.5 inches thick and is covered with a half-inch coat of plaster. The one inverted siphon on the conduit is 879 feet long (slope distance), and 36 inches in diameter; it has a total drop of 5 feet between its upper and lower ends, sustains 120 feet head, and is constructed of No. 11 sheets, lap-riveted. The capacity of the ditch is about 50 second-feet.[31]

At its lower end the conduit empties into a concrete-lined forebay, or regulating reservoir, with a capacity of 175,000 cubic feet. The forebay varies in width from 22 to 125 feet, is 302.5 feet long, has side slopes of ½ to 1, and is 12 feet deep. At its upper end there is a 5-foot drop in its floor which forms a sand trap. The concrete lining is 8 inches thick and is covered with a coating of plaster half an inch in thickness.

As originally constructed the North Fork dam was 17 feet higher than the South Fork dam. Later the San Joaquin Light & Power Corporation built its plant, taking the water from the North Fork, with a power house so placed as to utilize the lost head in the North Fork flume, thereby reducing the length of the flume 200 feet.

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[31] At certain seasons the Tule is heavily impregnated with a carbonate of lime which coats the canal lining. At the same time there is a rapid growth of moss. Both of these phenomena tend to cut down the carrying capacity of the conduit in a very marked degree.

The single pressure pipe is made of riveted steel, is 2,814.8 feet long from forebay to power house, and has the following dimensions:

TABLE 131.—*Dimensions of pressure pipe of Tule River plant.*

Length of section.	Diameter.	Thickness of plates.	Length of section.	Diameter.	Thickness of plates.
Feet.	*Inches.*	*Gage No.*	*Feet.*	*Inches.*	*Inch.*
420	30	11	120	26	$\frac{3}{8}$
140	30	8	276	26	$\frac{7}{16}$
145	28	6	351	26	$\frac{1}{2}$
		Inch.	210	24	$\frac{1}{2}$
170	28	$\frac{1}{4}$	527.8	24	$\frac{9}{16}$
230	28	$\frac{5}{16}$			
225	28	$\frac{3}{8}$	2,814.8		

The pipe is laid in a trench, is covered, and terminates in a Y, one branch of which is connected to each unit. The static head at the nozzle centers is 1,130 feet.

GENERATING STATION.

Power house.—The Tule River power house is a steel-frame building, with concrete walls reinforced with wire mesh. The power house proper is 39 feet long, 30 feet broad, and 20 feet in height to the bottom chord of the steel roof trusses; a lean-to 39 feet long and 15 feet 9 inches wide, built against the lower side of the house, accommodates the transformers. The main part of the structure forms a single room, which contains two units set wheel-to-wheel along its main axis. Along the front wall of the room (or side opposite the pressure pipe) is the switchboard and exciter equipment, and back of these the front wall separates the generator room from the transformer compartment. In front of the power house, near the transformer compartment, there is a separate switchhouse.

The pressure pipe enters the generator room at right angles to and at the center of the back wall of the building. Immediately inside the wall it connects to the Y which branches to the two wheels, placed on the inner ends of the generator shafts. Each branch of the Y is fitted with a 14-inch hydraulically operated gate valve placed close to the power-house wall, and each branch terminates in an automatic by-pass needle nozzle, operating a single impulse wheel. The discharge from the wheels is caught in a tailrace 2,352 feet long that passes under the transformer room and leads into a canal which, a short distance upstream from the power house, delivers the water to the river for the use of other appropriators. The first 220 feet of the tailrace is tunnel 4½ by 4½ feet in section; the rest is standard ditch and 4½ by 4½ foot culvert.

Hydraulic equipment.—Each unit is fitted with a 40-inch single overhung Doble impulse wheel, rated at 1,800 horsepower. The automatic by-pass nozzles are controlled by Lombard governors, type R.

Generators.—The two electric generators are General Electric ATB form A 1,250-kilovolt-ampere (1,000-kilowatt at 0.8 power factor) 2,300-volt 314-ampere 3-phase 60-cycle machines, operated at 514 revolutions per minute.

Exciters.—Excitation is furnished by two exciter sets. One set is a General Electric type MF 85-kilowatt 125-volt 280-ampere continuous-current generator, operated at 1,200 revolutions per minute by a Doble wheel. The second set is identical with the first but is operated by a 60-horsepower General Electric induction motor instead of by an impulse wheel.

Transformers.—The two banks of transformers in the lean-to transformer house opening off the generator room are of General Electric 400-kilowatt single-phase 60-cycle water-cooled design, but now cooled by oil circulation, and raise the potential from 2,300 to 34,000 volts. The connections are delta on the low and Y with grounded neutral on the high tension side. A spare transformer is provided for connection to either bank in case of emergency.

Wiring.—The low-tension switches are of the General Electric 500-ampere 4,500-volt oil type. The high-tension switching equipment consists of one 3-phase Kellman oil switch, tested for 200 amperes at 30,000 volts. The station is fitted with a 5-panel switchboard. The first panel contains two synchronous ammeters, one Thomson voltmeter, two rheostat controls, two knife switches, and one Thomson polyphase wattmeter. The second panel contains one General Electric voltage regulator, type DA, 125-K6, one Thomson ammeter, one double remote-control switch, one time-limit relay, type B. The third and fourth are generator panels and contain identical equipment. Each is fitted with one power-factor indicator, one Thomson indicating wattmeter, one Thomson ammeter, and one Thomson voltmeter, one Thomson polyphase wattmeter, one rheostat control, and a generator switch. The fifth panel contains one Thomson indicating wattmeter, two time-limit relays, two transformer remote-control switches, and one Thomson polyphase meter. A synchroscope is mounted on the bracket on the end of the board, and a curve-tracing voltmeter on the wall back of the switchboard.

The outlet for each conductor from the transformers through the main wall of the building to the switchhouse, and from the high-tension switches through the side of the switchhouse to the pole top disconnecting switches at the end of the transmission line, is through a window 24 inches square glazed with two panes of glass pierced at their centers by circular openings 4 inches and 6 inches in diameter, respectively.

A pole line originally carrying a single 3-phase circuit of three 7-strand aluminum cables, each of conductivity equivalent to a No. 2 copper wire, runs from the plant 19 miles to Porterville; the conductor has been changed to No. 2 copper. The line is operated at 35,000 volts with grounded neutral. The poles are 35 to 40 feet long, and the spans are 350 feet long.

A General Electric aluminum form F 35,000-volt lightning arrester is mounted in the switchhouse.

STEAM-ELECTRIC PLANTS.

LOS ANGELES STEAM PLANT NO. 3.

Buildings.—The Los Angeles No. 3 steam and transformer station on Alhambra Avenue, in East Los Angeles, is constructed of brick and reinforced concrete and measures in plan 203 by 166 feet. The plant was put into commission by the Edison Electric Co. of Los Angeles April 27, 1904, and after May 19, 1907, when Kern River No. 1 plant began transmission, served as the receiving and transformer station for both the Santa Ana 33,000-volt and the Kern River 60,000-volt power. The total steam equipment of the plant amounts to 10,000 kilowatts and the transformer equipment to 26,700 kilowatts. Only the steam equipment of the plant is here described; the transformer equipment is listed in Table 142 in connection with the description of the transmission system. A summary of the equipment of Los Angeles No. 3 and Long Beach steam plants is given in Table 132.

Mechanical equipment.—The water supply at the plant is obtained from two wells on the premises and from the city mains. The boiler and make-up water is delivered by one 6 by 5¾ by 6 inch Dow duplex and one 6 by 7½ by 6 inch Worthington duplex pump to a treating tank, from which it is served to the boilers by two Snow 16 by 10 by 12 inch and two Dean 10 by 6 by 12 inch feed-water pumps. The feed-water heater installed with the two original units was a Cookson 500-horsepower open heater; with the third unit, a Cochrane 5,000-horsepower open heater was added.

With the two 2,000-kilovolt-ampere units eight 500-horsepower Stirling boilers were installed, each of which had 5,020 square feet of heating surface; these boilers supply steam at 150 pounds pressure. The superheaters originally in use have been removed. With the 6,000-kilovolt-ampere unit seven 751-horsepower Stirlings were added, each of which has 7,512 feet of heating and 1,600 feet of superheating surface; these supply steam at 170 pounds pressure at 150° superheat. A single stack 150 feet high by 10 feet interior diameter serves both sets of boilers.

Two Wheeler Admiralty condensers, each 6,000 square feet in capacity, were provided with the first installation, and a Worthington 24,000-square-foot condenser was added with the last unit.

TABLE 132.—*Summary of equipment of Los Angeles No. 3 and Long Beach steam plants, Southern California Edison Co., Dec. 31, 1920.*

	Long Beach steam plant.			Los Angeles No. 3.		
	No. 1.	No. 2.	No. 3.	No. 1.	No. 2.	No. 3.
Date in operation	Aug. 20, 1911	Feb. 2, 1913	Mar. 30, 1914	Apr. 27, 1904	Dec. 11, 1904	Sept. 29, 1906.
Turbo-generator:						
Make	General Electric Co. vertical.	General Electric Co. vertical.	General Electric Co. vertical.	General Electric Co. vertical.	General Electric Co. vertical.	Westinghouse horizontal.
Kilowatts	12,000	15,000	20,000	2,000	2,000	6,000.
Kilovolt-amperes	15,000	18,750	25,000	2,000	2,000	6,000.
Voltage	11,000	11,000	11,000	2,300	2,300	16,500.
Revolutions per minute.	750	750	750	750	750	750.
Cycles	50	50	50	50	50	50.
Number of stages	5	6	6			
Exciters:						
Kilowatt	125	125	200	50	50	
Voltage	125	125	125	125	125	
Speed	2,400	2,400	750	400	400	
Type	Turbo-driven	Turbo-driven	Motor-driven	Engine-driven	Engine-driven	
Condenser:						
Make	Wheeler	Wheeler	Alberger			
Square feet of surface in base.	16,000	21,500	16,000	6,000	6,000	24,000.
Square feet in auxiliary.	5,500	5,500	20,000			
Normal vacuum	28 inches	28 inches	28.5 inches			
Size tubes	1 inch outside diameter.	1 inch outside diameter.	1 inch outside diameter.	¾ inch outside diameter.	¾ inch outside diameter.	1 inch outside diameter.
Vacuum pump:						
Type	Rotative	Rotative	Rotative	Edwards triplex	Edwards triplex	Rotative.
Size	12 by 30 by 18 inch	14 by 34 by 18 inch	36 by 34 inch	16 by 10 inch	16 by 10 inch	10 by 24 by 18 inch.
Revolutions per minute.			33	120		
Driven by	Steam	Steam				
Circulating pump:						
Type	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal.
Size	30 inches	36 inches	40 inches			30 inches.
Capacity (gallons per minute).	24,000	30,000	40,000	3,700	3,700	15,000.
Head	35 feet	20 feet	25 feet			
Speed (revolutions per minute).	240	600	260	600	600	417.
Driven by	14 by 18 inch steam engine.	230-horsepower turbine.	350-horsepower motor	75-horsepower motor	75-horsepower motor	420-horsepower motor.

Hot-well pumps:						
Number and type	2 horizontal centrifugal.	2 horizontal centrifugal.	2 vertical centrifugal			Centrifugal.
Size	5-inch	6-inch 2-stage				2-stage.
Driven by	1 motor and 1 turbine	1 motor and 1 turbine	35-horsepower motors			
Speed	1, 500		1, 500			
Step-bearing oil pumps:						
Type	2 duplex	2 duplex	2 triplex, 1 duplex	1 duplex	1 duplex	
Size	12 by 2⅞ by 12 inches	14 by 3½ by 12 inches	2½ by 8 inches, 14 by 3½ by 12 inches.	7½ by 2 by 6 inches	7½ by 2 by 6 inches	
Capacity (gallons per minute).			30			
Pressure	1, 200 pounds	1, 200 pounds	1, 500 pounds			
Spare	2½ by 8 inch triplex 25-horsepower, motor driven.		30 horsepower motor			
Guide-bearing oil pumps:						
Type	2 duplex	2-duplex	2 screw			
Size	5½ by 3¾ by 5 inches	6 by 4 by 6 inches	10 horsepower motor driven.			
Capacity (gallons per minute).	1		25			
Pressure	135 pounds	135 pounds	150 pounds			
Speed (revolutions per minute).			920			
Oil drain pumps:						
Type	2 vertical centrifugal	2 vertical centrifugal	2 vertical centrifugal			
Size	1½-inch	1½-inch	1½-inch			
Capacity (gallons per minute).			70, 25-foot head			
Driven by	1 motor and 1 turbine	1 motor and 1 turbine	Motor			
Sump pumps:						
Type	Vertical centrifugal		Vertical centrifugal			
Size	1 inch		1 inch			
Motor	¾ horsepower		1 horsepower			
Capacity (gallons per minute).			30			
Boilers:						
Make	Stirling	Stirling	Stirling	Stirling K–0½		Stirling S031.
Number	8	8	8	8		7.
Size (brake horse-power) each.	777.5	777.5	850	500		751.
Pressure	225 pounds	225 pounds	225 pounds	150 pounds		150 pounds.
Superheaters	Babcock & Wilcox, 641 square feet.	Foster	Babcock & Wilcox			1,600 square feet.
Superheat	125°	125°	125°			150°.
Number of burners, each.	4	4	4	3		3
Economizers:						
Make			Sturtevant			
Number			4			
Size each			10,000 square feet			
Motors on scrapers			Two, 5-horsepower each.			

TABLE 132.—*Summary of equipment of Los Angeles No. 3 and Long Beach steam plants, Southern California Edison Co., Dec. 31, 1920*—Contd.

	Long Beach steam plant.			Los Angeles No. 3.		
	No. 1.	No. 2.	No. 3.	No. 1.	No. 2.	No. 3.
Feed pumps:						
Number and type	2 duplex	3 centrifugal	2 centrifugal	2 duplex		2 duplex.
Size	12 by 10 by 18 inches	Two 5 inches, 4-stage; one 6 inches, 4-stage.	7 inches, 6-stage	10 by 6 by 12 inches		16 by 10 by 12 inches.
Capacity (gallons per minute).	750		700			
Driven by		Turbine, 200-horsepower motor.	175-horsepower motors.			
Speed (revolutions per minute).		2,150, 700	1,440			
Fuel-oil pumps to burner:						
Number and type	2 duplex	2 duplex	2 duplex	2 duplex		
Size	7½ by 5 by 6 inches	7½ by 5 by 6 inches	7½ by 5 by 6 inches	4½ by 3¾ by 4 inches		
Fuel-oil supply pumps:						
Number and type	2 triplex					
Size	6 by 8 inches					
Driven by	5 horsepower motors					
Water-service pump:						
Type	Simplex		Centrifugal	Duplex		Duplex.
Size	8½ by 5 by 10 inches		5 inches, 6-stage	6 by 5¾ by 6 inches		6 by 7½ by 6 inches.
Driven by			30 horsepower motor			
Capacity (gallons per minute).			200			
Accumulator for step oil:						
Size	9 inches by 9 feet	9 inches by 9 feet	9 inches by 9 feet			
Pressure	1,200 pounds	1,200 pounds	1,200 pounds			
Stacks:						
Diameter at top	12 feet 6 inches	12 feet 6 inches	12 feet 6 inches		10	
Height above floor	150 feet	150 feet	180 feet		150	
Feed-water heater:						
Make	Cochrane	Cochrane		Cookson	Cochrane	
Size	7,000 horsepower	7,000 horsepower		500 horsepower	5,000 horsepower	
Type	Open	Open		Open	Open	
Fuel-oil heaters:						
Make	2 American	2 American	2 American			
Size	400 horsepower	400 horsepower	400 horsepower			
Type	Coil	Coil	Coil			
Air compressor:						
Type	Locomotive		Horizontal Simplex	Vertical duplex		
Size	14½ by 8½ by 12 inches		314 cubic feet	8 by 8 inches		
Driven by	Steam		50-horsepower motor	10-horsepower motor		

Transformers:									
Number	7	3	4	6				6	15.
Kilovolt-amperes	2,000	6,250	8,333	400				700	1,500.
Primary voltage	30000/60000	30000/60000	30000/60000	11,000				30000/60000	30000/60000.
Secondary voltage	11,000	11,000	11,000	440				2,300	2,300.
Type	FO	FO	FO	Self-cooled				O.F.Water-cooled.	O.F.Water-cooled.
Transformer system pumps:									
Oil pumps:									
Number and type.	2 centrifugal		2 centrifugal					2 centrifugal.	
Size	3 inches							4 inches.	
Motor	7½ horsepower							10-horsepower.	
Speed (revolutions per minute).	1,450							1,450.	
Water pumps:									
Number and type.	2 centrifugal							2 centrifugal.	
Size	4 inches							4 inches.	
Motor	10-horsepower							10-horsepower.	
Speed (revolutions per minute).	1,450							1,450.	
Pump for city water:									
Type			Centrifugal						
Size			4 inches, 2-stage						
Motor			30 horsepower						

The condenser is cooled by means of an open-air tower to which a second section was added when the equipment of the plant was increased. This cooling equipment covers approximately 17,290 square feet of ground surface outside the plant and presents approximately 500,000 square feet of cooling surface. The water falls over wooden mats composed of vertical slats. About 17.5 second-feet of cooling water is needed for the first units, and 33 second-feet for the last unit installed. The fall in the first section of the tower is 20 feet, and that in the last section added 28 feet. Tests of the last section have shown that under ordinary conditions, with the air at 65° F., and humidity 60 per cent, circulating water that enters the tower at 108° is cooled to 89° and about 141,000,000 British thermal units are dissipated per hour. Oil fuel is used exclusively at the plant.

Electrical equipment.—The station is equipped with two 8-pole 2,000-kilovolt-ampere steam turbo-generators[32] of the vertical Curtis type, installed in 1904, delivering 3-phase 50-cycle alternating-current at 2,300 volts potential and operating at 750 revolutions per minute, and one Westinghouse-Parsons 6,000-kilovolt-ampere horizontal turbo-generator installed September 29, 1906, operating at 750 revolutions per minute and supplying 3-phase 50-cycle alternating current at 16,500 volts. The voltage of this 6,000-kilovolt-ampere generator enables it to supply Los Angeles 15,000-volt distribution without the use of transformers. This generator is at present disconnected from the steam end of the unit and is being operated as a synchronous condenser.

The total exciter capacity at Los Angeles No. 3 is 175 kilowatts, supplied by two 6-pole 50-kilowatt direct-current generators, type MP, delivering 400 amperes at 125 volts, operated at 400 revolutions per minute, and driven by a General Electric marine-type 9½ by 15 by 6 inch engine, and one 75-kilowatt direct-connected motor-driven General Electric generator.

LONG BEACH STEAM PLANT.

Location.—The Long Beach plant was built to meet the demands for a centrally located steam reserve necessitated by the tremendous growth of load of Southern California Edison system. Its first unit was put into operation August 22, 1911. The seashore was selected as the site because it assured the ample supply of circulating water necessary for the condensers, and the site at Long Beach was selected because at that point the intake could be built on the channel leading to the inner harbor and thus be protected from violent storms.

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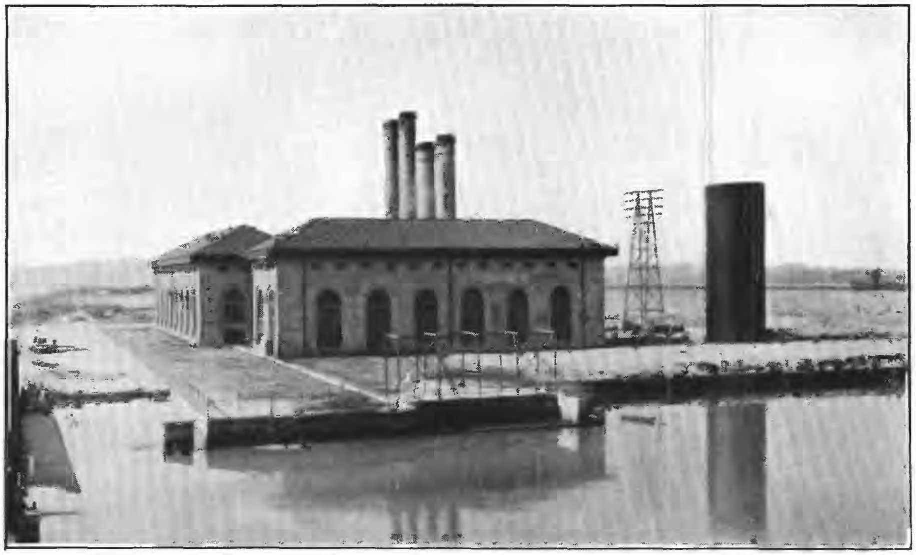
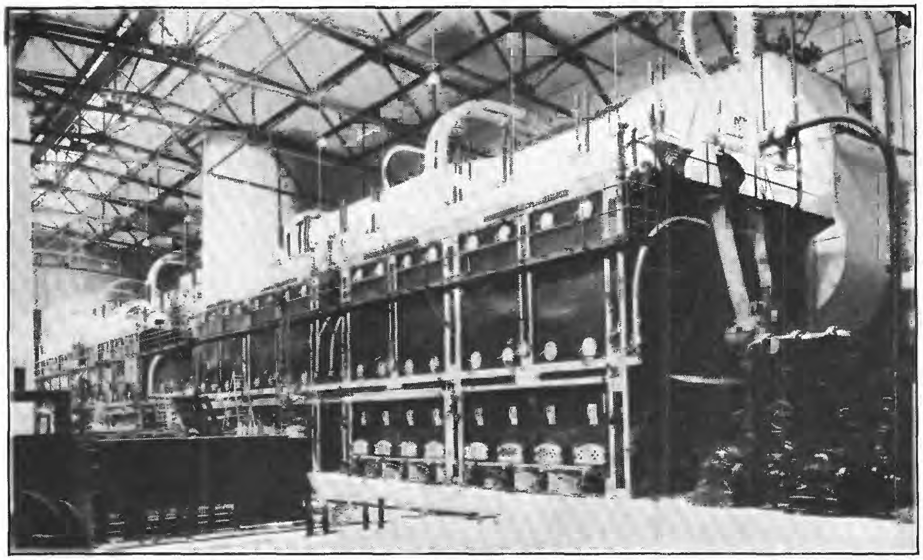
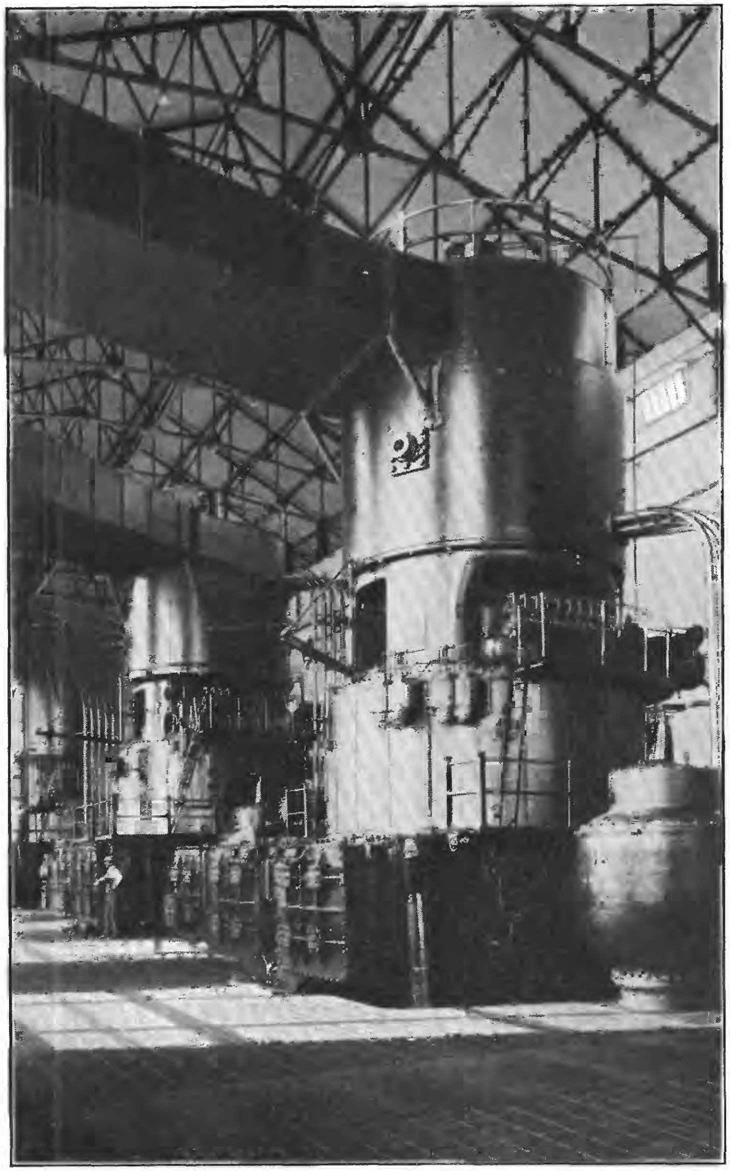
[32] The ratings of all three generators at Los Angeles No. 3 plant are based on 100 per cent power factor.



A. POWER AND TRANSFORMER HOUSES.



B. PART OF BOILER INSTALLATION.



C. TURBOGENERATORS NOS. 1, 2, AND 3.

LONG BEACH STEAM PLANT, SOUTHERN CALIFORNIA EDISON CO.

Photographs by the company.

The site embraces about 10 acres of the sand spit between the ocean and inner harbor on the west shore of the channel entry. Immediately in front of the site is the track of the Los Angeles & Salt Lake Railway.

Buildings.—The plant is housed in two tile-roofed reinforced concrete buildings (see Pl. LXV, *A*), the generator station and the transformer house. The buildings combine superior engineering design with simple, graceful architecture, presenting a very pleasing appearance. The buildings are so arranged that other units can be added, as need therefor arises, to practically double the present capacity of the plant.

The generator station is T shape in plan, the top of the letter, parallel to the ocean shore, containing the generator room 263 feet 2 inches by 72 feet 4 inches in plan, and the shank containing the two boiler rooms and shop and warehouse, 221 feet 5 inches by 211 feet 5 inches, extending back toward the inner harbor.

East of the generator room and between it and the channel leading into the harbor is the transformer house, 62 feet 4 inches wide in front by 202 feet 2 inches deep. Both buildings are 60 feet high to the cornice—a height equivalent to that of a four-story building, but the generator and boiler rooms and the transformer compartment (in the transformer house) all extend the full 60 feet. Only the end of the generator room and the switching section of the transformer house are divided by floors.

The three turbines are placed in line, slightly in front of the central axis of the generator room. (See Pl. LXV, *C*.) Along the back wall are the oil pumps that supply the generator step bearings, the exciter sets, and the motor generator and auxiliary equipment. About 18 feet of the floor at the end of the room is partitioned off for offices, and above these are two balconies, one above the other, overlooking the generator room. The first balcony contains the switchboard, and the one above it the generator field rheostats and the Edison storage batteries which operate remote-control switches. Spanning the entire room are one 50-ton and one 110-ton electric traveling cranes.

The two boiler rooms may be reached through two doors at the back of the generator room. Down the center of each boiler room is an aisle about 20 feet wide, on each side of which there is space for four banks of boilers, two to the bank. Halfway down the room each row of boilers is divided by the base of the stack which serves it. The bases of the stacks are octagonal below the roof line but of circular section above. The stacks for rows Nos. 1 and 2 are 150 feet high and those for Nos. 3 and 4 are 180 feet; all stacks are 12 feet

6 inches in diameter at top. The room within the bases, below the junction of the flues, is utilized for lavatories and locker rooms. Back of each row of boilers and between it and the wall is an 8-foot aisle which gives access to the back of the furnaces and tubes. To the rear of the room there is a broad concrete terrace under which are fuel-oil supply tanks.

In the transformer house a single compartment about 22 feet wide and extending the full length and height of the building contains all the transformers. The rest of the building has four floors, of which the first and second contain all the 11,000 and 33,000 volt and the third and fourth the 60,000-volt bus and switching equipment.

The intake for the condenser water is a concrete structure on the bank of the harbor channel. The supply is admitted through eight gates, 20 feet high by 8 feet wide, provided with double screens and trash racks. The depth of the water on the sill of the gates varies from 8.5 feet at low to 13.6 feet at mean high water. Inside the gate the walls of the supply channel curve in gradually, until at about 70 feet from the outside edge of the intake, the section is contracted into a horseshoe-shaped tunnel 5 feet 10 inches wide at the arch by 6 feet 6 inches high from the floor to the crown. This tunnel passes under the transformer house to the generator room. Water is discharged from the plant through a similar tunnel that leads south to the beach, where a concrete structure between high and low tide lines provides for discharging the water at about the low-tide level.

Mechanical equipment.—The equipment for unit No. 1[33] (Pl. LXV, *B*) consists of eight Stirling boilers, which are arranged in four batteries of two each Each boiler is furnished with a Babcock & Wilcox U-shaped superheater, and each is designed to deliver 30,000 pounds of steam per hour at 225 pounds pressure and 125° superheat. The feed-water supply is delivered, with the condensate, to a Cochrane feed-water heater in the south end of the boiler room, from which it is pumped to the boilers.

Oil fuel is used exclusively. The supply is delivered from a pipe line, which passes near the site, to four 10,000-barrel storage tanks placed several hundred feet from the plant. From these storage tanks it is pumped to the supply tanks directly behind the boiler room. These small tanks are carefully calibrated, and by measuring the draft from them an excellent check can be kept on the amount of oil consumed. The oil is heated by steam coils in small heating tanks, and from them it is pumped to the burners by two steam pumps. The four burners of each boiler are placed in the back of the furnace and act on a heating surface of 7,775 square feet.

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[33] Three units are equipped similarly, but various parts of the equipment for units Nos. 2 and 3 are made larger than those for unit No. 1 to correspond with the increased capacity of the main generators. The general features of the equipment are summarized in Table 132.

The steam main, which is 14 inches in diameter, passes along the row of boilers and through the wall into the generator room, 15 feet above the floor, directly to the top of the vertical turbine. It is supported by stirrups and is not provided with expansion joints. Branches from the main supply all auxiliary steam equipment.

In the base of the turbine is a Wheeler dry-tube condenser which presents a cooling surface of 16,000 square feet and an auxiliary that presents a surface of 5,500 square feet. The cooling water supplied to the condenser is drawn from a well at the inner end of the intake tunnel through a 36-inch cast-iron pipe, which passes up to the condenser and down into a well at the end of the discharge tunnel in the manner of a siphon. The pump in this line has to overcome only the friction losses in the system. The maximum head against which it is designed to act is 35 feet. The pumping equipment consists of a 30-inch double-suction Krogh centrifugal pump operated at 240 revolutions per minute by a Harrisburg 14 by 18 inch simple engine, and is designed to deliver 24000 gallons of water per minute when working against a head of 35 feet.

Vacuum is maintained by a Wheeler rotative dry-vacuum pump with a 12-inch steam, 30-inch air cylinder, and 18-inch stroke, installed in the generator room.

The main and auxiliary exhaust, circulating water, vacuum, hotwell suction, and discharge piping is carried in a basement which is reached by hatchways through the floor of the generator room.

Probably the most noteworthy point in the equipment of the plant is the ample provision for keeping a constant check on the economy of its operation. A very close measurement is easily made of the fuel oil used each hour; check is kept on the condensate and make-up water by means of a Venturi meter in each line; the total flow of water to the boilers from the feed pumps is metered by a Venturi recording meter; the total flow of steam to the station from the boilers is measured by a recording steam-flow meter, and each boiler is equipped with an indicating steam-flow meter. Temperature recorders are installed in the steam main to the turbine, and vacuum and steam gages are also provided. Each boiler is equipped with an indicating gas analysis recorder, so that data are constantly at hand for the proper regulation of the fires. First-class machinery operated intelligently under the checks furnished by this elaborate system of recording instruments should give continuously a very high efficiency.

Electrical equipment.—The first generator installed (Aug. 20, 1911) is an 8-pole General Electric ATB 15,000-kilovolt-ampere 11,000-volt 50-cycle 3-phase alternator driven by a 5-stage vertical Curtis turbine, operated at 28 inches vacuum, 200 pounds pressure, and 125° superheat. The machine is designed to give 788 amperes per terminal at 80 per cent power factor.

There are two exciters, either of which can furnish current enough to handle both the No. 1 and No. 2 units. Each is a General Electric 4-pole 125-volt direct-current generator, driven by a horizontal Curtis turbine (which operates noncondensing) at 2,400 revolutions per minute.

The plant is controlled from the bench board in the gallery overlooking the generator room, but all the switches are of the electrically operated remote-control type and are situated in the transformer house. There are four leads from the generator (the fourth for emergency use), each of which is 1,500,000 circular mils cable. These leads pass from the unit down through tubes into the basement, where they are carried in a cable trench to the back of the building, and then through fiber ducts to the transformer house. Three 300-kilovolt-ampere reactance coils are connected with the generator leads. After entering the transformer house the leads are connected through flexible joints to the copper-tube conductors used universally in the busses and station wiring. These tube conductors connect through General Electric H-3 oil switches to the double 11,000-volt generator busses, from which are fed the outgoing 11,000-volt circuits used for local distribution, each protected by aluminum-cell lightning arresters, and transformers supplying light and power in the station. The generator busses are also connected, through oil switches, to the transformers, which in turn connect through disconnecting switches to double 35,000-volt or to double 70,000-volt busses.

The No. 1 unit is equipped with seven General Electric FO 2,000-kilowatt 50-cycle single-phase transformers that step up from 11,000 to 35,000 or to 70,000 volts, are connected delta on the low and Y on the high tension side, and are arranged in two banks, with a spare. Each bank is in a separate cell in the side of the transformer room.

The outgoing 11,000-volt circuits are protected by aluminum-cell lightning arresters. The four outgoing 70,000-volt lines are provided with aluminum lightning arresters, which are mounted on a steel frame between the transformer house and the generator room.

Between the transformer house and the main station is a small building that houses the pumps that circulate the transformer oil through the closed coils in the cooling tank, which is between these two buildings. The filters for the oil used to lubricate the step and guide bearings of the turbine and the motor-driven pump which supplies the oil to the pressure pumps are also in this building.

Feed water for the boilers is supplied under ordinary operation from two wells on the company's property about 1½ miles north of the plant, each equipped with a 5-inch 2-stage vertical Krogh pump that discharges into a cast-iron pipe line running to the plant. At the steam plant the water is discharged into a steel standpipe 36 feet in diameter and 100 feet high. There is also a connection with the city water system which can be called upon in emergency.

Transmission line.—When first operated the Long Beach plant supplied power to the 33,000-volt line and to local feeders at 11,000 volts, but early in 1913 it began serving the main system through a double 60,000-volt main line,[34] running northeast to Newmark and there tapping in on a similar main paralleling the old Los Angeles-Santa Ana transmission to Colton, now known as the Los Angeles to Colton 60,000 transmission line. Two 60,000-volt lines have been added, one to Katella and one to Torrance.

REDONDO STEAM PLANT.

Location.—Prior to the completion of the Big Creek plants Nos. 1 and 2, the Redondo steam plant was not only a reserve plant but carried a large part of the base load on the system of Pacific Light & Power Corporation. Redondo, on the seacoast, 19 miles southwest of Los Angeles, was chosen for the location of the plant for the same reason that led to the selection of the site at Long Beach—that is, there was abundant supply of cooling water for use in the condensers. Fuel was also obtainable near by, oil being served through a pipe line from neighboring wells in which the Pacific Light & Power Corporation owned an interest.

The plant began operation in September, 1907, and at that time contained three 5,000-kilovolt-ampere units operated by reciprocating engines.[35]

Buildings.—The buildings housing the original equipment at Redondo consisted of a generator room, 200 feet long by 81 feet deep, with a boiler room 157 feet long by 129 feet wide putting out at right angles from its rear. The three units were placed in a row slightly in front of the main axis of the generator room with the auxiliary machinery, such as exciters, between the units. In the seaward end of the plant were the three engine-driven centrifugal circulating pumps which supplied cooling water to the condensers through a main running along inside the front wall of the station. The supply for the circulating system was drawn in through two 50-inch pipes, which were operated on the siphon system and which passed in through the front wall and ran across the plant parallel to the end

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[34] Operated at 33,000 volts for a short time.

[35] The reciprocating equipment at the Redondo plant was put into operation on a guaranty of 170 kilowatt-hours per barrel of fuel oil consumed. An extended test, in which the utmost refinements were used, demonstrated that the plant would produce 252.84-kilowatt-hours per barrel of oil, an excess over the original guaranty that earned the contractors a bonus amounting to $363,310. By the definitions given in this contract a barrel was taken to be 334 pounds of oil; each pound of which was to contain 18,500 British thermal units, and the guaranteed performance of the plant was to be 1 kilowatt-hour for 36,300 British thermal units. The actual performance during the test was 1 kilowatt-hour for 24,438 British thermal units. Records of the first 16 months' operation of the plant gave 1 kilowatt-hour for 26,100 British thermal units.

wall of the building and along the row of pumps. These pipes were supported on a concrete-pile wharf running out to deep water, and flow was maintained through them by means of circulating pumps. They were primed, however, by means of a vacuum pump. Connection to each of the circulating pumps was made from both supply-pipe lines, and the condensers of the various units were served through a common main. The discharge was through a single 50-inch line.

The boiler room of this first installation contained nine batteries of Babcock & Wilcox water-tube boilers arranged in three rows at right angles to the main axis of the generator room. Each row contained three batteries of two boilers each. The equipment was served by two stacks, one of which provided for the two rows on the landward side, and the other took care of the single row toward the sea. At the landward side of the boiler room there were three fuel-oil tanks each having a capacity of 1,000 barrels.

In 1911, when it became necessary for the Pacific Light & Power Corporation to install additional steam power, it was decided that the new units should be turbo-generators, instead of reciprocating units, and that they should be placed in the seaward end of the original station, which was at that time occupied by the circulating pumps. An addition to the generator room was thus avoided, but a 100-foot extension had to be built on the seaward side of the boiler room. This extension accommodated three additional rows of boilers. To provide for the last two of these rows, an additional stack was constructed. The circulating pumps displaced by the new generators were moved into a small house built for them midway between the plant and the ocean, and at the same time certain changes were made in the design of the circulating system. The details which follow cover the plant as it stood subsequent to these alterations.

Mechanical equipment.—Each of the 18 original Babcock & Wilcox water-tube boilers is composed of 21 sections, 18 feet long, each section containing 14 tubes, 4 inches in diameter. Above the tube sections there are three steam drums, 23 feet 4 inches long and 42 inches in diameter. The equipment is designed to operate at 200 pounds steam pressure per square inch, and 100° superheat at the boiler, obtained through Babcock & Wilcox forged steel superheaters. Each furnace is fired from the bridge wall forward by three burners, the firing being controlled from the front of the boiler. The heating surface for each boiler is 6,042 square feet.

The later boiler equipment consists of three rows, each row contains three banks, and each bank two Babcock & Wilcox boilers, Stirling type, rated at 604 horsepower. Each boiler is provided with 438 3½-inch water tubes, three 42-inch steam drums, and one 48-inch mud drum. They are operated at 190 pounds pressure and are provided with Babcock & Wilcox superheaters, which raise the temperature of the steam 100°. Each boiler is fired from the front wall of the furnace by means of three Hammel oil burners.

The main steam pipes from the boiler system to the units are 14 inches in diameter and are anchored to the walls of the building and cross-braced. The joints are of the steel-flange type. Each row of boilers of the original installation was piped to serve its respective end of one unit; but piping is now provided with valves to permit connection of all boilers. The entire high-pressure steam-piping system is covered with a 3-inch layer of nonconducting material to prevent losses from radiation.

Fuel oil is served to all the furnaces by a central oil system, which replaced three pumps originally installed to serve the sets of boilers separately. The intensity of the fires is controlled by the pressure in the fuel-oil pumping main, which varies from 50 to as low as 10 pounds, according to the demands for power. The pressure maintained by the pumps in the fuel-supply mains is entirely controlled by the steam pressure in the boilers, so that a uniform pressure in the plant is automatically maintained. Another automatic regulator, operated by the pressure of oil in the supply main, determines the pressure of steam admitted through a special steam main for atomizing use in the burners. Still another automatic regulator from the oil line determines the air supply admitted by the dampers.

The make-up boiler feed water is supplied by the Hermosa Beach Water Co. and is fed to the boilers by five duplex horizontal outside center-packed pumps with compound steam ends and one 1,000-gallon per minute four-stage steam-turbine driven centrifugal pump. The pump equipment allows three pumps to be held in reserve at all times. Feed water for the boilers is heated by means of two Cochrane open feed-water heaters rated at 10,000 horsepower each. The steam for these heaters is supplied from the exhaust of the station auxiliaries.

The Wheeler Admiralty condensers for the original units give 5,200 square feet of cooling surface each. The condensate, with the make-up water, is passed through a Volz reheater in the top of the condenser in order to attain higher efficiency. The equipment provides two of these condensers for each unit, one being attached to the low-pressure cylinder of each of the engines. A 28-inch vacuum is maintained by an Edwards vertical triplex air pump attached to each condenser. Each of the three cylinders of this pump has a diameter of 16 inches and a single-acting stroke of 10 inches. The discharge from the condenser air pumps of the three engine-driven units is filtered through six marine-type feed-water filters before it is fed back to the boiler.

The new units are equipped with Alberger surface double condensers. The main section of the condenser is placed under the turbine, with the auxiliary section, which is smaller, beside it. Both sections are immediately below the floor of the generator room. The large section has a surface area of 16,000 square feet and the smaller section 8,000 square feet. Vacuum is maintained by two engine-driven 10 by 30 by 24 inch dry-vacuum pumps.

The remodeled circulating system differs radically from that originally installed. Instead of being closed throughout, it now consists of two parts—a siphon system discharging into a concrete screen tank and a pressure system operating from the inner end of this tank to the condensers. The discharge pipe has also been remodeled and now passes through a reinforced-concrete tunnel 5 feet square, opening under the shore end of the intake wharf instead of through a steel pipe running out along the wharf and discharging into the ocean. The outer section of the circulating system now has three 50-inch steel siphons, 740 feet in extreme length, running the full length of the pile wharf, and then up the beach about 100 feet to the screen basin, which measured 58 by 52 feet in plan and is excavated to a depth of about 25 feet below the surface of the beach and 9 feet below tide level. The ends of the intake pipes turn down to the bottom of this basin. The outer end of each main pipe is provided with seven 26-inch suction pipes that extend down into the ocean. The object of this design is to prevent high velocity in the intake and thereby avoid sucking in sand. Flow is started in the lines by large vacuum pumps in the end of the pump house. The vacuum line runs out to the shore end of the wharf and connects to a standpipe separator which removes entrained air from the highest part of the siphons. After flow has once been established it can be maintained by the use of a smaller vacuum pump placed beside the large ones. The intake basin is divided into three bays by two walls that run about two-thirds of the way across it. At the outer end of each bay there is a screen of flat steel bars inclined at about 45°. Inside the screen each of the three channels is again divided by a central wall, and in each of the two smaller channels so formed there are three vertical sets of wire-mesh screens which remove the sea growths that have passed through the inclined screen. Back of the screen sets are the intakes of the circulating pumps.

Each of the three circulating pumps is designed to supply 24,000 gallons per minute against a total head of 40 feet. Their intakes are 32 inches and their discharge pipes 30 inches in diameter. They are of the centrifugal type and are operated by Fleming-Harrisburg tandem compound noncondensing, side-crank engines, 16 by 27 by 18 inches, rated at 400 horsepower. The discharge from the pumps passes to a manifold outside of the building, and from this feeds into three 50-inch reinforced-concrete circulating water pipes, one of which serves the original engine equipment, and each of the others one of the turbines. At the manifold there are cross connections by which any one of the pumps may be connected to any one of the three discharge pipes. After passing through the condensers the water is received in a reinforced-concrete hot well, from which it is discharged into the concrete outfall tunnel.

The engines of the three original electric generators are 34 by 70 by 56 inches combined, double, horizontal, and vertical compound "Manhattan" side-crank McIntosh & Seymour units, provided with automatic gridiron valves. Each machine has two horizontal high-pressure cylinders and two vertical low-pressure cylinders designed to operate with 175 pounds pressure and 100° superheat.

Electrical equipment.—Each of the three original generators is a General Electric 5,000-kilovolt-ampere 3-phase 50-cycle flywheel alternator, designed for a speed of 100 revolutions per minute. The generator is direct-connected between the two parts of the double engine, and its speed is controlled by a governor which is fitted into the flywheel. Dash pots fitted to the governor weights prevent oscillation in speed becoming magnified when two or more units are operated in parallel, and the increase or decrease in speed is further controlled by an electrically operated speed changer which is fitted to the governor and operated by remote control from the switchboard gallery.

The two turbo-generator units are General Electric form T ATB 8-pole 12,000-kilowatt (at 80 per cent power factor) vertical units, which give 960 amperes at 9,000 volts, operating at 750 revolutions per minute. They are driven by form H Curtis turbines operating at 180 pounds pressure and 100° superheat. Three duplex oil pumps supply lubricating oil to the step bearings of the turbines at 1,200 pounds pressure. This pumping equipment is on the operating floor along side of the turbo-generators. Each pump is of sufficient capacity to handle one turbine, and the third is held in reserve. As the generator potential of the turbine units is 9,000 volts, or half of that of the engine-driven units, the potential is stepped up by two banks of autotransformers with a ratio of 2 to 1. These banks are placed in cells between the boiler room and the turbines. General Electric 5 per cent reactances are installed in the leads between the generators and autotransformers.

The four General Electric 75-kilowatt continuous-current exciters of the original equipment are operated by 9 by 17 by 12-inch Harrisburg tandem-compound, noncondensing horizontal engines, which are designed for the same pressure and superheat as the main engine. Excitation for the turbo-generators is furnished by a General Electric 4-pole 100-kilowatt continuous-current generator, which is driven at 2,400 revolutions per minute by a two-stage noncondensing Curtis steam turbine. The power generated is transmitted over five 15,000-volt circuits for delivery to the railways and one 60,000-volt circuit connecting to the system network.

OXNARD STEAM PLANT.

Location.—Oxnard steam plant, formerly the property of Ventura County Power Co., is near the Southern Pacific Railroad station in Oxnard.

Building.—The power house is a brick building measuring 50 by 106 feet with concrete floor and foundations and corrugated-iron roof supported on steel trusses. The substation immediately adjoining the power house is of similar construction and measures 30 by 59 feet.

Mechanical equipment.—Steam is supplied from two batteries of Babcock & Wilcox boilers, each battery having a capacity of 302 horsepower. A single steel stack, held in position by cable guys, serves both batteries of boilers. The station is equipped with two Wheeler admiralty rectangular surface condensers, presenting 900 square feet of condensing surface, and two Edwards triplex vertical 8 by 16 inch air pumps.

Electrical equipment.—The generating equipment consists of two units. The first is an Allis-Chalmers Bullock 375-kilovolt-ampere 2,300-volt 3-phase 50-cycle generator, which is direct-connected to and operated by an Allis-Chalmers Reynolds-Corliss tandem-compound, 16 by 32 by 16 inch condensing engine.

The second generating unit is a General Electric horizontal Curtis 500-kilovolt-ampere 2,300-volt 3-phase 50-cycle turbo-generator.

There are two exciters, of which the first is a General Electric 25-kilowatt 125-volt direct-current generator, direct-connected to and driven by a Fleming side-crank 9 by 10 inch single engine. The second exciter is a General Electric 22-kilowatt 125-volt direct-current generator, direct-connected to and operated by a General Electric 3-phase 50-cycle 35-horsepower induction motor.

The plant was operated almost exclusively as a standby station for several years before its acquisition by the Edison company, the greater part of the system load supplied by the Ventura company being carried by purchased power.

VISALIA STEAM PLANT.

History.—During its first six years of operation Mount Whitney Power Co. generated its entire output by water power, but in 1905 the demand for power had increased to such an extent that it was necessary for the company to begin the construction of a steam station, which it built on the outskirts of Visalia. The original steam plant was completed and its single 1,000-kilovolt-ampere unit began operation in August, 1906. Early in the summer of 1912 the plant was lengthened and its generating capacity was increased by the addition of a second unit of 750 kilovolt-amperes capacity. In 1914 the station was reconstructed and the installation further enlarged by the addition of a 5,000-kilovolt-ampere unit.

Building.—The Visalia steam plant was originally housed in two brick buildings—one a combined steam station and office building and the other a transformer and switchhouse. The various additions and changes have necessitated the removal of all but the part of the old brick power house that immediately adjoins the new concrete and steel generating station and that is used for machine shop, office, and auxiliary supplies. The only part of the power house here described is that now in active use as a steam generating station.

The north side of the power house is toward the street, and the front or generator room faces westward toward the transformer house. The length of the west face (front) of the building is 104 feet, the depth on the south side 117 feet, the length of the back is 75 feet, and the depth on the north side 52 feet. From the above layout it will be seen that in ground plan the power house is L-shaped; the irregular section measuring 25 feet front by 52 feet depth being on the northwest corner, and comprising the only part of the old generating station that has been incorporated in the new.

The generator room occupies the entire 104-foot front of the power house to a depth of 27 feet 8 inches and is at the second-floor level, 16 feet above the ground; the condensers are under the turbines on the main floor. This front part of the plant, containing the generators and their auxiliaries, is the only part that has two floors, the boilers being installed on the ground floor and the boiler room extending the full height of the building.

The boiler room is 89 feet 3 inches by 74 feet 6 inches, and the eight boilers are arranged in four banks, facing a central firing aisle 17 feet 6 inches wide that runs down the main axis of the room. There is a 7-foot aisle back of the boilers at the north side of the room, a 6-foot aisle back of those at the south side, and a 5-foot aisle along the back of the plant between the wall and the ends of the two rows of boilers. The two banks of boilers in each row are also separated by aisles; the one at the north being 10 feet and that at the south 5 feet in width.

Concentration of the boiler equipment in the back part of the boiler room leaves a space at the front of the room about 75 feet long by 25 feet deep. The feed pumps and heaters occupy the part of this space between the south row of boilers and the front wall of the room; the north half of the space is thus left free for other uses.

The transformer house measures 43 feet 6 inches long by 24 feet 6 inches wide outside and is connected to the turbine room in the power house by a footway at the second-story level, so that access may be had directly to the transformer station from the main building. The upper floor of the transformer building houses the high-tension switches and the lower floor the transformers. The lightning arresters are outdoors. The low-tension leads from the switchboards are lead-covered cables.

Mechanical equipment.—The four boilers which were installed with the first and second units are now arranged in the banks on the north side of the boiler room. They are Stirling class Q–17 water-tube boilers, equipped with 270 3¼-inch tubes, three 42-inch steam drums, and one 42-inch mud drum. Each boiler is fired by two oil burners supplied with fuel from three tanks on the premises. The tanks are filled from cars that are run in on a spur track from the Southern Pacific main line. The furnaces of these boilers have a heating surface of 3,030 square feet each.

The four boilers that were installed with the third unit are arranged in the two banks which form the row on the south side of the boiler room. They are Stirling class M–22 water-tube boilers, each equipped with 440 3¼-inch tubes, three 42-inch steam drums, and one 48-inch mud drum. Each boiler is fired by three Hammel oil burners. Each of the four banks of boilers has a separate steel stack.

Feed water is heated by a No. 6 Stillwell heater, operated by the exhaust from the steam-driven auxiliaries, and designed to receive steam at a boiler pressure of 200 pounds. Duplicate boiler-feed pumps, operated by Terry steam turbines, designed to operate at 2,800 revolutions per minute with 200 pounds steam pressure, are direct-connected to the pumps, which are Platt No. 4 3-stage centrifugal pumps, designed to supply 500 gallons per minute under a head of 520 feet, operating at the same speed as the turbine. There is also a Worthington duplex 10 by 5½ by 10 inch auxiliary feed pump.

The condenser installed on the first floor under No. 1 turbine is of the Worthington surface type, presenting 3,600 feet of cooling surface. The hot well forms part of the condenser. The vacuum pump is on the turbine floor, above the condenser.

A Wheeler rectangular jet condenser, placed beneath the unit, is used in connection with No. 2 turbine. The exhaust steam from the turbine discharges through a cast-iron elbow into the end of the condenser shell, an expansion joint being placed in the vertical run. A hand-operated gate valve is placed between the elbow and the condenser, so that if necessary the turbine can be operated noncondensing. A Westinghouse Leblanc condenser is installed immediately under No. 3 unit.

The tail pump for the No. 2 condenser is an 8-inch Wheeler centrifugal circulating pump, driven by a 20-horsepower Kerr steam turbine.

No. 1 dry-vacuum pump is a Worthington rotative 6 by 12 by 12 inch machine placed between the unit and the back wall of the generator room. Dry vacuum for No. 2 unit is similarly placed, and is a Wheeler 6 by 14 by 10 inch rotative pump.

Six wells drilled in 1912 connected in sets of three to two 8-inch centrifugal pumps driven by induction motors are used for cooling the condensers. Until the third unit was installed the plant used a cooling tower but has now put in an open-air spray cooling system, the water forced through the spray falling into the collection tank. The sprays of this system have a capacity of 1,500 gallons of water per minute.

Electrical equipment.—The three turbo-generators are all of the horizontal type.

No. 1 unit is a Westinghouse 1,000-kilowatt 2,300-volt 251-ampere 3-phase 60-cycle alternator, driven at 1,800 revolutions per minute by a Westinghouse Parsons steam turbine. The generator is designed for a continuous overload capacity of 25 per cent.

No. 2 unit is a General Electric type ATB 2-pole form HT 937-kilovolt-ampere 2,300-volt 235-ampere alternator, driven at 3,600 revolutions per minute by a Curtis 750-kilowatt form C condensing turbine, designed to operate with a steam pressure of 175 pounds.

No. 3 unit is a Westinghouse 5,000-kilovolt-ampere maximum 2,400-volt 1,200-ampere 3-phase 60-cycle alternator, driven at 3,600 revolutions per minute by a Parsons steam turbine.

Two exciter sets are now installed—the first a motor-generator set composed of a General Electric 75-horsepower type I 2,300-volt 3-phase 60-cycle motor and a General Electric direct-connected type DLC form A 50-kilowatt 125-volt 400-ampere 1,200-revolution generator; the second a General Electric turbo-generator consisting of a type CC 2-pole 25-kilowatt 125-volt 200-ampere continuous-current generator driven at a speed of 3,600 revolutions per minute, by a Curtis steam turbine operating noncondensing at 175 pounds steam pressure.

The switchboard is placed between unit No. 1 and the front wall of the power house, the leads passing out from it to the transformer house, where the high-tension switching equipment is on the top and the transformers on the ground floor.

The transformer equipment consists of three Allis-Chalmers single-phase 2,500-kilovolt-ampere water-cooled oil-insulated transformers, with a ratio of 33,000 to 2,300 volts. The plant serves as a ubstation as well as a generating station.

TULARE STEAM PLANT.

History.—Tulare steam plant was constructed by Tulare County Power Co. during 1911 and 1912 and went into operation April 17, 1912. It was acquired by Mount Whitney Power & Electric Co. with other properties of Tulare County Power Co. in 1915 and purchased with Mount Whitney Power & Electric system by Southern California Edison Co. in 1920. The plant was operated in 1920 during a shortage of power but is not now in operation and will probably be dismantled and a larger machine installed for a condenser only.

Buildings.—The entire equipment of Tulare steam plant is housed in a single brick building with concrete foundation, steel roof trusses, and wooden roof. In plan the building measures about 79 by 55 feet; one end is partitioned off by a transverse wall into a generator room 56 feet 6 inches by 55 feet 7 inches; the rest of the building, 22 feet 6 inches by 55 feet 7 inches, is divided by two longitudinal partitions into transformer room, laboratory and work room, and office. The plant is just east of Tulare, near the Atchison, Topeka & Santa Fe Railway, and the fuel oil is received into a tank on the end of the property from cars on the track. The steel stack, which is 78 inches in diameter and 80 feet high, rests on a concrete foundation outside the boiler-room wall and therefore does not pass through the roof of the station. The boilers are placed next to the end wall of the plant, in the north side of the generator room, facing out toward the main unit, which occupies the central part of the room. The three boilers are arranged in one bank of two and a separate, with an aisle between. Between the boilers and the west wall of the generator room are the feed pumps and feed-water heater. Between the south wall of the generator room and the horizontal turbo-generator set there is an open well into the basement, in which are placed the condenser and the circulating pumps and mains. The switchboard is on the main floor, parallel to the south wall, between the well and the east side of the plant, a location which places it just in front of the partition wall separating the generator and the transformer rooms. The transformers are on the south side of the transformer room in cells formed by fire walls.

Mechanical equipment.—The three Stirling class S–20 water-tube boilers, with 357 3¼-inch tubes, three 42-inch steam and one 42-inch mud drums are equipped with three Hammel oil burners to each boiler. Oil is delivered to the burners by duplicate equipment of Worthington duplex 6 by 4 by 6 inch 400-horsepower pumps.

Feed water is supplied by two vertical Blake 12 by 7 by 18 inch pumps, in addition to which there is an Eppinger-Carpenter auxiliary feed pump of the duplex type. The feed-water heater is of the vertical type. A Westinghouse-Leblanc condenser is set under the main unit in the basement; cooling water may be supplied by a 2-stage centrifugal pump, connected to the base of the condenser and operated by a Westinghouse steam turbine, or by duplicate equipment, each set of which consists of a 2-stage centrifugal pump, with 12-inch inlet, driven by a Westinghouse 440-volt 25-horsepower induction motor.

Electrical equipment.—The main generator of the Tulare plant is a horizontal Westinghouse-Parsons 3-phase 60-cycle 2,400-volt 350-ampere 1,500-kilovolt-ampere alternator, operated at 3,600 revolutions per minute. A 125-volt 300-ampere 25-kilowatt Westinghouse exciter is mounted on the end of the main shaft of the generator, between bearings, and there is also a separate Westinghouse 125-volt 25-kilowatt exciter operated by a Westinghouse steam turbine.

The transformer equipment at the station consists of three 1-phase 600-kilowatt 33,000/11,000–2,200-volt Allis-Chalmers water-cooled transformers.

TRANSMISSION SYSTEM.

The transmission system resulting from the absorption of the Pacific Light & Power system by Southern California Edison Co. reaches most of the important load centers in the southern part of California. Both companies had operated in the same territory, and their consolidation has resulted in the elimination of duplication in transmission facilities. The full effect of the change has so far been retarded by the war.

In the development of their transmission systems, Southern California Edison Co. and Pacific Light & Power Corporation presented many similarities. Both began operations with plants located along the San Bernardino and San Gabriel mountains east of Los Angeles, connected to the main load center in that city by lines of moderate length. Power demands soon exceeded the capacities of these plants and each company found it necessary to construct a larger generating station on Kern River, with lines running southward, and later the Pacific Light & Power Corporation constructed its Big Creek plants still farther north, with very high voltage lines running to Los Angeles.

The first hydroelectric transmission line on Pacific Light & Power system, connecting Azusa plant with the steam station in Los Angeles, was put into operation in June, 1898. Later the company purchased the Sierra plant east of Azusa with lines extending from it to Pomona and San Bernardino that had been in operation since 1893, and later acquired certain electric transmission lines in and around San Bernardino, owned by San Bernardino Gas & Electric Co., and lines in the vicinity of Riverside, supplied by the Highgrove and Riverside plants. Pacific Light & Power Co. also formed Mentone Power Co. to construct Mentone plant, at the mouth of Santa Ana Canyon east of Redlands, and extended a pole line carrying two 3-phase 15,000-volt circuits of No. 5 copper westward along the San Bernardino base line road to connect with the lines from Sierra plant in San Bernardino. The lines from the Riverside and Highgrove plants tied in to the old main line at San Bernardino and at a point north of Upland, thus forming a small loop which passed through Colton, Highgrove, and Riverside. The Sierra and Azusa plants connected to the line through short 15,000-volt stubs, and the old Azusa lines, that formed the connection between the eastern and western portions of the system, terminated at Kern River substation in East Los Angeles, the company's main distribution center for Los Angeles and vicinity, prior to the completion of Eagle Rock substation. After the completion of the Big Creek transmission lines the company constructed a 60,000-volt line from Vernon substation to Riverside, replacing the old line.

Another 15,000-volt 2-circuit line, running southwestward from Los Angeles to the company's main steam plant at Redondo, was constructed in 1907, and from the Redondo plant four 15,000-volt lines extended due east 11 miles to the Dominguez substation, the principal point of delivery of power for the Pacific Electric Railway Co. These lines, with the Kern River and Big Creek lines, described in detail later, formed the backbone of the system acquired from Pacific Light & Power Corporation.

The nucleus of the old Southern California Edison transmission system was the 33,000-volt main line from Santa Ana No. 1 to Los Angeles No. 3, put into operation by Southern California Power Co. in December, 1898. In point of time this had been preceded by the line transmitting power from Mill Creek to Redlands in 1893, with the extension made to Riverside in 1896, but these lines form only a part of the network now covering Redlands district. The Santa Ana–Los Angeles main line was the backbone of the system covering San Bernardino Valley, the foothill country near Pasadena, and the territory near Santa Ana, and south and west of Los Angeles the Kern River transmission, completed later, formed a distinct division of the system because of its geographic location and much higher voltage, although operated parallel with the old line. The Kern River lines of both companies served more truly as great feeders than the Santa Ana lines, as no power was distributed en route. On the contrary, the Santa Ana lines frequently received power from the west end, having to deliver more along the route than was furnished by the hydroelectric plants at their east end.

Big Creek lines.—The most interesting line on the system is the ouble-tower line running from the Big Creek plants, east of Fresno, in a southerly direction to Los Angeles, built by Pacific Light &

Power Corporation in 1913–14 and unusual for its length, its very high voltage, and the large amount of power it carries.

The length of the lines from Big Creek power house No. 1 to the Eagle Rock receiving station just north of Los Angeles is 240.4 miles, and for the entire distance there are two tower lines, each carrying a single 3-phase circuit with wires strung in a horizontal plane. The total width of the right of way is 150 feet and the tower lines are 82 feet apart center to center. Big Creek No. 2 plant connects to the main line by a tap about three-fourths of a mile in length.

The two 3-phase circuits are operated at 50 cycles and 150,000 volts potential. The terminal substation is provided with synchronous condensers designed to equalize the voltage at both ends of the line.[36] Steel-core aluminum cable conductors are used throughout the length of both lines. The cores are composed of seven strands of double-galvanized plow-steel wire and the outside of the cable of 54 strands of aluminum wire. The diameter of the separate strands of both the steel and aluminum wire is 0.1059 inch and the finished cable 0.953 inch. The aluminum in each mile of cable weighs 2,999 and the steel 1,119 pounds, giving a total of 4,118 pounds per mile for each of the six conductors. The elastic limit of the aluminum is about 14,000 pounds per square inch and that of the steel 130,000 pounds, and the ultimate tensile strength of the aluminum 24,000 pounds and of the steel 160,000 pounds, giving an ultimate tensile strength of 33,600 pounds per square inch for the entire cable. The conductors are strung to avoid a maximum stress over 14,250 pounds per square inch. McIntyre sleeve joints are used around the core wire at splices, with compressed aluminum sleeves around the entire cable. The mountain sections of the transmission system are subject to snow conditions for a short time during each year. It was therefore necessary in calculating the tensions in the conductors and in designing the towers in this section to make allowances for the unusual conditions. The lines were therefore strung for 3,130 pounds tension per square inch at 83° F. under snow conditions, while under ordinary conditions 4,740 pounds tension was allowed.

Each tower line is provided with a ground wire of ½-inch 7-strand Siemens Martin galvanized-steel cable, having an ultimate strength of 15,000 pounds; the weight of this ground wire for both lines is 1,306,000 pounds.

The side members of the towers are A frames of structural-steel angles, connected by a cross-bracing and lattice system. Across the top of the two A frames there is a structural-steel frame support from which the suspension insulators are hung. Each corner of the tower

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[36] The line loss at full load is 9.5 per cent, to which must be added 5 per cent loss in transformers, auxiliaries, etc. The capacity of each circuit is 57,500 kilowatts at 0.85 power factor for 11 per cent regulation, using two synchronous condensers. (Woodbury, Proc. Am. Inst. Elec. Eng. vol. 33, 1914.)

is supported by a steel footing consisting of a square bedplate of angle irons from the corners of which four angle-iron posts rise and are riveted or bolted together into a pyramidal frame set in the earth, with its apex just above the surface of the ground. Three types of towers are used on the lines—standard, anchor or angle, and special. The standard towers are designed to withstand the breaking of two out of the three conductors on the same side of the tower and weigh 5,600 pounds, including the footings, which alone weigh 1,300 pounds. The anchor or angle towers, which are designed to stand the breaking of all three conductors on one side of the tower and also to stand the side strain resulting from their use on angles as great as 60°, weight 8,050 pounds, of which 1,600 pounds is in the footings. The special towers weigh 5,790 pounds, of which 1,300 is in the footings and are used on unusually long spans.

As already noted, all three conductors are suspended at the same height above the ground, one at each side of the tower outside the frame and the third passing through the center of the tower. The standard and special towers both support the insulators 43 feet above the ground; the anchor or angle towers support them 37 feet above the ground. The spread of the A frames forming the side members of the standard and special towers in the direction parallel to the line is 18 feet, and the frames are spaced 20 feet on centers. The spread of the A frames in the angle or anchor towers is 24 feet and the frames themselves are spaced 24 feet, giving a square base. The normal span is 660 feet, but where snow conditions are encountered this is reduced to 550 feet. The minimum clearance of conductors is 25 feet at center of span normally. In the mountain region the spans are naturally not all equal, even where standard towers are used. The maximum span between standard towers is somewhat over 1,822 feet, but at the crossing of Kings and Kern rivers, where special towers have been employed, the spans are 2,776 and 2,871 feet, respectively. The total number of towers in both lines is 3,341, of which 2,588 are of the standard type.

Locke 2565–P insulators were used both on the suspension and on the dead ends throughout both lines, but 40 miles of circuit has been replaced with Locke No. 6000 and 114 miles of circuit with Locke No. 5996. Nine disks, 10 inches in diameter, hung in series, are used at all ordinary points of suspension, but at dead ends two sets in parallel, each containing 11 disks in series, are used. The insulators were tested for a dry flash of 90,000 and rain test of 56,000 volts per disk. Under most severe conditions tests gave a voltage of 420,000, or about three times the normal voltage of the line for the nine disks. Approximately 190,000 insulator disks are used in the transmission, about 58 per cent of which are on dead ends and anchors.

There are only two switching and transformer stations on the lines. One where the lines cross the Southern Pacific Railroad just north of Richgrove, known as the Vestal substation, connects to the system acquired from Mount Whitney Power & Electric Co. and receives energy from Kern River plant No. 3, and one just east of Bakersfield and 135 miles from Big Creek, known as Magunden, is a cross-over switching station.

Colton and Long Beach lines.—The original transmission line between Colton substation and Los Angeles station No. 3 was replaced during 1912 by a double circuit of 4/0 copper, supported on steel towers with suspension insulators now forming a very important trunk line through the territory east of Los Angeles. The normal span of the line is 700 feet between towers, with one intermediate telephone pole for each span. At Newmark switching station the Los Angeles-Colton line is joined by the line from Long Beach steam plant, which is of the same type except for a distance of approximately 7,500 feet north from the Long Beach steam plant where steel towers 105 feet high are provided to carry eight circuits at 60,000, 30,000, and 10,000 volts. From Newmark a line of 4/0 copper and wooden poles was built to Shorb in order to supply Pasadena at 15,000 volts. Two 60,000-volt lines of 4/0 copper have been built, connecting Newmark and Eagle Rock.

In addition to the two 60,000-volt circuits from Long Beach to Newmark, the company has another 60,000-volt circuit running from Long Beach steam plant to Katella distribution substation, near Santa Ana. The line is mounted on wooden poles with suspension insulators and was installed in 1915, replacing an old 30,000-volt circuit. The Long Beach lines are tapped 5 miles south of the Newmark substation by two 60,000-volt 4/0 copper lines connecting the Vernon substation, which has 60,000-volt line connections to the Eagle Rock substation, Redondo steam plant, and Long Beach steam plant.

A wooden pole line designed for two circuits but carrying only one 3-phase circuit of No. 2 stranded copper, operated at 60,000 volts potential and 50 cycles, runs southeastward from Katella 30 miles to a substation at Capistrano, where the line connects through transformers and a 6,520-kilovolt-ampere frequency changer to the 60-cycle lines of San Diego Consolidated Gas & Electric Co., extending 78.5 miles farther to the city of San Diego.

Kern River lines.—Delivery of power to Los Angeles from Kern River began December, 1904, from Borel plant of the Pacific Light & Power system over twin pole lines 127 miles in length, each carrying a single 3-phase circuit of No. 000 copper; the potential at the power house was 57,000 volts. There were four switching stations along the line—Indian station 25 miles, Oak 44 miles, Lake 71 miles, and Newhall 96 miles south of Borel—each station was equipped to sectionize both lines, so that in case of accident to either line between stations, the injured section could be cut out and transmission continued over the uninjured line.

The second and last line from Kern River to Los Angeles was the steel tower line put into operation by the Edison Co. from Kern River plant No. 1, May 19, 1907. These towers carried two 3-phase circuits of 7-strand copper cable equivalent to No. 4/0, operated at 50 cycles, with 75,000 volts at the power house and 60,000 volts potential at the receiving station. The towers were originally designed and constructed to carry three circuits on pin insulators, but except for a short distance at each end of the line only two circuits were ever installed. The towers were reconstructed about 1915 to carry two circuits with suspension insulators.

There are 1,140 galvanized towers in the line, varying from 30 to 60 feet high according to the topography along the line. The towers are wedge shaped, being formed by two angle-iron A frames with a bottom spread of 13 feet, set parallel to each other, 12 feet apart, and cross braced. Near the top there are two cross pieces; the upper carrying four and the lower carrying two insulators, comprising the equipment for the two circuits. The members of the tower were designed to withstand a wind pressure of 32 pounds per square foot on the tower and on the wires of a 700-foot span, and also to withstand the unbalanced stress caused by the failure of any single wire. At the surface of the ground the towers are bolted to stubs of 4 by 4 by $\frac{3}{8}$-inch angles 6.5 feet long, coated with asphalt over their galvanized surfaces. The lower end of each stub is bolted to a cast-iron plate 24 inches in diameter, set in the bottom of a 6-foot hole with earth firmly tamped in above.

Prior to 1917 one of the Borel lines was changed to run to Eagle Rock and the other to San Fernando substation. Both now terminated at Castaic substation on the tower line from Kern River plant No. 1, and the east pole line has been rerouted south of the Tehachapi Mountains by way of Mojave and Lancaster instead of parallel to the west line. Ventura and Santa Barbara territories are supplied from two 60,000-volt lines, one out of the San Fernando substation and the other out of the Castaic substation. These two lines are brought into a substation at Saticoy, from which the Ventura territory is supplied at 15,000 volts. Two 60,000-volt lines are extended from Saticoy to supply Santa Barbara.

General information concerning the transmission system is given in Tables 137–139.

DISTRIBUTION SYSTEM.

Information on substations and distribution lines is given in Tables 138–142.

The Eagle Rock receiving or substation at the south end of the Big Creek 150,000-volt transmission lines is of such importance as to merit a detailed description. The station is on the west slope of the San Rafael Hills at Eagle Rock Park, 9 miles north of Los Angeles. The building is of composite reinforced-concrete and steel construction and measures in plan 168 by 131 feet. The station consists of two main divisions—the receiving station proper and the condenser and switchboard room. The former is at the north end of the station and measures in plan 114 by 131 feet, the latter is at the south end of the station and measures in plan 54 by 131 feet.

The receiving station is divided into five main floors and a basement, the respective levels of which are as follows:

	Ft.	in.
Depth of basement below first-floor level	13	
Height of second floor above first-floor level	16	8
Height of third floor above first-floor level	29	5
Height of fourth floor above first-floor level	45	
Height of fifth floor above first-floor level	71	2
Height of bottom of roof truss above first-floor level	94	8
Height of ridge of roof above first-floor level	103	11
Height of center line of 150,000-volt circuit	124	11½
Height of top of horn gaps	128	¼

The two 3-phase incoming 150,000-volt circuits are received at steel-line frames mounted on the roof, and enter the building through the open floors of overhangs on the east and west sides of the substation. The station is equipped with a double system of 150,000-volt busses running north and south through the central portion of the fourth and fifth floors, between the 150,000-volt switching rooms which are located on either side. The transformers, stepping down from 150,000 volts to 72,000 and 18,000 volts, are in transformer rooms running north and south through the central portion of the station, directly under the 150,000-volt bus and switch rooms. The transformer rooms extend in clear height from the first to the fourth floor level. The oil treating and storage tanks are in rooms in the basement directly under the transformer equipment. The 72,000-volt busses and switches are between the transformer rooms and the west side of the station, and the 18,000-volt busses and switches are between the transformer room and the east side of the station, the outgoing lines leaving the station at the third-floor level.

The portion of the substation housing the condensers and other auxiliary equipment is divided into two parts, the condenser room 38 feet 6 inches by 131 feet and an auxiliary space 15 feet 6 inches by 131 feet. This auxiliary space is divided into three floors, while the condenser room proper extends the full height of this portion of the building. On the lower floor of the auxiliary space are the Westinghouse 5,000-kilovolt-ampere condenser transformers. On the second floor is the switchboard room, and on the third floor telephone entrances, etc. Access to the switchboard room is obtained from the ground floor in the condenser room by means of a steel stairway. This portion of the building measures 47 feet 2 inches in height from the ground floor to the peak of the ventilator over the condensers, 28 feet to crane runway, and 37 feet 9 inches to lower chord of roof trusses. The basement floor is 10 feet 6 inches below the first floor.

The building can in future be extended, as occasion requires, on either of its four sides. At present the transformer equipment consists of four banks of 150,000/72,000/18,000-volt 13,500-kilovolt-ampere transformers; one bank of 18,000/220-volt 225-kilovolt-ampere station light and power transformers; one bank of 50,000/60,000/72,000-volt 10,000-kilovolt-ampere compensators; two banks of 18,000/6,600-volt kilovolt-ampere transformers. Two synchronous condensers now installed are General Electric AT1 3-phase 50-cycle 16-pole 6,600-volt 1,312-ampere units, 15,000-kilovolt-ampere (maximum), 375 revolutions per minute. The condensers are connected to an 18,000-volt bus through two banks of three 5,000-kilovolt-ampere transformers connected delta on both sides. The exciter of each condenser is mounted on the main shaft. Two regulating exciters are provided for the excitation of the condenser exciters.

TABLE 133.—*High-tension transmission lines operated by Southern California Edison Co., 1904–1920.*

	Miles.
1904	200
1905	220
1906	220
1907	337
1908	350
1909	350
1910	350
1911	350
1912	380
1913	410
1914	416
1915	416
1916	502
1917	1,173
1918	1,219
1919	1,329
1920	1,518

TABLE 134.—*High-tension transmission lines operated by Pacific Light & Power Corporation, 1909–1916.*

	Miles.
1909	254
1910	254
1911	254
1912	254
1913	815
1914	970
1915	1,185
1916	1,222

The growth in length of transmission lines operated by Mount Whitney Power & Electric Co. from 1903 to 1919 is shown in Table 135, and more detailed information concerning the transmission system as it stood at the end of 1919 is given in Table 136. All figures for 1920 are included with data for Southern California Edison Co.

TABLE 135.—*High-tension transmission lines operated by Mount Whitney Power & Electric Co., 1903–1919.*

	Miles.		Miles.
1903	60	1912	170
1904	61	1913	171
1905	61	1914	192
1906	61	1915	216
1907	62	1916	209
1908	66	1917	209
1909	82	1918	208
1910	169	1919	219
1911	169		

TABLE 136.—*Transmission lines of Mount Whitney Power & Electric Co., 1919.*

District.	Miles of line.	Voltage.	Number of circuits.	Character of supports.
Visalia	9.7	33,000	2	Wood poles.
Do	50.5	33,000	1	Do.
Porterville	2.0	33,000	2	Do.
Do	74.0	33,000	1	Do.
Do	2.0	33,000	1	Steel poles.
Do	3.3	60,000	2	Wood poles.
Tulare	68.9	33,000	1	Do.
Do	1.1	33,000	2	Do.
Do	7.5	60,000	2	Do.
	219.0		10	

TABLE 137.—*High-tension transmission lines operated by Southern California Edison Co., Dec. 31, 1920.*

Miles of line.	Character of supports.	Voltage.	Number of circuits.
482	Steel towers	150,000	1
189	do	60,000	2
6.8	do	60,000	1
1.25	do	60,000	4
.4	do	30,000	3
6.2	do	30,000	1
77	Wood poles	60,000	2
409	do	60,000	1
23	do	50,000	2
169	do	50,000	1
38.7	do	30,000	2
116	do	30,000	1
1,518.35			

TABLE 138.—*Growth in number of substations and distribution system of Southern California Edison Co., 1904–1920.*

Year.	Number of substations.	Overhead lines.	Underground conduits.
		Miles.	*Miles.*
1904	18	510	25
1905	22	660	38
1906	24	825	52
1907	27	1,000	60
1908	30	1,055	65
1909	31	1,110	76
1910	32	1,160	81
1911	35	1,200	98
1912	38	1,246	111
1913	51	1,577	128
1914	60	1,803	130
1915	63	2,100	137
1916	72	2,432	129
1917	109	[a] 5,788	290
1918	109	6,045	291
1919	121	6,156	292
1920	133	6,396	293

[a] Total primary circuit. Includes system formerly operated by Pacific Light & Power Corporation.

TABLE 139.—*Growth in number of substations and distribution system of Pacific Light & Power Corporation, 1909–1916.*

Year.	Number of substations.	Overhead lines.	Underground conduits.
		Miles.	*Miles.*
1909	8	1,330	122
1910	9	1,540	125
1911	9	1,750	128
1912	13	2,014	131
1913	16	2,212	153
1914	26	2,526	161
1915	26	3,224	164
1916	29	3,536	164

Table 140 shows the number of substations and the length of overhead distribution lines of Mount Whitney Power & Electric Co. from 1900 to 1919, and Table 141 shows in detail the substations in operation at the end of 1919.

TABLE 140.—*Growth of substation distribution system of Mount Whitney Power & Electric Co., 1900–1919.*

Year.	Number of substations.	Overhead lines.	Year.	Number of substations.	Overhead lines.
		Miles.			*Miles.*
1900	4	....	1910	12	390
1901	5	....	1911	12	462
1902	5	....	1912	12	526
1903	6	46	1913	12	738
1904	6	73	1914	15	1,024
1905	6	88	1915	15	1,331
1906	6	117	1916	17	1,428
1907	7	129	1917	20	1,544
1908	9	167	1918	16	1,557
1909	11	221	1919	17	1,662

TABLE 141.—*Substations of Mount Whitney Power & Electric Co. in operation Sept. 30, 1919.*

Substation.	Location.	Buildings.		Put in operation.	Voltage.		Capacity.	Service.
		Type.	Dimensions.		Incoming circuits.	Outgoing circuits.		
			Feet.				*Kilovolt-amperes.*	
Venice	Venice Hill	Fenestra steel and glass.	14 by 14		33,000	6,600	1,500	Receives at 33,000 volts, distributes at 6,600 volts, 2 phase, 3 wire.
Visalia	Visalia	Brick [a]			33,000	2,200	1,000	Also a distributing substation. The transformers described (p. —) step up to 33,000 volts and 3-phase power at 2,200 volts is taken off the primaries for local distribution.
Tulare	Tulare	Fenestra steel and glass.	14 by 28		33,000	6,600 2,200	3,350	Receives at 33,000 volts, distributes at 6,600 volts, 2 phase, 3 wire, and 2,200 volts, 3 phase, 3 wire.
Tipton	Tipton	do	14 by 14		33,000	6,600	1,500	Receives at 33,000 volts; distributes at 6,600 volts, 2 phase, 3 wire.
Delano	Delano	Concrete; two stories	45 by 27	1915	33,000	6,600	1,200	Do.
Exeter	Exeter	do	45 by 27	1915	33,000	2,200 6,600	2,500	Receives at 33,000 volts; distributes at 2,200 volts, 2 phase, 3 wire, and 6,600 volts, 2 phase, 3 wire. Power is also supplied at Exeter to the substation of the Visalia Electric Ry., 33,000 volts being delivered.
Lindsay	Lindsay	Brick	58 by 88	1912	33,000	2,200 6,600	3,600	Receives at 33,000 volts; distributes at 2,200 and 6,600 volts, 2 phase, 3 wire.
Porterville	Porterville	Concrete	56 by 32	1916	33,000	2,200 6,600 11,000	3,600	Receives at 33,000 volts; distributes at 6,600 volts, 2 phase, 3 wire; 2,200 volts, 3 phase, 3 wire; 11,000 volts, 3 phase, 3 wire.
Ducor	Ducor	Corrugated iron	15 by 30		33,000	6,600	Removed.	Receives at 33,000 volts; distributes at 6,600 volts, 2 phase, 3 wire.
Success	Near Springville	do	16 by 30		33,000	11,000	375	Receives at 33,000 volts; distributes at 11,000 volts, 3 phase, 3 wire.
Sugar (not in operation)	South of Visalia—sugar factory station.	do	11 by 12		33,000	6,600	600	Receives at 33,000 volts; distributes at 6,600 volts, 2 phase, 3 wire.
Packwood	Sec. 7, T. 19 S., R. 24 E.	Fenestra steel and glass.	14 by 14	1913	33,000	6,600	600	Receives at 33,000 volts; distributes at 6,600 volts, 2 phase.
Woodville	Sec. 20, T. 21 S., R. 26 E.	do	14 by 14	1913	33,000	6,600	1,000	Do.
Earlimart	Sec. 27, T. 23 S., R. 25 E.	do	14 by 14	1913	33,000	6,600	1,500	Do.
Terra Bella	Terra Bella	do	14 by 14	1913	33,000	6,600	1,500	Do.
Strathmore	Strathmore	do	14 by 14	1913	33,000	6,600	3,000	Do.
Tulare steam plant	Tulare	Brick; steel columns	57 by 56	[b] 1915	33,000	2,200 11,000	1,800	Receives at 33,000 volts; distributes at 2,200 volts, 3 phase, 11,000 volts, 3 phase.
Strathmore No. 2	Sec. 27, T. 20 S., R. 26 E.	Corrugated iron	54 by 40	[b] 1916	33,000	11,000	1,500	Receives at 33,000 volts; distributes at 11,000 volts, 3 phase.

[a] See description of steam plant, pp. 686–689

[b] Purchased from Tulare County Power Co.

TABLE 142.—*Substations of Southern California Edison Co. in operation Dec. 31, 1920.*

Substations owned by company prior to purchase of Pacific Light & Power Corporation.

Substation.	Location.	Building.		Put into operation.	Voltage.		Capacity.	Service.
		Type.	Dimensions.		Incoming circuits.	Outgoing circuits.		
			Feet.		*Volts.*	*Volts.*	*Kilovolt-amperes.*	
Alhambra	2520 Poplar Street, town of Alhambra.	Tile, plaster	36 by 28	1918	15,000	2,200	1,500	Receives power at 15,000 volts from network; distributes 2,200 volts locally to Alhambra.
Altadena	On Atlanta Street, town of Altadena.	Wood frame, plastered, corrugated-iron roof.	18 by 24	1914	15,000	2,200	750	Receives power at 15,000 volts from network; serves 2,200 volts locally.
Anaheim	Equipment only owned by Southern California Edison Co., located in municipal power plant of Anaheim.				10,000	2,400	750	Receives power at 10,000 volts from Katella; serves 2,400 volts for local use.
Ardmore	949 South Ardmore Street. Equipment only owned by Southern California Edison Co., located in Los Angeles Railway substation.			1920	15,000	2,200	1,200	Receives power at 15,000 volts from network; distributes 2,200 volts locally in Los Angeles.
Athens	On Virgil Street, town of Athens.	Wood frame and corrugated iron.			10,000	2,200	112.5	Receives power at 10,000 volts from Inglewood-Long Beach line; serves 2,200 volts locally.
Belvidere	East Third Street and Downey Road, town of Belvidere.	Steel frame, corrugated iron.	16 by 16	1921	15,000	2,200	750	Receives power at 15,000 volts from network; distributes 2,200 volts locally to Belvidere.
Ben Hur roller coaster.	Ben Hur roller coaster in Ocean Park.	do	10 by 14		2,200	2,200	200	Receives power at 2,200 volts from Ocean Park; serves 2,200 volts to amusement concessions.
Beverly Hills	400 Camden Street, town of Beverly Hills.	Concrete, corrugated-iron roof.	16 by 20	1912	10,000	2,200	750	Receives power at 15,000 volts from network; distributes 2,200 volts locally to Beverly Hills.
Bloomington	Town of Bloomington	Wood frame, corrugated iron.	10 by 12		10,000	2,200	50	Receives power at 10,000 volts from Colton; distributes 2,200 volts locally to Bloomington.
California Portland Cement Co.	West of Colton. Equipment only owned by Southern California Edison Co., located in California Portland Cement Co.'s building.				60,000	440	4,500	Receives power at 60,000 volts from Long Beach-Colton line; transforms to 440 volts for consumers only.
Camarillo	Town of Camarillo	Outdoor		1908	15,000	2,200	750	Receives power at 15,000 volts from network; distributes 2,200 volts locally to Camarillo.

Capistrano	San Diego Boulevard north of Capistrano.	Reinforced concrete	105 by 87	1917	60,000	70,000 10,000	5,000	Receives power at 60,000 volts 50 cycles from Long Beach steam plant; delivers 70,000 volts 60 cycles to transmission line of San Diego Gas & Electric Co.; also distributes 10,000 volts to Capistrano.
Castaic	Leased lot in Rancho San Francisco, near the junction of Santa Clara River and the Southern Pacific R. R.	Concrete, with corrugated-iron roof.	43 by 68	1907	60,000	60,000 30,000	10,850	Receives power at 60,000 volts from Kern River and city of Los Angeles; serves 60,000 volts to San Fernando and 15,000 volts to Acton and Fillmore.
Chino	On Edison Avenue, city of Chino.	Reinforced concrete	53⅓ by 99⅔	1912	60,000	60,000 11,000 2,200	15,300	Receives power at 60,000 volts from Newmark; serves 60,000 volts to Colton, 11,000 volts to Ontario, East Chino, Pomona, and Corona, and 2,200 volts to Chino.
Claremont	At corner of First Street and Alexander Avenue, Claremont.	Brick, plastered, corrugated-iron roof.	26 by 46	1912	10,500 10,500	2,300	300	Receives power at 10,500 volts from Pomona and Chino, respectively; serves 2,300 volts locally.
Colton	Mount Vernon and N streets, town of Colton.	Reinforced concrete	53 by 161	1912	60,000 30,000 10,000	60,000 30,000 10,000	17,000	Receives power at 60,000 volts from Long Beach steam plant and 30,000 volts and 10,000 volts from Canyon plants; distributes 60,000, 30,000, and 10,000 volts to cement plants, and locally also exchange of power with The Southern Sierras Power Co. at 60 cycles.
Culver City	Overland Avenue, north of Pacific Electric Ry.	Steel frame, corrugated iron.	36 by 26	1920	60,000	15,000 2,000	16,500	Receives power at 60,000 volts from Long Beach-McNeil line; distributes 15,000 volts to Ocean Park, Sawtelle oil wells, and Pacific Electric Ry.; also 2,200 volts locally.
Dalton	1 mile south of Foothill Boulevard, near Azusa.	Wood frame, corrugated iron.	19 by 19	1921	60,000 15,000	15,000	4,500	Receives power at 60,000 volts from Puente and 15,000 volts from Azusa; distributes 15,000 volts to network.
Downey	On Church Street, city of Downey.	Wood frame, corrugated iron.			10,000	2,300	300	Receives power at 10,000 volts from Whittier; serves 2,300 volts for local consumption.
East San Pedro		do			10,000	2,300	300	Receives power at 10,000 volts from Long Beach steam plant; serves 2,300 volts locally.
El Monte	193 feet frontage, on Esmeralda Street, El Monte.	do	12 by 15		10,000	2,200	150	Receives power at 10,000 volts from Puente; serves 2,200 volts locally.
El Segundo	On Center Street, in the town of El Segundo.	do			10,000	2,300	100	Receives power at 10,000 volts from Redondo steam plant; serves 300 volts to oil refinery.
Fairview	Newport Highway, near town of Fairview.	Brick	28 by 38	1921	60,000	10,000	4,500	Receives power at 60,000 volts from Katella; distributes 10,000 volts locally.
Fillmore	Santa Clara Street, town of Fillmore.	Brick	28 by 38	1921	60,000	15,000 2,200	4,200	Receives power at 60,000 volts from Castaic; distributes 15,000 volts to network and 2,200 volts locally to Fillmore.
Frazier Pier	Frazier Pier, Ocean Park.	Steel frame, corrugated iron.	10 by 14		2,200	110/220	250	Receives power at 2,200 volts from Ocean Park; serves 110/220 volts to amusements.
Fullerton	On Whittier Street, city of Fullerton.	Wooden frame, corrugated iron.	24 by 32	1906	30,000	10,000 2,200	4,850	Receives power at 30,000 volts from Matella-Puente; serves 10,000 volts to Santa Ana, Buena Park, Placentia, and Whittier, and 2,200 volts locally.
Garden Grove	On Penn Avenue, in the city of Garden Grove.	do			10,000	2,300	150	Receives power at 10,000 volts from Katella; serves 2,300 volts locally.

TABLE 142.—*Substations of Southern California Edison Co. in operation Dec. 31, 1920*—Continued.

Substation.	Location.	Building.		Put into operation.	Voltage.		Capacity.	Service.
		Type.	Dimensions.		Incoming circuits.	Outgoing circuits.		
			Feet.		*Volts.*	*Volts.*	*Kilovolt-amperes.*	
Gardena Heights	Leased lot at Compton Street and Santa Monica Road, in the town of Gardena Heights.	Wooden frame, corrugated iron.	....	......	10,000	2,300	750	Receives power at 10,000 volts from Inglewood-Long Beach line; serves 2,300 volts locally.
Hawthorne	41.06 feet frontage, on Baloona Avenue, town of Hawthorne.	.....do	14 by 14	......	10,000	2,200	750	Receives power at 10,000 volts from Inglewood-Long Beach line; serves 2,200 volts to Hawthorne Water Co. and locally.
Highlands	On Main Street, city of Highlands.	.....do	15 by 20	......	10,000	2,200	300	Receives power at 10,000 volts from Colton; serves 2,200 volts locally.
Inglewood	99.5 feet frontage, on Los Angeles Street, city of Inglewood.	Corrugated iron	10 by 12	1905	60,000	2,200	7,950	Receives power at 60,000 volts from Long Beach steam plant; serves 2,200 volts locally.
Katella	171.1 feet frontage on State highway, approximately 2 miles north of the north city limits of the city of Santa Ana.	Reinforced concrete; 2 buildings.	20 by 40 each	......	60,000	60,000 10,000	15,000	Receives power at 60,000 volts from Long Beach steam plant; serves 60,000 volts to Puente and 10,000 volts to Orange, Santa Ana, Whittier, Anaheim, and Garden Grove.
La Habra	Fullerton Road and Ocean Avenue near town of Fullerton.	Steel frame, metal lath, and plaster.	25 by 27	1920	60,000	10,000 2,000 2,200	4,500	Receives power at 60,000 volts from network; distributes 10,000 and 2,200 volts locally.
Lake	Elizabeth Lake	Concrete	18 by 24	1904	50,000	50,000	....	Line-switching station.
La Verne	At corner of Fifth and D streets, city of Lordsburg.	Brick, plastered, corrugated-iron roof.	16 by 22	1912	11,000	2,300	100	Receives power at 11,000 volts from Pomona; serves 2,300 volts locally.
Llewellyn	Equipment only owned by Southern California Edison Co., located in Llewellyn Iron Works building, town of Torrance.	....	....	1914	15,000	2,200	....	Receives power at 15,000 volts from Torrance; distributes 2,200 volts to consumer only.
Limonera	Equipment only owned by Southern California Edison Co., located in building of Limonera Ranch Co., Ventura County.	....	....	1919	15,000	2,200	750	Receives power at 15,000 volts from network; distributes 2,200 volts to consumer only.
Lomita	On Narbonne Avenue, town of Lomita.	.....do	....	......	15,000	2,200	750	Receives power at 15,000 volts from Torrance; serves 2,200 volts locally.

Long Beach	On Locust Street, in the city of Long Beach.	....do	30 by 60	1907	10,000	10,000 2,200	6,000	Receives power at 10,000 volts from Long Beach steam plant; serves 10,000 volts to Long Beach Water Co. and 2,200 volts locally.
Los Alamitos	Town of Los Alamitos	Wood frame, corrugated iron.	14 by 28	1917	60,000	10,000	4,500	Receives power at 60,000 volts from Long Beach steam plant; distributes 10,000 volts to network.
Los Angeles No. 1	100.55 feet frontage, on Boylston Street, Los Angeles.	Reinforced concrete	28.7 by 66	1912	15,000	15,000 2,200	4,275	Receives power at 15,000 volts from Los Angeles loop; serves 15,000 volts to Los Angeles loop and 2,200 volts locally.
Los Angeles No. 2	110.28 feet frontage, on East Fourth Street, Los Angeles.	Steel frame and reinforced-concrete brick.	100 and 94 by 140	1903	15,000	15,000 2,200 [a]110/220	12,355	Receives power at 15,000 volts from Los Angeles No. 3; serves 15,000 volts to Los Angeles loop, and 2,200, 110/220 direct current, and 500 direct current locally.
		Battery room, brick with concrete floor.	54 by 94 and 88	......	......	[a] 500	......	
Los Angeles No. 4	On alley at West Thirty-first Street, Los Angeles.	Reinforced concrete, metal-tile roof.	23 by 33	1904	15,000	15,000 2,200	3,600	Receives ower at 15,000 volts from Los Angeles loop; serves 15,000 volts to Los Angeles loop and 2,200 volts locally.
Los Angeles No. 5	119.7 feet frontage, corner of Thirtieth and San Pedro streets, Los Angeles.	Concrete, metal-tile roof.	....do	1904	15,000	15,000 2,200	4,200	Do.
Los Angeles No. 6	On Porter Street, Los Angeles.	Reinforced concrete	28¾ by 66	1912	15,000	15,000 2,200	4,800	Receives power at 15,000 volts from Los Angeles No. 3; serves 15,000 volts to Los Angeles loop and 2,200 volts locally.
Los Angeles No. 7	On South Figueroa Street, Los Angeles.	Wooden frame, corrugated iron.	19½ by 14	1913	15,000	2,200 15,000	1,200	Receives power at 15,000 volts from Los Angeles loop; serves 2,200 volts locally and 15,000 volts to Los Angeles loop.
Los Angeles No. 8	Equipment only owned by Southern California Edison Co. Located near Vineyard, in Los Angeles.	Brick	......	......	15,000	2,200	2,400	Receives power at 15,000 volts from Culver City loop; serves 2,200 volts locally.
Los Angeles No. 16	Basement at Seventh and Olive streets. Equipment only owned by Southern California Edison Co., located in Coulter Dry Goods Co.'s building.	......	......	1917	2,200	[a] 220	1,000	Receives 2,200 volts alternating current from Los Angeles No. 1; distributes 110/220 direct current locally.
Macneil	100 feet frontage on Pioneer Avenue, city of Burbank.	Wooden frame, corrugated iron.	......	......	60,000	60,000 30,000 15,000 2,200	5,700	Receives power at 60,000 volts from San Fernando; serves 60,000 volts to Los Angeles No. 3, Culver City, 15,000 volts to Lankershim, and 2,200 volts to Van Nuys, Burbank, Lankershim, and locally.
Mill Creek	Northeast corner of sec. 13, T. 1 S., R. 2 W., San Bernardino base and meridian.	....do	16 by 20	1913	33,000	10,000	2,250	Receives power at 33,000 volts from Mill Creek No. 2 and No. 3; serves 10,000 volts to Beaumont, etc.
Mojave	About ½ mile west of Mojave.	Outdoor	......	1919	50,000	2,200	450	Receives power at 50,000 volts from Borel lines; distributes 2,200 volts locally at Mojave.

[a] Direct current.

TABLE 142.—*Substations of Southern California Edison Co. in operation Dec. 31, 1920*—Continued.

Substation.	Location.	Building.		Put into operation.	Voltage.		Capacity.	Service.
		Type.	Dimensions.		Incoming circuits.	Outgoing circuits.		
			Feet.		*Volts.*	*Volts.*	*Kilovolt-amperes.*	
Moneta	On Western Avenue and Gladstone Street, in the town of Moneta.	Outdoor			15,000	2,200	1,200	Receives power at 15,000 volts from Torrance; serves 2,200 volts locally.
Monrovia	Corner of Primrose and Chestnut streets, city of Monrovia.	do	16 by 24	1902	15,000	2,200	750	Receives power at 15,000 volts from Azusa; serves 2,200 volts locally.
Montrose	Equipment only owned by Southern California Edison Co. Located in building of Glendale & Montrose Ry., in Montrose.	Wooden frame and plaster.			15,000	2,200	750	Receives power at 15,000 volts from Eagle Rock; serves 2,200 volts to Glendale & Montrose Railway.
Moor Park	About 1 mile west of Moor Park, on highway.	Wood frame, corrugated iron.	10 by 12	1920	15,000	2,200	450	Receives power at 15,000 volts from network; distributes 2,200 volts locally to Moor Park.
Newmark	Near the northwest corner of Rancho La Merced.	Reinforced concrete	37⅝ by 132⅛	1913	60,000	60,000 15,000	9,000	Receives power at 60,000 volts from Los Angeles No. 3, Long Beach steam plant; serves 60,000 volts to Colton and 15,000 volts to Alhambra and Montebello.
Norwalk	On Church Street, in the town of Norwalk.	Wooden frame, corrugated iron.			10,000	2,200	300	Receives power at 10,000 volts from Whittier; serves 2,200 volts locally.
Ocean Park	56.5 feet frontage, on Lake Street, city of Ocean Park.	Concrete, with corrugated-iron roof.	53½ by 23	1910	15,000	30,000 2,400 2,200	4,800	Receives power at 15,000 volts from Culver City; serves 30,000, 2,400, and 2,200 volts locally.
Oilwells	West Third Street near La Brea Boulevard, Los Angeles.	Corrugated iron on wood frame.	40 by 50		15,000	2,200	1,200	Receives power at 15,000 volts from Culver City; distributes 2,200 volts locally to oil leases.
Ojai	Equipment only owned by Southern California Edison Co., located in Ojai Light & Power Co.'s plant.				15,000	2,200	750	Receives power at 15,000 volts from Ventura; distributes 2,200 volts to Ojai Light & Power Co.
Orange	On Atchinson Street, in the city of Orange.	Brick, plastered, corrugated-iron roof.	16 by 22	1912	10,000	2,200	300	Receives power at 10,000 volts from Katella; serves 2,200 volts locally.
Owensmouth	123.24 feet frontage, on Sherman Way, in the city of Owensmouth.	do	17$\frac{1}{12}$ by 26⅛	1913	15,000	2,200	225	Receives power at 15,000 volts from San Fernando; serves 2,200 volts locally.

Oxnard	East Fifth Street, town of Oxnard.	Brick (power house)	30 by 59		15,000	2,200	900	Receives power at 15,000 volts from Saticoy; distributes 2,200 volts locally to Oxnard.
Piru	Town of Piru	Corrugated iron on wood frame.	12 by 24		15,000	2,200	750	Receives power at 15,000 volts from Castaic; distributes 2,200 volts locally to Piru.
Pomona	Corner of Second and Parcella streets, city of Pomona	Brick, with corrugated-iron roof.	30 by 36	1901	10,000 10,000	2,300 10,000	1,050	Receives power at 10,000 volts from Chino and 10,000 volts from Puente; serves 2,300 volts locally and 10,000 volts to San Dimas, Lordsburg, and Claremont.
Puente	210 feet frontage, on Anaheim-Puente Road, near the town of Puente.	Reinforced concrete	53⅜ by 101⅜	1913	15,000 60,000	60,000 10,000 15,000	9,000	Receives power at 15,000 volts from Katella and 60,000 volts from Newmark; serves 60,000 volts to Colton, 10,000 volts to Whittier, El Monte, and Pomona, and 10,000 volts locally.
Redlands Junction.	81.5 feet frontage, on Barton Avenue, 2 miles west of the west city limits of Redlands.	Wooden frame, corrugated iron.			10,000	2,200 110	30	Receives power at 10,000 volts from Colton; serves 2,200 and 110 volts locally.
Redlands	Corner of Sixth Street and Citrus Avenue, city of Redlands.	Brick, corrugated-iron roof.	50 by 121	1902	10,000 30,000	30,000 2,200	2,040	Receives power at 10,000 volts from Colton and 30,000 volts from Canon plants; serves 30,000 volts to Colton and 2,200 volts locally.
Redondo	45.75 feet frontage on Camino Real, city of Redondo.	Concrete, corrugated-iron roof.	42 by 25	1910	15,000	2,300	1,050	Receives power at 15,000 volts from Redondo steam plant; serves 2,300 volts locally.
Rivera	Leased lot, on Topeka Street, town of Rivera.	Wooden frame, corrugated iron.			10,000	2,300	150	Receives power at 10,000 volts from Whittier; serves 2,300 volts locally.
Riverside-Portland cement.	Equipment only owned by Southern California Edison Co. Located in cement plant of Riverside-Portland Cement Co., near Crestmore.				30,000	440	9,000	Receives power at 30,000 volts from Colton; serves 440 volts to cement plant.
San Antonio	Cucamonga and Monte Vista streets.	Steel frame, metal lath, and plaster.	25 by 27		60,000	10,000	6,000	Receives power at 60,000 volts from Chino; distributes 10,000 volts to network.
Santa Ana	On Sycamore Street, city of Santa Ana.	Concrete, corrugated iron.	25 by 42	1909	10,000	10,000 2,200	1,500	Receives power at 10,000 volts from Katella; serves 10,000 volts to Tustin and 2,200 volts locally.
San Dimas	On Fifth Street, west of San Dimas Avenue, San Dimas.	Brick, plastered, corrugated-iron roof.	16 by 22	1912	11,000	2,200	75	Receives power at 11,000 volts from Pomona; serves 2,200 volts locally.
San Fernando	100.3 feet frontage on Stanford Street, Los Angeles.	Concrete, corrugated-iron roof.	43 by 68	1907	60,000	60,000 15,000 15,000 2,200	5,100	Receives power at 60,000 volts from Castaic; serve 60,000 volts to Macneil and Saticoy, 15,000 volts to rock crushers and Van Nuys, and 2,200 volts locally.
San Pedro	Corner of Olive and Mesa streets, Los Angeles.	Reinforced concrete	28 by 66	1912	15,000	2,200 10,000	1,500	Receives power at 10,000 volts from Long Beach steam plant; serves 2,200 volts locally and 10,000 volts to dredger.
Santa Paula	Highway east of town of Santa Paula.	Brick	21 by 46		15,000	2,200	600	Receives power at 15,000 volts from network; distributes 2,200 volts locally to Santa Paula.
Saticoy	Sixth Street between E and B, town of Saticoy.	Wood frame, corrugated iron.	16 by 28		60,000 15,000	60,000 15,000 2,200	7,500	Receives power at 60,000 and 15,000 volts from San Fernando and Castaic; distributes 60,000 volts to Santa Barbara, 15,000 volts to Oxnard and Ventura, and 2,200 volts locally to Saticoy.
Seal Beach	North Avenue and Eighth Street, town of Seal Beach.	Corrugated iron	30 by 16		15,000	2,200	250	Receives power at 15,000 volts from Los Alamitos; distributes 2,200 volts locally to Seal Beach.

TABLE 142.—*Substations of Southern California Edison Co. in operation Dec. 31, 1920*—Continued.

Substation.	Location.	Building.		Put into operation.	Voltage.		Capacity.	Service.
		Type.	Dimensions.		Incoming circuits.	Outgoing circuits.		
			Feet.		*Volts.*	*Volts.*	*Kilovolt-amperes.*	
Sierra Madre	On Bonita Avenue, city of Sierra Madre.	Brick, plastered, corrugated-iron roof.	16 by 22	1912	15,000	2,300	600	Receives power at 15,000 volts from Azusa or Eagle Rock; serves 2,300 volts locally.
Sunland		Wooden frame, corrugated iron.			15,000	2,200	360	Receives power at 15,000 volts from Pasadena; serves 2,200 volts locally.
Sawtelle	41.88 feet frontage on Oregon Avenue, city of Sawtelle.	do	30 by 20	1914	15,000	10,000 2,200	750	Receives power at 15,000 volts from Culver City; serves 30,000 volts to Ocean Park, 10,000 volts to Sherman, and 2,200 volts locally.
Tehachapi	Monolith	Outdoor			50,000	10,000	450	Receives power at 50,000 volts from Borel lines; distributes 10,000 volts to Tehachapi.
Tejon	Leased lot in Castaic Rancho, 3 miles north of town of Lebec.	Concrete, corrugated-iron roof.	41 by 39	1907	60,000	60,000		Receives power at 60,000 volts from Kern River No. 1; serves 60,000 volts to Castaic.
Torrance	Western and Dominguez avenues, near town of Moneta.	Reinforced concrete	143 by 54.5	1920	60,000	15,000 2,200	15,750	Receives power at 60,000 volts from Redondo and Long Beach steam plants; distributes 15,000 volts to network and 2,200 volts locally.
Van Nuys	Corner of C and Figueroa streets, Los Angeles.	Brick, plastered, corrugated-iron roof.	26⅛ by 48⅝	1913	15,000	2,200	300	Receives power at 15,000 volts from San Fernando; serves 2,200 volts locally.
Venice Pier	Venice Pier, Venice	Steel frame, corrugated iron.	10 by 14	1913	2,200	110/220	300	Receives power at 2,200 volts from Ocean Park; serves 110/220 volts to amusements.
Ventura	Spruce Street and Seaside Park, city of Ventura.	Brick	18 by 36	1908	15,000	15,000 2,200	450	Receives power at 15,000 volts from Saticoy; distributes 15,000 volts to Ojai and 2,200 volts locally to Ventura.
Vestal	Highway north of town of Richgrove.	Reinforced concrete	67 by 131	1920	150,000 60,000	60,000	15,000	Receives power at 150,000 volts from Big Creek plants and 60,000 volts from Kern River No. 3; distributes 60,000 volts to San Joaquin Valley 60-cycle network.
Whittier	On Penn Street, city of Whittier.	do	28 by 50	1914	10,000	2,300 10,000	750	Receives power at 10,000 volts from Puente and Katella; serves 2,300 volts locally and 10,000 volts to Norwalk, Rivera, and Downey.
Wilmington	Corner of Sixth and D streets, Los Angeles.	Wooden frame, corrugated iron.	30 by 30	1912	10,000	2,400 10,000	300	Receives power at 10,000 volts from Long Beach steam plant; serves 2,400 volts locally.

Substations acquired through purchase of Pacific Light & Power Corporation.

Artesia	Adams and Second streets, town of Artesia.	Corrugated iron	15 by 22	1914	15,000	[b] 2,200	300	Receives power at 10,000 volts from Los Alamitos and delivers same to local 2,400-volt distribution system and to series street-lighting system.
Compton	Wilmington and School streets, Compton.	do	15 by 20	1914	15,000	[b] 2,400	750	Receives power at 15,000 volts from network of 15-kilovolt-ampere lines, and delivers same to local 2,400-volt distribution system and to series street-lighting system.
Covina	College Street near Citrus Avenue, Covina	Concrete with tile roof.	14 by 47	1901	15,000	[b] 2,400	750	Do.
C Street	San Bernardino	Main building brick, iron roof.	24 by 50 (main building).	[c]1904	30,000 15,000	[b] 15,000 [b] 2,400	4,500	Receives power at 30,000 volts from Canyon plants and delivers same to local 15,000 and 2,400 volt local distribution lines and systems and to series street-lighting system.
Eagle Rock	North of Eagle Rock Park adjacent to Los Angeles.	Reinforced concrete	126 by 168 by 104	1913	150,000	[b] 60,000 15,000	54,000	Receives power at 150,000 volts from power houses Nos. 1 and 2 of the Big Creek project. Transmits power to various substations only at 60,000 and 15,000 volts.
Glendora	Vermont Avenue and Ada Street, Glendora.	Corrugated iron	8 by 12	1914	15,000	[b] 2,400	360	Receives power at 15,000 volts from network of 15-kilovolt-ampere lines and delivers it to local 2,400-volt distribution system and to series street-lighting system.
Huntington Beach	Railroad Avenue and Indiana Street, Huntington Beach.	do	15 by 20	1914	10,000	[b] 2,400	100	Receives power at 10,000 volts from network of 15-kilovolt-ampere lines and delivers same to local 2,400-volt distribution system and to series street-lighting system.
Indian switching station.	Near Loraine	Concrete, iron roof	18 by 24	1904	50,000	50,000	....	Line switching station.
Lancaster substation.	Eighth and Fern streets, Lancaster.	Corrugated iron	15 by 20	1914	[b] 50,000	[b] 10,000 [b] 2,400	1,500	Receives power from Borel power house or Eagle Rock substation at 50,000 volts. Delivers power at 10,000 volts to distribution system and at 2,400 volts also to local distribution system and to multiple street-lighting system.
Los Angeles No. 10.	Third and Los Angeles streets, Los Angeles.	Brick, iron roof	25 by 92	1898	15,000	[b] 2,400 [a] 500 [a] 220	4,500	Receives power at 15,000 volts from network of 15-kilovolt-ampere lines and delivers same to local 2,400-volt alternating current, 500-volt direct current, and 220-volt direct-current distribution systems and to street-lighting systems.
Los Angeles No. 11.	Mission Road, near East Lake Park, Los Angeles.	Reinforced concrete, tile roof.	Main building, 20 by 90; wing, 36 by 75.	1904	[b] 15,000	[b] 15,000 [b] 2,400	3,400	Receives power from Eagle Rock and network of 15-kilovolt-ampere lines at 15,000 volts. Delivers power to Pacific Electric and Los Angeles Railways and to 15-kilovolt-ampere network at 15,000 volts to local 2,400-volt distribution system and to series street-lighting system.
Los Angeles No. 13.	Hoover and Santa Barbara streets, Los Angeles.	Corrugated iron	72 by 26	[d]1906	15,000	([e])	1,175	Receives power at 15,000 volts from network of 15-kilovolt-ampere lines and delivers same to series street arc circuits.

[b] Alternating current

[c] Additional outdoor equipment added 1916.

[d] New station 1915.

[e] Series arc circuits.

TABLE 142.—*Substations of Southern California Edison Co. in operation Dec. 31, 1920*—Continued.

Substation.	Location.	Building.		Put into operation.	Voltage.		Capacity.	Service.
		Type.	Dimensions.		Incoming circuits.	Outgoing circuits.		
			Feet.		*Volts.*	*Volts.*	*Kilovolt-amperes.*	
Los Angeles No. 14.	Sunset Boulevard and Cahuenga Avenue, Los Angeles.	Concrete and brick with tile roof.	14 by 65	1902	15,000	[b] 2,400	3,750	Receives power at 15,000 volts from network of 15-kilovolt-ampere lines and delivers same to local 2,400-volt distribution system and series street lighting system.
Los Angeles No. 15.	Alvarado and Scott streets, Los Angeles.	Brick	24 by 42	1914	15,000	[b] 2,400	1,500	Receives power at 15,000 volts from Eagle Rock substation and delivers same to local 2,400-volt distribution system and to series street-lighting system.
Magunden	Sec. 36, T. 29 S., R. 28 E., Mount Diablo base and meridian in Kern County.	Reinforced concrete	99 by 112 by 59	1913	150,000	150,000		Line switching station along the Big Creek transmission lines.
Montebello	Cedar Avenue near Whittier Road, Montebello.	Corrugated iron	16 by 22	1914	15,000	[b] 2,400	400	Receives power at 15,000 volts from the network of 15-kilovolt-ampere lines and delivers same to local 2,400-volt distribution system.
Newport	Bay Avenue and Thirty-third Street, Newport.	do	15 by 20	1914	10,000	[b] 2,400	150	Receives power at 10,000 volts from network of 10-kilovolt-ampere lines and delivers same to local 2,400-volt distribution system and to street-lighting system.
Oak switching station.	Five miles south of Monolith.	Concrete, iron roof	18 by 24	1904	50,000	50,000		Line switching station.
Pedley transformer station.	Sec. 32, T. 2 S., R. 6 W. San Bernardino meridian, near the Riverside hydroelectric power plant, otherwise known as Pedley power house.	Corrugated iron	18 by 48 with 12 by 12 and 8 by 23.6 additions.	1913	60,000	15,000	3,000	Receives power through 60,000-volt transmission line from La Habra and Colton, and after same is transformed to 15,000 volts delivers same to the network of 15-kilovolt-ampere lines.
Redondo transformer station.	Between Ninth and Tenth streets, next to Redondo steam plant, Redondo.	Reinforced concrete	21½ by 53 by 25	1914	15,000	60,000	15,000	Receives power at 15,000 volts from the Redondo steam plant and after same is transformed to 60,000 volts delivers it to a 60,000-volt line connected to the Vernon substation and Torrance.
Ramona	Sixth and Hellman streets, Ramona Park.	Corrugated iron	15 by 20	1912	15,000	[b] 2,400	750	Receives power at 15,000 volts from the 15-kilovolt-ampere network of lines and delivers same to local 2,400-volt distribution system.
Sunnyslope	Santa Anita Road and Huntington Drive.	do	16 by 24	1903	15,000	[b] 2,400	750	Receives power at 15,000 volts from network of 15-kilovolt-ampere lines and delivers same to local 2,400-volt distribution lines.

Sycamore Avenue	Sycamore Avenue and Linden Avenue, Eagle Rock.	do	15 by 20	1912	15,000	[b] 2,400	750	Receives power at 15,000 volts from network of 15-kilovolt-ampere lines and delivers same to local 2,400-volt distribution system and to street-lighting system.
Tropico	Southern Pacific Ry. and Oxford Avenue, Tropico.	do	16 by 24	1913	15,000	[a] 2,400	600	Receives power at 15,000 volts from network of 15-kilovolt-ampere lines and delivers same to local 2,400-volt distribution system and to street-lighting system.
Vernon	East Fifty-second Street and Pacific Boulevard, near Vernon.	Concrete	85 by 135	1913	60,000	60,000 15,000 [b] 2,400	36,000	Receives power at 60,000 volts from Eagle Rock substation and Redondo steam plant and delivers same to 60,000-volt transmission line, to 15,000-volt network of lines, to local 2-400-volt distribution system, and to street-lighting system.

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[a] Direct current.

[b] Alternating current.

ONTARIO POWER CO.

HISTORY.

Ontario Power Co. was organized in October, 1901, to generate and distribute electrical power in the vicinity of Ontario, San Bernardino County. In connection with such operations it was authorized to acquire and develop water-bearing lands and furnish water for irrigation and domestic purposes.

Soon after its organization the stock of the company was transferred to Wm. G. Kerckhoff, A. C. Balch, and other gentlemen, who were at the time officers of Pacific Light & Power Co. On December 31, 1901, the creation of a bonded indebtedness of $400,000 was authorized, to finance the development of water rights and water-bearing lands purchased from Ontario Electric Co., a small local concern. The proposed developments threatened the water supply of San Antonio Water Co., which therefore purchased the stock of Ontario Power Co., and has ever since operated the system.

San Antonio Water Co. was formed in the early days of the citrus industry in California as a mutual association of fruit growers in the district lying between the Southern Pacific Railroad and the San Bernardino Mountains, on the alluvial slopes near the mouth of San Antonio Canyon. By the terms of its articles of incorporation the water company can not supply water to anybody but stockholders, and is operated not for profit nor to pay dividends, but as a mutual concern. The profits of the shareholders in the corporation are obtained from the sale of the products of their land, and this profit is naturally increased by a reliable irrigation system. The shares in the company are appurtenant to the irrigated land in the district.

San Antonio Water Co. was entitled to but half of the waters flowing from San Antonio Canyon, and as development in the colony took place it was found that this supply would be inadequate, especially in years of low flow. A tunnel was therefore driven in the wash near the mouth of the canyon to intercept the underflow, and as the additional supply thus obtained was insufficient for the needs of the company another tunnel in Cucamonga Wash east of San Antonio Canyon was purchased by the company.

The average measured flow for the month of July for San Antonio Canyon during the period of records prior to the construction of the tunnel was 700 miner's inches, of which the company was entitled to 350 inches. The San Antonio tunnel added 150 inches and the Cucamonga tunnel 200 inches, making a total of 700 miner's inches or 14 second-feet for the low-season supply available for use of the company. As this quantity was still insufficient during the dry years, wells were sunk east and west of Upland (North Ontario) to augment the supply. The western wells were in the vicinity of Claremont and the eastern in the vicinity of Cucamonga. These wells were pumped by steam power until it became evident that a cheaper means of operation would have to be obtained. When San Antonio Water Co. purchased Ontario Power Co. in 1902 it not only secured additional land and water rights, but also the source of power necessary for the successful operation of its pumping developments. The power company was incorporated on a basis which permitted it to sell surplus power to persons not stockholders in the water company, whereas the water company itself could supply water only to stockholders.

The Ontario No. 1 power plant was completed by the company in 1902, and has since that time furnished power for the water company, for local distribution, and for sale first to Pacific Light & Power Corporation, and in later years to Southern California Edison Co. The Ontario plant No. 2 was completed by the company and put into operation in 1919. It is 3¾ miles upstream from plant No. 1. A small steam plant formerly operated in Ontario is no longer in commission.

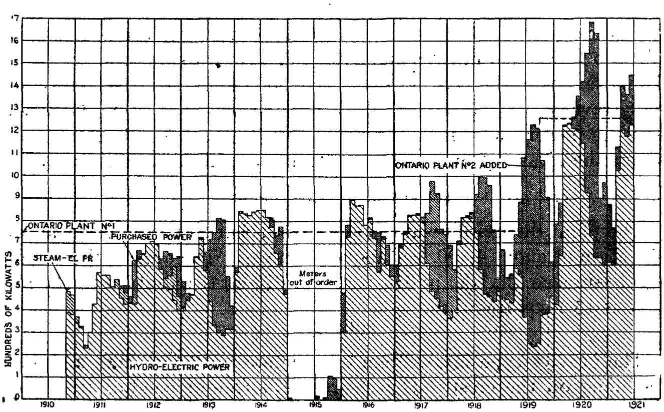

FIGURE 35.—Ontario Power Co., mean monthly loads, 1910-1921.

LOAD.

Nearly 60 per cent of the power delivered is used for the operation of pumps, of which about one-fourth belong to the San Antonio Water Co. Approximately one-tenth of the power delivered is used for cooking and heating, and a like amount is used for commercial lighting. A very good idea of the relative importance of the various loads on the system may be obtained from the classified electric revenues at the bottom of Table 267, Appendix A.

Mean monthly loads for the system from November, 1910, to December, 1914, and from January, 1916, to June, 1921, are given in figure 35. It is impossible to give similar data for the year 1915, on account of the fact that the meters at the hydroelectric station were out of order. It will be noted from the figure that there is a give and take exchange of power between the Ontario Power Co. and Southern California Edison Co.

ELECTRIC SYSTEM.

ONTARIO PLANT NO. 2.

LOCATION.

Ontario plant No. 2 on San Antonio Creek was constructed by Ontario Power Co. in 1918 and 1919 and went into operation in 1919. The intake is in the NW. ¼ NW ¼ sec. 30, T. 2 N., R. 7 W., the conduit traverses sec. 30, T. 2 N., R. 7 W., and sec. 25, T. 2 N., R. 8 W., and the power house is in the SE. ¼ sec. 25, T. 2 N., R. 8 W., just above the intake of Sierra plant of Southern California Edison Co.

SOURCE OF WATER SUPPLY.

The plant diverts its water supply from San Antonio Creek, at an elevation of about 4,100 feet above sea level. The area of the drainage basin (see Pl. LX, p. 616, and pp. 613–614) tributary to the intake is 15.1 square miles.

CONDUIT.

The gravity-type intake dam of concrete is 10 feet high and 100 feet long on the crest. The entire 3,274 feet of conduit from the intake to the head of the pressure pipe is concrete pipe 30 inches in inside diameter, laid on a grade of 2.5 feet per thousand.

A single riveted-steel pressure pipe 24 inches in diameter 1,419 feet long leads from forebay to power house. The pipe is laid in a trench and covered. The drop in the conduit from intake to forebay is 8 feet, and the static head from water surface in forebay to center of nozzle at power house is 314 feet. The estimated working head is 290 feet.

GENERATING STATION.

Power house.—The power house is of reinforced concrete and is 30 feet long, 25 feet wide, and 12 feet high. The building contains a single unit transmitting at generator voltage and arranged for remote control from Ontario No. 1 power house, 3¾ miles down the canyon.

Hydraulic equipment.—The one unit is operated by a single Pelton impulse wheel 70 inches in diameter on a pitch line of buckets, supplied through two nozzles and controlled by an oil-pressure governor.

Generator.—The generator is a 500 kilovolt-ampere 11,500-volt 25.1-ampere 3-phase 50-cycle inductor alternator direct-connected to the wheel, supported on ring-lubricated pedestal bearings, and operated at 250 revolutions per minute.

Exciter.—A 17.5-kilowatt 125-volt 140-ampere continuous-current exciter generator mounted on the end of the main unit and direct-connected to its shaft is operated at the same speed, 250 revolutions per minute.

Wiring.—The station is equipped with a hand-operated oil switch, and the output of the station is transmitted over a 3-phase circuit of No. 6 copper at generator potential 11,500 volts, 3¾ miles to Ontario No. 1 plant. The line is carried on wood poles and pin insulators.

ONTARIO PLANT NO. 1.

LOCATION.

Ontario plant No. 1 is on San Antonio Creek. The intake is in sec. 36, T. 2 N., R. 8 W., San Bernardino base and meridian; the conduit traverses secs. 1, 2, 11, 12, 13, and 14, T. 1 N., R. 8 W., and sec. 36, T. 2 N., R. 8 W. The power house is in sec. 13, T. 1 N., R. 8 W., on the west side of the canyon, a short distance above its mouth, at an elevation of 2,400 feet above sea level.

SOURCE OF WATER SUPPLY.

The plant receives its water supply directly from the tailrace of the Sierra plant of Southern California Edison Co. (See pp. 613–614.) The area of the drainage basin (see Pl. LX, p. 616) tributary to the Ontario Co.'s intake is 18.0 square miles.

CONDUIT.

With the exception of several siphons at canyon crossings, the entire line is composed of concrete pipe, 30 inches inside diameter, laid directly through the tunnels as in the Lytle Creek system (see p. 610) of Southern California Edison Co. The capacity of the line is 22 second-feet. The details of the conduit are as follows:

TABLE 143.—*Length of tunnels and siphon sections on Ontario conduit.*

	Feet.
Intake to tunnel No. 1	520
Tunnel No. 1	97
Tunnel No. 1 to tunnel No. 2	900
Tunnel No. 2	115
Tunnel No. 2 to siphon No. 1	193
Siphon No. 1	668
Siphon No. 1 to siphon No. 2	1,625
Siphon No. 2	595
Siphon No. 2 to tunnel No. 2½	1,020
Tunnel No. 2½	30
Tunnel No. 2½ to tunnel No. 3	60
Tunnel No. 3	263
Tunnel No. 3 to tunnel No. 4	25
Tunnel No. 4	239
Tunnel No. 4 to tunnel No. 5	30
Tunnel No. 5	538
Tunnel No. 5 to tunnel No. 5½	1,175
Tunnel No. 5½	45
Tunnel No. 5½ to siphon No. 3	250
Siphon No. 3	971
Siphon No. 3 to tunnel No. 7	730
Tunnel No. 7	239
Tunnel No. 7 to tunnel No. 8	50
Tunnel No. 8	221
Tunnel No. 8 to tunnel No. 9	1,005
Tunnel No. 9	155
Tunnel No. 9 to siphon No. 4	325
Siphon No. 4	1,639
Siphon No. 4 to forebay	197
	13,920

NOTE.—Tunnel No. 6, 110 feet long, is in bottom of siphon No. 3.

The elevation of the conduit is 3,155.8 feet at its head and 3,119.8 feet at the forebay, giving a mean grade of 2.57 feet per 1,000.

The forebay, as in many of the minor hydroelectric systems in southern California, is a small concrete box, whose capacity is only sufficient to keep water over the head of the pressure pipe. From the forebay a single pressure line, consisting of 770 feet of 24-inch and 1,237 feet of 20-inch pipe, runs down the crest of a mountain spur to the power house. The upper part of this pipe line is of lap-riveted and the lower part of lap-welded steel. Except at one or two points the entire pressure line is laid in a trench and is covered. The static head obtained is 700 feet.

GENERATING STATION.

Power house.—The Ontario power house is an iron-roofed stone building, 64 feet long by 40 feet wide, housing three units which are arranged en échelon along one side of the generator room. On the opposite side, set out a short distance from the wall and near one end of the room, is a switchboard, with the rheostats and switching equipment behind it. In the same end of the room and between the end of the board and the wall of the building are the lightning arresters. Between the other end of the switchboard and the opposite end of the building are exciters. The generator floor is commanded by a 4-ton traveling crane.

Hydraulic equipment.—The pressure pipe, after descending the mountain, continues along the north side of the power house and from it branches are made to each unit. The wheels discharge into a common tailrace running parallel to the pressure line and under the opposite side of the power house. Each unit is operated at 375 revolutions per minute by a single-rotor Doble wheel of 460 horsepower capacity, mounted between bearings on the generator shaft. The wheels are 5 feet in diameter on center line of the buckets and are supplied through 3⅜-inch single deflecting needle nozzles regulated by Lombard governors, type F.[37]

Generators.—The three generators are General Electric ATB 16-pole 250-kilovolt-ampere 11,500-volt 12.5-ampere 3-phase 50-cycle revolving-field alternators. The bearings are designed for ordinary ring lubrication and are bolted to heavy cast-iron bedplates.

Exciters.—Excitation is furnished by three sets of exciters operating in parallel. Two out of the three are driven at 900 revolutions by Doble wheels, and are General Electric 4-pole 9-kilowatt 125-volt 72-ampere direct-current generators. The third set is a motor-generator exciter composed of 15-horsepower induction motor which drives a General Electric 4-pole 11-kilowatt 125-volt 88-ampere direct-current machine at 1,200 revolutions per minute.

Wiring.—The outgoing circuits of Ontario plant No. 1 are operated at 11,500 volts without transformation, except that a local circuit transmitting a very small amount of power for local distribution is stepped down to 2,200 volts. The outlets are through tiles in the wall behind the switchboard. There are five General Electric 11,500-volt oil switches, three of which are connected to the transformer leads and the other two to the outgoing lines. The switchboard contains 7 panels; Nos. 1 and 2 serve the exciters, 3, 4, and 5 are generator panels, and 6 and 7 are feeder panels.

The two sets of lightning arresters are of the multigap type.

Power is transmitted to plant No. 1 from No. 2 at 11,000 volts and is fed into the main bus, which feeds out directly to the substations.

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[37] Tests of the unit at this plant are said to have given a maximum efficiency of 77.7 per cent at the switchboard and 83.6 per cent for the water wheel alone. See Trask, F. E., Am. Soc. Civil Eng., Trans., vol. 55, p. 173, 1905.

TRANSMISSION LINES AND SUBSTATIONS.

The transmission lines operated by the company at the end of 1920 are given in Table 144.

TABLE 144.—*High-tension single-circuit transmission system of Ontario Power Co. in operation Dec. 31, 1920.*

District.	Miles constructed.	Character of supports.	Voltage.
Ontario-Upland	23.5	Poles	10,000

At the end of 1920 Ontario Power Co. operated substations and distribution lines as given in Table 145.

TABLE 145.—*Substations and distribution lines of Ontario Power Co. in operation Dec. 31, 1920.*

Substation.		Rated capacity.
No. 1	kilovolt-amperes	300
No. 2	do	300
No. 3	do	600
No. 4	do	300
		1,500
Overhead distribution	miles primary	112

ESCONDIDO MUTUAL WATER CO.'S POWER SYSTEM.

HISTORY.

The irrigation system which serves Escondido Valley, in the northern part of San Diego County, was constructed originally by the Escondido Irrigation District, organized under the Wright Act on December 7, 1889. The Escondido Irrigation District was succeeded by or was reorganized as Escondido Mutual Water Co. on May 9, 1905. The irrigation conduit, storage reservoir, and distribution canals were constructed in the years 1894 and 1895, but no hydroelectric power was developed on the system until 1914.

MARKET.

The power developments are entirely subsidiary to irrigation. Power is supplied to the homes and farms of the stockholders within the district, the United States Indian Service is allotted a small amount, and all surplus is wholesaled to San Diego Consolidated Gas & Electric Co. through its Escondido substation. Kilowatt-hours sold to United States Indian Service and wholesaled (since April, 1917, the date of first delivery) to San Diego Consolidated Gas & Electric Co., by years, 1917–1919, are as follows:

TABLE 146.—*Power generated and sold by Escondido Mutual Water Co., 1917–1919.*

Year.	Sold to Indian Service.	Wholesaled to San Diego Consolidated Gas & Electric Co.
	Kilowatt-hours.	*Kilowatt-hours.*
1917	76,876	1,196,400
1918	31,476	1,611,900
1919	8,000	[a] 530,600

[a] To May 31.

ELECTRIC SYSTEM.

RINCON PLANT.

LOCATION.

Construction of the Rincon plant was begun in 1914 and the plant was put into operation in June, 1915. The power house is in sec. 2, T. 11 S., R. 1 W., San Bernardino meridian, near the junction of Paradise Creek and San Luis Rey River.

SOURCE OF WATER SUPPLY.

The principal water supply for the Escondido irrigation project is diverted from San Luis Rey River, in the north-central part of San Diego County. The conduit runs southwestward to the headwaters of Bear Valley Creek into which it discharges above Escondido reservoir. A supplementary supply from the 8 square miles of the Bear Valley Creek drainage basin above the Escondido dam is also available for storage and for irrigation. The drainage basin of the San Luis Rey River (see Pl. LXVI) above the point of diversion lies on the western slope of the Coast Range, and entirely within San Diego County. The average length of the basin east and west is about 18 miles, and its width north and south 12 miles. The total area above the intake, which is at an elevation of about 1,670 feet above sea level, is 238 square miles. The maximum elevations within the area are on the eastern boundary, where Hot Springs Mountain rises to 6,400 feet and on the north side of the basin, where Palomar Mountain rises to an elevation of 6,126 feet above sea level. The principal sources of San Luis Rey River are four streams which head the northeastern part of the basin at an elevation of 3,700 feet and flow southwestward, joining in Warner Valley. The main stream below the junction receives several important tributaries from the east, in the valley, and at its lower end enters a rugged canyon that extends to Rincon Valley about 4 miles below the intake dam. No important tributaries enter below Warner Valley.

The rocks of the basin are chiefly granitic. The forest cover on the sides of the canyon west of Warner Valley is chiefly brush; the floor of the valley, ranging in elevation from 2,700 to 2,900 feet, is entirely meadow land. Above the valley the slopes of the hills are covered with brush; and, on the tops of ridges above 5,000 feet, there are limited areas of open forest, chiefly of Jeffrey pines.

The Bear Valley drainage above the Escondido reservoir is similar to the canyon of the San Luis Rey. Escondido dam is about 1,385 feet and the maximum elevation at any point in the basin 2,200 feet above sea level. The stream rises on the west slope of one of the secondary ridges west of the main Coast Range and flows southwestward to the reservoir. The forest cover is brush and the rocks granitic.

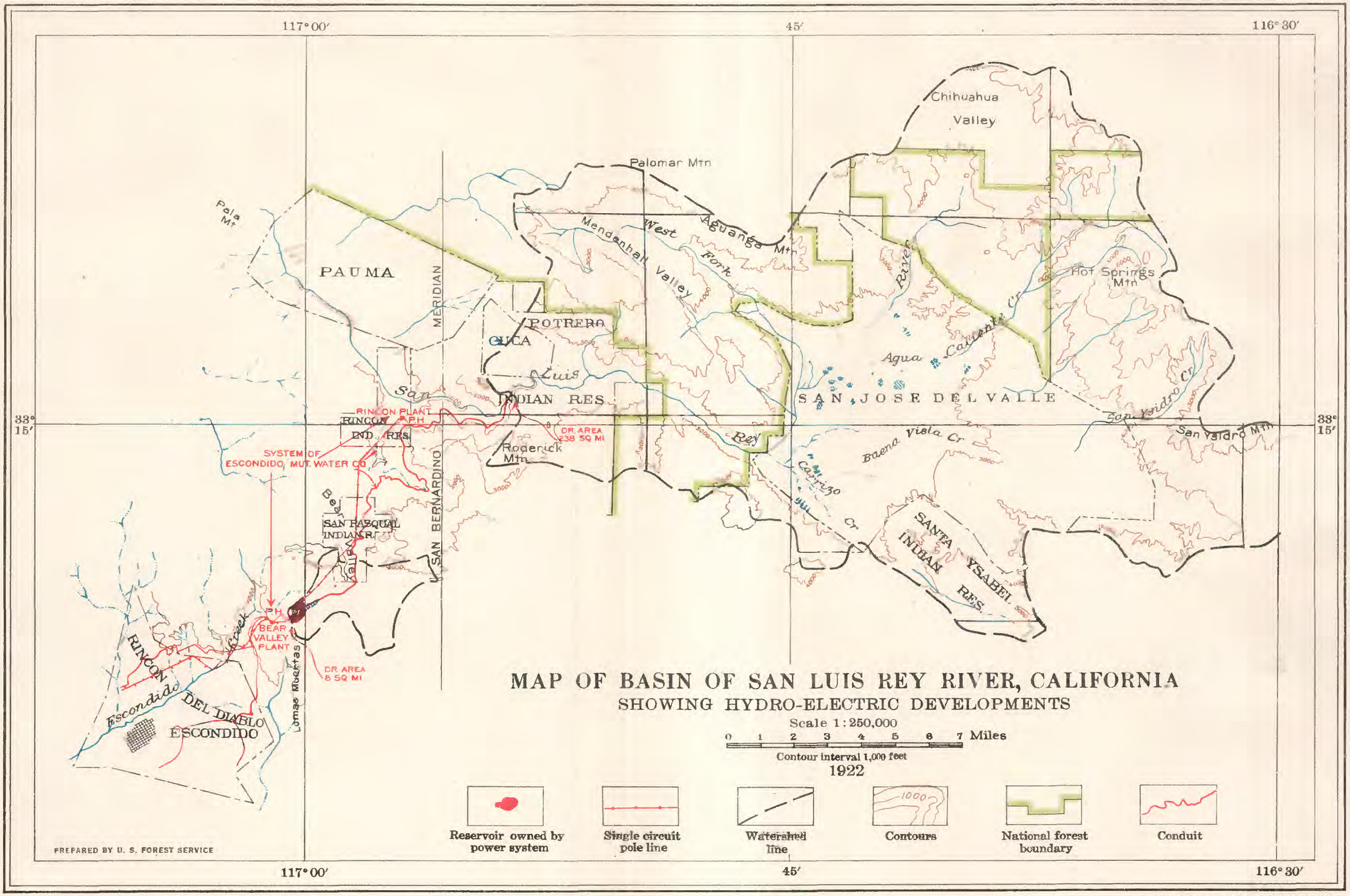
Mean seasonal precipitation in the San Luis Rey drainage basin above the intake is between 16 and 42 inches. The mean precipitation in the canyon and on the Bear Valley drainage is probably from 20 to 28 inches.

A stream-gaging station has been maintained on the San Luis Rey where it leaves Warner Valley since October 3, 1911. The records show that the minimum discharge commonly occurs early in the fall. The minimum monthly mean discharge is negligible.

Destructive floods occur at irregular intervals, the maximum recorded since establishing the station occurred January 27, 1916, when the discharge reached 58,600 second-feet. The maximum 24-hour discharge at the same station, on the same day, was 28,100 second-feet.

The average seasonal run-off at the Warner dam site for the 8-years ending September 30, 1918, was 44,490 acre-feet. The minimum seasonal run-off was for the year ending September 30, 1913, 5,910 acre-feet; the maximum for the year ending September 30, 1916, 182,000 acre-feet.

No storage has been developed in the San Luis Rey River basin above the intake of the conduit. The most important reservoir site above the intake is the lower part of Warner Valley. A dam 107 feet in height, or with a crest elevation of 2,727 feet, at this site would create a reservoir of 200,000 acre-feet capacity with a surface area of 6,050 acres. The site is, however, not controlled by the Escondido company.



MAP OF BASIN OF SAN LUIS REY RIVER, CALIFORNIA
SHOWING HYDRO-ELECTRIC DEVELOPMENTS
1922

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

CONDUITS.

The intake is on San Luis Rey River in sec. 33, T. 10 S., R. 1 E.; and the main conduit traverses secs. 31 and 33 of that township, secs. 5 and 6, T. 11 S., R. 1 E., sec. 36, T. 10 S., R. 1 W., and secs. 1, 2, 11, 12, 13, 14, 15, and 22, T. 11 S., R. 1 W., San Bernardino base and meridian. The main conduit is 15.6 miles long, divided (at the end of 1919) into 64,327 feet of ditch, 14,142 feet of flume, and 3,766 feet in the six tunnels. Below the lower portal of the last tunnel the conduit discharges into Bear Valley down which the supply flows for 3½ miles to the Escondido reservoir. The flumes are in general 4 feet wide by 3 feet deep, the ditch was originally excavated to a minimum depth of 3 feet, with side slopes of 1 horizontal to 1 vertical and a bottom width of 5 feet.

The intake dam on San Luis Rey River is a low masonry structure, at an elevation of 1,760 feet above sea level. A tunnel heading at the dam and extending through a sharp point in the south wall of the canyon diverts water into a flume line constructed along the rugged canyon wall. Where the canyon opens out into the Rincon Valley the flume gives place to a sidehill ditch, which extends nearly unbroken for the rest of the distance to the upper portal of the tunnel leading through the ridge to Bear Valley. The capacity of the conduit as originally constructed in 1894–95 was 40 second-feet, but it has been reduced to as low as 25 second-feet, owing to caves in tunnels, slides in conduit and broken boards in the flume.

At the sharp point where San Luis Rey River enters Rincon Valley the company has installed its upper development, the Rincon plant, by constructing a small concrete-box forebay in the ditch line and leading a pressure pipe down the point to the power house. By agreement with the Indian Service the company is allowed to divert 6 second-feet at its intake and return this amount through the Rincon plant, agreeing in return to sell power to the Indians at 0.125 cent per kilowatt-hour within a maximum demand of 70 kilowatts. The water, after being discharged at the power house, may be used for irrigation as if allowed to flow down the river, and there is probably a saving in the amount lost by percolation and evaporation.

The part of the canal (31,700 feet) from the intake down to Rincon forebay has been enlarged since 1910 to carry the additional supply for the plant, and measurements show a maximum capacity of 43 second-feet, which was to be increased to 50 second-feet by the end of 1919.

Water owned by the Escondido company and not used in the Rincon plant flows through Rincon forebay and on down the main conduit.

The intake or box forebay, where the Rincon pipe line leaves the ditch, is constructed of concrete with gates to control the flow into the pipe which has the following dimensions:

TABLE 147.—*Dimensions of pressure pipe, Rincon plant.*

Type of pipe.	Length of section.	Diameter.	Thickness of plate.
	Feet.	*Inches.*	*Gage.*
Riveted; drive joints	280	20	14
Do	100	20	12
Do	10	20 to 16	12
Do	130	16	12
Riveted; flanged joints	185	16	10
Do	170	16	8
Do	155	16	6
Do	155	16	4
Do	10	16 to 12	4
Lap welded; flanged joints	920	12	....
	2,115		

The elevation of water surface at the forebay is 1,724 feet, and the elevation of nozzle centers at the power house 899.6 feet, giving a static head of 824.4 feet. The company reports the effective head as 810 feet.

GENERATING STATION.

Power house.—Rincon and Bear Valley power houses are practically duplicates, both being constructed of reinforced concrete with a corrugated galvanized-iron roof supported on wooden roof trusses and containing a single room about 30 feet long by 18 feet wide with a bay 16 feet long by 14 feet deep putting out from one side. The two units are in the main part of the room, with the shafts in line parallel to the main axis of the building. The switchboard is placed along one and the bank of three transformers along the other end wall of the bay. The governors are between the main units and the bay.

Hydraulic equipment.—The lower end of the Rincon pressure line lies parallel to the side wall of the power house opposite the bay and terminates in two branches, each making an angle of 45° to the left of the main axis of the pipe and passing through the power-house wall just above the floor level. Inside the wall each branch passes through a hand-operated gate valve and terminates in a nozzle casting that makes a second 45° bend to the left, so that the nozzles are at right angles to the axis of the pressure lines. The flanged ends of the curved nozzle castings are bolted to the cast housings of their respective wheels. Each wheel is supplied through a single stationary needle nozzle in which the needle may be regulated by hand. A jet deflector inside the wheel housing is operated by a Pelton type O–1 governor.

Each of the two units is operated by a single overhung Pelton-Doble impulse wheel. The units are set wheel to wheel, and the wheels are provided with heavy cast housings that rise from the floor to a point just above the end of the main shaft, above which there is a riveted steel hood. The two pedestal bearings carrying the main shaft of each unit are bolted to a heavy cast bedplate, separate from the wheel housing.

Generators.—The two generators, identical in characteristics, are Westinghouse 150-kilovolt-ampere 2,400-volt 36.1-ampere 3-phase 60-cycle alternating-current machines, operated at 900 revolutions per minute.

Exciters.—Each generator is excited by a Westinghouse 45-kilowatt 125-volt 36-ampere continuous-current generator mounted on the main shaft.

Transformers.—A bank of three Westinghouse single-phase self-cooled 100-kilovolt-ampere transformers steps the generator potential of 2,400 volts up to 11,000 volts for transmission.

Wiring.—A set of Westinghouse low-equivalent lightning arresters is mounted on the inside wall of the power house in the bay, near the switchboard. The power house transmits all of its output to Escondido by way of Bear Valley power house over a 3-phase single-circuit pole at 11,000 volts, save a small amount of energy delivered to the Indian Service in Rincon Valley.

BEAR VALLEY PLANT.

LOCATION.

Bear Valley plant was constructed by Escondido Mutual Water Co. in 1914 and 1915, beginning regular operation in June, 1915. The power house is in sec. 6, T. 12 S., R. 1 W. San Bernardino meridian, on Bear Valley Creek.

SOURCE OF WATER SUPPLY.

The parts of San Luis Rey River and Bear Valley Creek drainage basins tributary to Bear Valley plant are described on pages 719–720.

RESERVOIR.

The only reservoir operated on either of the drainages tributary to the Escondido irrigation system is Escondido reservoir in Bear Valley, which stores the run-off from the small tributary drainage of Bear Valley Creek and the supply diverted through the main conduit from San Luis Rey River.

Escondido dam is in sec. 5, T. 12 S., R. 1 W., and the reservoir floods parts of secs. 4 and 5, T. 12 S., R. 1 W., and secs. 32, 33 and 34, T. 11 S., R. 1 W., San Bernardino base and meridian.

The Escondido dam, built in 1894–95, is a rock-fill structure with redwood plank facing on the water side. The height of the dam, as originally constructed, was 76 feet, crest length 390 feet, bottom length 100 feet, thickness at top 10 feet, thickness at bottom 140 feet. The spillway is 24 feet wide and 7 feet deep below the crest of the dam.

The slope of the water face of the dam is 0.5 horizontal to 1 vertical; the slope on the back of the dam is 1 horizontal to 1 vertical for the upper half of the structure, and below that level the slope is 1½ horizontal to 1 vertical. The cubic contents of rock fill in the dam is 37,159 yards, of which 6,000 yards are in the hand-laid dry rubble wall on the water face. This wall is 15 feet thick at the bottom and 5 feet thick at the top. The rest of the dam is composed of loose rock fill of angular granite ranging up to 4 tons in weight. An inclined slide gate controls the discharge which passes through a 24-inch pipe laid under the base of the dam.

Water can now be stored to an elevation of 1,458 feet above sea level, at which elevation the capacity of the reservoir is 3,800 acre-feet; the outlet pipes are at an elevation of 1,397 feet. The run-off of Bear Valley drainage area above the dam and the supply diverted through the conduit from San Luis Rey River are reported sufficient to have filled the reservoir each year except 1912, when the supply was very low and diversions from the San Luis Rey were interfered with by an accident in one of the tunnels.

CONDUIT.

A small concrete dam 75 feet long on the crest diverts water from the Bear Valley Creek a short distance below the Escondido reservoir and forms a forebay at the head of the pressure pipe leading to Bear Valley power house. The sectional lengths, diameters, thickness, and type of this pipe are as follows:

TABLE 148.—*Dimensions of pressure pipe, Bear Valley plant.*

Type of pipe.	Length of section.	Diameter.	Thickness of plate.
	Feet.	*Inches.*	*Inches.*
Riveted; drive joints	2,980	20	14
Do	125	20	12
Riveted	150	20	10
Do	150	20	8
Do	165	20	6
Do	10	20 to 16	6
Riveted; flange joints	75	16	8
Do	115	16	6
Do	115	16	4
	3,885		

The elevation of water surface in the forebay is 1,390 feet, and that of nozzle centers at the power house 990 feet, giving a static head of 400 feet. The effective head, when plant is operating at full rated load, is reported by the company to be 346.5 feet.

GENERATING STATION.

Power house.—The power house is located on Escondido Creek, 6 miles northeast of Escondido. The building is reinforced concrete, with corrugated galvanized-iron roof supported on wooden roof trusses. The single room in the building is approximately 30 feet long by 18 feet wide, with a bay 16 feet long by 14 feet deep putting out from one side. The two generating units are in the main part of the room with their shafts in line, parallel to the main axis of the building; the switchboard is placed along one and the bank of three transformers along the other end wall of the bay. The governors and the exciters are between the main units and the front of the bay.

Hydraulic equipment.—The lower end of the pressure line lies parallel to the upstream wall of the power house and terminates in a double 45° Y, both branches of which run parallel to each other and to the right, through the power-house wall. Inside the wall each branch passes through a hand-operated gate valve and terminates in a 45° nozzle casting, with flanged end which bolts to the cast housing of the wheel. The nozzles are fixed in position, but the position of the needle can be regulated by hand. A jet deflector inside the wheel housing, operated by a rocker arm from a Pelton type 0–1 governor provides automatic regulation.

Each of the two units is operated by a single overhung Pelton-Doble impulse wheel. The units are set wheel to wheel. Each wheel is provided with a heavy cast housing which rises from the floor to the lower side of the main shaft, above which there is a riveted steel hood. The two pedestal bearings of the generator of each unit are mounted on a heavy cast bedplate separate from the base of the wheel.

Generators.—The generators, identical in characteristics, are Westinghouse 150-kilovolt-ampere 2,400-volt 36.1-ampere 3-phase 60-cycle alternating-current machines, operating at 600 revolutions per minute.

Exciters.—Each unit is excited by a Westinghouse 45-kilowatt 125-volt 36-ampere continuous-current generator mounted on a bracket on the main generator frame and operated by the main shaft.

Transformers.—A bank of three Westinghouse single-phase self-cooled 100-kilovolt-ampere transformers steps the generator potential up to 11,000 volts for transmission.

Wiring.—A set of Westinghouse low-equivalent lightning arresters is mounted on the inside wall of the power house in the bay near the switchboard. The single outgoing circuit connects to the main line leading to Escondido substation.

CITY OF LOS ANGELES BUREAU OF POWER AND LIGHT.

HISTORY.

The hydroelectric power system of the city of Los Angeles is an outgrowth of the Los Angeles Aqueduct, which was constructed primarily to furnish an adequate municipal water supply.

A complete description of the Los Angeles Aqueduct and its history would require far more space than is available in the present work. The following outline therefore is restricted to consideration of the present and proposed power developments.

On recommendation of the chief engineer, William Mulholland, a report was made by a board of consulting engineers, consisting of John R. Freeman, Frederic P. Stearns, and James D. Schuyler, members of the American Society of Civil Engineers, appointed to pass on the feasibility of the Los Angeles Aqueduct, dated Los Angeles, December 22, 1906. It mentioned three points on the main line where surplus fall would permit the development of power. The first of these points was at the lower end of Elizabeth Lake tunnel, where it was then estimated a total fall of 1,500 feet could be most advantageously used in two drops, one of 1,060 feet and the next of 415 feet net head on the wheels at the San Francisquito sites; the second was in San Fernando Valley, where a net fall of 215 feet would be available; at the third site, near Little Lake, 15 miles below Haiwee reservoir, a net fall of 270 feet would be available.[38] According to an estimate based on the average delivery of 400 second-feet of water, the mean or flat-load output of power delivered at the switchboard in Los Angeles by the development of these sites would be as follows:

	Horsepower.
From upper San Francisquito	25,000
From lower San Francisquito	11,000
From San Fernando	6,000
From Little Lake	7,000
	49,000

It was suggested in the report that by means of equalizers below and above the sites the output of power could be made to follow the daily variation in load and at the same time a normal flow of 400 second-feet could be maintained in the aqueduct. The Elizabeth Lake tunnel was planned with this variation in view, so that it could deliver at a maximum 1,000 second-feet. An estimate based on a 40

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[38] The heads at some of these points were changed by the final locations, and other plants have been added to the proposed system.

per cent load factor for the two San Francisquito Canyon sites indicated that 80,000 horsepower at peak could be developed there, which, with 13,000 horsepower at San Fernando and Little Lake, would give 93,000 horsepower at peak from plants along the aqueduct alone.

Bonds to the extent of $23,000,000 were voted by the citizens of Los Angeles on June 12, 1907, for the construction of the aqueduct. Under this issue no expenditures were contemplated for the development of the power sites along the main line of the aqueduct, although the possibility of such development was kept prominently before the public, and the route finally chosen was such as would lend itself most readily to the construction of the various plants.

In addition to the main plants mentioned by the board of consulting engineers several sites not directly on the line of the aqueduct but along small tributary streams dropping down the abrupt eastern scarp of the Sierra north of Owens Lake afforded excellent locations for small plants that could be used in developing power for constructing the main aqueduct. The proceeds of sales of aqueduct bonds could be expended for such stations. Three plants were therefore constructed by the Bureau of Los Angeles Aqueduct on such sites, two, known as Division Creek No. 2 and Cottonwood No. 1, being of permanent type, and Division Creek No. 1 being of a temporary type. Power from these plants was used as far south as the cement plant at Monolith, near Tehachapi.

On recommendation of the Los Angeles Board of Public Works an appropriation of $10,000 was made available by action of the common council for the fiscal year beginning July 1, 1909, for a preliminary engineering investigation in connection with the main power developments. In September of the same year the Bureau of Los Angeles Aqueduct Power, under the Board of Public Works, was created with a chief electrical engineer (E. F. Scattergood) under the general direction and supervision of the chief engineer of the aqueduct (William Mulholland). Shortly afterwards a consulting board on the power development was formed, the three members being W. F. Durand, O. H. Ensign, and Harris J. Ryan. The board made a preliminary report which was placed before the people March 4, 1910, in anticipation of the bond election of April 19, 1910, at which $3,500,000 in bonds were voted for the construction of the first step in the power development. Owing to various delays, however, the proceeds from this issue did not become available until April, 1912. This bond issue of March 4, 1910, was limited in amount by the provision of the city's charter as it then stood, but in March, 1911, the charter was amended to permit the authorization of larger amounts of power bonds. Proceedings for a larger bond issue were begun in September, 1911, but owing to negotiations with the power companies no additional bonds were authorized until May, 1914.

After the bond election of 1910 it was decided that the first active work on the main projects should be the construction of the power tunnel connecting the lower end of Elizabeth Lake tunnel with the head of the San Francisquito No. 1 power drop, the excavation of the surge chamber at that point, and the construction of the pressure mains and power house with installed machinery to one-half of the final capacity; also the construction of the power tunnels leading from plant No. 1 to San Francisquito plant No. 2, in San Francisquito Canyon. Preliminary surveys of the final location of the power tunnels were made in the spring of 1911, and in July of that year excavation of the tunnel was begun under the immediate supervision of Mr. John Gray, the work being carried on by the construction force of the aqueduct, although paid for by the power bureau.

During the autumn of 1912 the city council began negotiations with Los Angeles Gas & Electric and Pacific Light & Power Corporations and Southern California Edison Co. with the view to arranging for the purchase of their systems within the city. These negotiations failed, the power companies making a counter proposal to purchase and retail the power which the city proposed to develop. The city authorities in turn declined this offer.

The question of authorizing power bonds to the extent of $6,500,000 was put before the people on April 15, 1913, in conjunction with six other proposed bond issues. Most of these bond issues failed to receive a majority vote; the power bond received a 50 per cent majority, but not the necessary two-thirds.

In October, 1913, when the council was about to call another power-bond election, the companies requested a renewal of negotiations, offering to lease their systems to the city and undertaking to work out the ultimate sale of their systems to the city. The city attorney was instructed to embody these ideas in a contract giving the city control of the systems, the sale being made subject to the companies' ability to secure releases under their trust deeds. This contract was submitted to them January 26, and on February 26, 1914, they reported that they could not legally lease their systems to the city and give the city control. As the city could not lease under any other conditions under its charter, the council passed the necessary resolutions preliminary to calling another power-bond election to be held in May, 1914.

Construction at San Francisquito plant No. 1 had to be suspended in part in January, 1914, for lack of funds, but on May 8 the people voted a bond issue of $6,500,000 for the completion of the plant and construction or acquisition of an electrical distribution system within the city. On August 1, 1914, suit was brought in the superior court attacking the validity of this issue, but on June 2, 1915, the State supreme court confirmed the decision already handed down by the superior court that the bonds were valid.

On July 2, 1915, power bonds amounting to $507,000 were sold and work was resumed on San Francisquito plant No. 1. Work was also begun on a transmission line and a central receiving station. During November and December the sale of $3,939,000 additional bonds permitted extension of activities to other construction on the power system.

The Los Angeles Board of Public Works having in the meantime completed the construction provided for by the bond issue of 1910, the city's electric works and power bureau were, according to the charter amendment of 1911, transferred on December 18, 1914, from the Department of Public Works to the Los Angeles Department of Public Service, and the Bureau of Power and Light, operating under direction of a chief electrical engineer (E. F. Scattergood), was created in the Department of Public Service.

It was definitely understood when the $6,500,000 in bonds were authorized May, 1914, that $5,250,000 of the funds derived from their sale would be used for providing a municipal distribution system. After considerable unsuccessful negotiation with the companies, the Board of Public Service Commissioners petitioned the California State Railroad Commission on November 18, 1914, to fix a just compensation which should be paid for the distribution system of Southern California Edison Co., by condemnation under the public-utilities act of California.

The case before the Railroad Commission was submitted February 26, and the final briefs were filed April 29, 1916.

The city of Los Angeles claimed that the valuation of the Edison Co.'s distribution system within the city should be fixed at not to exceed $3,887,839. The company contended that the valuation should be as follows:

Physical properties	$4, 200, 000
Going concern	5, 187, 623
Severance and miscellaneous damages	12, 502, 444
	21, 890, 067

Decision in this case, handed down by the commission September 6, 1916, allowed:

Physical properties and going concern	$4, 750, 000
Severance damages	1, 578, 000
	6, 328, 000

Two districts (East Los Angeles-Highland Park-Garvanza and Hollywood-East Hollywood) served by Pacific Light & Power and Los Angeles Gas & Electric corporations were not included in the proceedings before the Railroad Commission. The city, being unsuccessful in the negotiation begun in January, 1916, for the acquisition of the distribution lines of these companies, purchased materials to parallel them and began work during the early part of the year in the East Los Angeles-Highland Park-Garvanza district. Plans were completed for the second system, covering Hollywood and East Hollywood, but work in that district was abandoned when an agreement was concluded April 30, 1917, with Pacific Light & Power Corporation and Southern California Edison Co. for distribution of power within the city; a transmission line from the central receiving station on Los Angeles River to a substation site that had been purchased in Hollywood had been constructed, and some rights of way for distribution lines had been obtained. During 1917 work was started on lines paralleling the distribution system of Los Angeles Gas & Electric Corporation in the territory lying south of Exposition Boulevard, and this work was continued eastward.

By April 30, 1917, the city had completed San Francisquito plant No. 1 to one-half of its ultimate capacity, a central receiving station, a double-circuit steel-tower transmission line from San Francisquito to a central receiving station in the city and a switching station at San Fernando, a local substation near the receiving station, substation No. 2 for supplying Highland Park-Garvanza district, double 33,000-volt lines from receiving station to Hollywood, the distribution system south of Exposition Boulevard, and a temporary frame substation (No. 4) at Slauson Avenue and Figueroa Street with double 33,000-volt lines from the receiving station. A double 33,000-volt line to the harbor district was also under construction, forming with the others mentioned above a high-tension loop around the city and to the harbor district. Energy purchased from the Pasadena municipal system was distributed through substation No. 2 until San Francisquito plant No. 1 went into operation April 10, 1917.

In March, 1918, a substation was put into operation to serve the harbor district, and early in 1918 a steel-frame and hyrib-plastered substation was constructed at Hunter and Mateo streets to serve the southeast industrial district served by Los Angeles Gas & Electric Corporation and isolated steam plants.

As a result of negotiations between the city and Southern California Edison Co., extending from August, 1918, to May, 1919, a second contract was entered into, giving the city an option on the company's complete distribution system (including that acquired through purchase of Pacific Light & Power Corporation) within the municipal boundaries as it stood July 1, 1919, for $11,000,000, with provision for further adjustments for additions and for depreciation subsequent to that date and prior to purchase. The option under this contract as since extended expired March 1, 1921.

The original operating agreement expired June 30, 1919, and a further temporary operating agreement was entered into pending purchase of the distribution systems by the city. Power clauses of the purchase agreement provide that for ten years the city shall confine its regular power generation to hydroelectric plants owned or controlled by it, except that during that time it may purchase and operate the existing steam plant of Los Angeles Gas & Electric Corporation. The company, under the contract, agrees to deliver and the city to purchase for a period of 30 years all energy required in excess of that generated at such municipally owned or controlled plants, at rates to be fixed from time to time by the Railroad Commission. The company, in turn, has a 30-day option to purchase any surplus energy the city may generate. It is provided also that by majority vote of the people the power agreement may be terminated at any time after the expiration of ten years.

On June 3, 1919, power bonds to the extent of $13,500,000 were authorized at the regular elections, of which $11,000,000 were for purchase of Southern California Edison distribution system, $2,250,000 for partial installations of San Francisquito No. 2, San Fernando, and Franklin Canyon plants, and $250,000 for preliminary work at Owens River Gorge.

During the year ending June 30, 1919, the capacity of the central receiving station was increased from 45,000 to 66,000 kilovolt-amperes, plans were prepared and preliminary construction begun on a partial development at San Francisquito No. 2 plant (28,000 horsepower), a third 33,000-volt line was run to the harbor district from the Slauson Avenue substation southward, and a cross-town line was run from the central receiving station to the Slauson Avenue substation.

The San Francisquito plant No. 2 was completed and placed in operation in July, 1920; its installed capacity is 35,000 kilovolt-amperes.

The Franklin Canyon plant went into operation in June, 1921. Its capacity is 2,500 kilovolt-amperes.

In 1920 substation No. 4, near Slauson Avenue, and the new Figueroa Street substation went into commission. The new Figueroa substation is directly across the street from the old one.

The machinery has been purchased and delivered for the San Fernando power plant, with an installed capacity of 7,000 kilovolt-amperes.

LOAD.

The mean monthly loads shown graphically in figure 36 have been computed from the hydroelectric output in kilowatt-hours per month of the San Francisquito No. 1, San Francisquito No. 2, River Power, and Franklin Canyon plants at the lower end of the aqueduct and from power purchased by the municipal system in and near Los Angeles. The peaks from which the load factors were computed do not include relatively small deliveries from the city of Pasadena. The load factors are sometimes affected by methods of dividing peak

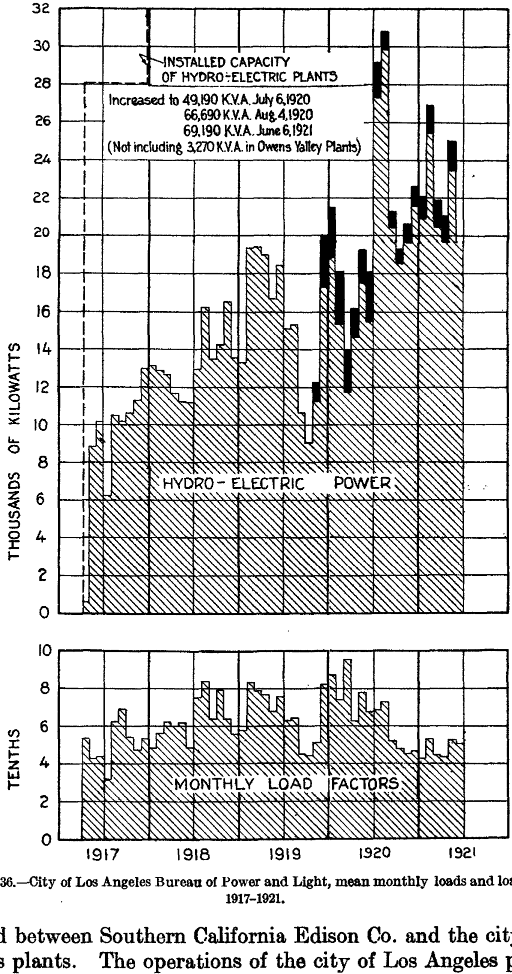

FIGURE 36.—City of Los Angeles Bureau of Power and Light, mean monthly loads and load factors, 1917–1921.

demand between Southern California Edison Co. and the city of Los Angeles plants. The operations of the city of Los Angeles plants in Owens Valley are not included in the figure. Under an operating agreement entered into with The Southern Sierras Power Co., power was transmitted from these plants over the tower line of that company from November, 1919, to June, 1921, when the contract terminated; 825,185 kilowatt-hours was delivered in November and December,

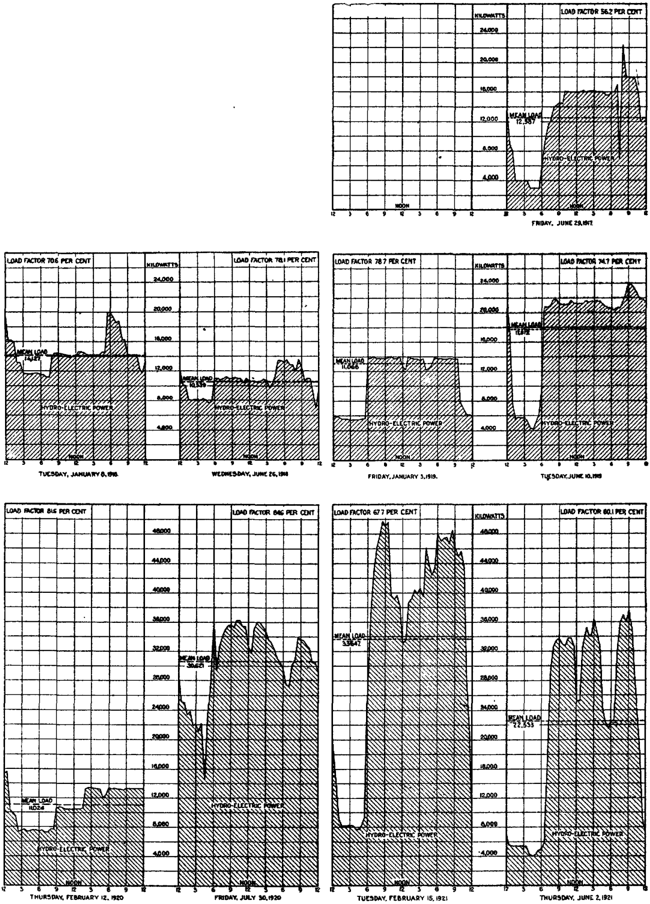

FIGURE 37.—City of Los Angeles Bureau of Power and Light, daily load curves, 1917–1921.

1919; 6,508,248 kilowatt-hours during the calendar year 1920; and 4,084,147 kilowatt-hours during the six months, January to June, 1921; the monthly deliveries ranged from about 400,000 to 785,000 kilowatt-hours and the peaks at Colton from 590 to 1,250 kilowatts.

Daily load curves for the years 1917 to 1921 are shown in figure 37.

The Power Bureau reported 13,494 horsepower connected to the municipal distribution lines June 30, 1918, and 21,773 horsepower connected on June 30, 1919.

Number of consumers, sales in kilowatt-hours, revenues, costs, and total earnings by months, from April, 1917, when San Francisquito No. 1 plant first went into operation, to June 30, 1919, are given in Table 149.

TABLE 149.—*Statement of consumers, kilowatt-hours consumption, and earnings of Los Angeles Aqueduct power system.*

	April to June, 1917.	Year ending June 30, 1918.	Year ending June 30, 1919.	Year ending June 30, 1920.
Light:				
Active consumers	[a] 1,597	[a] 7,783	[a] 10,357	11,832
Kilowatt-hours furnished	111,123	2,316,224	3,686,088	4,602,726
Lighting revenue	$5,419.45	$96,748.81	$148,959.52	$186,334.87
Power:				
Active consumers	[a] 17	[a] 89	[a] 155	345
Kilowatt-hours furnished	48,231	4,617,907	18,580,690	26,928,793
Power revenue	$809.75	$37,654.29	$166,486.18	$252,674.36
Total consumers	[a] 1,614	[a] 7,872	[a] 10,512	12,177
Total kilowatt-hours furnished consumers	159,354	6,934,131	22,266,778	31,531,519
Street lights:				
Number	1,130	[a] 2,706	[a] 2,763	2,949
Kilowatt-hours furnished	223,232	3,061,941	3,116,109	3,370,541
Street-lighting revenue	$10,251.04	$115,381.42	$115,989.74	$124,944.12
City of Pasadena:				
Kilowatt-hours furnished	0	[b] 5,116,649	9,306,600	12,525,160
Revenue	0	$28,953.22	$52,847.90	$80,111.53
Total kilowatt-hours delivered to consumers over city system	382,586	15,112,721	34,689,487	47,427,220
Portion of total operating expenses applicable to city system	(c)	$217,674.00	$300,139.00	$306,536.00
Cost per kilowatt-hour of city sales	(c)	$0.01440	$0.0087	$0.0065
Total revenue from city distribution system	$16,480.24	$278,737.74	$484,283.34	$644,064.88
Southern California-Edison Co. (under operating agreement):				
Kilowatt-hours delivered	12,496,490	[d] 69,453,434	91,806,070	75,007,790
Revenue received	$77,598.42	$604,134.01	$661,770.41	$705,876.44
Total kilowatt-hours sold	12,879,076	84,566,155	126,495,557	122,435,010
Total operating expense (including generation and transmission of energy delivered to Southern California Edison Co.)	(c)	$271,422.00	$471,753.00	$496,080.00
Cost per kilowatt-hour of total sales	(c)	$0.00321	$0.0037	$0.0040
Total earnings from municipal system	$94,078.66	$882,871.75	$1,146,053.75	$1,349,941.32

[a] Average.

[b] Includes energy and revenue for November and December, 1917, and January, 1918.

[c] Accurate distribution of charges between operation and construction not available for this period.

[d] The kilowatt-hours shown as delivered to the Southern California Edison Co. under the operating agreement is the amount of energy for the months of July, 1917, to March, 1918, inclusive, that the city would be required to furnish, providing the companies had furnished the minimum under the contract. In the month of July, 1917, the companies furnished an excess of their minimum of 928,921 kilowatt-hours, due to a break in the Los Angeles Aqueduct, which caused a partial shutdown of the city's plants. This excess, which the companies were obliged to furnish, was made good by the city in the month of September, 1917. In the months of April, May, and June, 1918, the companies furnished an excess of their minimum of 399,578,341,825 and 607,063 kilowatt-hours, respectively. This excess, which was furnished by the companies in these months, was made up by the city in the month of August, 1918. The amounts shown, therefore, for these three months is the amount of energy actually delivered by the city, as the shortage was not made good until after the close of the fiscal year. In the months of August, September, October, and December, 1917, and January, February, and March, 1918, the city furnished energy in excess of the requirements of the operating agreement amounting to 7,306,307 kilowatt-hours, as against the shortage in July, 1917, April, May, and June, 1918, of 2,277,387 kilowatt-hours, leaving a balance of 5,028,920 kilowatt-hours for the year.

TABLE 150.—*Proposed plants, city of Los Angeles (exclusive of plants on aqueduct).*

Name of plant.	Drainage basin.	Average static head.	Proposed installed capacity.
		Feet.	*Kilowatts.*
Owens River gorge plant No. 1	Owens River	394	11,338
Owens River gorge plant No. 2	do	690	30,884
Owens River gorge plant No. 3	do	844	37,777
Owens River gorge plant No. 4	do	415	18,575
Rock Creek plant	do	1,553	8,400
Pine Creek plant	do	2,323	[a]8,325
Big Pine Creek plant No. 1	do	1,212	3,655
Big Pine Creek plant No. 2	do	1,792	8,825
Big Pine Creek plant No. 3	do	1,250	6,119
Sawmill Creek plant	do	2,254	[a]1,350
Cottonwood Creek plant No. 1	do	2,078	4,665
Cottonwood Creek plant No. 2	do	2,029	4,850
South Fork of Kern plant No. 1	Kern River	1,728	[a]7,500
South Fork of Kern plant No. 2	do	2,499	[a]18,650
			170,913

[a] Estimate, not final.

The city has filed on 292,250 theoretical horsepower on the Middle and South forks of Kings River and the main river below the junction with the intention of holding these filings to assure itself of an adequate power supply providing it does not obtain its supply from Colorado River. By its filing on Boulder Canyon on Colorado River the city has stated its desire to cooperate with the Government and other cities and communities in the development of that power and to receive its proportion of such power as is developed.

ELECTRIC SYSTEM.

GENERAL RELATIONS.

Los Angeles now (July 1, 1919) operates or has in operating condition five power plants, all hydroelectric. Three of these were built on streams tributary to Owens River from the west, to supply power for constructing the aqueduct, and two of the three—Division Creek No. 2 and Cottonwood No. 1—will form part of the ultimate aqueduct power development. Pending their connection to the permanent power system of the aqueduct they are being used only to supply light and power for the towns of Lone Pine and Independence and surrounding territory and to pump water into the aqueduct at certain times of the year. Two plants, San Francisquito No. 1 and River power plant, both of which were put into operation during 1917, are on the main line of the aqueduct or on the distribution system at its lower end.

Construction has been begun on San Francisquito No. 2 plant, on the main aqueduct, and preliminary work on the developments at Owens River gorge.[39]

DIVISION CREEK PLANTS.

SOURCE OF WATER SUPPLY.

The Division Creek drainage basin—the smallest in the State used for the development of power—comprises about 5 square miles on the eastern wall of the Sierra, where the mountains break off abruptly into Owens River valley. The elevation at the upper intake is 5,693 feet above sea level, and the maximum elevation along the crest of the Sierra at the western boundary of the basin is 12,417 feet. The tremendous drop in the stream can be realized only by noting that it is but 4 miles in an air line from the crest of the range to the intake. As almost the entire drainage area is bare granite the forest cover is extremely sparse. Measurements taken by the engineers of the aqueduct show that the mean annual precipitation probably varies from about 15 inches in the lower part of the basin to somewhat more than 30 inches in higher parts. There is no storage, either artificial or natural, within the drainage basin. The low flow of the stream, like that of all streams draining the eastern scarp of the Sierra, comes during the winter months from October to January. The minimum flow shown by the records [40] was slightly over 5 second-feet.

DIVISION CREEK PLANT NO. 1.

Location.—Division Creek No. 1, the lower plant on Division Creek and the only temporary generating station on the aqueduct power system, was rushed to completion in order to furnish power for the dredges working on the open canal between the intake of the aqueduct on Owens River and the Alabama Hills. It began operation in April, 1908.

The diversion is made in sec. 5, T. 12 S., R. 34 E. The conduit runs through secs. 4 and 5 of T. 12 and sec. 33 of T. 11 to the power house in sec. 33, T. 11 S., R. 34 E., on the lower part of the Division Creek débris fan, just west of the road from Independence to Big Pine.

The plant receives its entire supply directly from the tailrace of Division Creek No. 2 (pp. 737-739) except the small amount of stream flow coming from the area between the intakes of the two plants.

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[39] The system has since been enlarged by the addition of the San Francisquito plant No. 2 (35,000 kilovolt-amperes) and Franklin Canyon plant (2,500 kilovolt-amperes), on the lower part of the aqueduct, and the Haiwee plant (1,050 kilovolt-amperes), on the aqueduct south of Owens Valley. The Haiwee and Cottonwood No. 1 plants were connected by a transmission line, and a loop was constructed from Olancha around the east side of Owens Lake and back to the main line near Lone Pine. Small branches have been run to mines, chemical works, and pumping plants.

[40] For records of flow on Division Creek see U. S. Geol. Survey Water-Supply Paper 300, pp. 351-352, 393; 310 p. 194, 1913.

Conduit.—Both of the Division Creek plants take advantage of the very steep slopes on the débris fan below the mouth of the main canyon to divert directly (or almost directly) into pressure pipes following down the maximum declivity of the fan and omitting entirely gravity conduits. Division Creek No. 1 intake diverts the stream into about 300 feet of concrete-lined ditch, leading from the head dam into a small concrete-lined forebay excavated in the loose material of the débris fan just below Division Creek No. 2 power house. The water from the Division Creek No. 2 unit also discharges into the same forebay.

The pressure main runs in a straight line from the forebay to the power house and consists of 5,700 feet of 12-inch lap-riveted steel pipe, varying in thickness from No. 16 to No. 10. The line is covered for its entire length. The elevation at the intake is 4,427 feet above sea level; at the forebay it is 4,405 feet, and at the power house 3,972 feet, giving a static head of 433 feet. The working head is 400 feet.

Power house.—The power house is a temporary frame structure, 36 feet long by 20 feet wide, with iron roof, and contains a single unit. The impulse wheel is in the lower end of the building, and a belt runs back from a pulley on the wheel shaft to the generator, which is near the upper or west end of the room. The transformers are in the south side of the room and are surrounded by a railing. The total cost of installation was $15,130.

Hydraulic equipment.—The water wheel is a Doble impulse motor, controlled by a Replogle governor which operates a hood deflector over the stream.

Generator.—The single unit is a General Electric 120-kilovolt-ampere 200-horsepower 440-volt 3-phase 60-cycle induction motor, run as a generator at a speed of 900 revolutions per minute and provided with ordinary ring lubrication.

Transformer.—The power house is equipped with a single bank of three Westinghouse 1-phase 60-cycle 440/33,000-volt 40-kilowatt transformers.

Wiring.—The station is connected to the main line through a 33,000-volt air-break switch. The high-tension wire busses are supported on insulators on the lower chord of the roof trusses. The lines pass out through inclined tile outlets at the east end of the power house.

DIVISION CREEK PLANT NO. 2.[41]

Location.—Division Creek plant No. 2, the upper plant on Division Creek, was put in before the Bureau of Los Angeles Aqueduct Power took charge of this branch of the work. It began operating March

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[41] The plans to complete the system contemplate the diversion of Sawmill Creek, the nearest stream south of Division Creek, through an additional development at Division Creek plant No. 2.

22, 1909. The intake is in sec. 1, T. 12 S., R. 33 E.; the conduit traverses sec. 1, T. 12 S., R. 33 E., and secs. 6 and 5, T. 12 S., R. 34 E.; the power house is in sec. 5, T. 12 S., R. 34 E.

Conduit.—The small concrete intake dam of Division Creek No. 2 diverts water directly into the head of a pressure pipe which follows down the north side of the stream. There is no gravity line on the conduit, the entire 10,418 feet being steel-pressure pipe. Of this total the first 6,291 feet is 18–inch riveted pipe 14 gage to ¼ inch thick, and the last 4,127 feet is 15-inch (outside diameter) lap-welded pipe ¼ to ⅜ inch thick. The entire line was laid in a trench in the loose material of the débris fan and was covered with earth. The elevation of water surface at the headworks is 5,693 feet above sea level, and the elevation of the nozzle at the power house is 4,427 feet, giving a total static head of 1,266 feet. The effective working head with 8 second-feet passing through the line is 1,216 feet.

Power house.—Although constructed in the early days of the aqueduct work, the power house forms part of the city's permanent power development and for that reason was built in a substantial manner. Except the roof, which is of corrugated iron and is carried on steel roof trusses, the building is reinforced concrete, is 25 feet long north and south and 23 feet wide east and west, and has a clear height of 18 feet from the floor to the lower chord of the roof trusses. The southwest corner of the generator room is inclosed in a concrete curtain wall of sufficient height to contain the transformers. This transformer space measures 10 feet 9 inches by 18 feet 9 inches in plan, and is covered by the reinforced-concrete floor of the switching gallery, to which access may be had from the generator floor by means of a steel ladder. Except for this gallery the building has but one floor. The transformer compartment may be entered through a sliding door. The door does not open toward the main part of the generator room but toward its front wall, so that trouble in the transformer compartment is rendered less likely to spread through the door to the generator equipment. The main generating unit is placed near the front wall of the building, in the opposite end from the transformer compartment. The single panel switchboard is placed near the back wall of the room parallel to the side wall of the transformer compartment, and the pipes conveying cooling water to the transformers are supported by brackets against the face of this wall. Eyeholes formed by sections of pipe let through the wall afford means of observing the thermometer on the back of the transformers without leaving the main generator floor. The total cost of the installation, including diverting works and power house but not the transmission line, was $49,202.

Hydraulic equipment.—The pressure pipe approaches the power house parallel to and just outside of the north end wall and enters the building just above the floor line through a gooseneck casting which connects directly to an automatic needle by-pass nozzle and which contains, just between the wall and the nozzle, a hand-operated gate valve. As the pipe enters above the floor line the entire unit is set very high, the generator bearings being supported on a heavy iron base bolted to the floor, and the impulse-wheel housing being supported on a separate high cast-iron base. The hydraulic equipment is of Doble manufacture. The wheel is regulated by a Lombard governor, type F.

Generators.—The generator is a Westinghouse revolving-field alternator rated at 600 kilovolt-amperes (804 horsepower), 2,200-volt 157-ampere 3-phase 60-cycle, with a continuous overload capacity of 25 per cent. The rotor is mounted on the same shaft as the wheel. The two bearings are of the ordinary oil-ring type and rest on a heavy cast-iron bedplate.

Exciter.—The exciter, carried on the end of the main shaft of the unit, is a Westinghouse 20-kilowatt 125-volt 150-ampere direct-current generator operated at the same speed as the unit—600 revolutions per minute.

Transformers.—The transformer equipment consists of a single bank of three Westinghouse 200-kilovolt-ampere 33,000/2,200-volt oil-insulated water-cooled single-phase transformers. A spare transformer of the same type is placed in the corner of the generator room, just in front of the transformer compartment door, so that in emergencies it can be rolled in and connected. The transformer equipment is connected delta on the low-tension and Y on the high-tension side.

Wiring.—The single-panel switchboard contains only the ordinary meter equipment and the Westinghouse type D oil switch for the generator. The rheostat is mounted above the board. The Kelman 33,000-volt oil switches on the high-tension side of the transformers are carried in the gallery that forms the roof of the transformer compartment. From the oil switch the circuit passes through disconnectors and choke coils. The single 3-phase outgoing circuit passes through inclined tile outlets that run from the switch gallery through the end wall of the power house. Just outside the tiles the lines are supported on insulators carried on brackets, and from this set of supports they run to the pole-top disconnecting switches. This power house, as well as Division Creek No. 1, is connected with the Cottonwood Creek system by a No. 4 copper line 40 miles long, operated at a voltage of 33,000.

A combination horn-gap and water-resistance lightning arrester is mounted outside of the station on a pole structure.

COTTONWOOD PLANT NO. 1.[42]

LOCATION.

The Cottonwood plant, although put into operation primarily to furnish power for building the aqueduct, is of a permanent type of construction. The first unit went into commission November 13, 1908, before the Bureau of Los Angeles Aqueduct Power was formed, and the second October 13, 1909.

The intake is in sec. 21, T. 17 S., R. 36 E.; the conduit traverses secs. 21 and 22, T. 17 S., R. 36 E.; the power house is in sec. 23, T. 17 S., R. 36 E.

SOURCE OF WATER SUPPLY.

The Cottonwood Creek basin (Pl. LVII, in pocket), the sole source of water for the plant, is directly west of Owens Lake and about 8 miles southeast of Mount Whitney, in the western part of Inyo County. In maximum length, from southeast to northwest, the basin measures about 10 miles; its average width is about 4 miles, and its total area above the intake of the plant is 40 square miles. The elevation at No. 1 intake is 5,107 feet above sea level, and from this point the elevation increases rapidly as we proceed toward the main crest of the Sierra, where the maximum elevation is 14,042 feet. A large part of the western boundary is more than 11,000 feet above sea level, and only a very small part of it lies below 10,000 feet. The region is among the most precipitous and rugged in the State. Bare granite is exposed throughout most of the area and the forest cover is decidedly scant. Data gathered by the engineers of the Los Angeles aqueduct indicate that the mean annual precipitation in the basin probably ranges from slightly more than 10 inches in the lower areas to about 20 inches in some of the higher country. The minimum flow of the stream usually comes in the winter months, from October to January, when the low temperatures on the higher parts of the region freeze most of the small feeders. During the short period covered by records[43] the minimum flow of the stream is shown to have dropped to 5 second-feet.

There is no artificial storage in the drainage basin and the only natural storage is that afforded by the three small Cottonwood lakes.

CONDUITS.

Diversion is made by a small masonry dam into an intake and short line of rubble masonry lined conduit on the north side of the creek. Just below the intake the flow passes through a set of inclined trash racks and is then, during ordinary operation, passed into

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[42] The plans of the complete system contemplate the installation of two more plants on Cottonwood Creek above Cottonwood No. 1.

[43] U. S. Geol. Survey Water-Supply Paper 300, pp. 383-390, 393, 1913.

the lower part of a rectangular sand box between the conduit and the stream. The supply for the plant flows from the box over a weir spillway in the side wall at the opposite end from the inlet and falls into a rubble and concrete lined head of the conduit, where the flow is controlled by gates operated by a windlass. In the side of the sand box toward the stream there are three sliding sluice gates which are operated by screws and handwheels from above. The intake and head of the conduit are connected by a by-pass which runs along the side of the sand box, so that water can be allowed to flow into the conduit without passing through the sand box.

The total length of conduit from the Cottonwood intake to the head of the pressure pipe is 10,807 feet. A short distance below the intake water is carried around a rocky point by an inverted siphon of 24-inch riveted steel pipe. The length of the siphon is 4,203 feet and is operated under a head of 220 feet at its lowest point. All the gravity conduit is concrete-lined ditch excavated in a bench cut out of the side hill. The thickness of the lining is 6 inches. The cross section of the conduit is rectangular, 30 inches wide by 28 inches deep, and the entire line is covered with loose slabs of concrete 1.5 feet wide by 3 feet long and 3 inches thick, which are laid over the channel and then covered with a thin layer of earth. The elevation of water surface at the intake is 5,107 feet and the elevation at the forebay is 5,050 feet, giving a total drop along the line of 57 feet. The normal grade of the gravity conduit is 0.003 and the total drop in it 22 feet; the rest of the drop is in the siphon. At its lower end the concrete-lined ditch ends in a small masonry forebay 8 feet wide by 30 feet long by 7 feet deep.

The single lap-riveted pressure pipe runs down a moderate incline and out to a point about halfway to the power house. It than turns to the south and descends the steep front of the foothills. Its total length is 4,535 feet, of which 525 feet is 24-inch and 4,010 feet is 22-inch riveted steel pipe. The thickness of the pipe varies from No. 10 to one-half inch. The profile of the line is, in general, excellent. There is a sharp pitch in the first part of the line, a more moderate grade to the point where it passes over the crest of the foothills, then a steep slope down to the power house. The static head is 1,267 feet and the effective head 1,200 feet.

GENERATING STATION.

Power house.—The Cottonwood power house is a reinforced building with iron roof on steel trusses. A ventilator occupies the central third of the peak of the roof (Pl. LIX, *D*, p. 616). The elevation at the power house is 3,780 feet. The units discharge into a short flume that drops the water into the main aqueduct. The building is 78 feet long, 37 feet 4 inches wide, and 19 feet high to the lower chord of the roof trusses. The two units are placed along the main axis of a generator room 35 feet wide by 44 feet 6 inches long, occupying the north end of the building. The south end of the station is partitioned off into two transformer rooms between which is a central opening; the doors to the transformer rooms are at each side. Each of the transformer compartments contains a single bank. Connection from the transformers to high-tension switches in a open gallery above them are run up through the concrete floor slab. The lightning-arrester equipment and the outlets are in the south end of the power house between the transformer space and the end wall. The switchboard is parallel to the back wall of the generator room between the main units. The exciters are between the units and the back wall at either end of the switchboard. The cost of the development was $104,002.

Hydraulic equipment.—The pressure pipe enters just below the floor line, at right angles to the main axis of the building, on the center line of the generator room. Inside the wall it connects to a Y casting, one branch feeding each main unit, the two units being arranged wheel to wheel. In each branch of the Y is a hand-operated gate valve. No. 1 unit is driven by a single overhung Pelton wheel with a single deflecting needle nozzle controlled by a Lombard governor, type R. The wheel housing rests on the cast-iron base bolted to the concrete. Unit No. 2 is operated by an overhung Doble impulse wheel; the wheel housing rests on a cast-iron plate fastened to the foundation and the wheel is served through an automatic needle by-pass nozzle controlled by a Lombard governor, type R.

Generators.—The station is equipped with two Westinghouse 750-kilovolt-ampere 2,200-volt 197-ampere 3-phase 60-cycle alternators, operated at 600 revolutions per minute. The total installed capacity of the plant is therefore 2,010 horsepower. The units are supported by two bearings with ordinary ring lubrication and are designed for 25 per cent continuous overload capacity.

Exciters.—No. 1 exciter, belt-driven from No. 1 unit, is a Westinghouse 25-kilowatt 125-volt 200-ampere direct-current generator, operated at 1,100 revolutions per minute. No. 2 exciter, operated by an Allis-Chalmers impulse wheel, is an Allis-Chalmers 45-kilowatt direct-current generator, giving 360 amperes at 125 volts with 900 revolutions per minute, and is controlled by an Allis-Chalmers governor.

Transformers.—The station is provided with two banks of three (each) Westinghouse 250-kilovolt-ampere 1-phase 60-cycle 2,200/33,000-volt oil-insulated water-cooled transformers. One bank is placed in each transformer compartment.

HAIWEE TEMPORARY PLANT.

LOCATION.

The Haiwee temporary power plant was constructed by the Bureau of Waterworks and Supply to utilize a part of the fall available below the Haiwee reservoir until such time as the ultimate development is constructed by the Bureau of Power and Light. The power house was connected to the city's Owens Valley system and began transmitting power July 9, 1919.

The power house is in the SE. ¼ sec. 2, T. 21 S., R. 37 E., 1,600 feet below the Haiwee dam on the Los Angeles Aqueduct. It is nearly 2 miles above the proposed power-house location of the Bureau of Power and Light.

SOURCE OF WATER SUPPLY.

The Haiwee plant depends for its supply entirely upon flow diverted through the aqueduct for municipal purposes in and around Los Angeles and power developed at the San Francisquito plants. The supply of the Haiwee reservoir is delivered through 23 miles of open cut and 38 miles of concrete-lined open ditch of 900 second-feet capacity.

The reservoir is formed by two hydraulic-fill dams, one at the extreme north and the other at the extreme south end. North Haiwee is a hydraulic-fill dam 1,480 feet long, 70 feet wide on the crest, 250 feet thick at the base, and 34 feet high. The water face of the dam is paved. The crest elevation is 3,766 feet above sea level. The dam is not provided with outlet works but is merely an embankment that prevents the water escaping from the reservoir northward into the valley.

The South Haiwee dam is a hydraulic-fill structure 1,510 feet long, 20 feet wide on top, 420 feet thick at the bottom, and 90 feet in maximum height. The crest elevation of the dam is 3,774 feet, and high-water level is 3,760 feet above sea level. The upstream face of the dam is paved for protection against wave action. The capacity of the reservoir at maximum water level is 63,800 acre-feet.

CONDUIT.

A circular concrete-lined tunnel 10 feet in inside diameter and 1,200 feet long from the permanent reinforced-concrete outlet tower of the aqueduct system pierces a rocky point at the south end of the dam. The elevation of the outlet of the tunnel at the connection tower is 3,680 feet above sea level. A lap-riveted steel pressure pipe 1,600 feet long and 105 inches in diameter has been installed to connect the lower end of the tunnel to the temporary power house. Below the branch to the last wheel is a valve connecting to a 52-inch by-pass discharging into the aqueduct below the tailrace of the temporary installation. A branch pipe 5 feet in diameter runs from the main line to each of the three turbines, operating under a head that ranges from 70 to 100 feet, depending upon the stage of the water in the Haiwee reservoir.

The elevation of the maximum water surface in the Haiwee reservoir is 3,760 feet, of the center line of the turbines 3,672.5 feet, and of the bottom of the draft tubes at the power house 3,650 feet above sea level, giving a difference of elevation of 87.5 feet between the maximum water surface in the reservoir and turbine centers and of 110 feet between the maximum water surface in the reservoir and the bottom of the draft tubes at the power house.

GENERATING STATION.

Power house.—The temporary power house is a reinforced-concrete building 50 feet long and 25 feet wide with corrugated sheet-iron roof supported on timber roof trusses. The turbines are installed on the main floor in three cells 13 feet 9 inches deep by about 15 feet wide, separated by 12-inch concrete walls. The transformers are in the open space near the front wall opposite the turbine of the central unit. The generator floor is 17 feet 6 inches above the main or turbine floor, and the generator room is 12 feet high from the floor to the lower chord of the roof trusses. The units are of the vertical type, each direct-connected to its turbine. They are arranged in a row parallel to and 7 feet 3 inches from the back wall of the power house. The switchboard is between the central unit and the front wall of the generator room, directly above the transformers, which occupy a similar position on the lower floor.

Hydraulic equipment.—The pressure line is parallel to and close beside the back wall of the power house. A short branch at right angles connects through a gate valve inside the power house to the casing of a Platt Iron Works Francis turbine with vertical shaft, 22-inch runner, and rated capacity of 500 horsepower. Each turbine discharges through a single straight-draft tube, 17 feet long from the turbine base, into a steep-flow ditch connecting with the aqueduct below the power house.

Generators.—The three units, identical in design, are Westinghouse 350-kilovolt-ampere 200-volt 3-phase 60-cycle alternators, each direct-connected to its turbine and operating at 300 revolutions per minute.

Transformers.—The generator output is stepped up by a single bank of three Wagner 300-kilovolt-ampere single-phase 60-cycle transformers, connected 2,200 volts delta on the low-tension to 33,000 volts Y-grounded on the high-tension side. The outgoing line runs north to the Cottonwood plant.

SAN FRANCISQUITO PLANT NO. 1.

HISTORY.

The power house of San Francisquito plant No. 1 is in sec. 22, T. 6 N., R. 15 W., San Bernardino base and meridian, in Clearwater Canyon, 47 miles north of Los Angeles, at an elevation of 2,100 feet above sea level.

Construction on San Francisquito No. 1 power system was begun in 1911, but before that time a large amount of work had been completed on the Elizabeth Lake tunnel, which, although on the main aqueduct, forms part of the power development. Work on the surge chamber, pressure pipes, and power house was carried on by the Bureau of Los Angeles Aqueduct Power; work on the tunnel was carried out by the Los Angeles Aqueduct Bureau. By the end of 1913 all the machinery and electrical equipment for the power house and receiving substation and a part of the equipment for the transmission lines was on the ground; the surge chamber was completed; the penstock material was on the ground and a part at each end of the line installed; the power-house building was inclosed and the machinery all housed therein and partly installed. Owing to the controversy between the operating companies and the city, however, it was impossible to get the plant into operation until April 10, 1917.

CONDUITS.

The portion of the Los Angeles Aqueduct which is of immediate interest in connection with the San Francisquito plants (Nos. 1 and 2) extends from the point where the aqueduct drops into the Fairmont reservoir down to the outlet of the Dry Canyon reservoir or from an elevation of 3,036.01 feet down to 1,505.45 feet above sea level. Fairmont reservoir, with a capacity of 7,620 acre-feet at the 3,035-foot contour, will act not only as a forebay reservoir but will store an emergency supply sufficient to operate the plants for a short time if a break should occur on the aqueduct above that point. The Dry Canyon reservoir, with a capacity of 1,300 acre-feet, will equalize the varying daily discharge through the two plants, so that an even flow will be passed into the aqueduct below in spite of unequal discharge from the plants due to varying load demands throughout the day.

Fairmont reservoir is formed by a hydraulic-fill dam with concrete core wall. When completed[44] the dam will be 115 feet high, 20 feet wide, and 1,506 feet long in the crest and will contain 607,114 cubic yards of material; 84,000 cubic yards, supplied from the north end of Elizabeth Lake tunnel, was used in the toes. The upstream slope is 3 : 1 and the downstream slope 2 : 1.

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[44] The height of the dam was increased in the early part of 1918 to raise the maximum water-surface elevation to 3,025 feet and increase the storage to 6,625 acre-feet.

The aqueduct enters the northwest corner of the reservoir, maintains its ordinary general section, and increases rapidly in grade, running down a smooth incline toward the floor of the lake. (See Pl. LXVII, *A*.) Water is discharged from the reservoir through a reinforced-concrete gate tower provided with 12 sliding steel gates which are operated from the platform at the top of the tower by screws and handwheels. The gates are set in three rows of four each in the tower at vertical intervals of 21.5 feet—four gates at each level. A channel leads from the reservoir through trash racks to an additional gate in the base of the tower. Water from the tower is admitted directly into the head of Elizabeth Lake tunnel, which has a circular section 10 feet 2 inches in diameter and a length of 40,617 feet.[45] The maximum elevation at water surface in the reservoir is 3,036 feet above sea level; the elevation of the top of the tunnel at the same point is 2,960.5 feet and the center elevation at the lower end of the tunnel, 2,900 feet; so that the tunnel will be acting under static heads varying from 75.5 to 0 at its upper end and from 60.5 to 136 feet at the lower end, the head depending on the position of water surface in the Fairmont reservoir.

At the head of the pressure drop the tunnel runs out through the point of a hill. Back far enough from the natural surface to give sufficient depth a large surge chamber has been excavated in the bedrock from the ground surface down to the tunnel level. The elevation of the bottom of this surge chamber is 2,891.1 feet above sea level, and the diameter of its cylindrical section, which continues up 15.5 feet at that elevation, is 30 feet. At an elevation of 2,906.6 feet the sides begin to flare out into a cone which attains a diameter of 100 feet at an elevation of 2,992 feet and then maintains a cylindrical form and the same diameter up to 3,039.5 feet. At 3,037 feet there is a weir spill 19 feet 8 inches long. The surge chamber is lined with concrete and is heavily reinforced vertically by rectangular twisted rods. There are also 6 horizontal rings, 17.1 feet center to center, constructed of 12-inch I-beams at six levels, the lower one being at the bottom and the upper one at the top of the cone-shaped part of the chamber. These, in connection with the vertical reinforced system, were designed to withstand water pressure from the outside. The structure extends about 30 feet above the ground surface.

Three pressure pipes leave the bottom of the surge chamber. The first section of each pipe tapers from 9 to 7 feet in diameter in about 65 feet, and at the end of this taper there is a butterfly valve in each line, designed to be operated by oil pressure under gravity flow from a tank. The valves are set in a chamber cut out of the solid rock. The three lines are concreted in solidly from the surge chamber

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[45] Of this total 26,870 feet is in Elizabeth tunnel proper and the rest in a tunnel that extends to the power drop.

A. CONTROL TOWER, OUTLET OF FAIRMONT RESERVOIR INTO ELIZABETH TUNNEL, LOS ANGELES AQUEDUCT.

B. SAN FRANCISQUITO POWER HOUSE NO. 1, CITY OF LOS ANGELES BUREAU OF POWER AND LIGHT.

C. SAN FRANCISQUITO POWER HOUSE NO. 2, CITY OF LOS ANGELES BUREAU OF POWER AND LIGHT.

D. KERN RIVER POWER HOUSE NO. 3, SOUTHERN CALIFORNIA EDISON CO.

Photograph by the company.

to the valves. From the valves two of the pipes run almost horizontally through tunnels to the surface of the hill, where the main pressure drop begins. The pipes are so arranged that at all conditions of operation they are below hydraulic grade. The third pipe ends at the valve, but its tunnel will be excavated so that the pipe can be installed when the last third of the power plant is developed. The total length of pipe from the surge chamber to the portal of the tunnel is about 400 feet. The characteristics of the lines are given in Table 151.

TABLE 151.—*Length, type, and dimensions of pressure pipes of San Francisquito plant No. 1.*

Pipe line.	Length of section.	Type of pipe.	Diameter of pipe.	Thickness of pipe.
Center line:	*Feet.*			*Inches.*
Taper section	24.00	Double riveted lap jointed.	9 to 7 feet	3/8
Pipe	29.00	....do	7 feet	3/8
Butterfly gate	4.00			
Pipe	412.82	Double riveted butt jointed.	7 fect	3/8
Expansion joint	7.09			
Pipe	328.47	Double riveted butt jointed.	7 feet	3/8
Do	68.74	Triple riveted butt jointed.	....do	3/8
Expansion joint	7.09			
Pipe	52.65	Quadruple riveted jointed.	7 feet	3/8
Do	90.25	....do	....do	7/16
Do	52.64	Triple riveted butt jointed.	....do	1/2
Do	76.06	Quadruple riveted butt jointed.	....do	1/2
Do	82.73	Triple riveted butt jointed.	....do	9/16
Do	142.48	Quadruple riveted butt jointed.	....do	9/16
Do	126.53	Welded	....do	11/16
Do	118.11	....do	....do	3/4
Do	58.52	....do	....do	13/16
Expansion joint	5.33			
Pipe	84.23	Welded	7 feet	7/8
Do	77.37	....do	....do	15/16
Do	78.74	....do	....do	1
Do	39.37	....do	....do	1 1/16
Taper section	19.69	....do	7 feet to 6 feet 8 inches.	1 1/16
Pipe	75.93	....do	6 feet 8 inches	1 1/16
Do	59.06	....do	....do	1 1/8
Do	39.37	....do	....do	1 3/16
Pipe	54.54	....do	....do	1 1/4
Total riveted pipe [a]	1,378.02			
Total welded pipe (7 feet)[b]	588.20			
Total welded pipe (6 feet 8 inches)	228.90			
Total welded pipe [c]	836.79			
Grand total	3,031.91			

[a] Including taper section, butterfly gate, and expansion joints.
[b] Including expansion joint.
[c] Including expansion joint and taper section.

TABLE 151.—*Length, type, and dimensions of pressure pipes of San Francisquito plant No. 1*—Continued.

Pipe line.	Length of section.	Type of pipe.	Diameter of pipe.	Thickness of pipe.
	Feet.			*Inches.*
East branch of center line:				
Taper section	11.92	Welded	6 feet 8 inches to 4 feet 9 inches.	7/8
Needle gate valve	10.50			
Pipe	326.66	Welded	4 feet 9 inches	7/8
Do	98.43	do	do	15/16
Do	149.83	do	do	1
Do	157.48	do	do	1 1/16
Taber section	19.69	do	4 feet 9 inches to 4 feet 6 inches.	1 1/16
Pipe	168.73	do	4 feet 6 inches	1 1/16
Do	194.77	do	do	1 1/8
Total welded pipe (4 feet 9 inches).	732.40			
Total welded pipe (4 feet 6 inches).	363.50			
Grand total [d]	1,138.01			
East line:				
Taper section	29.01	Double riveted lap jointed.	9 to 7 feet	3/8
Pipe	33.93	do	7 feet	3/8
Butterfly gate	4.00			
Pipe	421.02	Double riveted butt jointed.	7 feet	3/8
Expansion joint	7.10			
Pipe	328.47	Double riveted butt jointed.	7 feet	3/8
Do	71.62	Triple riveted butt jointed.	do	3/8
Expansion joint	7.10			
Pipe	52.64	Quadruple riveted butt jointed.	7 feet	3/8
Do	90.25	do	do	7/16
Do	52.65	Triple riveted butt jointed.	do	1/2
Do	76.06	Quadruple riveted butt jointed.	do	1/2
Do	82.73	Triple riveted butt jointed.	do	9/16
Do	142.48	Quadruple riveted butt jointed.	do	9/16
Do	125.49	Welded	do	11/16
Do	118.12	do	do	3/4
Do	57.33	do	do	13/16
Expansion joint	5.33			
Pipe	84.52	Welded	7 feet	7/8
Do	77.37	do	do	15/16
Do	78.74	do	do	1
Do	39.37	do	do	1 1/16
Taper section	19.68	do	7 feet to 6 feet 8 inches.	1 1/16
Pipe	75.47	do	6 feet 8 inches	1 1/16
Do	59.06	do	do	1 1/8
Do	39.37	do	do	1 3/16
Do	58.18	do	do	1 1/4
Total riveted pipe [a]	1,399.06			
Total welded pipe (7 feet) [b]	586.27			
Total welded pipe (6 feet 8 inches.	232.08			
Grand total	2,237.09			

[a] Including taper section, butterfly gate, and expansion joints.

[b] Including expansion joint.

[d] Including taper section and needle gate valve.

TABLE 151.—*Length, type, and dimensions of pressure-pipes of San Francisquito plant No. 1*—Continued.

Pipe line.	Length of section.	Type of pipe.	Diameter of pipe.	Thickness of pipe.
East branch of east line:	*Feet.*			*Inches.*
Taper section	11.92	Welded	6 feet 8 inches to 4 feet 9 inches.	7/8
Needle gate valve	10.49			
Pipe	327.80	Welded	4 feet 9 inches	7/8
Ball junction section	19.69	do	do	15/16
Pipe	78.74	do	do	15/16
Do	154.89	do	do	1
Do	157.49	do	do	1 1/16
Taper section	19.69	do	4 feet 9 inches to 4 feet 6 inches.	1 1/16
Pipe	166.76	do	4 feet 6 inches	1 1/16
Do	210.76	do	do	1 1/8
Total welded pipe 4 feet 9 inches in diameter.[e]	738.61			
Total welded pipe 4 feet 6 inches in diameter.	377.52			
Grand total	1,158.23			
West branch of east line:				
Taper section	11.92	Welded	6 feet 8 inches to 4 feet 9 inches.	7/8
Needle gate valve	10.49			
Pipe	327.04	Welded	4 feet 9 inches	7/8
Ball junction section	19.69	do	do	1/16
Pipe	78.74	do	do	15/16
Do	151.47	do	do	1
Do	157.49	do	do	1 1/16
Taper section	19.69	do	4 feet 9 inches to 4 feet 6 inches.	1 1/16
Pipe	168.37	do	do	1 1/16
Do	201.08	do	do	1 1/8
Total welded (4 feet 9 inches)[e]	734.43			
Total welded (4 feet 6 inches)	369.45			
Grand total	1,145.98			

[e] Including ball-joint section.

About two-thirds of the distance from the surge tank to the power house each of the three main penstocks branches into smaller pipes that continue to the station. The present installation includes only three smaller pipes. Each of the smaller pipes branches through a Y-casting directly behind its unit, and each branch of the casting serves the wheel on its respective end of the unit. The elevation at the center of the nozzles at the power house is 2,097.5 feet above sea level, giving a total static head of 938.5 to 863 feet, depending, as did that on the tunnel, on the elevation of water surface in Fairmont reservoir. The plant was designed for an ultimate average flow of 400 second-feet, with 1,000 second-feet maximum. This maximum is to be attained without the water level in the surge chamber falling below the hydraulic grade line corresponding to that flow. Taking into account friction in the tunnel and friction in the penstocks, it has been estimated that the loss of head at peak with 1,000 second-feet flowing will be 127 feet and that the loss with 400 second-feet mean flow will be 36 feet. The average output of the switchboard, it is calculated, will be 22,380 kilowatts and the maximum 51,750 kilowatts.

GENERATING STATION.

Power house.—The part of the power house now finished (Pl. LXVII, *B*) will contain but two-thirds the main generating units and exciters, but the plans provide for extending the building at the west end to full capacity. The building is of reinforced concrete with concrete-slab roof carried on steel roof frames; is 200 feet 9 inches long, 99 feet 5 inches wide, and 51 feet 4 inches high from floor to crest of roof parapet (outside dimensions); the clear height from floor to crane runway is 29 feet $7\frac{5}{16}$ inches. The generator room in the front of the building is separated from the transformer, bus, and switch rooms at the back of the building by a concrete curtain wall. The generator room runs the full length and full height of the station and has a breadth in the clear of 48 feet 6 inches.

The transformer and switch space occupies the full length of the back part of the power house and has a clear width of 46 feet 4 inches. It is divided into two main floors by a floor slab 22 feet above the ground floor. The upper floor is occupied by the high-tension switch and bus room; the lower floor is divided by a longitudinal wall near its center into two sections—that next to the back wall of the building containing the transformer equipment and that next to the generator room the low-tension switch equipment, low-tension busses, and conduits. This front compartment is subdivided by a floor 11 feet above the main floor and by longitudinal walls.

Hydraulic equipment.—At the back of the power house there is a long pit. An automatic relief valve and by-pass is to be installed in each pipe where it passes through this pit, when the development is fully completed, as an additional precaution against damage that might occur if the governor-operated relief (in the form of auxiliary nozzles) should fail and cause a rise of pressure due to a sudden checking of the water column between the surge chamber and the power house. The surge chamber acts as an absolute relief against any rise in pressure due to the column of water in the tunnels.

The by-pass needle-nozzle system is of special design, the shape of the curve of the needle being such that the nozzle, in opening or closing, complies with the requirements for speed regulation and at the same time with those for pressure rise in the penstocks; the bore of the nozzle is 10 inches. The discharge from the auxiliary needle nozzle, instead of being free or being deflected down into the tailrace by baffle plates, impinges on an Ensign vortex baffle. This vortex baffle, being constructed on the same general shape as the water-wheel buckets, turns the discharge back on itself and drops it into the tailrace to flow gently away into the San Francisquito No. 2 tunnel system.

The overhung wheel on each end of the main shaft of each of the three units now installed is 10 feet 2 inches in diameter on pitch line, carries 18 buckets, has a speed of 200 revolutions per minute, and is controlled by a Lombard governor (special type) on each unit.

Generators.—Each of the three generators of the present installation is a Westinghouse 9,363-kilovolt-ampere (7,500-kilowatt at 80 per cent power factor) 6,600-volt 820-ampere 3-phase 50-cycle alternator. The speed of the units is 200 revolutions per minute. The bearings are engine-type, ring-oiled, water-cooled revolving shell. The present installed capacity—28,090-kilovolt-ampere (37,688 horsepower)—is half the proposed ultimate capacity of the plant.

Exciters.—Two exciters are placed near the center of the power house in line with the main generating units. Each is driven by a Doble single overhung impulse wheel, supplied through a 3-inch needle nozzle and controlled by a Lombard governor, type F. The generator of each set is a Westinghouse 250-kilowatt 1,000-ampere 250-volt direct-current generator, operated at 400 revolutions per minute. The exciter switchboard is on the main floor of the plant directly opposite the exciters.

Transformers.—There is a bank of transformers for each main unit, but all connect with the low-tension bus, which is, with the present installation, continuous throughout the power house. The transformers are Westinghouse single-phase 50-cycle units of the oil-insulated water-cooled type. Their ratio is 6,600/61,500 Y. A double-circuit steel tower line runs southward from the power house to the central receiving station in Los Angeles.

SAN FRANCISQUITO PLANT NO. 2.

LOCATION.

The conduit leading from San Francisquito No. 1 plant to San Francisquito No. 2 power house was constructed by the Los Angeles Aqueduct for the Power Bureau at the time that San Francisquito No. 1 conduit was completed. The work on No. 2 power house, however, was done entirely under the Bureau of Power and Light and was not started until March, 1919. The first unit was placed in operation on July 6 and the second on August 1, 1920.

The intake at the afterbay at San Francisquito power house No. 1 is in the SW. ¼ SE. ¼ sec. 22, and the conduit traverses secs. 22, 27, 34, and 33, T. 6 N., R. 15 W.; secs. 5 and 6, T. 5 N., R. 15 W.; and secs. 1, 12, and 11, T. 5 N., R. 16 W. The power house is in the SW. ¼ NE. ¼ sec. 11, T. 5 N., R. 16 W. The small dam and reservoir in the head of Drinkwater Canyon are also in sec. 11.

SOURCE OF WATER SUPPLY.

The entire supply of water available for power development at San Francisquito plant No. 2 is that discharged from power house No. 1, briefly described on page 750.

CONDUIT.

The intake of the conduit for San Francisquito plant No. 2 is at the lower end of the afterbay of San Francisquito No. 1 power house. The length of the conduit from that point to the control valves in the tunnel just before it reaches the surge chamber for No. 2 power house is 31,522 feet. The conduit consists of a series of eight concrete-lined tunnels of standard horseshoe cross section, with roof arched on a radius of 5 feet 1 inch and a total height of 11 feet 7 inches from invert to crown of arch. The slope in these tunnels is 2 feet per thousand throughout.

As San Francisquito No. 1 power house is on Coldwater Canyon, a tributary to San Francisquito Creek from the west, and power house No. 2 is on the east bank of the stream, a siphon is necessary at the San Francisquito Creek crossing; another was found necessary at Bee Canyon, farther down the conduit. These two siphons are riveted steel pipe, and their lengths between portals are 276 and 930 feet, respectively. Except for the two siphons the entire conduit is tunnel.

Normal water-surface elevation in No. 1 tailrace is 2,088.5 feet, and the elevation of the floor of the No. 2 intake is 2,078.5 feet. Normal high-water level in the surge chamber at the lower end of the conduit is 2,055 feet, showing that only part of the tunnel line is operated under pressure.

The last tunnel continues about 300 feet beyond the present branch to the surge chamber and formerly discharged into a ravine just below the site of power house No. 2; a by-pass tunnel was later constructed from the present site of the gates to the proposed regulating reservoir in a branch of Drinkwater Canyon, and a flume was run down to the aqueduct heading at the mouth of the canyon. A third tunnel has now been completed from the junction of the other two to the surge chamber; this tunnel is concrete lined, is nearly circular, and is 11.5 feet in diameter. A gate chamber was excavated, and two 9.5 by 10 foot gates have been installed at the junction of the three tunnels, one in the tunnel leading to the regulating reservoir and one in the tunnel leading to the surge chamber. The extension of the original tunnel has been bulkheaded off at the junction, and it is now used as an entrance gallery to the gate chamber.

The surge chamber is of uniform cylindrical cross section. It is 34 feet inside diameter for about 45 feet from the bottom, then increases gradually to 37 feet in diameter at the top. The elevation of the top of the chamber is 2,079.9 feet; normal maximum water level, 2,055.0 feet; bottom, 2,009.9 feet; invert elevation of supply tunnel, 2,014.4 feet; and invert elevation of the three 9-foot outlets to the pressure pipes, 2,011.9 feet. The pipes are solidly concreted into the three outlet tunnels for 50 feet from the surge chamber to the butterfly-gate chamber, where the south and middle lines connect to the present pressure pipes and the north line is dead-ended for connection to a future pipe. Each pipe tapers from 9 to 7 feet in diameter in the first 50 feet. The 7-foot butterfly gates are operated by oil pressure and are arranged for remote control from the power house. The north and south outlets leave the bottom of the surge chamber at angles of 45° from the center line but curve toward it and finally parallel it with 25 feet between centers of the lines. From the butterfly-valve chamber two tunnels 220 feet long run to the portals above the power house, and the south and middle pipe lines are supported in these tunnels on concrete piers, with sufficient room on either side of the pipe for inspection. The tunnel for the third line has not been excavated.

The by-pass tunnel from the gates at the end of the main conduit back of the surge shaft to the regulating reservoir is about 1,200 feet long and is connected by a concrete-lined conduit running through the floor of the Drinkwater Canyon reservoir to the base of an outlet tower near the toe of the dam. The dam will be of composite fill, the downstream slope of tunnel muck and shale, and the main body and upstream face of gravel and clay mixed. The water face will be concreted, and a clay puddle core 6 feet thick will extend down into a trench cut in the bedrock. The dam will contain about 105,000 yards of fill; about 30 per cent of the material had been placed at the end of 1921. Water will be stored to a depth of slightly over 35 feet, with maximum surface elevation at 2,055 feet above sea level and a corresponding capacity of 92.5 acre-feet. The supply may be fed back through the pressure pipes or wasted through the dam and down the canyon into the aqueduct.

Only two of the three penstocks that will eventually be installed had been completed at the end of 1921. The south penstock is 1,430.14 feet long and the middle one 1,431.25 feet long. Both pipes are of riveted steel throughout, with angle-iron hoop stiffeners around the lighter-weight sections near the top of the lines. The plate thickness ranges from ¼ inch at the top to ⅞ inch at the bottom.

From 7 feet in diameter at the butterfly valves both pipes reduce, by steps of 3 inches, to 6 feet in diameter at the power house, where they run through large concrete-block anchors and connect to Larner-Johnson valves immediately behind the turbine scroll cases. The pipes are supported throughout on concrete piers, and concrete-block anchors have been constructed at the principal bends or breaks in grade. Two expansion joints are provided in each line.

The maximum water surface in the surge chamber is 2,055 feet above sea level, and the minimum tail water at the power house is 1,515 feet above sea level, giving a maximum head of 540 feet.

GENERATING STATION.

Power house.—San Francisquito No. 2 generating station (Pl. LXVII, *C*) is a reinforced-concrete building housing the entire equipment—generators, transformers, and switches. It is 126 feet long, 86 feet wide, and 59 feet high from the main floor level to the top of the parapet surrounding the nearly flat roof, which is carried on steel trusses. The clear height of the generator room is 51 feet to the lower chord of the roof trusses.

The generator room, 34 feet in clear width, extends the full length and height of the front of the building. The part of the power house between the generator room and the back wall of the building may be termed a transformer and switch house. Its main-floor level is the same as the generator room, 1,560 feet above sea level, but it is divided into two stories by a second floor 28 feet above the main floor. A longitudinal wall divides both upper and lower stories, the upper into a front bus and switch room 18 feet 3 inches wide, extending the full length of the power house, and a back bus and switch room 25 feet 6 inches wide and also extending the full length of the building. In a similar manner a longitudinal wall divides the lower or main floor into rooms, one of which is a transformer room 109 feet long from the north end of the building by 25 feet 6 inches wide and the full 28 feet height between the main and second floors. A space 13 feet 9 inches wide parallel to the longitudinal axis of the building by 25 feet 6 inches deep between the south wall of the transformer room and the south end of the building accommodates tracks for moving the transformers in and out of the room for repair. The west side of the transformer room is divided by concrete curtain walls into three main transformer bays approximately 36 feet long by 12 feet deep, with a transformer truck track running the entire length of the room in front of them.

The remaining space, 18 feet 3 inches wide, between the front wall of the transformer room and the back wall of the generator room is utilized for rooms containing the main switchboard, low-tension switches, auxiliaries, and a repair-shop bay. The repair-shop bay opens directly into the back and south end of the generator room and into the passage south of the transformer room. It is 41 feet long by 18 feet 3 inches deep. The space given up to rooms for auxiliaries, etc., is approximately 80 feet long by 18 feet 3 inches wide and is divided into two floors by a mezzanine floor 13 feet above the main floor. The space is divided as follows:

On the main floor near the center of the building is a rheostat and auxiliary room 30 feet long, with a generator oil-switch room 14 feet long at its right, and a station transformer and auxiliary exciter room of the same size at its left. Between the latter and the north end of the building is a room 21 feet 5 inches long containing oil-storage tanks.

On the mezzanine floor the central position is occupied by the main switchboard room, with low-tension switch rooms on either side and a storage-battery room in the north end of the building.

In the generator room the three units, of which only two have been installed, are of the vertical type and are to be set in line 14 feet from and parallel to the front wall and 30 feet apart on centers. The exciter switchboard is centered under the main switchboard room but flush with the wall. The governor for each unit is back and slightly to the right of its generator base. The exciters in ordinary use are mounted on the tops of the generators. A 100-ton Shaw electrically operated crane with 36-foot lift commands the entire generator floor. The clear width of the generator room between the pillars supporting the crane runway is 34 feet, and the width between walls 37 feet.

A turbine room containing the reinforced-concrete generator bases, relief valves, Larner-Johnson valves on the main pipe lines, and oil-sump tanks extends under the entire generator room. The turbine scroll cases are embedded in concrete foundations. The relief valves discharge into a separate compartment above the main tailrace outlets.

Large air ducts from the back of the building pass under the transformer and switch rooms to the upper part of the turbine room.

Elevations at the power house, in feet above sea level, are as follows:

Main-floor level	1,560
Turbine-room floor	1,539.5
Center line of turbines	1,535
High water in tailrace	1,521
Low water in tailrace (weir crest)	1,515
Bottom of tailrace	1,508

Hydraulic equipment.—At the back wall of the power house the pressure pipes pass through large concrete-block anchors and bend in a vertical plane to an angle of about 16° from the horizontal. At the back wall of the turbine room each pipe connects through a Larner-Johnson valve with 84-inch inlet and 54-inch discharge to the cast-steel scroll case of the turbine, incased in the concrete of the foundations. Each turbine is provided with a 30-inch relief valve and with a 16-inch bursting plate, as a guard against sudden rises of pressure in the penstocks.

The turbines were manufactured by the Wellman-Seaver-Morgan Co. and are of the Francis type, with 63.5-inch runners and single straight-draft tubes. The turbines are designed for a maximum efficiency of 92.5 per cent when discharging 330 second-feet; the efficiency of each wheel when discharging 440 second-feet under a 515-foot head and developing 20,500 horsepower is 80 per cent.

Each turbine is regulated by a Woodward type ACT 7¾-inch governor with a rating of 45,000 foot-pounds. The governor operates in conjunction with the relief valve.

Generators.—The two generators, identical in all respects, are General Electric type AT1 17,500-kilovolt-ampere 6,600-volt 1,530-ampere 3-phase 50-cycle alternators, operated at 428 revolutions per minute.

Exciters.—A General Electric type MPC 75-kilowatt 250-volt 300-ampere exciter is mounted on top of each unit and is operated at 428 revolutions per minute by the main shaft. Emergency excitation is furnished by a motor-generator set in one of the auxiliary rooms. The generator of this set is a General Electric type RMC 90-kilowatt 250-volt 360-ampere direct-current machine operated at 965 to 1,000 revolutions per minute by a General Electric type I form K 135-kilowatt 2,200-volt induction motor. A small motor-generator set near the back wall of the generator room serves as a charging set for the storage batteries. The generator of this set is a 9.6-kilowatt 150-volt machine.

Transformers.—Two banks, each consisting of three General Electric type WC form HDHP single-phase 50-cycle 5,833-kilovolt-ampere transformers, are in normal use, and a spare is installed for use in emergency. The transformer connections are 6,600 volts delta on the low-tension and 60,500/104,790 volts Y-grounded on the high-tension side.

Wiring.—The generator leads pass through a 6,600-volt oil switch and then through disconnecting switches either to the low-tension side of the transformers directly or through a 6,600-volt bus-tie oil switch to the 6,600-volt bus.

The three 5,833-kilovolt-ampere transformers of each bank are connected 6,600 volts delta on the low-tension to 104,790 volts Y-grounded on the high-tension side. The high-tension leads from each bank of transformers may be connected to either the back or the front 110,000-volt bus on the third floor of the power house through disconnecting switches and General Electric K-36 300-ampere oil circuit breakers; each bus may be connected in a similar manner through oil circuit breakers and disconnecting switches to either of the two outgoing lines. Two sets of General Electric electrolytic lightning arresters are installed on a concrete base back of the power house.

In the immediate future one of the outgoing circuits will be operated at 60,000 volts and connected to the Edison system through a line leading to the Castaic substation. The other circuit, of 4/0 copper supported on a steel-tower stub line about 1 mile long, connects to the main 300,000 circular mil 110,000-volt line leading from San Francisquito No. 1 power house to Los Angeles.

The standard steel towers used on this branch, as well as on the main line, are 50 feet high from ground surface to the lower arm, 10 feet from arm to arm, and 6 feet from the upper arm to the peak of the tower, making a total height of 76 feet over all. The towers are 18 feet square at the bottom, 4 feet square from the lower to the top cross arms, and peaked to the top. The cross arms are 16 feet long between insulator supports. The corners of the towers are bolted to stubs set in the ground.

RIVER POWER PLANT.

LOCATION.

River power plant in San Fernando Valley was constructed by the Los Angeles Bureau of Power and Light and began operation December 22, 1917. The plant was added to the proposed system in order to utilize, when it was not necessary to deliver water to Franklin reservoir, the head available between San Fernando reservoir and the lowest point on the siphon. The power house is at the point where the siphon crosses Los Angeles River.

SOURCE OF WATER SUPPLY.

A short description of the power developments originally proposed is given on pages 726 to 727.

The aqueduct is designed to deliver a maximum of 400 second-feet to San Fernando No. 2 reservoir, the capacity of which is 23,000 acre-feet, or to a by-pass, running around the west side of the reservoir, through which the supply may be delivered directly to the distribution system if necessary. From the reservoir an inverted siphon extends southeastward through San Fernando Valley, crossing Los Angeles River and terminating in a tunnel through the Santa Monica Mountains, which delivers water to Franklin Canyon distribution reservoir.

The approximate lengths, diameters, and plate thickness of the pipe from San Fernando reservoir to the power plant are as follows:

TABLE 152.—*Dimensions of San Fernando siphon to River power plant.*

Length.	Diameter.	Thickness.
Feet.	*Inches.*	*Inches.*
23,150	72	$\frac{1}{4}$
7,235	72	$\frac{5}{16}$
1,450	68	$\frac{5}{16}$
1,860	66	$\frac{5}{16}$
13,850	66	$\frac{3}{8}$
9,300	64	$\frac{3}{8}$

Elevations at various points on the pressure system are:

	Feet.
San Fernando No. 2 reservoir maximum water level:	
Present	1,120
Ultimate	1,142
River power-house center line of shaft	622.5
River power-house floor level	619.4
River power-house center line of lower nozzle	618.75
River power-house tailrace floor	611.7

The maximum static head will therefore ultimately be 523.25 feet from maximum water level in San Fernando No. 2 to center line of the lower nozzles of the main unit at the power house. From 80 to 85 second-feet of water is utilized.

GENERATING STATION.

Power house.—River power house is a reinforced-concrete building with wooden-roof system on the north side of Los Angeles River with the south end of the building toward the stream and the main entrance toward the west. The building is 62 feet 11 inches long by 37 feet 11 inches wide outside, with concrete walls 1 foot 5½ inches thick. A transverse concrete wall, 1 foot 4 inches thick, divides the interior into a generator room 41 feet long by 35 feet wide and 19 feet high to lower chord of roof trusses, in the south end, and a transformer room 17 feet 8 inches by 35 feet in the north end of the building. The main doorway, 12 feet 4 inches wide, is at the center of the west side of the building. Two doors, one 7 feet and one 3 feet wide, give access to the transformer room from the generator room. The shaft of the main unit is parallel to the principal axis of the building and 23 feet from the front wall, with the water wheel at the right end of the shaft near the south wall of the power house. The exciter is in the south end of the generator room between the main unit and the front wall. A two-panel switchboard forms part of the wall separating the generator and transformer rooms, with a switching equipment in the transformer room on the opposite side of the wall immediately behind the switchboard. The three transformers are set in a row parallel to the north wall of the building. A set of disconnecting switches operated by lever from the switchboard is installed on the roof.

Hydraulic equipment.—A branch leaving the main Franklin Canyon siphon passes through the west wall of the power house under the floor line and through a 34-inch gate valve operated by a water wheel and provided with a hand-operated by-pass to the main unit. Water is delivered to a single Pelton impulse wheel through two stationary needle nozzles, one placed horizontally under the floor line and the other inclined downward at an angle of about 60° and supported and supplied through a heavy gooseneck casting rising above the first nozzle and forming part of the wheel housing. The position of the needle in both nozzles is regulated by hand, but after leaving the nozzle tip each jet passes through a cylindrical deflector, which is controlled by a Pelton type O-5 governor. Water is discharged from the wheels into the river through a short concrete tailrace under the east wall of the building.

The wheel shaft revolves in ring-oiling pedestal bearings bolted to the cast base of the wheel housing. The shaft of the wheel is rigidly connected to that of the generator by a bolted flanged coupling. The diameter of the wheel on the pitch line of the buckets is 92 inches,

Generator.—The Westinghouse 3,600-kilovolt-ampere 5,700-volt 365-ampere 3-phase 50-cycle alternating-current generator mounted between ring-oiling pedestal bearings resting on the sole plate of the machine operates at 187 revolutions per minute.

Exciter.—A Westinghouse 50-kilowatt 250-volt 200-ampere continuous-current exciter is operated by a belt from a pulley on the end of the water-wheel shaft of the main unit.

Transformers.—Three Westinghouse 1,200-kilovolt-ampere single-phase water-cooled transformers connected delta on both the low and high tension sides step the generator voltage up to 33,000 for transmission.

Lightning arresters.—A four-tank set of Westinghouse electrolytic arresters is installed in an inclosure between the south end of the power house and the bank of the river.

Wiring.—The generator connects to the transformers through a General Electric nonautomatic 15,000-volt 500-ampere oil switch, and the transformers connect to the outgoing line through a set of Kellman 33,000-volt oil switches. Disconnecting switches are installed in both the high and low tension circuits. A pole line with pin insulators and copper conductors, operated at 33,000 volts, connects the power house to the city's distribution system through the Hollywood substation.

FRANKLIN CANYON PLANT.

LOCATION.

The Franklin Canyon plant is in Franklin Canyon immediately north of the town of Beverly Hills, about 11 miles west of the business section of Los Angeles. The plant is on the distribution system of the Bureau of Waterworks and Supply but is operated by the Bureau of Power and Light. It went into operation June 3, 1921.

SOURCE OF WATER SUPPLY.

The Franklin Canyon plant is supplied through the distribution main that feeds the River power station and from the River power house at the point where the line crosses Los Angeles River in the southwestern part of San Fernando Valley. When a surplus supply is available, water is discharged through the River power house into the river and either runs to waste or is pumped from the sands at a lower point on the stream. Water not so wasted continues through the distribution main to the Franklin Canyon system.

CONDUIT.

From the River power house the pipe line runs up the northern slope of the Santa Monica Mountains and enters the Franklin tunnel at an elevation of slightly over 850 feet above sea level. At the lower portal of the tunnel water is discharged into the Upper Franklin reservoir, the forebay of the Franklin Canyon plant. Discharge from the power house empties into the Lower Franklin reservoir at the head of the water-supply distribution system.

Beginning at the River power house, which is described on pages 757-759, 600 feet of 64-inch pipe and 4,313 feet of 62-inch pipe connect to the north portal of the Franklin tunnel, which is 7,765 feet long and 6 feet 10 inches by 7 feet 8 inches in cross section and has an area of 41.63 square feet and a slope of 1.1 feet per thousand. The maximum water-surface elevation at the Upper Franklin reservoir is 850 feet and the reservoir capacity 128 acre-feet. The reservoir is formed by a small earth dam riprapped on the upstream side.

Water is admitted at the dam to a 54-inch pressure pipe 5,920 feet long through a concrete outlet tower, with gate valves raised by threaded stems leading to an operating platform at the top of the tower. At the power house the pipe connects through a reducer to the gate valve controlling supply to the turbine. High-water level in the tailrace, determined by high water in the Lower Franklin reservoir, is 575 feet above sea level, with a corresponding capacity of 1,100 acre-feet. Low-water level in the tailrace is determined by a submerged dam or weir with crest elevation of 565.5 feet above sea level. The maximum difference in elevation from maximum water level in the Upper Franklin reservoir or forebay to minimum tail water at the power house is therefore 284.5 feet.

GENERATING STATION.

Power house.—The Franklin Canyon power house is a reinforced-concrete building with wooden roof system and tile roof. The entire generating, switching, and transformer equipment is housed in a single building. The lightning arresters are on a concrete terrace outside at the east end of the power house. The building is 47 feet 4 inches long and 32 feet 4 inches wide outside at the generator-floor level, and the clear height from the main floor to the lower member of the roof trusses is 19 feet 3 inches. A transverse wall divides the interior into a generator room 24 feet 5 inches by 29 feet and a transformer room 18 feet 11 inches by 29 feet. A 10-foot doorway in the back of the generator room is the only entrance to the building.

The single unit of the vertical type is in the center of the generator room, 11 feet 4 inches back from the front wall. The generator housing is raised on a special cast-iron cylindrical base 3 feet 5 inches high, and the turbine scroll case is installed in a shallow pit beneath it, reached from the main floor by a short flight of concrete steps. The gate valve in the main line is directly behind the unit, and the governor is on the main floor between the unit and the front wall. The entrance from the generator into the transformer room is through a small door at the back of the partition. The switchboard of three panels is set flush with the partition beside this door, and directly behind the board in the transformer room is the low-tension switch.

The transformers are set in line along the partition, with the bus supported by a steel framework above them and the high-tension switches opposite them against the end wall of the building. A lavatory, with small station transformers installed above it, is in the back of the transformer room.

Elevations at the power house, in feet, are as follows:

Main-floor level	580.1
Center line of turbine scroll case	576.1
Top of draft-tube outlet	564.9
Bottom of draft-tube outlet	561.3
Top of submerged dam in tailrace	565.5
High water in tailrace	575.0

Hydraulic equipment.—The main supply line reduces from 52 to 42 inches in diameter behind the power house and connects inside the wall and under the floor through a 42-inch electrically operated gate valve to the scroll case of the turbine. The turbine is an S. Morgan Smith Francis type unit with 33-inch runner, designed to operate at 600 revolutions per minute and rated at 3,000 horsepower. The turbine discharges through a single-draft tube and is regulated by a Woodward type HR governor designed for 10,500 foot-pounds. A relief valve and a 12-inch gate valve connecting to a bursting plate give protection against abnormal rises in pressure in the pipe line.

The unit and the relief valve discharge into a concrete-box afterbay about 14 feet wide and 10 feet long, connecting to a short covered channel and concrete pipe running out into the Lower Franklin Canyon reservoir, into which the water is discharged through a series of openings in the top of the pipe.

Generator.—The generator, of the vertical type, with the exciter mounted above it on the head of the main shaft, is a General Electric type AT1 2,500-kilovolt-ampere 4,400-volt 328-ampere 3-phase 50-cycle alternator operated at 600 revolutions per minute.

Exciter.—The General Electric type MPC continuous-current exciter mounted above the main unit and connected directly to its shaft is rated at 28 kilowatts or 187 amperes at 150 volts.

Transformers.—The station is equipped with a bank of three Westinghouse 1,000-kilovolt-ampere 4,400/33,000-volt 50-cycle oil-insulated water-cooled transformers.

Wiring.—The generator leads connect through a General Electric K-12 500-ampere 15,000-volt oil switch and 600-ampere 7,500-volt disconnecting switches to the transformers, which connect directly to a single bus of 4/0 solid copper. The bus connects to two transmission lines, the leads running first through 300-ampere disconnecting switches and then through Kelman 33,000-volt oil circuit breakers. Beyond the circuit breakers are choke coils and pole-top switches, and each line is protected by General Electric electrolytic lightning arresters. One line runs to Hollywood and the other to the River power plant, but pole-top switches are so arranged between them that they may be interconnected.

THE NEVADA-CALIFORNIA POWER SYSTEM.

HISTORY.

THE NEVADA-CALIFORNIA POWER CO.

Important discoveries of mineral which were made in 1904 near the sites of the present towns of Tonopah and Goldfield, Esmeralda County, Nev., led to a great influx of miners into a territory until then almost uninhabited. The conditions in this desert country were such that the price of power generated locally by steam or by gas engines was almost prohibitive. The Nevada Power, Mining & Milling Co., the first hydroelectric company to enter the field, reported on January 29, 1906, that the cost of coal in the region was $12 per ton in carload lots, and that water was $3 per thousand gallons at Tonopah and $7 per thousand gallons in Goldfield. These conditions, coupled with the prospect of a long life for many of the mines, offered a most attractive field for hydroelectric power and led to the organization of the power company by Denver and Pittsburgh capitalists.

A hurried reconnaissance showed that Bishop Creek was the most available source of power supply and plans were immediately made to utilize the stream to its fullest extent. In March, 1905, the officials of The Nevada Power, Mining & Milling Co. entered into a contract with Hillside Water Co., which had previously acquired water rights and 5,000 acres of land along Bishop Creek. This contract provided that The Nevada Power, Mining & Milling Co. should obtain the approval of permits for reservoir sites partly on Government lands on South Fork and should build the necessary dams to store the water for the use of both corporations.

In order to insure market for power to be developed on Bishop Creek, some of the stockholders of The Nevada Power, Mining & Milling Co. advanced the money necessary to purchase the stock of Goldfield Electric Light & Power Co. and Tonopah Light & Power Co., which were operating in the two principal mining camps. These properties were later turned over to The Nevada Power, Mining & Milling Co. and paid for in bonds at par.

The first plant constructed on Bishop Creek was plant No. 4. The first two units of the station were tested out September 20 and the first power delivered in Tonopah September 21, 1905. In the early part of 1906 the power company reported that 1,026 horsepower in motors had been installed or contracted for in the mining region and also reported that the peak load of the Goldfield Co. was 225 horsepower, and that of the Tonopah Co. 200 horsepower. The growing demand for power made it necessary to order a 1,500-kilovolt-ampere unit for plant No. 4 in December, 1905. Two more 1,500-kilovolt-ampere units were added in 1907 and 1908. In the meantime plant No. 5 had been completed and put into operation in September, 1907.

In 1907 The Nevada Power, Mining & Milling Co. was reorganized as The Nevada-California Power Co., which after an appraisal of the properties proceeded to purchase the stock of Hillside Water Co., making first payment of $25,000 on the total price of $100,000 September 1, 1907, and agreeing to pay the balance during the ensuing three years.

The Nevada-California Power Co. continued the progressive development begun by its predecessor by constructing plant No. 2 (which began operation in November, 1908), a second main transmission line, with important branch lines, into Nevada, South Lake (Hillside) reservoir on South Fork, and Sabrina reservoir on Middle Fork of Bishop Creek.

SUBSIDIARIES OF THE NEVADA-CALIFORNIA POWER CO.

INTERSTATE TELEGRAPH CO.

In 1912 the telephone lines which had been operated by The Nevada-California Power Co. in connection with its transmission system and also with a small amount of commercial business were formally transferred to ownership of Interstate Telegraph Co., stock control of which remained in the hands of The Nevada-California Power Co. until 1915, when it was transferred to The Nevada-California Electric Corporation, organized as the holding company of the system. Interstate Telegraph Co. has an outstanding capital stock of $500,000 and bonded indebtedness of $250,000. Aside from its use in operating the transmission system, it serves the scattered commercial business along the transmission line of The Nevada-California Power system.

THE SOUTHERN SIERRAS POWER CO.

The officials of The Nevada-California Power Co. comprehended the vicissitudes of mining regions and therefore desired to secure a power market that could be developed while the mines were still prosperous and that would afford a source of revenue after they had become exhausted. The Southern Sierras Power Co. was therefore formed for the main purpose of constructing a steel tower line from the Bishop Creek plants southward to San Bernardino, with a network of transmission and distribution lines in Riverside and San Bernardino counties. The Southern Sierras Power Co. was incorporated June 15, 1911, and was controlled from the outset through the ownership of all but directors' qualifying shares of its stock, by The Nevada-California Power Co.[46] Part of the necessary funds for construction of The Southern Sierras system was obtained by sale of its bonds and the rest was advanced by The Nevada-California Power Co.

To extend the market for its power The Southern Sierras Power Co. purchased stock control of Corona Gas & Electric Light Co. (July 12, 1911) and purchased its properties under approval of the Railroad Commission dated March 29, 1918, also certain properties of Lytle Creek Power Co. in San Bernardino (Oct. 24, 1911), San Jacinto Light & Power Co. (Feb. 26, 1912), Elsinore Electric Light & Power Co. (March, 1913), and Barstow Utility Co. (June 24, 1913), all properties of Coachella Valley Ice & Electric Co. (April 2, 1918).

The construction of Bishop Creek plants 3 and 6 was undertaken in the name of The Southern Sierras Power Co., but Bishop Creek No. 3 was later transferred to and Bishop Creek No. 5 acquired from the Nevada-California Power Co., so that of the five plants in operation on Bishop Creek, The Southern Sierras Power Co. owned Nos. 5 and 6 and The Nevada-California Power Co. Nos. 2, 3, and 4.

The small properties of Lytle Creek Power Co. in San Bernardino, San Jacinto Light & Power Co., and Elsinore Electric Light & Power Co., were consolidated with The Southern Sierras system upon purchase. Barstow Utility Co., was not connected with the system but was purchased under a contract by the terms of which the original owners were to maintain and operate the system for two years, the expenses of such operation and the cost of certain equipment being paid by The Southern Sierras Co. The electric system owned by the Barstow Utility Co. served only a few stores and residences in Barstow and was originally operated in connection with an ice-manufacturing business. It is now connected to the hydroelectric lines.

The trunk tower line from Bishop Creek to San Bernardino was completed by The Southern Sierras Power Co. in February, 1913.

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[46] The stock has since been transferred to The Nevada-California Electric Corporation.

The San Bernardino steam plant and several important transmission lines radiating southward had begun operation in June, 1912. A large part of this construction was carried on by Sierras Construction Co., a concern incorporated for that purpose by The Nevada-California Power Co.

BISHOP LIGHT & POWER CO.

Bishop Light & Power Co. was incorporated April 23, 1902, under the laws of California. The entire $15,600 par value of stock outstanding was purchased by The Nevada-California Power Co. in May, 1909, and transferred by the latter to the Nevada-California Electric Corporation., in 1915. Bishop Light & Power Co. operated only an electric distributing system in and near Bishop, purchasing energy from The Southern Sierras Power Co. Stock of the Bishop Light & Power Co. appeared among assets of the holding corporation, and dividends paid by the company appeared in dividend revenue of the holding corporation. The properties of the company were finally purchased by The Southern Sierras Power Co. in March, 1918.

The financial backers of The Nevada-California Power Co., prior to December 31, 1915, also purchased stock in Pacific Power Corporation and stock of Holton Power Co. The Pacific Power Corporation has since been formally added to The Nevada-California system, but at the end of 1921 the Holton Co. was still controlled through stock ownership by some of the financial backers of The Nevada-California system but not by the holding corporation.

CORONA GAS & ELECTRIC LIGHT CO.

Corona Gas & Electric Light Co. was incorporated July 10, 1903, under the laws of California, to operate a gas and electric system in the city of Corona, Riverside County. Its entire outstanding stock to the amount of 50,000 was purchased by The Southern Sierras Power Co. July 12, 1911, and transferred to The Nevada-California Electric Corporation in 1915. Its properties were purchased by The Southern Sierras in March, 1918. The company operated an electric distribution system in Corona and its immediate vicinity. It purchased about 450,000 kilowatt-hours of electric energy annually from The Southern Sierras Power Co. and Southern California Edison Co. and marketed this through its own distribution system.

The amounts of stock and bonds outstanding of Corona Gas & Electric Light Co. and several of the other minor concerns controlled by The Nevada-California Electric Corporation are included in Tables 268 and 269, Appendix A.

PACIFIC POWER CORPORATION.

Pacific Power Corporation was the direct successor of Pacific Power Co., which was controlled through ownership of its entire outstanding stock by Hydro-Electric Co. Hydro-Electric Co. began the development of a system by constructing a plant on Mill Creek below Lundy Lake in 1910. Before the plant was completed it was taken over by Pacific Power Co., acting as an operating company, and completed about January 1, 1911, together with the line running northeastward into Nevada. The transmission line connecting the Pacific Power system with the Bishop Creek plants of The Nevada-California system was constructed and put into operation December 18, 1913.

In 1914 Pacific Power Co. defaulted on the interest of its first-mortgage bonds, of which there were $800,000 outstanding. Between January and June, 1915, the bonds and stock of the company were acquired by the Central California Electric Corporation,[47] formed as a holding company by D. A. Chappell and others who were already connected with Pacific Power Co. and with The Nevada-California Power Co. Foreclosure proceedings were instituted and the California properties of Pacific Power Co. were sold on August 30, 1915, and Nevada properties August 31, 1915, to D. A. Chappell and J. S. Cain, representing the bondholders. The amounts received by the German American Trust Co., trustees, at this sale were credited on the bonds and unpaid coupons pursuant to the deed of trust. Trustee's deed was delivered by German-American Trust Co. as trustee to the purchasers, who in turn sold and deeded all the properties to the Pacific Power Corporation and on October 1, 1915, the properties and business of the old Pacific Power Co. were turned over to Pacific Power Corporation.

At the end of 1916 Pacific Power Corporation owned and operated that part of The Nevada-California Power system lying northwest of Bishop Creek, including two hydroelectric generating stations on streams draining into Mono Lake, with two main transmission lines, one running from Mono Lake northeastward into Nevada and the other southeastward to connect with the main Nevada-California Power system at the control station near plant No. 5 on Bishop Creek.

The entire outstanding capital stock, except directors' qualifying shares of the Central California Electric Corporation, holding com-

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[47] The Central California Electric Corporation was organized under the laws of Delaware January 22, 1915, with a capitalization of $10,000,000, divided into $5,000,000 preferred and $5,000,000 common stock. It authorized a first-lien bond issue of $7,500,000 on April 1, 1915, of which $800,000 par value was at one time reported outstanding. At a later date a second lien of $1,500,000 was authorized and bonds to the full amount of the issue were reported outstanding. A large part of these securities were issued against those of the Pacific Power Corporation, owned by the Central California Electric Corporation. Important readjustments were made before the end of 1916, so that on December 31 of that year only $23,000 of the first and $11,570 of the second lien bonds were outstanding.

pany for Pacific Power Corporation, having been acquired by The Nevada-California Electric Corporation, holding company for The Nevada-California Power system, Pacific Power Corporation sold its entire properties May 29, 1917, to The Nevada-California Power Co., also controlled by the electric corporation.

THE NEVADA-CALIFORNIA ELECTRIC CORPORATION.

Up to 1915 The Nevada-California and The Southern Sierras power companies were both holding and operating companies, but in March, 1915, The Nevada-California Electric Corporation was organized as a holding corporation for all but directors' qualifying shares of The Nevada-California Power Co., The Southern Sierras Power Co., Interstate Telegraph Co., Bishop Light & Power Co.,[48] Corona Gas & Electric Light Co.,[48] Hillside Water Co., and Sierras Construction Co.

Aside from the above, which are primarily operating companies, The Nevada-California Electric Corporation controls the following:

Cain Irrigation Co. is a subsidiary owning lands and water rights in Mono Lake basin and controlling through stock ownership California-Nevada Canal Water & Power Co., which also owns rights in the same territory.

Silver Lake Power & Irrigation Co. is a nonoperative organization which at one time started power developments near Owens River gorge.

Deseret Water, Oil & Irrigation Co. is a small subsidiary owning nonoperative property in Owens Lake basin, and its only operative property is the auxiliary steam station in Tonopah.

MARKET.

TERRITORY AND POPULATION.

The Nevada-California Power Co. operates plants in Inyo and Mono counties, Calif., and sells electricity in Esmeralda, Mineral, and Nye counties, Nev.; The Southern Sierras Power Co. operates in Inyo, Mono, San Bernardino, Riverside, and Imperial counties, Calif. The physical and industrial conditions in these counties are briefly described on pages 450–453, and their area and population are shown in Table 76 (p. 449).

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[48] Properties since sold to The Southern Sierras Power Co.

TABLE 153.—*Incorporated communities served by The Nevada-California* Power *system*.

[All in California.[a]]

City or town.	County.	Population.			
		1890	1900	1910	1920
Banning	Riverside				1,810
Bishop	Inyo			1,190	1,304
Blythe				350	1,622
Corona	Riverside		1,434	3,540	4,129
Elsinore	do		279	488	633
Hemet	do			992	1,480
Perris					499
Redlands			4,797	10,449	9,571
Rialto				1,200	961
Riverside			7,973	15,212	19,341
San Bernardino	San Bernardino	4,012	6,150	12,779	18,721
San Jacinto	Riverside	661	583	898	945
		4,673	21,216	47,098	61,016

[a] Yuma and Sommerton, Ariz., are served by Arizona utilities that purchase at wholesale from The Nevada-California system on the California side.

The unincorporated places served are listed below.

In California.

Atolia.
Barstow.
Big Pine.
Borosolvay.
Coachella.
Indio.
Inyokern.
Keeler.
Oro Grande.
Randsburg.
Trona.
Therma.
Victorville.
West End.

In Nevada.

Belmont.
Divide.
Goldfield.
Hawthorne.
Manhattan.
Millers.
Round Mountain.
Silver Peak.
Tonopah.

LOAD.

Classified sales in kilowatt-hours and connected load for The Nevada-California Power Co., 1913–1920, and The Southern Sierras Power Co. for the same years are given in Table 154. Similar data for Holton Power Co., operated by The Nevada-California Power system under lease, will be found in Table 171.

Sales and connected load reported by The Nevada-California Power Co. under industrial power are almost entirely mining load in Nevada. Practically the only load of this class on The Southern Sierras system is along the tower line from Bishop Creek to San Bernardino. The principal power load on the Southern Sierras system is in the San Bernardino and Riverside district and southeastward.

A consolidated statement of classified power load for the entire Nevada-California system, including all companies, for the year 1920 is given in Table 155, which also gives the average rate of revenue per kilowatt-hour and the revenue per horsepower connected.

TABLE 154.—*Sales and connected load on lines of The Nevada-California and The Southern Sierras Power companies, 1913–1920.*

The Nevada-California Power Co.

Class of load.	1913				1914			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	178,719	0.3	917	5.3	350,918	0.6	1,404.67	7.2
Commercial	728,104	1.3	742	4.3	691,998	1.1	824.61	4.2
Municipal	107,088	.1	....	....	106,377	.2	24.81	.1
Power: Industrial	56,057,631	98.3	15,745	90.4	59,322,746	98.1	17,392.5	88.5
	57,071,542	100.0	17,404	100.0	60,472,039	100.0	19,646.59	100.0

Class of load.	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	394,038	0.7	1,466.61	7.9	447,854	0.9	1,540.2	8.6
Commercial	705,411	1.2	816.11	4.4	739,144	1.4	784.7	4.4
Municipal	111,435	.2	25.61	.2	95,197	.2	27.2	.2
All other	126,997	.3	80.16	.4	100,269	.3	8.7	....
Power:								
Industrial	56,143,860	97.6	16,051.20	87.1	49,620,868	97.2	15,430.8	86.6
All other	....	....	....	....	9,604	....	39.3	.2
	57,481,741	100.0	18,439.69	100.0	51,012,936	100.0	17,830.9	100.0

Class of load.	1917				1918			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	421,019	0.7	1,511.0	7.7	340,484	0.6	1,100	6.5
Commercial	774,322	1.0	929.0	.4	642,458	1.2	916	5.4
Power:								
Industrial	56,066,854	98.3	16,914.0	91.9	50,925,666	98.2	14,856	88.1
All other	9,902	....	7.5	....	6,661	....	5	....
	57,272,097	100.0	19,361.5	100.0	51,915,269	100.0	16,877	100.0

TABLE 154.—*Sales and connected load on lines of The Nevada-California and The Southern Sierras Power companies, 1913–1920*—Continued.

The Nevada-California Power Co.—Continued.

Class of load.	1919				1920			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	360,582	1.2	469	2.8	437,441	1.4	578	3.3
Commercial	670,958	2.2	506	3.0	684,032	2.1	527	3.0
Power:								
Industrial	28,054,876	94.1	15,585	91.9	30,349,664	96.4	16,400	93.6
All other	869,961	2.5	395	2.3	6,145	.1	10	.1
	29,956,377	100	16,955	100	31,477,282	100	17,515	100

The Southern Sierras Power Co.

Class of load.	1913				1914			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	....	....	955.6	6.4	....	....	1,610.9	15.7
Commercial	676,365	8.3	606.3	4.1	767,388	1.7	434.8	4.2
Municipal	....	....	4.0	....	39,861	.1	15.67	.1
All other	....	....	3.8	....	....	....	....	....
Power:								
Industrial	....	....	4,893.5	32.7	....	....	....	....
Agricultural	7,528,081	91.7	8,469.0	56.6	27,061,105	61.9	1,114.9	10.8
All other	....	....	1.0	....	....	....	3,055.2	....
Municipal	....	....	....	....	2,140,900	4.9	1,053.6	10.3
Commercial	....	....	....	....	13,748,270	31.4	....	58.9
	8,204,446	100.0	14,933.2	100.0	43,757,524	100.0	10,285.07	100.0

Class of load.	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	....	....	1,927.0	15.1	....	....	2,098.7	14.0
Commercial	861,759	2.0	467.0	3.6	1,029,956	2.4	590.5	4.0
Municipal	....	....	34.0	.1	....	....	29.0	.1
All other	....	....	....	....	....	....	....	....
Power:								
Industrial	24,463,036	57.5	3,469.0	27.1	....	....	5,191.0	34.5
Agricultural	....	....	5,633.0	43.9	41,455,593	97.6	5,212.0	34.7
All other	17,230,938	40.5	1,308.0	10.2	....	....	1,905.5	12.7
Municipal	....	....	....	....	....	....	....	....
Commercial	....	....	....	....	....	....	....	....
	42,555,733	100.0	12,838.0	100.0	42,485,549	100.0	15,026.7	100.0

The Southern Sierras Power Co.—Continued.

TABLE 154.—*Sales and connected load on lines of The Nevada-California and The Southern Sierras Power companies, 1913–1920*—Continued.

Class of load.	1917				1918			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	....	....	2,348.6	7.7	731,868	0.9	3,239.3	9.4
Commercial	1,115,000	29.3	584.3	.1	913,455	1.2	858.8	2.3
Municipal	....	....	29.6	.0	....	....	67.5	.0
All other	....	....	....	....	....	....	....	....
Power:								
Industrial	....	....	7,060.0	22.5	27,009,699	34.4	9,025.5	26.4
Agricultural	36,927,100	70.7	5,885.0	19.5	17,384,546	22.0	8,218.4	24.0
All other	....	....	2,200.0	7.2	251,636	.3	[a] 2,212.2	6.4
Municipal	....	....	2,348.6	7.7	2,607,319	3.3	1,257.5	3.5
Commercial	....	....	10,577.0	35.3	29,795,241	37.9	9,277.6	27.0
	38,042,100	100.0	29,949.5	100.0	78,693,764	100.0	34,156.8	100.0

Class of load.	1919				1920			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	762,332	0.7	3,639	8.8	936,777	0.9	4,690	9.9
Commercial	951,851	.9	862	2.1	1,159,825	1.2	1,169	2.5
Municipal	....	....	69	.2	....	....	....	....
All other	....	....	....	....	....	....	....	....
Power:								
Industrial	32,929,086	31.4	12,639	30.9	37,805,343	38.2	14,706	31.1
Agricultural	20,628,469	19.6	10,180	24.9	24,054,346	24.3	11,388	24.1
All other	296,460	.3	1,285	3.2	412,625	.4	1,058	2.2
Municipal	2,887,881	2.8	1,257	3.1	2,570,581	2.6	1,340	2.8
Commercial	46,506,069	44.3	10,980	26.8	32,020,370	32.4	12,939	27.4
	104,962,148	100.0	40,911	100.0	98,959,867	100.0	47,290	100.0

[a] Includes heating, 606 kilovolt-amperes.

TABLE 155.—*Classified connected power load, sales, revenues, and average rates, The Nevada-California Power system (all companies, Holton Power Co. included), 1920.*

Class of business.	Average horse-power connected.	Sales.	Revenue.	Average rate per kilowatt hour.	Revenue per horse-power connected.
		Kilowatt-hours.		*Cents.*	
Mining	19,084	27,656,654	$409,858.08	1.43	$21.47
Cement mills	4,300	11,152,640	138,271.66	1.23	32.16
Soda-potash	5,650	12,395,769	166,186.88	1.34	29.41
Cotton gins and mills	1,500	1,929,809	48,264.64	2.50	32.17
Other industrial	17,886	28,981,484	672,067.16	2.31	37.57
Total mining and industrial	48,420	82,116,356	1,434,648.42	1.74	29.63
Irrigation	14,474	29,740,374	535,607.03	1.80	37.00
Grand total, all classes	62,894	111,856,730	1,970,255.45	1.76	31.33

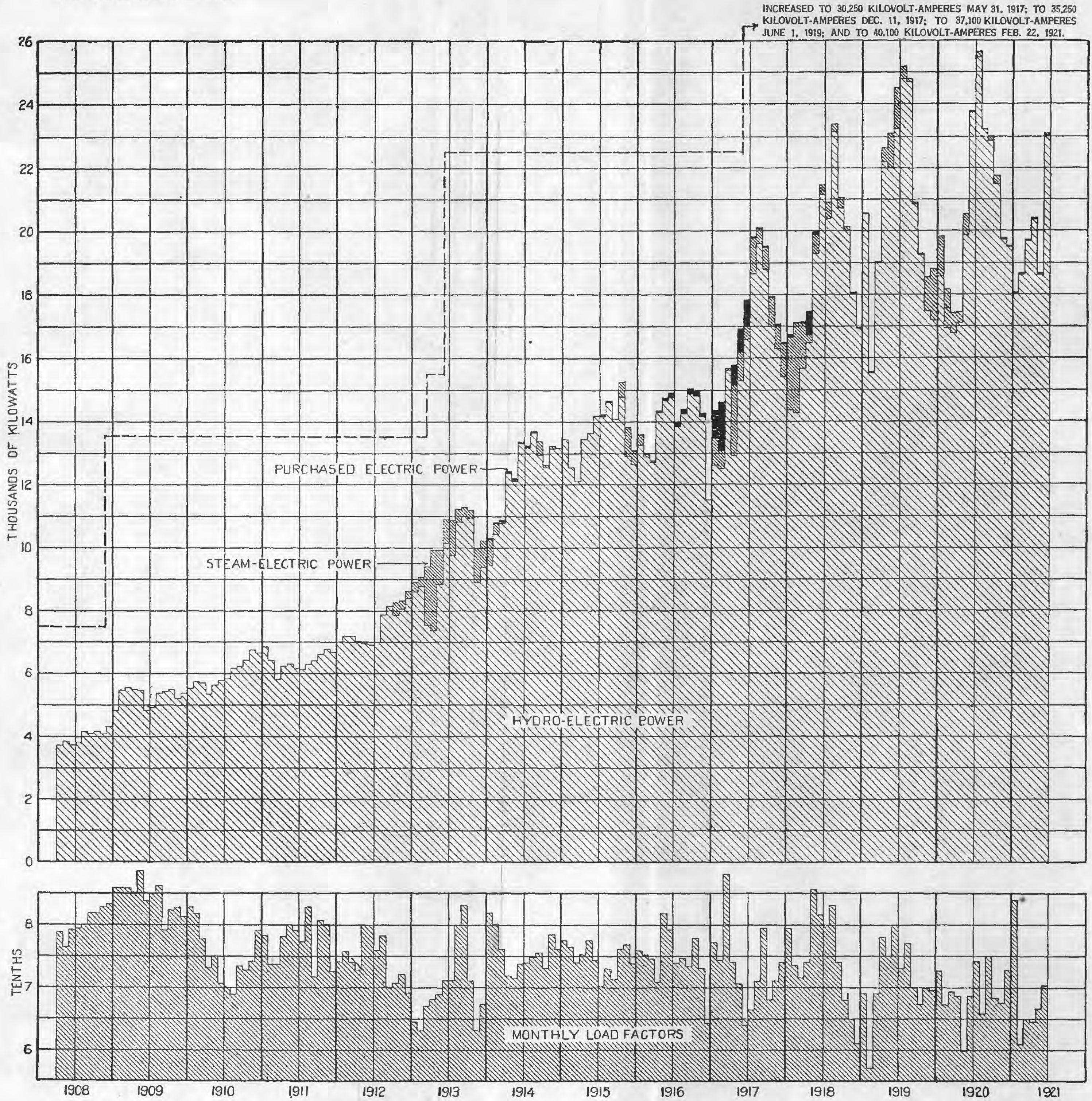
Power generated and purchased by The Nevada-California Power Co. is given in Table 156, similar information for The Southern Sierras Power Co. in Table 157, and for the Pacific Power Corporation (acquired by The Nevada-California Power Co. May 31, 1917), in Table 158. These tables include intercompany sales. Mean monthly loads for the entire Nevada-California system, including power delivered to the Holton system before it was leased and power delivered to and generated on that system after it was leased, are shown graphically in Plate LXVIII; in plotting the plate intercompany sales were eliminated. It is based on the output of the various generating stations. The plate represents not only power delivered to customers but power lost in transmission.

TABLE 156.—*Power generated and purchased by The Nevada-California Power Co., 1905–1920.*

Year.	Power generated.[a]	Power purchased.	Total.	Mean load.	System peak.	System load factor.
	Kilowatt-hours.	*Kilowatt-hours.*	*Kilowatt-hours.*	*Horse-power.*	*Horse-power.*	*Per cent.*
1905	523,731		523,731	318	410	77.6
1906	5,501,251		5,501,251	843	1,180	71.5
1907	14,867,760		14,867,760	2,271	3,250	70.0
1908	32,470,348		32,470,348	4,955	6,900	71.8
1909	46,201,645		46,201,645	7,070	9,070	77.8
1910	52,145,507		52,145,507	7,979	11,300	70.6
1911	55,652,300		55,652,300	8,516	11,300	75.3
1912	66,001,450		66,001,450	10,072	13,900	72.5
1913	64,697,900	[b] 18,799,462	83,497,362	12,777	19,300	66.1
1914	84,336,900	[c] 15,954,380	100,291,280	15,347	17,600	87.2
1915	96,247,600	10,120,714	106,368,314	16,277	18,000	90.3
1916	59,377,000	5,096,142	64,473,142	9,839	18,000	54.6
1917	62,429,000	6,414,360	68,843,360	10,535	16,000	65.8
1918	56,339,700	9,852,183	66,191,883	10,129	15,400	65.7
1919	42,677,100	7,333,690	50,010,790	7,653	13,700	55.8
1920	43,255,900	3,568,050	46,823,950	7,146	13,700	52.2

[a] All hydro; no steam plants operated.
[b] April to December inclusive.
[c] Purchased from plants 5 and 6 and San Bernardino steam plant.

NOTE.—Monthly mean loads, peaks, and load factors are computed for The Nevada-California Power Co. alone, excluding deliveries to other companies.



NEVADA-CALIFORNIA AND SOUTHERN SIERRAS POWER SYSTEMS, MEAN MONTHLY LOADS AND LOAD FACTORS, 1908–1921

TABLE 157.—*Power generated and purchased by The Southern Sierras Power Co., 1912–1920.*

Year.	Hydro-electric power generated.	Steam electric power generated.	Total power generated.	Power purchased.	Total power generated and purchased.	Mean load.	System peak.	System load factor.
	Kilowatt-hours.	*Kilowatt-hours.*	*Kilowatt-hours.*	*Kilowatt-hours.*	*Kilowatt-hours.*	*Horse-power.*	*Horse-power.*	*Per cent.*
1912		1,526,450						
1913	17,197,560	7,593,533	24,791,033	[a] 6,724,800	31,515,833	4,823	8,300	58.0
1914	23,175,000	1,328,220	24,503,220	[b] 23,149,386	47,652,606	7,292	10,600	68.8
1915	22,610,500	1,321,075	23,931,575	32,795,400	56,726,975	8,681	12,200	71.2
1916	57,096,000	785,950	57,881,950	332,050	58,214,000	8,884	13,500	65.8
1917	71,409,700	7,335,000	78,744,700	[c] 3,304,510	82,049,210	12,555	24,500	51.2
1918	[d] 104,960,375	6,282,900	111,243,275	[e] 1,256,650	112,499,925	17,215	28,200	61.0
1919	[f] 137,945,500	4,317,700	142,263,200	6,427,400	148,690,600	22,753	40,600	56.0
1920	136,318,250	3,300,900	136,619,150	[g] 1,841,425	141,460,575	21,588	37,800	57.1

[a] Part from Southern California Edison Co. at San Bernardino (515,200 kilowatt-hours), balance (6,209,600) from The Nevada-California Power Co.
[b] Southern California Edison Co. at San Bernardino 139,400 kilowatt-hours and The Nevada-California and Pacific Power at control 23,009,986 kilowatt-hours.
[c] Purchased at Colton and Barstow.
[d] Includes plant 2 August to November and Rush Creek for full year operated under lease.
[e] Southern California Edison Co. 623,350 kilowatt-hours, The Nevada-California Power Co. 633,300 kilowatt-hours.
[f] Includes Mill Creek plant November and December on account of plant leased by The Southern Sierras Power Co.
[g] Includes 2,300 kilowatt-hours from Green Creek.

NOTE.—Hydro power generated at plants 3, 5, and 6, Rush Creek and Blythe, and steam generated at city of San Bernardino in 1917.

TABLE 158.—*Power generated and purchased by Pacific Power Corporation, 1913–1917.*

Year.	Power generated.[a]	Power purchased.	Total.	Mean load.	System peak.
	Kilowatt-hours.	*Kilowatt-hours.*	*Kilowatt-hours.*	*Horse-power.*	*Horse-power.*
1913	6,235,071	[b] 271,920	6,506,991	996	
1914	8,320,350	2,313,440	10,633,790	1,627	4,000
1915	7,530,930	6,462,030	13,992,960	2,141	4,420
1916	12,070,400	3,643,160	15,713,560	2,398	3,350
1917	[c] 6,200,150	2,006,400	8,314,550	3,075	

[a] All hydro, no steam plants operated.
[b] Purchased from The Nevada-California Power Co. in December.
[c] Jan. 1 to May 31, 1917, when system was taken over by the Nevada-California Power Co.

Daily load curves for The Nevada-California system, including all companies operated and leased at the date of the curves, are shown in figure 38. Separate curves for Pacific Power Corporation prior to its acquisition by The Nevada-California system are shown in figure 39. In the latter curves power purchased was received from The Nevada-California Power Co. (See also fig. 40.)

Growth in number of consumers for The Nevada-California Power Co. is shown in Table 159, for The Southern Sierras Power Co. in Table 160, and for Pacific Power Corporation up to the year of its acquisition by The Nevada-California Power Co. in Table 161.

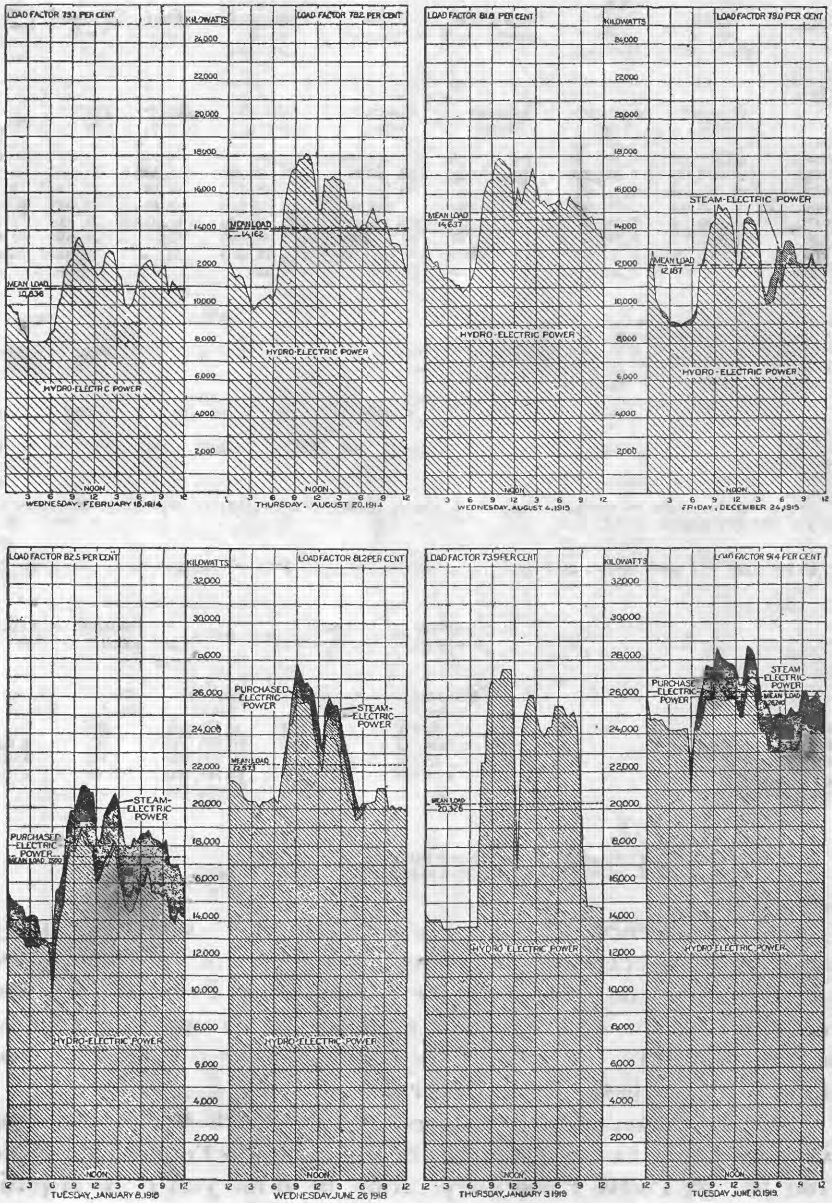
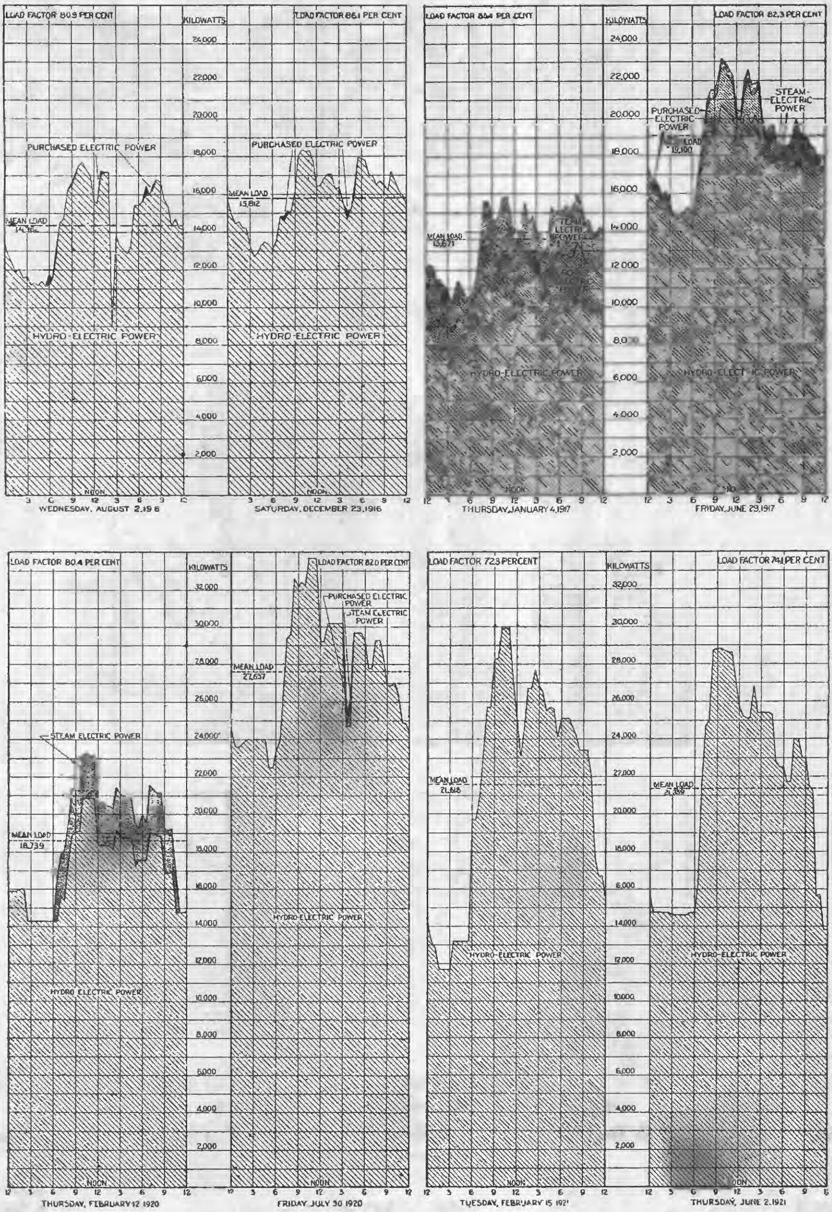


Figure 38.—The Nevada-California Power



system, daily load curves, 1914–1921.

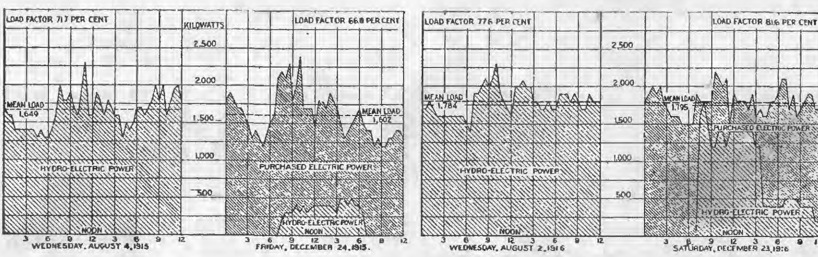


FIGURE 39.—The Nevada-California Power system (Pacific Power Corporation), daily load curves, 1915-16.

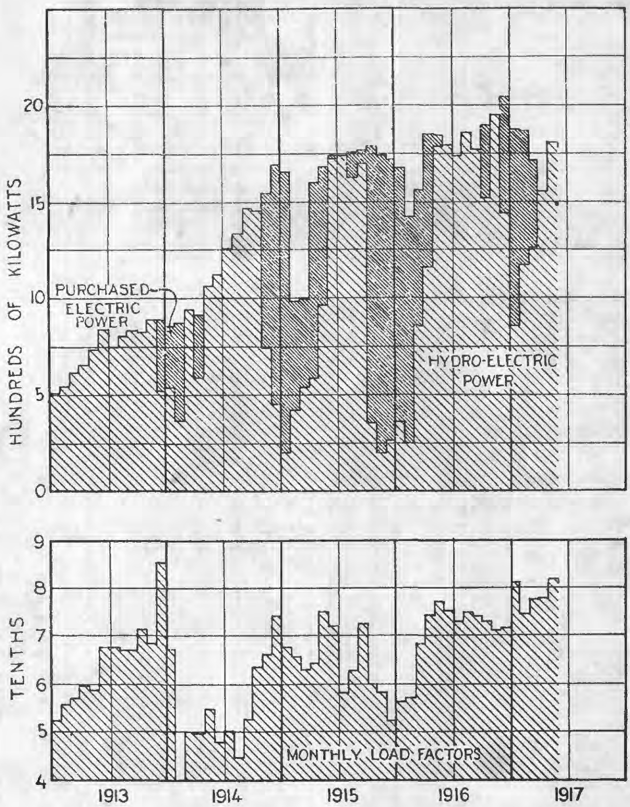


FIGURE 40.—Pacific Power Corporation, mean monthly loads and load factors from 1913 to date of absorption by The Nevada-California Power system.

TABLE 159.—*Growth in number of consumers on the system of The Nevada-California Power Co.*

	Consumers.		Consumers.
1908	1,305	1915	2,500
1909	1,849	1916	2,594
1910	1,935	1917	2,400
1911	1,960	1918	1,907
1912	2,089	1919	2,111
1913	2,095	1920	2,029
1914	2,429		

TABLE 160.—*Growth in number of consumers on the system of The Southern Sierras Power Co.*

	Consumers.		Consumers.
1912	972	1917	3,888
1913	1,565	1918	5,817
1914	2,516	1919	6,288
1915	2,926	1920	7,211
1916	3,408		

TABLE 161.—*Growth in number of consumers on the system of Pacific Power Corporation.*

Year.	Lighting consumers.	Power consumers.	Year.	Lighting consumers.	Power consumers.
1911	29	5	1914	110	7
1912	36	5	1915	98	10
1913	52	4	1916	90	8

In addition to the consumers listed in these tables, Coachella Valley Ice & Electric Co. served 220 in 1916 and 311 in 1917; Corona Gas & Electric Light Co. served 827 in 1916 and 709 in 1917; Rialto Light, Power & Water Co. served 292 in 1916 and 246 in 1917; and Bishop Light & Power Co. served 401 in 1916 and 428 in 1917.

ELECTRIC SYSTEM.

BISHOP CREEK PLANTS.

SOURCE OF WATER SUPPLY.

Bishop Creek, like all the streams draining the east slope of the Sierra in Owens Valley, is noteworthy for the altitude of its basin and for its heavy gradient. The basin (see Pl. LXIX) is small and irregular, and measures, above the mouth of the canyon, about 15 miles in maximum length north and south by 9 miles at its broadest point. The plants now in operation are numbered down the stream from plant No. 2 to plant No. 6, and utilize the entire available head from an elevation of 8,050 feet (the intake of plant No. 2) down to 4,459.5 feet (the nozzle of plant No. 6). Barely enough space intervenes between plants for the discharge from one to clear the intake pond of the next below. Above plant No. 2 there are two unutilized sites, which will be designated plant A and plant No. 1.

The elevation at the intake of plant No. 6, which is on the débris fan just below the mouth of the main canyon, is 4,719 feet above sea level; from this point the rise is rapid, and on the southwest boundary, along the crest of the Sierra, elevations range from 11,000 to about 14,000 feet. Along this crest are the sources of the three forks of Bishop Creek. The source of North Fork is in the vicinity of Piute Pass, that of Middle Fork on the side of Mount Haeckel, and that of South Fork in the amphitheater between Mount Thompson and Agassiz Needle. North Fork, flowing eastward, and Middle Fork, flowing northeastward, unite in the north-central part of the drainage basin and about 3 miles below their junction the stream formed by the two is joined by South Fork, which flows almost due north from its source. The upper part of the region, above the junction of the three forks, is a rugged, rocky basin cut by the ridges between the three branches. Below the junction the main stream flows northeastward through a deep canyon which is about 4 miles wide at its top. About 7 miles below the mouth of South Fork the stream enters Owens Valley, and below the mouth of the main canyon has built an extensive alluvial fan with very steep slopes.

To those familiar only with the western slope of the Sierra, it is difficult to convey an idea of the tremendous drop and awe-inspiring ruggedness of the eastern scarp. A slight understanding of the character of the country may be obtained from Plate LXX, *A*. A study of Plate LXIX shows that from the crest of the range, near the head of Middle Fork, to power house No. 4, at the mouth of the main canyon, a distance of 14½ miles in an air line, the total drop is about 9,000 feet. Between the reservoirs and plant No. 4 the stream drops at the rate of 350 feet per mile.

The rocks exposed in the Bishop Creek basin are almost entirely granitic, and the main ridge that forms its southwestern boundary is an unbroken series of tremendous pinnacles and domes. A broad belt of reddish mineralized rock, the exact nature of which the writer is unable to ascertain, runs north and south through the central part of the basin, but in comparison with the large area of fully exposed granite this belt is of minor importance.

The region is sparsely forested. There is probably more timber on the Middle Fork of the stream than on any other part of the basin, but even there the timber is stunted and is not of a first-class quality. Below the mouth of South Fork the vegetation consists of a scattering growth of Digger pines, with junipers along the crests of some of the ridges and a dense growth of sage brush on the side hills.

The mean seasonal precipitation in the basin ranges from 10 to 35 inches, and a very large part of it occurs in the form of snow that falls to great depths in the high regions. The one glacier at the head of Middle Fork is too small to have a marked effect on stream flow. The snow fields furnish an abundant supply of water during the summer but in the fall the stream flow gradually dwindles, and the water is drawn from Sabrina and South Lake reservoirs. The time of greatest uncertainty in regard to water supply comes early in winter, say the middle of December to the end of January—when the intense cold of the higher altitudes freezes the tributaries and the rains have not yet begun in the lower parts of the basin.[49]

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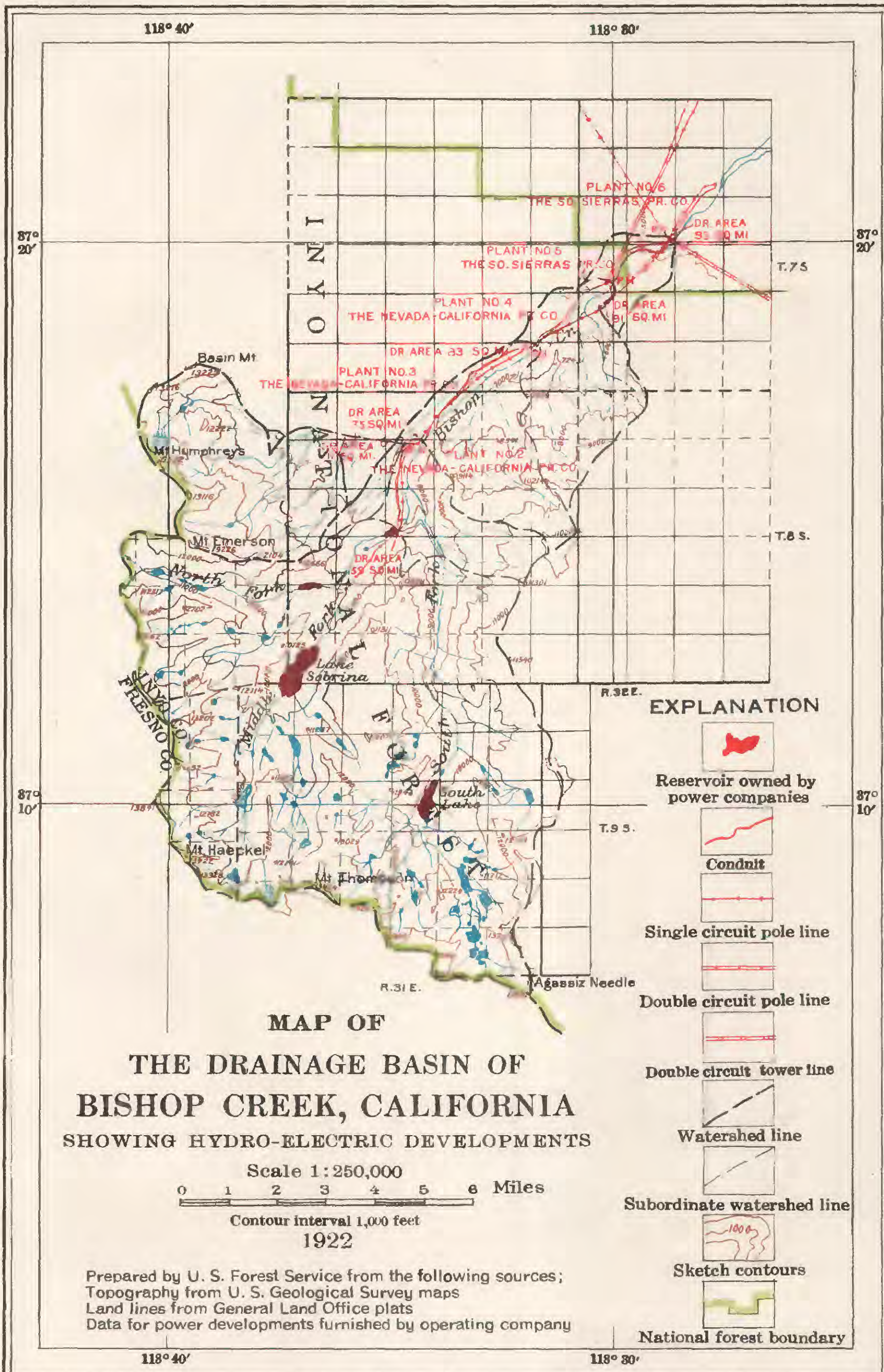
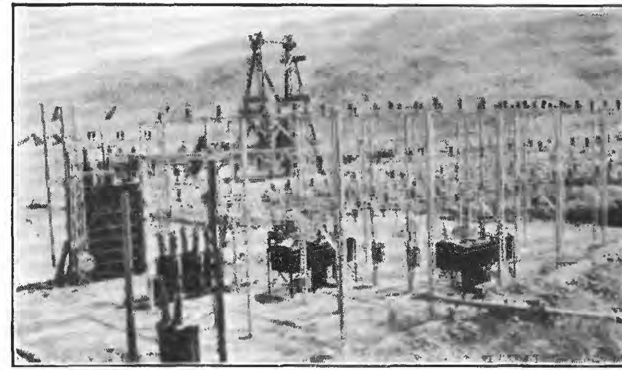
[49] For records of discharge of Bishop Creek to July, 1912, see U. S. Geological Survey Water-Supply Paper 300, pp. 287–296, 1913. See also Lee, C. H., An intensive study of the water resources of a part of Owens Valley: U. S. Geol. Survey Water-Supply Paper 294, 1912. This paper describes the streams just south of Bishop Creek.



ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY

A. HEADWATERS OF BISHOP CREEK.

Photograph by W. L. Huber.



B. CONTROL STATION AT NORTH END OF SOUTHERN SIERRAS TOWER LINE.

Photograph by C. O. Poole.

C. BISHOP CREEK POWER HOUSE NO. 5, AND INTAKE OF PLANT NO. 6, NEVADA-CALIFORNIA POWER SYSTEM.

D. BISHOP CREEK POWER HOUSE NO. 4 AND INTAKE OF PLANT NO. 5, NEVADA-CALIFORNIA POWER SYSTEM.

Photograph by W. L. Huber.

RESERVOIRS.

There are only three artificial reservoirs in the Bishop Creek drainage basin—North Lake, Sabrina reservoir, and South Lake, sometimes referred to as the Hillside reservoir. North Lake is very small, the works controlling it are unimportant, and the amount of storage involved is so insignificant that no description is needed.

Sabrina reservoir, on Middle Fork, has a capacity of 325,000,000 cubic feet and a water surface area of 159 acres. Sabrina dam is a rock-fill structure, 75 feet in maximum height and 1,065 feet in length along the crest. It was completed in 1910. The crest width of the dam is 10 feet, and the slopes are 0.75 horizontal to 1 vertical on the upstream and 1¼ horizontal to 1 vertical on the downstream side. The structure contains 47,000 cubic yards of fill. Round facing timbers, adzed to a flat surface on the outer side, are embedded in the upstream surface of the dam and are anchored back into the fill by iron tie-rods. A facing of 3-inch planks, laid horizontally, is spiked to these timbers. From the crest down to a point about 40 feet below the crest of the dam there are two layers of plank, and below that level there are three layers of plank. Layers of tarred canvas were placed between the layers of plank. The lower edge of the plank sheathing is carried down into a concrete fill in a trench which was excavated in the bedrock of the foundation.[50]

The maximum water surface at spillway level is 6 feet below the crest of the dam, which has an elevation of 9,079 feet above sea level. The outlet is through three 24-inch steel pipes set in concrete and is 65 feet below spillway level. The pipes are fitted with hand-operated gate valves protected by a small frame house at the lower toe of the dam. Water reaches the pipes through concrete inlet boxes, two of which have grid covers and one an inclined grating. The concrete spillway, with ogee section and 120 feet crest length, is at the east end of the dam. A wing wall at the side of the spillway supports the rock fill of the dam, and serves as an anchorage into which the end of the sheathing is built.

The dam at South Lake, completed in the fall of 1910 and in the spring of 1911, forms what is sometimes known as the Hillside reservoir, the original dam at the site having been operated by the Hillside Water Co. in connection with a small irrigation project near the mouth of Bishop Creek Canyon. Water released from the reservoir can be utilized through Bishop Creek plants Nos. 2, 3, 4, 5, and 6 before reaching the irrigation intake, and since the water company is controlled by The Nevada-California Power Co., it is probable that the reservoir is operated chiefly as a power supply. By agreement

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[50] W. L. Huber, civil engineer, informs the writer that the original design of the dam contemplated the use of a layer of derrick-laid rock, 5 to 15 feet thick, on each face of the dam, but that this rock was omitted.

with the irrigators a maximum of about 106 second-feet flow has to be released from storage during the irrigating season, but this water does not necessarily come from South Lake.

The dam at South Lake is of the same type as that at Sabrina reservoir—that is, rock-fill with timber sheathing on the upper face. The capacity of the reservoir is about 600,000,000 cubic feet,[51] and its area is 175 acres. The dam has a maximum height of 85 feet and its length along the crest, which is 10 feet wide, is about 650 feet. The upstream slope of the dam is 0.75 horizontal to 1 vertical, and the downstream 1¼ horizontal to 1 vertical. The structure contains 83,733 cubic yards of rock fill. The timbers, to which the facing is spiked, are, like those in the Sabrina dam, round logs adzed flat on one side and tied into the structure by iron rods extending into the fill. These logs are spaced 6 feet center to center. The plank facing is similar to that on the Sabrina dam, but there are one, two, and three thicknesses of plank as the depth increases. Only the double and triple facings contain the canvas sheeting. The bottom of the sheathing is sealed into a concrete-filled trench. The elevation of the crest of the dam is 9,707.5 feet, and the floor of the spillway is 6 feet lower. The spillway is excavated through solid rock at the east end of the dam and is 40 feet wide. Two 24-inch steel waste pipes, laid through the base of the dam, provide an emergency outlet. Flow through these pipes is controlled by hand-operated gate valves placed at the toe of the dam.

The bedrock of the ridge on which the dam is constructed lies at a higher level than the bottom of the former natural lake. In order to get the benefit of the storage below the old lake surface, it was therefore necessary to tunnel through bedrock below the lowest point in the dam's foundation. The upper portal of this outlet tunnel is in the lake about 1,380 feet upstream, and the lower portal 600 feet downstream from the dam. The total length of the tunnel is about 1,980 feet; the elevation of its floor at its upper end is 9,571.4 feet and at its lower portal 9,560 feet; and its unlined section measures 5 by 7 feet. A vertical shaft excavated through bedrock to the tunnel joins it at a point about 340 feet from its upper portal. Flow through the tunnel is controlled by a 3 by 5 foot gate at the foot of this shaft and by a 3 by 5 foot hinged gate in the lower end of the tunnel, just above a 36-foot concrete bulkhead pierced by a 36-inch pipe fitted with a 36-inch hand-operated gate valve. With reservoir full the upper gate sustains a head of 130 feet.

BISHOP CREEK PLANT NO. 2.

Location.—Bishop Creek plant No. 2 was constructed by The Nevada-California Power Co. and began to generate power in Novem-

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[51] Manifold & Poole, engineers for the company, give these figures. Other authorities have stated capacities as low as 430,000,000.

ber, 1908. In point of time it was the third development on the stream, plants Nos. 4 and 5 having been completed previously. The regulating reservoir is in sec. 16, T. 8 S., R. 31 E., the conduit traverses secs. 9 and 16, T. 8 S., R. 31 E., the power house is in sec. 9, T. 8 S., R. 31 E.

Conduit.—Bishop Creek plant No. 2 receives its water supply from all three forks of Bishop Creek. The supply from the South Fork is diverted by means of a small timber crib and rock-fill dam, at an elevation of 8,177 feet and carried through a riveted-steel pipe line[52] 7,800 feet long and varying from 38 to 34 inches in diameter, to a regulating reservoir having a capacity of 115 acre-feet, on the Middle Fork.

An earth dam with concrete core wall and concrete ogee gravity-section spillway, approximately 28 feet high, forms the regulating reservoir.[53] The dam has a crest width of 4 feet, downstream slopes of 2 horizontal to 1 vertical, and upstream slopes of 2 or 3 horizontal to 1 vertical, the degree of slope depending on the material. The elevation of the crest of dam is 8,055 feet and that of the crest spillway 8,050 feet above sea level. The length of the spillway is 40 feet. Since the regulating reservoir is near the mouth of Middle Fork it receives directly the natural flow of Middle and North forks and stored water released from Sabrina reservoir.

The concrete intake chamber through which water is discharged from the reservoir into the head of the main pipe line has a gate in each end protected by trash tracks. Each gate measures 4 by 8 feet, is constructed of steel, and slides in vertical grooves. The concrete head chamber is separate from the dam and is placed out a little way in the reservoir. A 48-inch steel pipe leads out of the side of the box and passes through the dam. The wood-stave pipe which forms the conduit of plant No. 2 begins at the lower end of this short steel pipe. The elevation at the head of the pipe is 8,027 feet. The wood-stave section is 9,950 feet long and is laid on an average grade of 0.00392 (3.92 feet per 1,000) along the hillside. The grade line is benched back far enough for safety, and the pipe is protected by a rough, dry-laid rock wall on each side, with an earth filling and covering. The rock work is kept far enough from the pipe and carried high enough to give a minimum thickness of 1 foot of earth. This method of covering wood-stave pipe is followed in the lines supplying all the other plants.

On June 26, 1919, a branch pipe line was completed that diverts a supplementary supply from Birch Creek, the next stream northwest of Bishop Creek, and discharges into pressure pipe of plant No. 2.

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[52] This pipe from South Fork is a temporary expedient although of substantial construction; plant No. 1, when built, will divert South Fork at a higher level and discharge into the regulating reservoir, and the present pipes will be abandoned.

[53] The first dam at this site was washed out June 26, 1909.

The unregulated flow from the 8 square miles drainage area on the three branches of Birch Creek is diverted at an elevation of about 8,242 feet above sea level by small dams and branch pipe line into a 24-inch main feeder pipe 9,513 feet long that passes over a low place on the ridge to connect with plant No. 2 pipe at an elevation of 7,989 feet above sea level. The feeder intakes are in sec. 6, T. 8 S., R. 31 E., and the line traverses secs. 6, 5, 8, and 9 of that township.

In November, 1919, a second feeder was completed from McGee Creek northwest of Birch Creek with discharges into the Birch Creek line and delivers water through it to plant No. 2. McGee Creek feeder is an 18-inch steel pipe line, 1,263 feet long. The intake is in the SW. ¼ sec. 1, T. 8 S., R. 30 E., at an elevation of 9,125 feet above sea level. The pipe runs southward through the same section. McGee Creek drainage area above the intake is 3 square miles.

Pressure pipe.—On the crest of the hill directly above the power house, the wood-stave conduit pipe joins a 48-inch riveted pressure pipe 2,647 feet long. Near the junction of the two sections a standpipe 80 feet high and 48 inches in diameter rises from the steel line The elevations at various points along the conduit are as follows:

TABLE 162.—*Elevations along conduit of Bishop Creek plant No. 2.*

Point.	Elevation.	Distance below spillway level.
	Feet.	*Feet.*
Spillway level at equalizing reservoir	8,050	0
End of pipe at equalizing reservoir	8,027	23
Lower end of wood-stave pipe	7,992	58
Center of nozzles at power house	7,099	951

From the above table it will be seen that the static head ranges from 928 to 951 feet, depending on the fluctuation of water level in the equalizing reservoir. The effective head is reported as 875 feet.

The course of the steel pipe from the standpipe to the power house is very direct, and at frequent intervals the pipe is secured by means of concrete-block anchorages. About half the pipe is laid in a trench and the rest above ground, with its sides protected by dry-laid stone walls and its top covered with earth and stone in the same manner as the wood-stave pipe.

This pipe line of No. 2 plant has a total length of 2,646 feet, a uniform inside diameter of 48 inches, a thickness ranging from one-quarter to seven-eighths inch. At its lower end it runs parallel to the upstream side of the power-house foundation. Branches to the first two units are made through 45° steel Y's; the branch to the third unit is through a 30° steel terminal Y. After passing the first Y the pipe is reduced to a diameter of 40 inches, and after passing the second to 30 inches. The third Y, in addition to having a main branch to feed the third unit, has a smaller branch to feed the exciters and a 12-inch branch leading to a blow-off equipped with a 12-inch gate valve and nozzle. As the wheels discharge at right angles to the main axis of the pipe line and the power house, there remains an additional 45° turn in each branch pipe. This turn is made at the nozzles of the units.

Power house.—Bishop Creek power house No. 2 is on the northwest bank of the the main stream at an elevation of 7,099 feet. The power house proper consists of two buildings of reinforced concrete, covered with pressed-metal tile roofs, supported on steel trusses. The end of the generator building is toward the stream, so that its side lies parallel to the axis of the pressure pipe. The second building is the switch and transformer house, some 30 feet from the generator house, but unlike it, placed broadside to the creek. The main building measures 82 by 38 feet in plan and the transformer house 63 by 25 feet. Both are 18 feet 6 inches high to the lower chord of the roof trusses.

The generator house contains three units placed with shafts in line parallel to its long axis. On the downstream side of the room toward the switch house is the switchboard, and back of it are the 2,200-volt switches. The exciter units are arranged along the wall near one end of the switchboard. The high-tension switches and transformers are in the second building.

Hydraulic equipment.—Units Nos. 1 and 2 are operated by single overhung Pelton impulse wheels, each 76¼ inches in diameter and rated at 3,950 horsepower, with a speed of 300 revolutions per minute. Each wheel is equipped with a deflecting needle nozzle with hand-regulated needle, and the deflecting apparatus is controlled by a Pelton oil-pressure governor. Unit No. 3 is equipped with a Doble single overhung impulse wheel of the same type, rating, and speed as units Nos. 1 and 2 but 81 inches in diameter. This third wheel is operated by an automatic needle nozzle with auxiliary needle by-pass, which is controlled by a Lombard oil-pressure governor, type Q. Each supply pipe has a mechanically operated gate valve. The wheel housings of all these units have cast bases and sheet-metal hoods.

Generators.—The three 2,000-kilovolt-ampere generators are of the same type, Westinghouse revolving field 2,200-volt 525-ampere 3-phase 60-cycle alternating-current machines, operating at 300 revolutions per minute. Name-plate ratings show a capacity of 2,000 kilowatts, but the machines can carry 2,250 kilovolt-amperes each. The bearings are of the ordinary ring type and are bolted directly to the concrete of the foundations.

Exciters.—No. 1 exciter is a Westinghouse 6-pole 100-kilowatt 125-volt 300-ampere continuous-current machine, operated at 580 revolutions per minute by a single overhung 150-horsepower Pelton impulse wheel. No. 2 exciter is a motor generator formed by adding a Westinghouse CCL 140-horsepower 2,200-volt 36.5-ampere induction motor to a combined exciter unit of the same type as No. 1.

Transformers.—In the transformer house there are two banks of Westinghouse 1,000-kilowatt single-phase 60-cycle water-cooled transformers, three in each bank, with a seventh (or emergency) transformer, which may be coupled into either bank. The transformers are supported on cast-iron bases, which rest on rollers laid across the top of concrete beams rising about a foot from the floor. By means of these rollers the transformers may be moved along the top of the beams to a track which runs beside the banks, and on reaching the track they can be rolled onto a steel truck and then wheeled along the track out of the doors at either end of the house. The transformers are connected delta on the low and Y on the high tension side to give a line potential of 55,000 volts.

The two 3-phase cast-iron tub oil switches are placed on concrete beams above the transformer track.

Wiring.—The switching apparatus in the station is very simple. Leads from the generator pass through ducts in the floor to the type D oil switches back of the switchboard and thence to the generator bus. From the generator bus insulated cables are carried through concrete ducts with cast-iron floor covers to the switch house, where they are connected to a type F 2,000-ampere electrically operated remotely controlled oil circuit breaker, and from this breaker they are led to type B oil switches, which are in turn connected to the low-tension transformer busses, there being a type B oil switch on each of the transformer banks.

The high-tension outlets are square double-glazed windows. No lightning arresters are installed at this station, the nearest protection of this nature being the set in operation on the lines leaving the control station near plant No. 5, approximately 6 miles from plant No. 2. The line from plant No. 2 and all other stations on Bishop Creek runs directly to the control station, where it is tied into a central bus system.

BISHOP CREEK PLANT NO. 3.

Location.—Bishop Creek plant No. 3 was constructed by The Southern Sierras Power Co. in 1912 and 1913 and began operation on June 12, 1913. Its construction was antedated by plants Nos. 4, 5, and 2. The intake is in sec. 9, T. 8 S., R. 31 E., the conduit traverses secs. 3, 4, and 9, T. 8 S., R. 31 E., and secs. 34, 35, and 36, T. 7 S., R.

31 E.; the power house is in sec. 36, T. 7 S., R. 31 E., on the northwest bank of Bishop Creek.

Conduit.—The intake dam for No. 3 conduit is constructed of reinforced concrete and is a very thin arch sustained by counterforts; the spillway, however, has an ogee gravity section. The dam is similar in type to the dams at the heads of Nos. 4, 5, and 6 conduits, and a detailed description of one will cover all.

The bottom of Bishop Creek canyon at the dam site is filled with a mass of débris and boulders which makes it impossible to carry the foundation of a dam of this kind down to bedrock. In preparing for the foundations, therefore, the creek bed was cleared, down to moderately firm material, compacted rock was placed on the cleared surface, and a thick reinforced-concrete apron was laid on the rock. A cut-off wall was carried down below the upstream edge of the apron to a depth which varied with the nature of the material encountered and with the height of the dam at that point.

At the intake of plant No. 3 the width of the apron up and down stream varies from about 5.5 to 16 feet, and the depth of the cut-off wall from about 6 to 10 feet. In thickness, the apron varies from 14 to 22 inches, and the cut-off wall has a uniform thickness of about 18 inches. The front face of the main wall or arch of the dam is vertical and the back face has a batter of 0.50 in 12. The thickness of the wall (or arch proper) at the top is 9 inches, but it is surmounted by a coping which is 18 inches wide, is flush with the front, and extends 9 inches back of the main wall. The extreme base of the main wall is thickened by two 45° slopes and rests on a line about one-third the width of the apron back from the upstream face of the cut-off wall. The counterforts supporting the arch wall slope down from its top to the back of the apron and vary in thickness from 14 to 22 inches.

The ogee spillway is constructed of concrete in which large rocks are embedded. The curve of the lower end of the ogee is continued into an upward turn, so that a concrete-lined water cushion about 18 inches in maximum depth is formed in the apron of the spillway. The stream bed for a short distance downstream from the concrete apron is paved with rock. A cut-off wall 2 feet 6 inches thick is carried down to firm material under the front of the spillway section; the bottom of the rest of the section is horizontal and the minimum thickness (2 feet 6 inches) of concrete is therefore under the water cushion.

The crest length of the dam is 220 feet. Beginning at the left, there are seven 16-foot panels supported at each end by counterforts; then the spillway with a 40-foot crest; then an intake chamber 18 feet wide at the head of the conduit; and finally three more panels. The radius of curvature of the dam is 320 feet. The maximum height of the structure is 17 feet above the apron, or about 27 feet above the lowest point in the foundations. The elevation of the crest of the dam is 7,089 feet of the crest of the spillway 7,085 feet, and of the center line of the outlet to the conduit pipe 7,074 feet. At each side of the spillway section there is also a 36-inch sluice pipe running through the concrete and emptying into the water cushion. The elevation of the center line of these pipes is 7,071.5 feet.

The concrete intake chamber is rectangular in plan, and water is admitted to its interior through two sliding steel gates, each 4 feet wide by 8 feet high. The head of the pipe line is protected by an inclined screen of flat steel bars set in the chamber. Water is discharged from the chamber through a bell section of steel pipe into the 60-inch wood-stave pipe of the conduit. Just at the lower end of the steel bell there is a short steel air-vent pipe which extends to the top of the intake structure.

The entire gravity line of the conduit is built of 60-inch wood-stave pipe, which is laid on a bench excavated in the hillside on a uniform grade of 0.004 (4 feet per 1,000) and covered with earth and rock in the same manner as that on the plant No. 2 line. The total length of this wood-stave pipe is 13,029 feet, and at its lower end it connects to the steel pressure pipe. At the point of connection there is an 80-foot vertical steel standpipe 54 inches in diameter, and about 1,000 feet from the lower end of the wood-stave line there is another 54-inch surge pipe, which, instead of being vertical, is laid in a trench up the hillside and over the crest of the saddle, so that it discharges into a neighboring drainage basin.

Pressure pipe.—The pressure pipe, which extends from the lower end of the wood-stave line to the power house, is part lap-riveted and part butt-riveted steel (no welded pipe is used, as in plant No. 4 pressure line). The total length of the steel pipe is 4,359 feet, of which 3,357 feet is lap-riveted pipe varying in thickness from three-sixteenths to one-half inch, and 1,002 feet is butt-riveted pipe varying in thickness from one-half to three-fourths inch. The diameter of the pipe varies from 54 to 48 inches. At its lower end the line runs diagonally toward the back wall of power house, and at the southwest corner of the building bends along the back wall. At the bend an 18-inch waste pipe was taken off and run along the upstream end of the power house through an Allis-Chalmers 10 per cent overload relief valve to the edge of the stream. This valve, however, has been removed and transferred to Rush Creek. The branches from the 48-inch main, back of the power house, to the 24-inch service pipes to the first two units are made through 24-inch cast-steel saddles, fastened to the side of the main. After the service pipes for two of the main units and the exciter have been taken from the 48-inch pipe its diameter is reduced to 24 inches and it turns through the back wall of the power house to supply the last of the three units. On the hillside above the power house the pipe line is laid in a trench and covered, and at eight different points it is secured by concrete pier anchorages.

As the elevation of the spillway level at the intake is 7,085 feet and the elevation of the power house is 6,276 feet the static head is 809 feet. The static head at the lower end of the wood-stave conduit is 63 feet.

Power house.—Bishop Creek power house No. 3 is built on the northwest bank of Bishop Creek with its main axis parallel to the stream. The water from the wheels is discharged straight out through arched raceways into the pool above plant No. 4 diversion dam. The power house is of reinforced concrete, with a metal-tile roof carried on steel trusses. In type the building is exactly like power house No. 2, but the transformer equipment, instead of being sheltered by a separate transformer house, is set in on a terrace near the downstream end of the power house.

The generator room, which occupies the entire interior of the building, is 82 feet long by 38.5 feet wide and 18.5 feet in clear height. The three main units are set in line along its main axis. The switchboard is parallel to the front wall, opposite the central unit, and far enough from the wall so that the low-tension equipment can be placed behind it, the rheostats being carried on a raised pipe frame above the board. The two exciter sets are in front of the first and second units. The pits which accommodate the gate valves and needle mechanism of the main water wheels extend nearly the full length of the back wall.

Hydraulic equipment.—Each unit is provided with a single Henry overhung impulse wheel, 73 inches in diameter on bucket centers; in wheels of this design the center is not a solid disk center but a spider, of the fly-wheel pattern, to the rim of which are bolted 15 buckets measuring 22.5 inches in width by 16 inches in height. The shape of the buckets is intermediate between the Pelton and the Doble types.

The service pipe for each unit enters through the back wall of the power house just below the floor line, and runs through an open pit to the needle nozzle. In this pit it passes through a 24-inch gate valve which can be operated either by hand or by a water motor. The needle nozzles are stationary and of 8-inch bore. The needles on the two outside units are regulated by hand and there is, in addition, a deflector hood, over the stream, operated by a Lombard governor, type M. The center unit is controlled by a Woodward governor which operates the needle of the nozzle and stream deflectors in conjunction with the automatic by-pass at the end of the power house.

Generators.—The three generators are Crocker-Wheeler 2,250-kilovolt-ampere 2,200-volt 590-ampere 3-phase 60-cycle alternators, operating at 300 revolutions per minute. The two pedestal bearings of each unit are bolted to the concrete of the power-house foundations.

Exciters.—The first of two exciter sets is a Crocker-Wheeler CCD 100-kilowatt 125-volt 800-ampere continuous-current generator, with a speed of 580 revolutions per minute, operated by a Henry impulse wheel fitted with a needle nozzle. The second set is like the first, with the addition of a 150-horsepower 2,200-volt 37-ampere 3-phase 60-cycle induction motor. The impulse wheels of these two units are supplied through a 6-inch pipe which leaves the 48-inch pressure line between the first and second main units and runs across under the floor of the plant to a Y near the exciters.

Transformers.—The transformers are set on a concrete foundation outside the power house and are so arranged that they can be rolled onto a car and transported to a repair pit when it is necessary. They are of the Westinghouse 2,000-kilovolt-ampere 2,200/55,000-87,000-140,000-volt single-phase outdoor type. They are connected delta on the low-tension and can be connected either delta or Y on the high-tension side. The line potential was originally 55,000 volts but is now 95,000 volts; the transformers are connected Y with grounded neutral.

Wiring.—The leads from the generators are carried through fiber ducts below the power-house floor to the generator oil switches on a steel framework in the rear of the switchboard, which contains five panels, one for each generator and one for each exciter. The generators are connected through these mechanically operated remotely controlled switches to a generator bus, which in turn connects through a 2,000-ampere type F oil circuit breaker and cables carried through ducts to the low-tension bus of the transformer bank. A single-pole disconnecting switch is installed in each circuit. Disconnecting switches are also provided on the high-tension side, and between the transformer high-tension bus and the line is a 3-pole air-break switch.

The transmission line running from plant No. 3 to the control station is supported on latticed steel poles with wishbone-type cross arms. In suspension strings the insulators consist of seven 10-inch disks; at dead ends eight units are used. The conductor is No. 0 stranded copper. The average length of span is 440 feet, and the poles are 56 feet in height, of which 6 feet is below the surface of the ground, set in substantial concrete footings.

BISHOP CREEK PLANT NO. 4.

Location.—The intake of plant No. 4 is in sec. 36, T. 7 S., R. 31 E., the conduit traverses secs. 36 and 25, T. 7 S., R. 31 E., and secs. 19

and 20, T. 7 S., R. 32 E.; the power house is in sec. 19, T. 7 S., R. 32 E., on the northwest bank of Bishop Creek.

Bishop Creek plant No. 4 was built by The Nevada Power Mining & Milling Co., the predecessor of The Nevada-California Power Co., and its first installation, consisting of two 750-kilovolt-ampere units, was put into operation September 20, 1905. A 1,500-kilovolt-ampere unit was ordered in December of the same year, and the capacity of the plant has since been increased by the addition of two more 1,500-kilovolt-ampere machines.

Conduit.—Plant No. 3 discharges directly into the pool formed by the new intake for plant No. 4. The first intake dam for No. 4 was about 300 feet downstream from the present structure, which was built in 1912. In type the new dam is the counterpart of the No. 3 headworks (p. 785) but is slightly larger. Its height is 25 feet, and its crest length 250 feet. The crest length of the spillway, which is near the center of the dam, is 50 feet, or 10 feet longer than that of No. 3 spillway. Two 36-inch sluices pierce the base of the spillway. The crest elevation of the dam is 6,272 feet and that of the spillway 6,267 feet above sea level.

Water is admitted into the intake chamber through a trash screen and a pair of 4 by 8 foot sliding gates. The head of the pipe in the downstream end of the chamber may be closed by a 68 inch by 68 inch emergency swinging gate hinged at one side. All the gates are operated by gears and handwheels from the deck on top of the box. Immediately below the hinged gate there is a short bell section of pipe which tapers from 60 inches to 52 inches. A short steel pipe air-inlet rises from this section to the level of the top of the structure. The lower end of the bell section connects to the pipe that led from the old dam by a section of wood-stave pipe 320 feet long.

The conduit originally consisted of 6,426 feet of 42-inch wood-stave pipe from the dam to the head of the main drop, but in 1915 this gravity line was replaced by 60-inch wood-stave pipe, and the 30-inch wood-stave section of the original pressure pipe was replaced by riveted steel pipe. Along the gravity line there is an air valve every 1,100 feet. The static head at the lower end of this section is about 64 feet, and it terminates in a steel Y, one branch of which contains a 30-inch and the other a 34-inch gate valve.

Pressure pipe.—Two pressure mains run by divergent routes from the Y to the power house.

The first line was made up of 1,063 feet each of 36-inch and 32-inch riveted steel pipe and 3,150 feet of 24-inch lap-welded steel pipe, the total length being 5,276 feet.

The 24-inch lap-welded pipe is of German manufacture. It was furnished in sections 30 feet long, with the different thicknesses of one-fourth, three-eighths, and one-half inch. This pressure line was anchored at various points by straps passing over it and fastened to bedrock by turnbuckles.

The second pressure line, running from the other branch of the Y to the power house, was installed at a later date and consists of 5,675 feet of riveted steel pipe, 30 inches in inside diameter, three-sixteenths to five-eighths inch thick. This line was put in to operate the two newer units but is cross-connected to the first line at the back wall of the power house.

The elevation of the spillway level at the intake is 6,267 feet, and the elevation at the power house 5,155 feet above sea level, giving a maximum static head of 1,112 feet; the working head is reported to be 1,053 feet.

Power house.—The generating station at plant No. 4 (Pl. LXX, *D*) comprises three main buildings. The power house proper is a reinforced-concrete building, 96 feet long by 32 feet wide, with a transformer bay, 66 feet long by 24 feet deep, on the side toward the creek. Its height is 17 feet 5 inches to the lower chord of the steel roof trusses which support its corrugated iron roof. The foundations are carried down into a bed of large boulders. The generators are placed in line, parallel to the long axis of the generator room and along its back wall. The switchboard is placed along the opening of the transformer bay (no longer in use), on line with the front wall of the main room. The track for a 10-ton hand-operated crane is supported on reinforced concrete girders. The discharge from the nozzles of the impulse wheels passes through tailraces running straight out under the main generator room floor and transformer bay, the discharged waters being immediately caught in a regulating reservoir at the head of the conduit to plant 5.

The switching apparatus was originally contained in a corrugated-iron switch house 50 by 85 feet in plan, and the lightning arresters in a third building, 30 by 9 feet, at the side of the switch house. In 1918 the switching system was changed, and the switch house has since been used as an office and storeroom.

Hydraulic equipment.—Each of the two 750-kilovolt-ampere units is provided with a single overhung Pelton wheel, rated at 1,450 horsepower, and operating at 450 revolutions per minute. Each wheel is supplied through a single deflecting needle nozzle. The deflecting mechanism is controlled by a Sturgess governor and the position of the needle is regulated by hand.

The first 1,500-kilovolt-ampere unit is operated by a 2,950-horsepower overhung Pelton impulse wheel with a speed of 400 revolutions per minute. This wheel receives its water through a single deflecting needle nozzle of 6-inch bore. The deflecting mechanism was originally controlled by a Lombard governor, type Q, and the position of the needle by hand, but the nozzle was later placed in a stationary position and provided with a hand deflector.

The second 1,500-kilovolt-ampere unit is operated by a 2,950-horsepower overhung Doble wheel and is fitted with a single 6-inch bore needle nozzle deflected by a Lombard governor, type Q; the needle of this unit is also regulated by hand.

The third 1,500-kilovolt-ampere unit is similar in every respect to the second, except that it is operated by a Doble automatic auxiliary needle nozzle controlled by a Doble-Lombard governor; on account of its excellent operating characteristics this unit is generally used to govern the entire system.

Oil for the governors is furnished by a motor-driven pump.

Generators.—The 750-kilovolt-ampere generators are National Electric Co. revolving-field 2,200-volt 197-ampere 3-phase 60-cycle machines, designed to operate at 450 revolutions per minute. The first 1,500-kilovolt-ampere generator is a Bullock 2,200-volt 394-ampere 3-phase 60-cycle machine, designed to operate at 400 revolutions per minute; the second and third 1,500-kilovolt-ampere generators are similar to the first in every respect but are more modern and are of Allis-Chalmers manufacture. All the units are of the revolving-field two-bearing type and the generator fields are mounted on the same shaft with their respective wheels. Generators Nos. 3, 4, and 5, on account of their earlier design and more liberal use of material, have since proved to have a capacity higher than that indicated on the name plates, 2,250 kilovolt-amperes being probably nearer their correct rating. The total plant capacity with this rating would be 6,750 kilovolt-amperes.

Exciters.—No. 1 exciter unit is a National Electric type NB, 60-kilowatt 140-volt 429-ampere continuous-current machine, operated at 850 revolutions per minute by a single 100-horsepower Pelton wheel. No. 2 exciter set is similar to the first, but may be operated as a motor generator by a General Electric form K 2,200-volt 75-horsepower motor, mounted on the same shaft. No. 3 exciter is a Doble motor-generator set consisting of a 100-horsepower overhung Doble wheel, operating at 625 revolutions per minute, controlled by a Replogle governor, a General Electric class 65 form B 55-kilowatt 440-ampere 125-volt continuous-current generator, and a General Electric type I form K 75-horsepower 18.5-ampere 2,200-volt 3-phase 60-cycle induction motor. Originally all the exciters were connected to the same bus, but in 1917 a double exciter bus was provided and double-throw field switches were installed on generator panels for units 3, 4, and 5.

Transformers.—The transformer equipment consists of one bank of three Stanley 500-kilowatt water-cooled single-phase transformers, stepping the 2,200 generator voltage up to 55,000; and two banks of three each (and a spare) Stanley 500-kilowatt shell-type single-phase transformers of the same ratio. All three banks are connected delta on the low-tension and Y-grounded on the high-tension side. The transformers are on a terrace near the north side of the power house.

Wiring.—The station was originally constructed practically in two parts and was provided with two separate switchboards, each containing four panels with ordinary equipment.

The line switching was reconstructed in 1917, and there is now one switchboard with three exciter panels, five generator panels, a totaling panel, and a station-equipment control panel.

The 2,200-volt bus is divided into two sections, to one of which the five generators and to the other the three banks of transformers are connected, all through nonautomatic oil switches. A 2,000-ampere 4,500-volt hand-operated oil switch is installed between the two sections of the bus and is used for switching the plant on or off the line as a unit.

From the low-tension transformer oil switches cables are carried through ducts in the floor to the low-tension bus of the transformers, which, with the high-tension bus and high-tension disconnecting switches, is supported on a pipe framework. The three banks of transformers are installed on a concrete terrace at the side of the generating station and are connected directly to the high-tension busses by means of single-pole disconnecting switches. The high-tension line leaving the station runs to the control station, where it is tied into the central or control bus.

BISHOP CREEK PLANT NO. 5.

Location.—The intake plant No. 5 (Pl. LXX, *D*) is in sec. 19, T. 7 S., R. 32 E. The conduit traverses secs. 17, 19, and 20, T. 7 S., R. 32 E. The power house is in sec. 17, T. 7 S., R. 32 E. The older part of the plant was put into operation by The Nevada-California Power Co. September, 1907, and is, therefore, next to the oldest development on Bishop Creek. An addition was made to the power house and a second unit installed during 1918 and 1919, beginning operation June 1, 1919.

Conduit.—The No. 5 intake dam is immediately below No. 4 power house and is of the same general type as the intake of plant 3 (pp. 785–786), but is not provided with an ogee spillway, nor is it arched in plan; the wing walls from the sides of the spillway bend upstream and not down. Water passing over the spillway drops vertically, its shock being absorbed by a water cushion at the base of the dam.

The dam is founded on boulders, is about 20 feet in maximum height and 335 feet long on the crest (including the length of the spillway—60 feet). The elevation of crest of dam is 5,144 feet and that of the spillway 5,139 feet above sea level. The two gates admitting water to the intake chamber are of the sliding steel type, 6 feet 6 inches by 5 feet. Over the head of the pipe, within the chamber is an emergency drop gate. The first section of the conduit is laid along a bench cut in the hillside and winds down the canyon to its mouth. The line is covered in the same manner as the conduits of the upper plants and consists of 3,500 feet of 54-inch wood-stave pipe, laid on a uniform grade of 0.004 (4 feet per 1,000). The static head on the lower end of this pipe is 32 feet, and at this point there is a steel Y with two 42-inch branches, provided with gate valves. The steel sections of the pressure pipes begin at the Y and run down the end of the hill and out on to the slope of a débris fan at the mouth of the canyon. Up to 1919 there was only one steel pressure pipe below the Y, consisting of 4,820 feet of riveted steel pipe 42 inches in diameter, varying in plate thickness from three-sixteenths to three-eighths inch. The second line is of practically the same design as the first, with the same plate thickness. Just below the Y there is a 12-inch standpipe in the line, and there are air valves in both the steel and wood-stave lines at intervals of about 1,000 feet.

The difference between the spillway elevation of intake dam, 5,139 feet, and the power house level, 4,732 feet, gives a maximum static head of 407 feet.

Power house.—As originally constructed, power house No. 5 measured 40 feet by 60 feet in plan, but when the second unit was added in 1919 a small L extension was added on the east side. The frame and roof trusses of the building are steel and the covering is corrugated galvanized iron. The station now contains 2 units. The pressure pipe for the old unit enters the end of the building and immediately passes through a 42-inch gate valve and branches through a Y to the nozzles of the impulse wheels. The discharge tunnel runs under the other end of the power house into the intake pool for plant No. 6. The new unit is installed in the L on the east side of the building, the pipe line connecting directly to a 24-inch hand-operated gate valve bolted to the scroll of the turbine. The transformer equipment originally in the generator room was replaced by 3 out-door transformers when the second unit was added. The 5-panel switchboard is located in the opposite end of the station from the No. 1 generator.

Hydraulic equipment.—Water passes from penstock No. 1 through a hydraulically-operated main gate valve and hand-operated gate valves in the branches of the Y to the nozzles of the Doble wheel of unit No. 1. The wheel has two rotors 60 inches in diameter, each of which is provided with a single automatic by-pass needle nozzle of 6-inch bore. The nozzles are controlled by a Lombard governor, type Q, and by hand. Pipe line No. 2 connects through a 24-inch hand-operated gate valve to a 2,800 horsepower Pelton-Francis horizontal turbine operating at 720 revolutions per minute with runner mounted directly on the main generator shaft.

Generators.—The generator of unit No. 1 direct-connected to the wheels is an Allis-Chalmers 1,500-kilovolt-ampere 2,200-volt 394-ampere 3-phase 60-cycle revolving-field machine operated at 400 revolutions per minute. The unit has three bearings set on the concrete of the foundation. Generator No. 2, direct-connected on the turbine shaft, is a Westinghouse 1,850-kilovolt-ampere 2,300-volt 3-phase 60-cycle machine operated at 720 revolutions per minute.

Exciters.—The exciter installed with unit No. 1 is an Allis-Chalmers 60-kilowatt 120-volt 500-ampere continuous-current machine driven at 900 revolutions per minute by a 100-horsepower overhung Pelton wheel. Main unit No. 2 carries a 25-kilowatt exciter mounted directly on the end of the generator shaft.

Three 1,000-kilovolt-ampere single-phase transformers connected 2,300 volts delta on the low-tension side and 95,000 volts Y with grounded neutral on the high-tension side are placed outdoors in conformity with the present standard practice of the company.

Wiring.—The switchboard contains five panels—two for the generators, two for the exciters, and a totaling panel. The generator bus connects to the low-tension transformer bus through lead-covered cables in fiber ducts. The high-tension transformer bus connects to the transmission line through a 3-pole air-break switch, and the line runs to the high-voltage bus at the control station near power house No. 5.

BISHOP CREEK PLANT NO. 6.

Location.—The intake of plant No. 6 is in sec. 17, T. 7 S., R. 32 E.; the conduit traverses secs. 9, 16, and 17, T. 7 S., R. 32 E.; the power house is in sec. 9, T. 7 S., R. 32 E., on the north side of Bishop Creek.

The plant was built by The Southern Sierras Power Co. in 1912 and 1913 and was put into commission March 12, 1913.

Conduit.—Like that of the other Bishop Creek stations, the No. 6 intake (Pl. LXX, *C*) lies immediately at the discharge of the plant above (plant No. 5). The dam is of the same type of construction as that described in detail for plant 3 (pp. 785–786), but instead of being arched in plan it is built in three straight sections. The section at the left contains seven panels on a line almost at right angles to the course of the stream. The second section contains a single panel, a spillway, and another single panel, all on line, running slightly upstream. From the right-hand end of this central section there is another short stretch which is almost parallel in alinement to the first section. The intake chamber is near the middle of this last section.

The crest elevation of the dam is 4,724 feet above sea level and the crest elevation of the spillway 4,719 feet, with 30-inch flashboards in place. The maximum height of the dam is 18 feet above the apron, and its length along the broken crest, including spillway, is 320 feet. The length of the spillway proper is 60 feet. The intake box is of the same general type as those already described. The two sliding steel headgates measure 6 feet 6 inches by 5 feet, and there is, in addition, an emergency flap valve inside the chamber, over the bell end of the pressure pipe.

Pressure pipe.—The pressure line curves gently along the bank of the creek for a short distance, but since it follows a much flatter gradient than the stream it soon reaches the level of the surrounding country. It then follows down the heavy slope of the débris fan. The pipe is composite; the first section consists of 2,976 feet of 60-inch (inside diameter) wood-stave pipe followed by a section of 4,360 feet of riveted steel pipe varying from 54 to 48 inches (inside diameter) and from one-fourth to three-eighths inch plate thickness. The first 1,100 feet of the wood-stave pipe is laid on a grade of 0.4 per cent and the balance of the line has an almost uniform slope to the power house. The total length of both sections aggregates 7,336 feet. There is no standpipe in the line, but spring relief valves are used. Aside from the one slight bend in alinement after leaving the dam, the pipe is straight, is laid along the surface of the ground, and, like the lines previously described, is protected by rock wall and earth fill.

At the back wall of the power house the 48-inch line terminates in a Y with two 30-inch branches, each controlled by a gate valve operated by a water motor. The elevation of the floor at the power house is 4,461 feet. The elevation of the center of the lower nozzles is 4,459.5 feet, giving a static head of 259.5 feet from the crest of the spillway with 30-inch flashboards. The working head at full load is 230 feet.

Power house.—Power house No. 6 is on the north side of Bishop Creek and is of the same type of construction as power house No. 3. It measures 43.5 by 32 feet inside and 18 feet 6 inches in the clear, to the lower chord of the steel roof trusses. The roof is corrugated iron. The entire interior of the building is taken up by the generator room, the transformer and high-tension equipment being of the outdoor type. The end of the building is toward the stream and the outdoor equipment is on a bank at a level somewhat higher than the building and at its opposite end. The pipe line, running parallel to the stream, enters at the middle of the back wall, below the floor. The single unit is placed along the main axis of the building. The exciter set is next to one end wall and toward the back of the building, and the switchboard is in a similar position at the other end of the station. In the front of the building is a large sliding door and a single small entry door.

Hydraulic equipment.—The wheel is of Pelton-Doble design and is one of the first units turned out after the merger of these two firms The main pressure line enters a Y with two 30-inch branches just inside the back wall of the power house and under the floor. A 32-inch gate valve, driven by a water motor, controls the flow in each branch of the Y, which feeds the two nozzles operating the single impulse rotor at that end of the unit. One of the nozzles in each pair is horizontal, the other inclined downward at an angle of about 30° from the vertical. The inclined nozzle is fed through a curved casting which forms the back of the wheel housing. The needles of the two horizontal nozzles are adjusted by ordinary handwheels; the inclined needles are adjusted by handwheels operating bevel gears through long rods that extend upward to the needle shank above the housing. The unit is of double overhung pattern. The diameter of the wheels is 8.5 feet and each rotor carries 12 buckets. The bore of the nozzles is 8 inches. Regulation is secured by hand control of the needles and governor control of deflectors operating over the two horizontal streams. The governor is a Lombard, type Q.

Generator.—The single unit is an Allis-Chalmers 2,000-kilovolt-ampere[54] 2,200-volt 500-ampere 3-phase 60-cycle alternator, operated at 164 revolutions per minute. The main shaft is carried on two pedestal bearings set on the concrete of the foundations; only ordinary ring lubrication is used.

Exciters.—The exciter is a motor-generator set coupled to a Pelton-Doble impulse wheel operated by double-needle nozzles. The motor in the set is an Allis-Chalmers 66-horsepower 2,200-volt 16.5-ampere induction motor. The generator is an Allis-Chalmers 125-volt 360-ampere 45-kilowatt continuous-current generator, operated at 860 revolutions per minute. The three parts of the unit are mounted on the same shaft and have the same bedplate. The needles of the exciter wheel can be regulated from the switchboard at the opposite end of the power house through a handwheel and chain and sprocket device.

Transformers.—The single bank of three Westinghouse 750-kilovolt-ampere single-phase 2,200/87,000-55,000-volt water-cooled outdoor-type transformers is installed under a steel bus frame (Pl. LIX, *C*). The transformers are now connected 2,200 volts delta on the low and 95,000 volts Y with grounded neutral on the high tension side.

Wiring.—The switchboard contains but two panels—one for the generator and the other for the exciter. The rheostat is carried on a framework above the board. The generator switch, which is of the

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[54] The rating here given is taken from the name plate of the machine, which has been found to carry 2,250 kilovolt-amperes and has been rerated by the company at that figure.

General Electric type F K-12 pattern, is immediately behind it. The synchronoscope is on a panel at one side. The ducts leading from the switchboard to the bank of transformers are of creosoted wood, and the leads are insulated cable. From the manhole opposite the transformers the leads run up the frame through disconnecting switches to the low-tension connections. A steel transformer-bus structure outside the power house is provided with disconnecting switches on both high and low tension sides. The outgoing line of No. 0 7-strand copper is carried on steel poles with wishbone-type cross arms and suspension insulators to the control station (Pl. LXX, *B*) of the San Bernardino tower line near plant No. 5.

MILL CREEK PLANT.

HISTORY.

The original Mill Creek plant on Mill Creek was constructed by Hydro-Electric Co. during 1910 and was transferred to Pacific Power Co. and put into operation about January 1, 1911. On March 8 of the same year the power house was destroyed by a snow slide, but the machinery was moved and installed in a temporary station which began operation on May 13 and continued until December 9, 1911, when the present power house was put into commission. During the period between March 8 and May 13 power was supplied to the system from a small plant on the shores of Lundy Lake, owned by the Standard mine.

SOURCE OF WATER SUPPLY.

The Mill Creek plant is operated with water from Mill Creek, which drains about 20 square miles of extremely rugged mountain country lying a few miles west of Mono Lake. (See Pl. LXXI, p. 802.) Elevations within the area above the plant range from approximately 7,763 feet above sea level at the intake to 12,500 feet on the west and south boundaries and to 11,500 feet on the north boundary. The stream flows northeastward from its head waters to the intake and receives but one tributary of any consequence—that coming from Lake Canyon, in the southeastern part of the basin. The rocks exposed throughout nearly the entire basin are granitic. The forest cover is in general very sparse.

The mean annual rainfall is probably between 30 and 35 inches. The low flow of the stream,[55] like that of other streams draining the east side of the mountains, comes during the winter, when the lakes and small feeders in the higher parts of the drainage basin are frozen.

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[55] The few miscellaneous measurements of stream flow available for this basin are published in U. S. Geol. Survey Water-Supply Paper 300, p. 225.

RESERVOIRS.

The only reservoir on the system is Lundy Lake, directly at the head of the conduit pipe line. The area of this lake before the dam was constructed was 85.3 acres. The company intended by the construction of a composite earth and rock fill dam to increase the area to 178 acres. The original water-surface elevation was 7,777.6 feet; the new surface elevation was to be 7,827.6 feet. The front of the dam is of earth fill with riprapped surface which has a slope of 3 to 1. There is a reinforced-concrete core wall on a line even with the upstream edge of the crest, and the backing behind the core wall is rock fill with a slope of 1½ to 1. The elevation of the center of the pipe line is 7,765 feet above sea level, and the available capacity above the top of the pipe and below the natural surface of the lake is 54,270,000 cubic feet or 1,246 acre-feet; leaks that developed in a rock slide at the north end of the dam have prevented raising the water surface of the lake much above its original level.

The pipe line runs under the dam and flow is controlled by a 48-inch gate valve at the lower toe. The intake at the mouth of the pipe is a reinforced-concrete box with a single inclined grizzly or screen in its front. This screen is 8 feet wide by 16 feet long and is inclined at 30° from the perpendicular. The side walls of the box are 12 inches thick and the floor and front sill are 18 inches. No gates are provided in the box. The bell-mouth section of pressure pipe opens directly out of the box into a 54-inch steel pipe 170 feet long. This connects to a 48-inch wood-stave pipe, which has a concrete covering 8 inches thick. About 370 feet from the intake the pipe passes through a 48-inch hand-operated gate valve which forms the only means of control except for the gates at the main pressure drop. There is no standpipe in this part of the line.

CONDUIT.

The total length of the gravity pipe line from the intake box to the standpipe at the head of the steel-pressure pipe is 12,068 feet. The first 170 feet of this line is of 54-inch steel pipe and the rest of 48-inch wood-stave pipe. The same type of construction is used as in the supply lines of The Nevada-California Power Co. on Bishop Creek. The side hill is benched out, the pipe laid on the bench, a dry rock wall is laid up 1 foot away from the outer side of the pipe, and the space around the pipe back-filled and covered over with earth to a depth of 1 foot. About 1,200 feet below the intake the pipe crosses from the south to the north side of Mill Creek and thereafter follows along the comparatively smooth slopes of the hillside to the mouth of the canyon in an almost straight line running nearly due east. At the end of this section just before reaching the standpipe at the head of the pressure line it makes a sharp bend northward. The standpipe is not of the vertical type but is laid up against the precipitous side of a rocky point.

The pressure pipe runs at an angle of about 45° to the general trend of the contours down the regular slope of the front range of the foothills to the old power-house site, the scene of the avalanche, and then nearly horizontally across a shallow wash to the new power house, about a thousand feet from the base of the hill. The dimensions of the steel pressure pipe are as follows:

TABLE 163.—*Dimensions of steel pressure pipe of Mill Creek plant.*

Type of pipe.	Length of suction.	Diameter.	Plate thickness.
	Feet.	*Inches.*	*Inches.*
Double-riveted lap joint	326.8	36	No. 9
Do	400	36	$\frac{3}{16}$
Do	410	34	$\frac{3}{16}$
Do	400	34	$\frac{1}{4}$
Do	372	34	$\frac{5}{16}$
Do	353	34	$\frac{3}{8}$
Do	554	30	$\frac{3}{8}$
Do	289	30	$\frac{7}{16}$
Triple-riveted double-butt joint	1,053.25	40	$\frac{1}{2}$
	4,138.05	....	....

The elevation of spillway level at Lundy Lake is 7,803 feet above sea level and elevation of nozzle at the power house 7,015.9 feet above sea level, giving a maximum possible static head of 787.1 feet. The effective head with 71 second-feet of water passing through the conduit is reported as 696 feet.

GENERATING STATION.

Power house.—The power house is just north of the mouth of Mill Creek canyon, at an elevation of 7,016 feet above sea level. The entire equipment is contained in a single building 71 feet 10 inches long by 33 feet 10 inches wide, with a bay 17 feet long by 8 feet deep at its back to contain the gates at the lower end of the pressure line. The type of construction of the power house is the same as that adopted on Bishop Creek, namely, reinforced-concrete pilasters with 6-inch reinforced-concrete curtain walls between. The roof is of corrugated iron and is carried on a steel roof system.

The two units are set wheel to wheel in separate pits sunk slightly below the floor level, with the generator shafts in line parallel with but slightly behind the main axis of the building. The pressure line runs parallel to the back wall of the building, and the branches to the wheels are taken off through a right angle. Just back of the wheels is the bay in the back of the room, and in this bay there is a gate valve in the supply line to each wheel. One of these gate valves is hydraulically operated and of Pelton design; the other is operated by a water motor and is of Doble manufacture. The governors are placed between their respective wheels and the back wall of the power house.

The switchboard, which is opposite the No. 2 generator at the east end of the generator room, is set slightly out from the front wall, so that the low-tension wiring and switches can be accommodated behind it. The rheostats are mounted above the board. The east end of the building, which is cut off by a curtain wall, forms a transformer room. On each side of this room are the three transformers (forming one bank), and down the center of the room there is a depression about 1 foot deep, so that the top of the steel car for moving the transformers comes even with the floor upon which they are set. In order to place the transformers on this car they have to be slid or rolled on iron strips laid on concrete. Once on the car they can be run into the end of the generator room under a 20-ton hand-operated traveling crane, which is carried on rails laid on concrete supports on the side walls of the building.

Hydraulic equipment.—No. 1 unit is operated by a single Doble overhung impulse wheel supplied through an automatic by-pass Doble needle nozzle, in which the position of the needle is regulated by hand. The supply is controlled by a Lombard governor, type Q, acting under oil pressure supplied to a pressure tank by a small motor-driven pump. Unit No. 2 is operated by a single overhung Pelton wheel supplied through a stationary needle nozzle. The wheel on unit No. 1 is rated at 2,650 horsepower and is 54½ inches in diameter. That on unit No. 2 is rated at 2,500 horsepower and is 51½ inches in diameter. Flow is controlled by a Pelton governor acting on the hood deflector which acts in conjunction with the needle. The supply passes through a hydraulically operated gate valve just before reaching the nozzle.

Both units are, as noted, sunk below the general level of the powerhouse floor, and in both the bearings and wheel housings rest on metal bedplates.

Generators.—Both generators are of the same type and capacity. They are Allis-Chalmers 1,500-kilovolt-ampere [56] 2,300-volt 377-ampere alternators, operated at 400 revolutions per minute.

Exciters.—Exciter No. 1 is an Allis-Chalmers 60-kilowatt 120-volt 500-ampere direct-current generator, driven by a Doble impulse wheel, with hand-operated needle, at a speed of 850 revolutions per minute. Exciter No. 2 is a 65-kilowatt 120-volt 540-ampere Allis-Chalmers direct-current generator driven at a speed of 850 revolutions per minute, either by a 96-horsepower 2,200-volt 23-ampere 3-phase 60-cycle motor of the same make or by a Doble wheel with hand-regulated needle.

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[56] Name-plate rating. It has been found that the units will carry 1,650 kilovolt-amperes each.

Transformers.—The six single-phase transformers are General Electric type EI 500-kilowatt 60-cycle 2,300/31,800 or 55,000 Y 60-cycle water-cooled pattern.

Wiring.—The leads from the generators and exciters are carried to the switchboard in trenches molded in the concrete of the power-house floor and covered by iron plates. The high-tension leads from each of the two transformer banks pass through a 3-phase 60,000-volt Kelman oil switch mounted above the transformer compartment. One set of the high-tension leads passes through Locke type wall-entrance bushings in the end of the building; the leads from the other high-tension oil switch pass through roof bushings. One transmission line runs to the Rush Creek plant and the other to Hawthorne, Nev. The latter originally ran as far as Wonder, Nev., but the line between Hawthorne and Wonder has been removed and the line between the Mill Creek power house and Hawthorne sold to Mineral County. The county has extended this line from Hawthorne to Mina, where a mining load is to be obtained.

Switching arrangements outside the power house permit connection of one bank of transformers to the Rush Creek line and the other to the Hawthorne line.

The single set of Westinghouse electrolytic arresters is mounted in a small corrugated-iron house a short distance from the east end of the power house.

RUSH CREEK PLANT.

LOCATION.

The Rush Creek plant and Gem and Agnew Lake storage reservoirs were constructed under the supervision of the engineering force of Pacific Power Corporation during 1915–1917 and the first unit in the power house put in commercial operation on October 17, 1916, with only the Agnew Lake supply connected; the second unit was put into operation December 11, 1917.[57]

The power house is on the west bank of Rush Creek immediately below the mouth of Reversed Creek and only a few hundred feet south of the head of Silver Lake.

The winter temperature in the region above the plants drops very low, and for this reason the smallest natural stream flow usually occurs in January and February. Measurements at the power-house site before the construction of the dams showed a minimum mean flow for these two months of less than 2 second-feet.[58] The stretch

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[57] Construction of power house was begun Aug. 1, 1915, and completed July 15, 1916; Gem Lake dam was begun July 15, 1915, and completed June 16, 1917; Agnew Lake dam was begun Sept. 21, 1915, and completed June 26, 1917; pipe line No. 1 was begun May 19, 1915, and was completed Oct. 1, 1916; pipe line No. 2 from Agnew Lake to power house was begun Mar. 24, 1917, and completed Nov. 11, 1917.

[58] For records of discharge of Rush Creek see U. S. Geol. Survey Water-Supply Papers as follows: 300, pp. 220–222, 225 (up to June 30, 1912); 360, pp. 167–171 (1912–13); 390, pp. 201–202, 298 (1913–14); 410, p. 249 (1 measurement).

of Rush Creek most valuable for power development is of course in the rapid fall between Gem and Silver lakes, and it is this part that is utilized by the plant.

SOURCE OF WATER SUPPLY.

Rush Creek is the most southerly of the Sierra streams discharging into Mono Lake. (See Pl. LXXI.) It rises on the east slope of Mount Lyell and from its headwaters flows nearly due east through a glacial cirque to the outlet of Gem Lake. Immediately below this lake there is a very rapid drop of about 500 feet to Agnew Lake, and immediately below Agnew Lake another rapid drop of about 1,250 feet to Silver Lake, which is on Rush Creek just below the mouth of Reversed Creek. Below Silver Lake, Rush Creek flows nearly due north, emerging from the mountains just below Grant Lake and then flowing through the comparatively level Pumice Valley to Mono Lake.

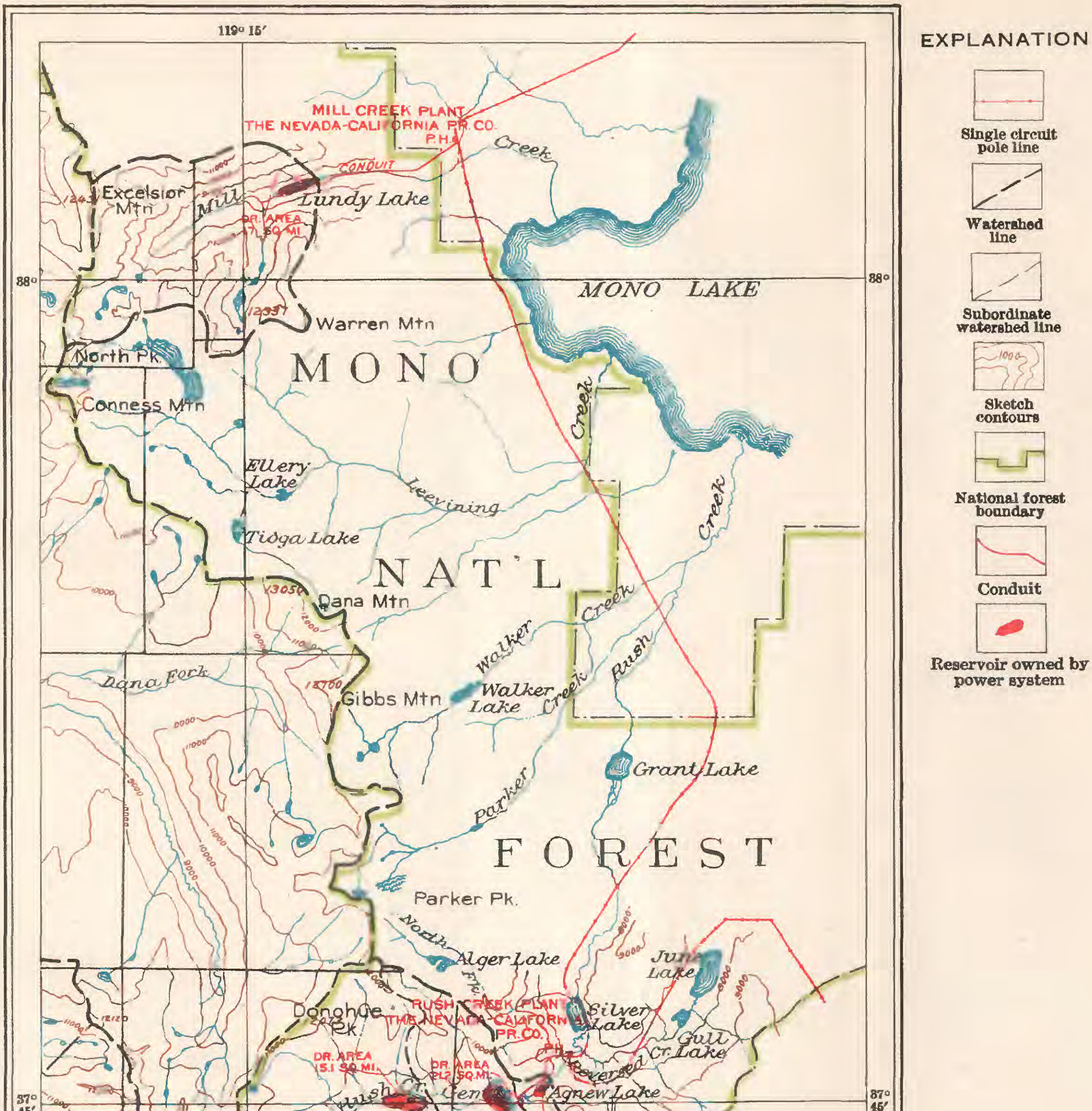
The elevation of crest of Mount Lyell, at the extreme headwaters of Rush Creek, is 13,090 feet; the elevation of the original stream bed at the outlet of Agnew Lake, the lower reservoir, 8,465 feet, and the elevation of the floor of the meadow at the mouth of Reversed Creek about 7,220 feet above sea level.

The area above Gem Lake outlet is 21.3 square miles and that above Agnew Lake outlet 22.4 square miles, there being 1.1 square miles tributary to Agnew Lake alone. Fully three-fourths of the area above Gem Lake lies at elevations exceeding 10,000 feet. The rocks exposed in the basin are largely granitic, but volcanic material, principally basalts, occurs in rather restricted areas. Owing to high elevations and poor soil the forestation is comparatively sparse except on the slopes directly around Gem Lake.

RESERVOIRS.

Gem Lake reservoir is the more important of the two lakes that will provide the storage for the plant. Before the construction of the dam, Gem Lake, as a whole, consisted of three lakes, Lower Gem Lake, with water-surface elevation at 8,980.2 feet and an area of 25.6 acres; Middle Gem Lake, with water surface at 8,981.75 feet and an area of 1.8 acres (forming merely a connecting link between the lower and upper lakes); and Upper Gem Lake, with water surface at 8,985.3 feet and an area of 162.5 acres. The differences in elevations of the three lakes were so small that the reservoir is formed by a single dam at the outlet of lower Gem Lake.

The areas and capacities of the reservoir at given elevations are shown in the following table:



MAP OF BASINS OF RUSH AND MILL CREEKS, CALIFORNIA

SHOWING HYDRO-ELECTRIC DEVELOPMENTS

Scale 1:250,000

0 1 2 3 4 5 Miles

Contour interval 1,000 feet

PREPARED BY U. S. FOREST SERVICE

1922

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

TABLE 164.—*Areas and capacities of Gem Lake reservoir.*

Elevation.	Area.	Capacity.	Elevation.	Area.	Capacity.
Feet.	*Acres.*	*Acre-feet.*	*Feet.*	*Acres.*	*Acre-feet.*
8,950.71	13.45	....	9,010	232.80	7,095.80
8,970	18.93	151.4	9,020	242.00	9,487.30
8,980	25.62	749.4	9,030	253.60	11,948.00
8,990	205.12	2,702.9	9,040	263.00	14,531.00
9,000	221.00	4,832.1	9,050	274.60	17,216.00

The excavation of a drainage trench through the bedrock between the original Upper and Lower lakes has added about 1,500 acre-feet to the effective storage capacity, and made it possible to draw down the upper lake below its original surface. The capacities given in Table 164 include the storage made available by this trench.

The Gem Lake reservoir is formed by a reinforced concrete multiple-arch dam, made up of 16 arches of 40-foot span each and two partial end arches, giving a total crest length of 688 feet. The total quantity of concrete placed in the dam was 8,606 cubic yards. The maximum height of the dam above the lowest point in its foundation is 112 feet, and height above the original stream bed 84 feet; the crest elevation is 9,053 feet, and normal maximum water-surface elevation 9,050 feet above sea level. Spillway openings, which can be fitted with stop planks, have been left near the crest of the dam in the two southern arches, the five openings 6 feet long by 2 feet deep in the end arch being at an elevation of 9,050 feet and the eight openings 6 feet long by 2 feet deep in the next arch at an elevation of 9,048 feet.

Agnew Lake reservoir is formed by a multiple arch dam of the same design as the Gem Lake but is much smaller. The dam consists of five full arches of 40-foot span each and two partial end arches; the total crest length is 278 feet. The total quantity of concrete placed in the dam was 713 cubic yards. The crest elevation of the dam is 8,495 feet, elevation of normal maximum water surface 8,492 feet, of original stream bed 8,465 feet, and at lowest point of foundation 8,459 feet, giving a maximum height of 30 feet above the original stream bed and 36 feet above the lowest part of the foundation. The area of the reservoir when filled to normal water-surface elevation is 38.37 acres and its capacity is 890 acre-feet, of which 18 acre-feet is due to drawing the lake below its former level. There are eight spillway openings, each 6 feet long by 2 feet deep, at an elevation of 8,492 feet in each of two central arches of the dam.

Computations based on short-term stream-flow records on Rush and Leevining creeks[59] show that with the Gem and Agnew Lake storage reservoir in operation a constant supply of nearly 40 second-

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[59] Leevining Creek is the next noteworthy mountain stream north of Rush Creek and is similar to it in most respects.

feet can be maintained through the Rush Creek plant during even the most severe droughts; it has already been noted that without storage the natural flow of the stream for the two lowest months has been less than 2 second-feet.

In order to hold an irrigation right of way the dams that form the Gem and Agnew Lake storage reservoirs were constructed for California-Nevada Canal, Power & Water Co. The storage is operated under contract between California-Nevada Canal, Power & Water Co. and The Nevada California Power Co., the pipe lines, power house, and transmission line belonging to the latter.

During the fall of 1918 a third reservoir was partly completed at Rush Creek Meadows, 1½ miles above the head of Gem Lake reservoir. Rush Creek Meadows dam is a single concrete arch, curved on a radius of 165 feet, 400 feet long on the crest, and 30 feet high. The upstream face is vertical; the downstream face rises in six steps 5 feet high by 1.2 feet broad. The dam is 5.4 feet thick at the crest and 11.4 feet thick at the lower part of the base. A trench 4 feet wide by 2 feet deep was carried down into bedrock under the upstream face of the arch, in order to give a water-tight junction with the foundation. The structure contains 1,712 cubic yards of concrete.

The water is discharged through two 30 by 30 inch openings, passing through the base of the dam 2 feet above the stream bed. The upper ends of the openings are protected by steel trash racks. The present capacity of the reservoir is 1,081 acre-feet; its ultimate capacity will be 5,660 acre-feet. The tributary drainage area is 15.1 square miles.

CONDUITS.

No open conduit is used in the Rush Creek plant, as the outlet tubes concreted into tunnels driven through the bedrock under the Gem and Agnew lake dams connect directly to the two pipe lines.

The outlet of the Gem Lake reservoir is about 20 feet below the original lake surface. From the lower end of the outlet tube, which is 260 feet long, the pipe line follows around the hillside on the north side of the canyon for a distance of 868 feet on a grade of 4 feet per thousand. This part of the pipe line is constructed of No. 9 plates, double riveted with lap joints, is 48 inches in diameter, and is laid on a bench and partly covered for protection. From the lower end of this so-called "flow line" the Gem "pressure line" extends to a cross connection immediately below Agnew Lake. The Gem pressure line is 4,584 feet long, 48 inches in diameter, and varies in shell thickness from No. 9 double-riveted lap joint to $\frac{9}{16}$-inch triple-riveted butt joint steel.

The welded pressure line that extends from the end of the outlet tube through Agnew dam to the cross connection between the Gem and Agnew lines is 555 feet long, 30 inches in diameter, and one-fourth inch thick. The tube under the dam is 20 feet long and 30 inches in diameter.

At the cross connection there is a hand-operated gate valve in the Agnew line, another in the cross pipe, and still another is to be installed in the line No. 2 immediately below the connection. A temporary welded-steel standpipe 50 feet high and 18 inches in diameter, supported by guy cables, rises from the Agnew pipe line immediately above the gate valve. This standpipe will be replaced by an air valve.

From the lower end of the cross connection to the power house there are two parallel pipe lines, 4,267 feet long, laid 5 feet apart on centers, varying from 30 inches inside diameter and eleven-thirty-seconds inch shell thickness to 28 inches inside diameter and fifteen-sixteenths inch shell thickness. Both of these lines are welded pipe of American manufacture.

The following elevations show the heads on the various parts of the pressure system:

	Feet above sea level.
Normal maximum water surface of Gem Lake reservoir	9,050.00
Head of pressure line at Gem Lake	8,959.40
Normal maximum water surface of Agnew Lake reservoir	8,492.00
Head of pressure line of Agnew Lake	8,463.35
Junction of pipe lines below Agnew Lake	8,449.00
Nozzle centers at power house	7,243.00

The static heads below normal maximum water surface, as given above, are 1,807 feet and 1,249 feet, respectively. The estimated effective heads, for which the water wheels were designed, are 1,650 and 1,200 feet, respectively.

GENERATING STATION.

Power house.—Rush Creek power house was originally designed as a one-story structure but was changed to a two-story structure after construction was begun, in order to raise the unit to a height sufficient to provide for possible future use of storage in the Silver Lake reservoir site. The floor of the generator room was raised from 7,226.80 feet, its original level, to 7,245 feet, the new level; the elevation of the nozzles becoming, after the change, 7,243 feet.

The building is constructed of reinforced concrete with corrugated-iron roof supported on steel trusses. It is of the mission style adopted by the Nevada-California system in its Bishop Creek stations. The part of the lower floor of the power house not occupied by machine foundations is utilized for storerooms. The transformers are of the outdoor type and are on a bench at the north end of the power house. The lightning arresters are on another bench excavated from the hillside just north of the transformers. Between the transformers and the side hill there is a steel gallows frame for use in making repairs to the transformers.

The generator room, which occupies the entire main floor of the building, is 79 feet 9 inches long, 42 feet 6 inches wide, 19 feet 6 inches high from floor to lower chord of roof trusses, and 15 feet high to top of crane rail. It contains two units, each operated by a single overhung impulse wheel placed parallel to the front wall of the building.

The two pressure pipes enter through the back wall of the building immediately below the level of the generator floor and are cross connected just inside the wall. In the cross connection are two hand-operated gate valves, and between these valves a pipe line 18 inches in diameter was to connect to a pressure regulator to be placed below the cross-over pipe and to exhaust into No. 2 tailrace. From experiment, however, it was found better to locate this regulator at the top of the two 30-inch welded steel pipes, where they connect to the 48-inch riveted pipe. Below the cross connection, on the line leading to each unit, there is a gate valve operated by a water motor. The nozzles are controlled by Pelton oil-pressure governors, and individual oil-pressure pumps and tanks are located near each unit.

Water is supplied to the impulse wheels of the exciters through an 8-inch pipe lying immediately below and parallel to the cross connection between the main lines, and supplied by a downturn from the outer side of each of the main lines. A 2½-inch outlet from the exciter pipe supplies water to a motor on the oil-pressure system of the governors of the main unit.

The exciters are in the northwest corner and the switchboard is parallel to the end wall in the northwest corner of the generator room.

The entire floor is commanded by a 20-ton traveling crane running on rails supported by concrete beams, which form the upper part of the reinforced framework of the power house.

Hydraulic equipment.—The single overhung impulse wheel of No. 1 unit carries 17 buckets, is 4 feet 4 inches in radius to the center line of the jet, and was constructed on what may be termed a compromise design, to give 8,000 horsepower under either 1,200 or 1,650 feet net head. The impulse wheel of No. 2 unit is also of the single overhung type, carries 19 buckets, measures 4 feet 8½ inches in radius to the center line of the jet, is designed for operation under the 1,650-foot effective head from Gem Lake only, and gives 8,000 horsepower with a speed of 300 revolutions per minute. The nozzles of both units are of the auxiliary needle by-pass type; the center of the auxiliary jet being 2 feet 11 inches below the center of the main jet. Both auxiliary jets discharge against Ensign vortex baffles, which are supported by concrete abutments in the east wall of the power house; discharge water then drops into the tailrace which leads to Rush Creek just above the head of Silver Lake. The nozzle diameter of unit No. 1 is 8 inches and that of unit No. 2 is 6½ inches.

Generator.—Generator No. 1 is a General Electric ATB form A machine designed for 5,000 kilovolt-ampere 2,300-volt 1,257-ampere 3-phase alternating current, at 300 revolutions per minute. Generator No. 2 is an Allis-Chalmers 6,250-kilovolt-ampere 2,300-volt 3-phase alternating-current machine.

Exciters.—The station is equipped with two exciter sets. Set No. 1 consists of a General Electric DLC form A 60-kilowatt 480-ampere 900/865 revolutions per minute 125-volt direct-current generator that may be driven either by a General Electric type I 90-horsepower form K 215-ampere 2,200-volt induction motor at 865 revolutions per minute with full load or by a Pelton-Doble impulse wheel. Generator, motor, and impulse wheel are mounted on a single bedplate.

No. 2 exciter consists of a direct-current generator and an impulse wheel mounted on the same bedplate, both generator and impulse wheel being duplicates of those used in exciter set No. 1. The impulse wheel on exciter set No. 1 has a hand-controlled needle and hand-operated gate valve; the No. 2 wheel has a similar hand-operated gate valve, but the needle is controlled by a Pelton governor.

Transformers.—The transformer equipment consists of a single bank of three 3,000-kilovolt-ampere 2,200/87,000 water-cooled outdoor-type transformers, connected to give a line voltage of 95,000, and a 3,200-kilovolt-ampere 3-phase outdoor-type water-cooled transformer that is used to connect the 95,000-volt system south of the plant with the 55,000-volt line extending from Rush Creek to Mill Creek power house.

Wiring.—The switchboard consists of two generator panels, one exciter panel, one auxiliary panel, and one totaling panel. Each generator connects to the generator bus through a K–12 oil circuit breaker, and between the generator bus and the transformer is a 3,000-ampere electrically operated oil circuit breaker, by means of which the plant is switched as a unit. The conductors are lead-covered cables carried through fiber ducts. A 3-pole General Electric air-break switch connects the high-tension bus of the bank of three 3,000-kilovolt-ampere single-phase outdoor-type transformers to the 95,000-kilovolt line. The 3,200-kilovolt-ampere 3-phase transformer is connected to the 95,000-volt transmission system through a Pacific Electric Manufacturing Co. 3-phase air-break switch and to the Mill Creek line by a 3-phase Kellman oil switch.

ADAMS AUXILIARY HYDROELECTRIC PLANT.

LOCATION.

On February 22, 1921, The Southern Sierras Power Co. completed and put into operation a small hydroelectric plant in Owens River gorge north of Bishop, Inyo County. This plant has been named the Adams auxiliary plant by the company. It utilizes part of a more extensive power site included entirely within sec. 16, T. 5 S., R. 31 E., which the company proposed eventually to utilize.

The intake of the Adams plant is immediately south of the north line of sec. 16, T. 5 S., R. 31 E. Mount Diablo meridian, and the entire conduit, pressure pipe, and power house are in the NE. ¼ of that section.

SOURCE OF WATER SUPPLY.

Owens River, from which the station diverts its entire supply, is formed by streams draining the east side of the Sierra and the lower ridges to the east in the southern part of Mono County. Deadman Creek, which may be considered the source of Owens River, rises at an elevation of 11,000 feet or more above sea level on the eastern slope of San Joaquin Mountain, flows in an easterly direction about 16 miles to the upper end of Long Valley, and is joined in its course by several minor streams that drain the south slopes of the volcanic ridges separating the Mono and Owens Lake basins. At the upper end of Long Valley the stream turns southward, and below this point it is designated Owens River. It receives a number of tributaries, among the largest of which are Hot, Convict, McGee, and Hilton creeks, which drain the east slope of the Sierra and flow from the base of the mountains through tortuous channels and swamps into the main river.

At the south end of Long Valley, in sec. 24, T. 4 S., R. 29 E., Owens River turns again due east into Owens River gorge, cut through an extensive lava tableland between Long Valley and Bishop Valley. The Adams plant is in the gorge about 12 miles below its head.

The maximum length of the tributary drainage basin in a southeasterly direction from the headwaters to the intake is about 32 miles. Its maximum width is about 20 miles. The most notable feature of the basin is the broad, flat expanse of Long Valley, flanked on the west by the high, precipitous peaks in the vicinity of Mount Morrison and on the east and north by much lower volcanic bluffs and ridges. Long Valley is entirely meadow and marsh land, bordered by gentle sagebrush slopes. The hills to the northeast and northwest are covered with a moderate growth, chiefly of pine, and the higher mountains near the headwaters of Convict and McGee creeks are entirely bare The rocks of the southwestern part of the drainage basin are granitic, the floor of Long Valley is alluvial, the rest and by far the largest part of the drainage area on both sides of the valley and to the north is lava.

The elevation at the intake is slightly over 5,500 feet, at the lower end of Long Valley about 6,700 feet, and at the upper end of the valley about 7,000 feet. The highest peak along the southeast boundary of the basin, Red Slate Mountain, stands 13,152 feet above sea level. Several peaks along the main ridge, particularly in the southeastern portion of that part of the basin above the plant, rise to 11,000 or 12,000 feet and more, but a large part of the area is below 8,000 feet.

The total drainage area at the United States Geological Survey gaging station a short distance down the gorge from the Adams plant is 450 square miles, which may be accepted as that at the plant.

The maximum recorded discharge at the Geological Survey gaging station is 875 second-feet and the minimum 150 second-feet.[60]

The flow of the stream will probably be entirely regulated by the dam to be constructed by the city of Los Angeles at the outlet of Long Valley.

CONDUIT.

A point of rock splits the channel of the stream at the point of diversion, and a low concrete ogee diversion dam about 25 feet long in the west channel raises the surface level of the stream into a timber flume heading in the east channel. The bottom elevation of the head of this flume is 12,530 feet above sea level. The flume box is 5 feet deep by 12 feet wide, inside. The sills are 6 by 8 inch by 18-foot timbers. The double side posts are two 3 by 8 inch by 8-foot timbers, and the caps 6 by 6 inch by 14-foot pieces. The slope of the flume is 4 feet in 1,000, and at its lower end it crosses to the southwest bank of the river by a short timber bridge.

The 12-foot flume is about 360 feet long and ends at a division box provided with gates and turnouts which will permit the discharge of water either back into the stream channel, into an 8-foot timber flume leading to the head of the pressure pipe, or into a future conduit leading to a tunnel of a larger proposed development. The length of 8-foot flume from division box to reinforced-concrete forebay chamber at the head of the pressure pipe is about 450 feet. The sills of the flume are 6 by 8 inch by 14-foot single timbers. The side posts are each composed of two 3 by 8 inch by 9-foot timbers, and the cap of a single 6 by 6 inch by 10-foot piece. The slope of the entire 8-foot flume is 2 feet per thousand. The forebay is large enough to maintain a safe head of water over the bell mouth of the pressure pipe and is provided with inclined trash racks.

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[60] For published records of gagings at this station see U. S. Geol. Survey Water-Supply Papers 300, 330, 360, 390, 410, 440, 460, and 480.

A single line of riveted steel pipe 66 inches in uniform diameter extends from the forebay to the power house. The elevation of the center line of the pipe at its head is 5,522 feet above sea level. The upper part of the line is on a uniform slope of approximately 30°, and the lower half of its length nearly level to the power house. The length of the pipe is 667 feet. The maximum capacity of the conduit and pipe is 350 second-feet.

The elevation of the water surface in the forebay is about 5,542 feet and of the center of the pressure pipe at the power house 5,390 feet, giving a static head of 153 feet, not including a short draft tube.

GENERATING STATION.

Power house.—The power house is constructed of reinforced concrete and is 54 feet 8 inches long by 32 feet deep (outside measurements), with a small addition measuring 13 feet 8 inches long by 6 feet deep at its back. The entire interior of the building is occupied by the generator room. A door 12 feet wide through the left side of the front wall gives access from the roadway to the main floor of the building. The horizontal turbine is in the extreme east end of the room, and the generator, to which it is direct-connected through a shaft carrying a flywheel, is in the center of the room. A governor and relief valve are between the unit and the front wall of the building. A butterfly valve with by-pass is installed at the point where the pressure pipe connects to the scroll cases of the turbine. The entire generator floor is commanded by a hand-operated crane carried on runways 28 feet 6 inches between centers supported on concrete pillars.

The height of the building from floor to eaves is 24 feet, and the roof is galvanized corrugated iron on steel trusses.

Hydraulic equipment.—The main unit is operated by a Pelton-Francis horizontal turbine with double-draft tube, rated at 3,750 horsepower and operating at 514 revolutions per minute. The diameter of the runner is 31 inches. The effective head is 140 feet.

Generator.—The main generator is a Westinghouse 3,000-kilovolt-ampere 3-phase 60-cycle 6,600-volt alternator.

Exciter.—The exciter is mounted on the end of the main unit.

Transformers.—The energy generated at the power house is transmitted down the canyon 3,400 feet to the lower boundary of sec. 16, where, at the proposed site of the final power house, a bank of three outdoor-type transformers has been installed. These step the potential up to 95,000 volts and connect, through a short branch line running westward, with the main Rush Creek-Bishop Creek transmission line.

SAN BERNARDINO STEAM PLANT.

History.—The San Bernardino steam plant was put into operation June 3, 1912, by The Southern Sierras Power Co. and serves as a peak-load and steam reserve plant for The Nevada-California system. It is connected with the San Bernardino substation, at the south end of the transmission tower line, the distributing center for the transmission lines in San Bernardino, Riverside, and Imperial counties. In the low water of the winter of 1912 considerable power from the plant was transmitted over the tower line and the Nevada-California transmission lines into the mining region of Nevada. This was unusual, and generally the power generated from the steam station is used solely at the south end of the system.[61]

Buildings.—The plant is on the southwest border of the city of San Bernardino and is housed in two reinforced-concrete buildings. Close beside the power house are the outdoor terminal transformer station, at the south end of the hydroelectric tower line, and the reinforced-concrete building containing part of the auxiliary equipment for the power-line regulation. On the east side of the power house are the cooling towers.

The power house is 132 feet long by 64 feet wide in plan, with an addition at the center of its east side, which measures 41 feet 8 inches by 35 feet. The original cooling tower measures 80 by 90 feet in plan and is 20 feet high. The company has since added other towers covering an area of 68 by 320 feet and has also installed a Permutit water-softening system having a capacity of 300,000 gallons per day. The cooling towers are of the atmospheric type and are about 25 feet high. The hot circulating water received from the condensers is distributed over the top of the towers by a series of troughs and in falling down is intercepted by a number of decks composed of 1 by 1 inch redwood laths laid in alternate directions, forming a screen which breaks the water into small drops and exposes it to the action of the air. On falling from the last screen it is caught in a receiving tank. The main part of the generating station houses only the boilers, turbo-generators, and auxiliary equipment. The addition contains the bus cells and switching equipment.

The main building is of concrete construction—a reinforced column framework with thin reinforced curtain walls between. The roof has a very gentle pitch in one direction, the slope over the boilers being slightly flatter than that over the generator room. A longitudinal wall, pierced by 10 archways, supports the roof and divides

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[61] A 400-kilovolt-ampere stand-by plant was installed in Tonopah by Deseret Water, Oil & Irrigation Co. later in 1917 and steam is kept up at this station so that it may be thrown on the line in ten minutes to operate the pumps in the mines in case of accident to the transmission line between Bishop Creek and Tonopah.

The Southern Sierras Power Co. also operates a 75-kilovolt-ampere Diesel engine on the small isolated distribution system near Blythe on Colorado River above Yuma.

the large room into two parts, one of which contains the boilers and the other the generating and most of the auxiliary equipment.

The boilers are arranged in four banks along and near the west wall of the plant. The equipment in the generator room is so placed that the two ends of the room are almost asymmetric in arrangement. The feed-water heater and the two duplex feed pumps for each unit are placed near the end wall close to their respective units. The circulating pump, hot-well, and rotary dry-vacuum pumps for each unit are arranged along the side wall of the room directly opposite the unit, which occupies the space between this auxiliary equipment and the central row of columns, the unit being placed as close to the end of the plant as possible. The feed-water heater for No. 1 unit is placed broadside to the end wall in line with the central columns, one duplex feed pump being set next to the wall and in the generator room and the other on the opposite side of the heater next to the wall and in the boiler room. The arrangement of the heater and feed pumps for No. 2 unit is slightly different. The end of the heater is next to the end wall of the plant, and two duplex pumps were originally placed side by side in the generator room next to the end wall of the building and with their ends next to the heater. One of these pumps has recently been displaced by a triplex centrifugal Lea Courtney pump direct-connected to a Moore steam turbine. The fuel-oil equipment, consisting of two duplex pumps, is directly opposite No. 1 unit, just behind the central row of columns. The switchboard is against the central part of the side wall of the generator room and is therefore directly on the opposite side of the wall from the bus cells and switching equipment in the addition.

Mechanical equipment.—The plant is designed for four banks, each consisting of two 500-horsepower Stirling water-tube boilers, but only seven boilers—three banks and a single boiler—are installed. Each boiler has 360 3¼-inch tubes, a single 48-inch mud drum, and three 42-inch steam drums per boiler. A 3-foot 6-inch alleyway along the west wall of the building gives access to the back of the boilers. There is also a transverse space of several feet between neighboring banks. All the main piping is carried on brackets, and the steam main running along the front of the boilers is provided with a sliding cradle supported on each bracket.

The boilers are fired from the front by Hammel oil burners, which are supplied with fuel oil taken from tanks on the premises by two 6 by 4 by 6 inch Platt Iron Works duplex oil pumps. Feed water is supplied by two sets of end-packed Platt Iron Works duplex 12 by 7 by 12 inch feed-water pumps, one set of two pumps being placed in each end of the plant. The feed-water heaters are No. 4 Stillwell's. The steam pressure maintained is 175 pounds.

Circulating water for both units is handled by two 12-inch double-suction Byron Jackson centrifugal pumps, which connect to a 75-horsepower Crocker-Wheeler motor. The pumps and motors are in a concrete pump house near the cooling towers.

Vacuum is maintained by a Wheeler 9 by 22 by 16 inch rotative dry-vacuum pump. One hot-well pump is motor-driven and the other is operated by a Kerr steam turbine; both of these pumps are 4-inch centrifugals. The condensers are of the Wheeler surface type.

The make-up supply for both the boiler and the cooling-water systems is drawn from artesian wells near the plant.

Electrical equipment.—Generator No. 1 is an Allis-Chalmers Parsons 6,600-volt 437-ampere maximum 3-phase 60-cycle horizontal turbo-generator, operated at 1,800 revolutions per minute. The capacity of the turbine is but two-thirds that of the generator, and the extra capacity of the generator is utilized in regulating the main transmission tower line from the Bishop Creek plants under certain conditions of load. The exciter for this unit is mounted on the end of the main generator shaft and is a 50-kilowatt 120-volt 417-ampere 4-pole direct-current interpole generator operated at 1,800 revolutions per minute.

No. 2 unit is a General Electric-Curtis class 4 form L turbine, which operates at 1,800 revolutions per minute on 175-pound steam pressure. The generator of this set is a 5,000-kilowatt 6,600-volt 417-ampere General Electric turbo-alternator. The exciter for this unit is not mounted on the generator shaft.

There are two separate exciters; one is a General Electric 2-pole interpole 75-kilowatt 125-volt direct-current machine, run by a Curtis noncondensing turbine at 360 revolutions per minute; the other exciter is a motor-generator set consisting of a General Electric type I 150-horsepower 440-volt induction motor, coupled to a General Electric 6-pole interpole 100-kilowatt continuous-current generator, operated at 900 revolutions per minute.

The main switchboard of 14 panels controls generators, exciters, two 6,250-ampere 60-cycle/50-cycle frequency changers, through which the system connects to the Southern California Edison system, and also controls a bank of three 2,000-kilovolt-ampere transformers and two banks of 4,000-kilovolt-ampere transformers, as well as the two incoming tower lines, the outgoing 55,000-volt line to the Imperial Valley district, and five outgoing 33,000-volt feeders.

An auxiliary board of 10 panels controls local feeders and certain station auxiliaries. The addition at one side of the power house containing the switching equipment is, unlike the main room, divided into three stories by two decks. On the lower floor of the addition are the generator oil switches, which are immediately back of the generator panels, the 10-panel auxiliary switchboard, the motor-generator set for railway signal service, and one of the 6,250-kilovolt-ampere frequency changers with its control board. On the first deck, immediately over the generator switches, is a double 6,600-volt station bus installed in a concrete compartment, and at one end of the deck are four 3-phase 100-kilovolt-ampere induction regulators for the control of voltage on the 2,300-volt city distribution circuits. On the second deck, or third floor, are the electrically operated type E circuit breakers controlling the two 12,000-kilovolt-ampere transformer banks connecting to the tower line, and a 6,600-volt bus to which are connected four type F oil circuit breakers for the control of two banks of 6,600-kilovolt-ampere 6,600/2,200-volt transformers and two banks of 150-kilovolt-ampere 6,600/440-volt transformers which supply 2,200-volt energy to the local city distribution bus and to the 440-volt station auxiliaries.

The frequency changer in this building is the property of the Southern California Edison Co., and connection is made with the other frequency changer at Colton through a 33,000-volt line.

All the transformers are of the outdoor type.

TONOPAH STEAM PLANT.

The Tonopah emergency steam plant, in Tonopah, Nev., was constructed and ready for operation October 20, 1917, only as a safeguard for continuous power supply in the mines in case of breakdown on the transmission lines from Bishop Creek. The plant is owned by Deseret Water, Oil & Irrigation Co., a subsidiary of The Nevada-California Power Co.

Building.—The Tonopah station is a single wood-frame building with wooden inner walls and corrugated galvanized outer walls and roof, 61 feet 6 inches long by 25 feet 6 inches wide inside. The walls are 15 feet high from the level of the concrete floor to the lower chord of the wooden trusses supporting a peaked roof. A wide door in the right center of the front wall of the plant and a small door in the right end of the building afford access to the interior.

Three marine boilers are placed transversely across the left end of the room; the furnaces toward the back; and the three 32-inch stacks, 40 feet high, resting on steel breechings, toward the front of the building.

The turbo-generator is placed transversely inside the main door, the exciter between the generator and the right end of the room, and the condenser and pumps in a pit 20 inches deep between the generator and boilers. The transformers are near the back wall at the right end of the station.

Mechanical equipment.—Steam is supplied at 150 pounds pressure by three Scotch marine fire-tube return-flue boilers; two are rated at 150 and the third at 135 horsepower. A Warren Webster feed-water heater is installed. The turbine is operated with a No. 5 Le Blanc condenser, and the circulating water is cooled in a 30 by 50 foot tower similar in design to those at the San Bernardino steam plant.

Electrical equipment.—The main unit, of the horizontal type, is a Westinghouse-Parsons 400-kilovolt-ampere 440-volt 525-ampere 3-phase 60-cycle steam turbo-generator operated at 3,600 revolutions per minute.

The 125-volt direct-current type M compound-wound exciter is operated at 390 revolutions per minute by a Westinghouse Standard vertical steam engine with two 7½ by 7 inch cylinders.

BLYTHE OIL-ENGINE PLANT.

The Blythe generating station, serving a small isolated system on Colorado River 60 miles north of Yuma, was constructed by The Southern Sierras Power Co. and put into operation November 25, 1917.

Building.—The entire equipment is housed in a single building with steel frame and roof trusses and corrugated-iron walls and roof. The building is 51 feet 2 inches long by 39 feet 1¾ inches wide, outside, with side walls 14 feet high and 34 feet from floor to peak of roof. A space 10 feet wide by 20 feet deep is partitioned off in the back of the building for office and lavatory. The rest of the station is a single large room. Large louver ventilators are installed in the upper part of the end walls.

Equipment.—The station is provided with two units—one a 150-horsepower 6-cylinder vertical Western Diesel engine direct-connected to a 125-kilowatt 2,300-volt 3-phase 60-cycle generator operating at 327 revolutions per minute, the other a 150-horsepower Snow horizontal oil engine belted to a second 125-kilowatt 2,300-volt 3-phase 60-cycle alternator. The total rated capacity of the plant is therefore 250 kilowatts.

The plant serves only the town of Blythe and immediate vicinity.

TRANSMISSION SYSTEM.

Although the lines of The Nevada-California system are operated in parallel, they fall naturally into three groups: First, the pole lines of The Nevada-California Power Co. eastward and northward of the Bishop Creek plants; second, the trunk tower line of The Southern Sierras Power Co. running from Bishop Creek southward to San

Bernardino, with the distribution lines connected thereto; and third, the pole transmission lines belonging to The Southern Sierras Power Co. running southeastward from San Bernardino plant to Imperial Valley and Yuma.

The first group includes the lines acquired from Pacific Power Corporation and supplied from the Mono Basin plants and the two parallel pole lines running from Bishop Creek plant No. 4 northeastward across Owens Valley and White Mountains to Silver Peak sub and switching station. At Silver Peak these lines diverge, one running north through Millers and Central to Round Mountain; the other running first eastward, then northward, and then westward through Alkali and Tonopah, finally closing in on the other line at Millers. Branch lines run from Alkali substation southeastward to Goldfield; and from Central substation eastward to Manhattan. The longest branch line was that which runs southeastward from Palmetto substation to Rhyolite, Pioneer, and Marble Quarry, a distance of 175 miles; this was removed in 1917. The interbranch that formerly left the main line east of the White Mountains and ran southeastward to the Loretta mine has also been removed.

The first of the parallel lines into Nevada was constructed in 1905 from power house No. 4 to Alkali switch station and thence to Tonopah, a total length of 118 miles, with a 10-mile branch from Alkali south to Goldfield. On the main line No. 0 7-strand aluminum conductor was used and on the branch No. 2 7-strand aluminum. One mile was replaced by No. 0 copper in the winter of 1905–6, and the number of poles was doubled.

In the second line, constructed in 1908, from power house No. 4 to Silver Peak, Millers, and closing in on the first line at Tonopah, No. 00 7-strand copper conductor was used as far as Palmetto substation, and No. 0 from Palmetto to Tonopah.

In 1910 the 38-mile line from Millers to Manhattan was constructed with No. 0 7-strand aluminum conductors. The line from Palmetto substation to Rhyolite, a distance of 72 miles, completed September 20, 1907, and removed in 1917, used No. 0 7-strand copper conductor.

In the standard construction of the Nevada lines, 35-foot cedar poles with 8-inch tops were used. The poles were spaced 17 to the mile and the conductors spaced on an equilateral triangle of 72 inches, the two lower conductors being carried on 7-foot cross arms and the upper conductor on a steel pin supported by an inverted U-shaped clevis fitted down over the top of the pole. On certain portions of the line this clevis was made out of light channel iron and very long, to supplement the short-length poles that were available in the vicinity.

The telephone line used at first only in the operation of Nevada system, but later also for commercial purposes, consists of two No. 9 (British wire gage) wires strung on a separate pole line with poles spaced 17 to the mile, the same as on the transmission lines, which were spaced 300 feet apart. The transmission insulators are nearly all No. 351 Locke pattern, 14 inches in diameter, or their equivalent. The insulator pins are made of 2-inch gas pipe.

The lines acquired from Pacific Power Corporation extended from Mono Lake northeastward into Nevada and southeastward to Bishop Creek. They comprised 98 miles of pole line in California and 107 miles in Nevada, all originally operated at 55,000 volts. The Nevada-California Power Co. removed the line from Hawthorne to Wonder and sold to Mineral County, Nev., the line from Mill Creek power house to Hawthorne, thus retaining only the 22 miles of 55,000-volt line between Rush and Mill Creek power houses out of the entire transmission system of Pacific Power Corporation.

The double-circuit steel-tower transmission line of The Southern Sierras Power Co., which extends from the control station at plant No. 5 on Bishop Creek in a southerly or southeasterly direction through Owens Valley across the Mojave Desert and San Bernardino Mountains to the city of San Bernardino, 239.5 miles, was constructed during 1911 and 1912. Sectionalizing stations for the line are located at Lone Pine, Inyokern, Randsburg, and Victorville, and it is therefore divided into five sections of approximately 50 miles each.

The standard steel towers are spaced an average distance of 660 feet apart and weigh 3,700 pounds. At angles of 2° or more the line is dead ended. When the angle is above 8° the towers are guyed; heavy towers weighing 4,700 pounds are used on angles greater than 22°. The towers measure 70 feet in height from ground to apex, and at each of the four corners there is a stub footing 6½ feet long entirely buried in the ground, with a plate of 12-inch channel iron 20 inches long fastened to its lower end. The four corner posts of the towers are bolted to the upper ends of four footing stubs. The distance from the ground surface to the first of the three cross arms is 44 feet, to the second 54 feet, and to the third 64 feet. The peak of the tower rises 6 feet above the upper cross arm. The upper and lower cross arms are 17 feet in length, and the center cross arm is 10 feet longer. On the northern portion of the transmission line a ground wire is strung on the peaks of the towers. The conductors are composed of 6-strand aluminum cable with a center core of plow-steel wire, each strand having a total cross section of 34,970 circular mils. Each conductor was strung to a tension of 1,500 pounds at 70° temperature, and at joints McIntyre soft steel sleeves were used in splicing the steel core. Three complete transpositions of each circuit are made in the total length of the line by systems of special towers.

The tower line was operated at 55,000 volts until July 7, 1919, when the potential was raised to 95,000 volts Y, with grounded neutral. The transformers of Bishop Creek plants 3, 5, and 6 have been changed to 95,000 Y grounded on the high-tension side and connected to the tower line. Plants 2 and 4 transmit to the control station at 55,000 volts where the potential is stepped up to 95,000 volts by a tie-in transformer. The original transmission line from Mill and Rush creek plants southeastward to Bishop Creek control station was operated at 55,000 volts with grounded neutral until 1918, when a new line of the two-pole and cross-bar type was completed. The three conductors of this line are 4/0 steel-cored stranded aluminum cables. The line south of Rush Creek is operated at 95,000 volts, but all the system north of Rush Creek plant is still operated at 55,000 volts. At both terminal substations the lines pass through 140,000-volt Bowie air switches mounted on dead-end towers.

The Southern Sierras distribution system in San Bernardino and Riverside counties, south of the city of San Bernardino, is partly steel and partly wooden pole construction and is operated at a potential of 33,000 volts. The line from San Bernardino to El Centro was put in operation in August, 1914. The section from San Bernardino to Banning always belonged to The Southern Sierras Power Co., but that from Banning to Calexico was originally the property of Coachella Valley Ice & Electric Co., and was not deeded to The Southern Sierras Power Co. until April, 1918. The conductors used on this line are No. 341 aluminum, spaced 72 inches on an equilateral triangle, with Locke insulators. The voltage is 85,000, and the total length of the line 166 miles. A 2,000-kilovolt-ampere synchronous condenser is installed at El Centro for regulating the voltage at the terminal. A line was built from El Centro to Yuma, 58.7 miles, in 1917. The length of circuit from Hawthorne, Nev., through the Mono Lake, Bishop Creek, and San Bernardino plants to El Centro is 531 miles, and to Yuma 590. The 33,000-volt line from Victorville to Barstow, 39.2 miles, was built in 1917.

Condensed information concerning the transmission and distribution lines is given in Tables 165 and 166; the substations are covered in detail by Tables 167 and 168.

TABLE 165.—*Growth of transmission and distribution lines, The Nevada-California Power system (including all subsidiaries except Holton Power Co.), 1913–1920.*

Year.	Number of substations (Nevada-California Power Co. and Southern Sierras Power Co.)	Length of line (miles).							
		140,000 volts.[a]	55,000 volts.		33,000 volts.	15,000 volts.	12,000 volts.	6,600 volts and less.	
		Southern Sierras Power Co.	Southern Sierras Power Co.	Nevada-California Power Co.	Southern Sierras Power Co.	Southern Sierras Power Co.	Nevada-California Power Co. and Pacific Power Co.	Nevada-California Power Co.	Southern Sierras Power Co.
1913	41	239.5	36	372	192	....	28	100	173
1914	51	239.5	165	372	232	16	41	114	209
1915	54	239.5	165	357	240	42	42	114	233
1916	54	239.5	165	357	251	43	42	114	262
1917	59	239.5	224	480	334	52	48	91	319
1918	65	239.5	224	480	367	44	48	94	292
1919	64	298.3	251	394	376	54	49	109	321
1920	69	298.3	251	368	409	68	50	58	387

[a] Operated at 55,000 volts until July 7, 1919, and at 95,000 volts since that date.

TABLE 166.—*Growth in number of substations and distribution system of The Nevada-California Power Co., 1905–1912.*

Year.	Number of substations.	Overhead distribution lines.	Year.	Number of substations.	Overhead distribution lines.
		Miles.			*Miles.*
1905	4	4.5	1909	7	131
1906	4	80.0	1910	7	133
1907	5	114.0	1911	8	135
1908	6	120.0	1912	8	137

TABLE 167.—*Substations of The Nevada-California Power Co.*

District.	Substation.	Location.	Building.		Put in operation.	Voltage.				Capacity of transformers.		Service.
						Incoming circuits.		Outgoing circuits.				
			Type.	Size.		No.	Volts.	No.	Volts.	No.	Kilovolt-amperes.	
				Feet.								
Silver Peak....	Silver Peak...	In town, 3 miles from Blair.	Corrugated iron...	36 by 56	1905	2	55,000	1 2	2,200 55,000	3	65	Power and lighting, on feeder to local power service; switching station on Alkali and Millers lines.
Goldfield.......	Alkali	10 miles from Goldfield.	Concrete..........	24 by 26	1906	2	55,000	1 1	6,600 55,000	3	225	Power and lighting locally; switching station on Tonopah and Goldfield lines.
Goldfield.......	Goldfield......	Northern part of town.	Stone............	43 by 60	1906	1	55,000	3	6,600	7 ...	3,450 [a]50	Power and lighting locally;
Tonopah.......	Tonopah......	3 blocks from center of town.	....do...........	65 by 31	1905	2	55,000	7 3 1	6,600 6,600 11,000	9 ...	10,500 [a]50	Power and lighting locally.
Manhattan.....	Manhattan....	West end of town, 6 blocks from center.	Concrete, with tile roof.	34 by 54	1909	1	55,000	1 2 1	55,000 11,000 6,600	4	1,200 [a]100	Switching station on Manhattant-Belmont line. Power and lighting locally; stepdown station for 11,000-volt line to Round Mountain.
Tonopah.......	Millers........	In mill yards of Tonopah Mining Co.	Corrugated iron...	30 by 44	1908	2	55,000	2 1	2,200 55,000	4	2,000	Power and lighting locally; switching station on Manhattan and Tonopah lines.

[a] Regulator.

TABLE 168.—*Substations of The Southern Sierras Power Co.*

District.	Substation.	Location.	Type of building.	Put into operation.	Voltage.				Capacity (kilovolt-amperes).	Service.
					Incoming circuits.		Outgoing circuits.			
					No.	Volts.	No.	Volts.		
	Control	Near plant 5, Nevada-California Power Co.	Outdoor	Mar., 1913	4 2	100,000 55,000	2 2	100,000 55,000	6,000	Receiver from hydroelectric station.
	Bishop-Big Pine [a]	Plant No. 6	do	May, 1918			2	6,600	225	
	Lone Pine	Near town	do	May, 1913	2	100,000	2 2	100,000 33,000	1,500	Switching-station service, local power and light and Keeler branch. Switches to Los Angeles aqueduct plant on one 33,000 circuit.
	Inyo-Kern	do	do	Apr., 1913	2	100,000	2 1 2	100,000 33,000 2,200	4,500	Local power and switching station and 33,000 branch to Trona.
	Randsburg	In town	do	June, 1913	2	100,000	2 3 4	100,000 33,000 2,200	1,500	Switching station. Serves local power and Golar, Mount Wells, and Atolia lines on 33,000 volts.
	Victorville	7 miles from town	do		2	100,000	2 2	100,000 33,000	3,000	Serves local power and Oro Grande-Barstow, Victorville-Oro Grande, and Adelante.
	San Bernardino terminal or substation.	Steam station	do	June, 1912	2	100,000	1 6	55,000 36,000	36,000	General lighting and power on Southern Sierras system.
San Bernardino	San Bernardino city	San Bernardino steam plant.	In switchroom of steam plant.	1913	1	6,600	5	2,200	1,200	Municipal lighting.
	Bloomington	Bloomington	Outdoor		1	33,000	1	2,200	150	
	Rialto	Rialto	do		1	33,000	1	2,200	75	
Biverside		Highgrove	do	1915	1	33,000	1	2,200	150	Do.
		Glen Aron	do	1916	1	33,000	1	2,200	300	Pumping loads.
		Rogers	do	1916	1	33,000	2	2,200	300	Do.
		Citrus experiment station.	do	1917	1	33,000	2	2,200	150	Do.
		Wineville	do	1919	1	33,000	1 2	2,200 220	400 250	Cannery and pumping.
	Riverside	West Riverside	do	1912	1	33,000	2	2,200	300	Pumping and miscellaneous power served through 19.5 miles.
Corona	Eastvale	Near Corona	do	1919	1	33,000	1	2,200	100	Pumping and miscellaneous.
	South Corona	do	do	1914	1	33,000	1	2,200	150	Do.
	Chase Plantation	do	do	1914	1	33,000	3	2,200	150	Do.
	El Cerrito Chemical	do	do	1918	1	33,000	1	440	100	Industrial.
	Corona	In Corona	do	1913	1	33,000	4	2,200	600	Local.

[a] Burned down. Fed direct from power plant No. 6.

TABLE 168.—*Substations of The Southern Sierras Power Co.*—Continued.

District.	Substation.	Location.	Type of building.	Put into operation.	Voltage.				Capacity (kilovolt-amperes).	Service.
					Incoming circuits.		Outgoing circuits.			
					No.	Volts.	No.	Volts.		
Corona	Corona Foothill	In Corona	Outdoor	1919	1	33,000	1	440	150	Pumping and miscellaneous.
	El Cerrito Ranch	Near Corona	do	1918	1	33,000	1	440	100	Do.
	E. T. Earl Ranch	do	do	1918	1	33,000	1	440	100	Do.
	Cold Water Canyon	do	do	1918	1	33,000	2	460	400	Do.
	Temescal Rock	do	do	1915	1	33,000	1	460	900	Industrial.
	E. T. Earl No. 2	do	do	1920	1	33,000	1	440	100	
Elsinore	Elsinore	Elsinore	do	1912	2	33,000	3	2,200	225	Lighting and pumping.
	Alberhill	Near Elsinore	do	1917	1	33,000	1	440	900	Served through 13.5 miles of overhead distribution lines.
							1	2,200	30	
	Sedoo	do	do	1912	1	33,000	1	2,200	150	
	Lucerne	do	do	1913	1	33,000	1	2,200	300	
Perris	Liberty Ranch	Perris Valley	do	1917	1	33,000	1	440	100	Pumping load mainly.
	Newport No. 1	do	do	1913	1	33,000	1	2,200	150	Do.
	Newport No. 2	do	do	1920	1	33,000	1	2,200	100	
	Ethanac	do	do	1914	1	33,000	3	2,200	600	Do.
	Perris	do	do	1912	1	33,000	4	2,200	900	Do.
	Nuevo	do	do	1917	1	33,000	2	2,200	450	Do.
	Marigold	do	do	1915	1	33,000	1	2,200	450	Do.
	Valverdi No. 1	do	do	1917	1	33,000	1	440	50	Do.
	Valverdi No. 2	do	do	1917	1	33,000	1	440	50	Do.
	Moreno	do	do	1917	1	33,000	1	440	300	Do.
	Sunnymead	do	do	1915	1	33,000	1	2,200	50	Do.
	March Field	do	do	1918	1	33,000	1	2,200	150	Do.
San Jacinto	San Jacinto	San Jacinto	do	1912	1	33,000	3	2,200	900	City lighting and power served through 24 miles of line.
	Lakeview	Between San Jacinto and Mareno.	do	1912	1	33,000	1	2,200	100	Do.
	Ostrich Farm	Near San Jacinto	do	1916	1	33,000	1	2,200	300	Do.
Hemet	Hemet	Hemet	do	1912	1	33,000	3	2,200	1,200	City lighting and power, also rural load, served through 26.5 miles of line.
	Sobopa Street	Near Hemet	do	1920	1	33,000	1	2,200	300	
	Magnesite			1917	1	33,000	1	2,200	300	
	Banning	Banning	Outdoor	1914	1	85,000	1	85,000	975	
							1	15,000		
							1	2,200		

	Blythe [b]	Palo Verde Valley	Corrugated iron, steel frame (generating plant).	1916	....	....	2	2,200	250	
Coachella	Coachella	Coachella	Outdoor	1914	1	55,000	2	15,000	1,500	
Imperial	Calipatria [c]	Calipatria	do	1914	1	55,000	3	15,000	900	
	El Centro [c]	El Centro	do	1914	1	85,000	4	2,200	3,750	Condenser.
							5	15,000	....	
Yuma	Yuma	Near Yuma	do	1917	1	85,000	2	2,200	1,500	City, industrial.
							1	33,000	....	
	Hanlon Heading	Hanlon Heading	do	1919	1	85,000	1	2,200	2,400	Dredges.
							1	15,000	....	

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[b] The Blythe plant has two 125-kilovolt-ampere generating units driven by semi-Diesel engines; it is a generating station only.

[c] Holton Power Co.

HOLTON POWER CO.

HISTORY.

In 1900 a very large area of what had hitherto been desert land, west of Colorado River and south of the line of the Southern Pacific Railroad, partly in Mexico and partly in California, was brought under irrigation. The project, at first very successful, was soon threatened with destruction by breaks in the banks of Colorado River, which in this part of its course, has in times past formed a delta, and now flows through a channel higher than the valley floor.[62] After several years of strenuous effort the river was controlled, and since the successful completion of this restraining work the development of the irrigated territory has been extremely rapid. As the growing population in the district provided an excellent market for power, W. F. Holt (one of the leaders in the development of the region) and his associates organized Holton Power Co. in September, 1903, and later incorporated Holton Interurban Railway Co., a subsidiary, to operate a railway between El Centro and Holtville. In 1911 Mr. Holt and his associates also incorporated Coachella Valley Ice & Electric Co., a cold-storage and electric system to operate in Coachella Valley on the main line of the Southern Pacific between Banning and Indio.

Holton Power Co. constructed its first hydroelectric plant on an irrigation canal at Holtville in 1906 and a second at the same place in 1910. This second plant was enlarged in 1913.[63] The company also

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[62] See La Rue, E. C., Colorado River and its utilization: U. S. Geol. Survey Water-Suppy Paper 395, 1916.

[63] Both Holtville hydroelectric plants received their water supply from an irrigation canal belonging to California Development Co., fed from the main canal diverting from the Colorado River a few miles below Yuma.

The power canal, itself 3 miles long, receives its supply at a check gate 3 miles east of Holtville at an elevation of 76 feet above sea level. The grade in the canal is 0.1 per cent and its capacity 300 second-feet.

Water was delivered directly from the end of the power ditch to the head of the pressure pipe, now partly wrecked, through a 50-inch gate valve. The pressure line was constructed of 52-inch redwood-stave pipe, was 1,398 feet long, and ran straight to the power house. The pipe was covered throughout its entire length. Power houses Nos. 1 and 3 (the steam station in El Centro is designated power house No. 2) were close together and were supplied through their single pipe. The static head at power house No. 1 was 47 feet and the working head at maximum load 28.6 feet. The static head of power house No. 3 was 66 feet and the working head 47.6 feet. The capacity of the pressure line at maximum power was 225 second-feet.

Power house No. 1 is constructed of brick and is 40 feet long, 25 feet wide, and 18 feet high. It was shut down in June, 1917; it contained a single Bullock revolving-field 250 kilovolt-ampere 2,400-volt 60.3-ampere 3-phase 60-cycle alternator direct-connected to a double horizontal Victor turbine with 27-inch runners designed to operate at 450 revolutions per minute. This generator was removed in 1920 and installed as an auxiliary in the Owens River power plant of The Southern Sierras Power Co.

The exciter is a Bullock 120-volt 39.5-ampere direct-current generator operating at 1,550 revolutions per minute.

The three Bullock oil-insulated water-cooled single-phase transformers with a capacity of 200 kilowatts each, in a compartment in a corner of the power house, step the potential up from 2,400 to 15,000 volts delta for transmission.

A set of Shaw disk lightning arresters is installed in the transformer room.

Power house No. 3, a concrete building 55 feet long, 30 feet wide, and 25 feet high, originally put in operation early in 1910, housed a single unit to which a second and much smaller was added before the plant was finally shut down in 1917. The station is entirely dismantled, although the walls and roof of the building still remain. The original unit was an Allis-Chalmers revolving field 700-kilovolt-ampere constructed a steam plant at El Centro in 1908 and a producer-gas electric station at El Centro in April, 1912. The load developed rapidly, soon exceeding the capacity of the hydroelectric plants, and the power developed at the auxiliary stations proved costly. The company therefore made arrangements to procure hydroelectric power from the lines of the Southern Sierras Power Co. through a main transmission line constructed by Coachella Valley Ice & Electric Co. from Banning to El Centro.

Up to the end of 1916 Holton Power Co. was controlled by W. F. Holt, who on December 31 of that year owned 6,232 shares of its stock; C. A. Hooper, trustee, 1,215; D. W. Wickersham, 1,000; H. E. Hubbard, 734, being the other large stockholders. During 1917 the entire stock, except directors' qualifying shares, was acquired by The Nevada-California Electric Corporation, and on December 31 of that year 12,490 shares were held by W. Sherman Fisher, trustee, officials of the electric corporation qualifying as directors through ownership of the remaining 10 shares. During 1919, 3,000 shares were transferred from the trustee to the treasury.

From its formation to 1916 Coachella Valley Ice & Electric Co. was controlled through stock ownership by Holton Power Co. and W. F. Holt. The first activities of the company were centered in the construction of an ice and cold-storage plant at Coachella to supply ice to local users and to the Pacific Fruit Express. The activities of the company were confined to this business until the later part of 1913, when it entered into contract with The Southern Sierras Power Co. to purchase power at Banning and transmit this energy over a main transmission line to El Centro, selling it at that point to Holton Power Co. This line was completed and the delivery of power to Holton Power Co. began in August, 1914. The Coachella Valley Co. began also to furnish local electric service in Coachella Valley and vicinity through a 50-kilowatt substation at Indio in August, 1914.

On December 31, 1915, Coachella Valley Ice & Electric Co. was controlled by Holton Power Co. through the ownership of 1,568 out of 3,000 shares of capital stock. During 1916, however, The Nevada-California Electric Corporation secured stock control and on December 31 of that year owned 2,966 shares, in addition to which part of the remaining shares served to qualify directors connected with The Nevada-California Corporation. By the end of 1917 all

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2,400-volt 168.5-ampere 3-phase 60-cycle alternator operated at 450 revolutions per minute, by a double horizontal turbine with 29-inch runners controlled by an Allis-Chalmers oil-pressure governor.

The exciter was an Allis-Chalmers 9-kilowatt 120-volt direct-current generator operated at 1,550 revolutions per minute.

Generator No. 2, installed later, was a 350-kilovolt-ampere machine, 2,400-volt 3-phase 60-cycle, giving a total installation of 1,050 kilovolt-amperes for power house No. 3. The same transformer and switching equipment served both power houses.

outstanding shares were controlled by the electric corporation and the property was sold to The Southern Sierras Power Co. on March 31, 1918.

MARKET.

TERRITORY AND POPULATION.

Holton Power Co. operates in a highly productive territory reclaime from the desert entirely by irrigation. The territory and tributary population are therefore decidedly restricted. The area includes a strip of country in Imperial County about 30 miles long by 20 wide, extending from the Mexican line due north to the south end of Salton Sea.

TABLE 169.—*Incorporated places served by Holton Power Co.*

City or town.	Population.	
	1910	1920
Brawley	881	5,389
Calexico	797	6,223
Calipatria		785
El Centro	1,610	5,464
Holtville	729	1,347
Imperial	1,257	1,885
	5,274	21,093

Energy is also sold to Mexicali Light & Water Co., of Mexicali, Mexico (population 4,324), on the California side of the United States border.

LOAD.

Power generated at the hydroelectric, steam-electric, and producer-gas engine plant of Holton Power Co. and power purchased from The Southern Sierras system through El Centro and Calipatria substations are given in Table 170.

TABLE 170.—*Power generated and purchased (kilowatt-hours) by Holton Power Co., 1913–1918.*

Year.	Power generated.		Total power generated.	Power purchased.	Total power generated and purchased.	Mean load.	System peak.
	Hydroelectric.	Steam.					
	Kilowatt-hours.	*Kilowatt-hours.*	*Kilowatt-hours.*	*Kilowatt-hours.*	*Kilowatt-hours.*	*Horsepower.*	*Horsepower.*
1913	2,615,641	1,834,352	4,449,993		4,449,993	681	1,007
1914	2,793,630	1,387,899	4,181,529		4,181,529	640	(b)
1915	2,105,740	13,275	2,119,015	5,940,664	8,059,679	1,233	(b)
1916	1,132,295	[a] 51,490	1,183,785	8,084,070	9,267,855	1,414	(b)
1917	424,965	[a] 56,620	481,585	11,381,950	11,863,525	1,815	(b)
1918		[a] 90,080	90,080	12,905,795	12,995,875	1,989	(b)

[a] Gas-engine and steam-electric combined.

[b] Not reported.

The current sold, in kilowatt-hours, and connected load for years 1913 to 1918 is given in Table 171, which shows that the market for power is almost exclusively directly or indirectly for agricultural uses and for the lighting of farming towns of the Imperial district.

The distribution lines in the valley are operated by Holton Power Co. The main transmission lines, completed from Banning to El Centro in August, 1914, and from El Centro to Hanlon Heading, on Colorado River below Yuma, in April, 1917, have been operated by The Southern Sierras Power Co. and its predecessor, Coachella Valley Ice & Electric Co. Holton Power Co. receives from this main line only at El Centro and Calipatria substations.

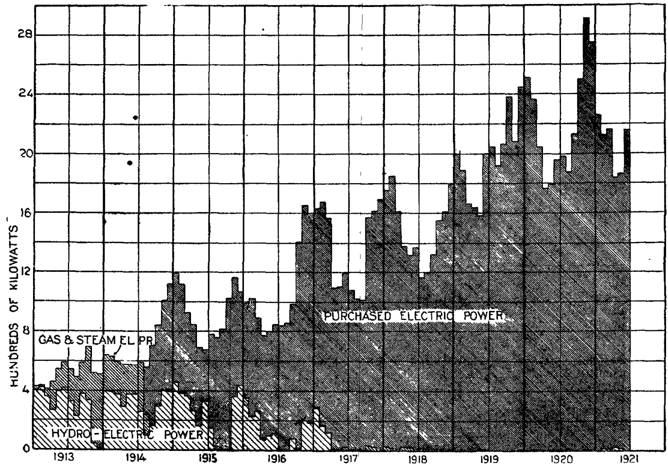

FIGURE 41 —Holton Power Co. (The Nevada-California Power system), mean monthly loads, 1913–1921.

During 1915 Coachella Valley Ice & Electric Co. sold only 388,950, and in 1916, 1,048,000 kilowatt-hours, exclusive of its deliveries to Holton Power Co. In 1917 its sales in Coachella Valley were 2,304,800 kilowatt-hours, and its sales at Hanlon Heading, on the Colorado, 1,588,600.

The contract of the Coachella Valley Ice & Electric Co. with The Southern Sierras Power Co. for delivery of power at Banning was executed November 8, 1913, for 43 years, and provided for the delivery of all power needed by the Coachella Valley Co. not in excess of a maximum demand of 3,000 kilowatts, at a rate of 1 cent per kilowatt-hour, with a minimum annual payment of $18,000 for the first 5 years and $28,000 per annum for the remaining 38 years.

The contract for sale of power from Coachella Valley Ice & Electric Co. to Holton Power Co. at El Centro was also signed November 8, 1913, to run for the period of 43 years, and to provide for the delivery of such power as might be needed at a price of 2 cents per kilowatt-hour with a minimum annual payment of $36,000 for the first 5 and $56,000 per annum for the last 38 years.

Mean monthly loads for the Holton Power system, for 1913 to 1919, are shown graphically in figure 41, which was prepared from monthly outputs in kilowatt-hours at various generating stations and kilowatt-hours purchased. The figure shows that since the completion of the main transmission line from Banning the principal part of the company's load has been carried with hydroelectric power.

TABLE 171.—*Current sold and connected load, Holton Power Co., 1913–1920.*

Class of load.	1913				1914			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	180,250	5.6	599	23.3	341,743	7.3	808	17.0
Commercial	441,292	13.9	619	24.1	746,248	15.8	1,162	24.4
Municipal	71,479	2.2	28	1.1	34,889	2.8	52	1.2
All other								
Power:								
Industrial	2,109,494	66.3	1,289	50.3	3,324,027	70.8	2,561	53.8
Agricultural								
Municipal								
All other	382,586	12.0	30	1.2	196,995	4.1	166	3.6
Other electric corporations								
	3,185,101	100.0	2,565	100.0	4,743,902	100.0	4,749	100.0

Class of load.	1915				1916			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence	396,562	6.2	1,288	19.1	1,314,648	22.2	1,562	22.2
Commercial	886,908	13.9	1,293	19.3			1,508	21.1
Municipal	160,440	2.4	64.8		170,649	2.9	91.1	1.3
All other	189,580	2.9						
Power:								
Industrial	4,509,833	70.8	3,819	56.9	3,835,762	64.6	[illegible]	55.2
Agricultural							[illegible]	.2
Municipal								
All other	247,801	3.8	319	4.7	611,856	10.3		
Other electric corporations								
	6,391,124	100.0	6,783.8	100.0	5,932,915	100.0	7,109.8	100.0

TABLE 171.—*Current sold and connected load, Holton Power Co., 1913–1920*—Contd.

Class of load.	1917				1918			
	Sales.		Connected load.		Sales.		Connected load.	
	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.	Kilowatt-hours.	Per cent of total.	Kilowatts.	Per cent of total.
Lighting:								
Residence			1,695.7	21.9	570,016	5.5	1,775.9	19.9
Commercial	1,744,400	17.2	1,565.7	20.3	1,110,000	10.8	1,549.4	17.4
Municipal			101.9	1.3			101.9	1.4
All other								
Power:								
Industrial			4,356.7	56.3	7,580,042	73.4	4,845.3	54.3
Agricultural	8,376,000	82.8	16.2	.2			8.8	.1
Municipal					409,410	4.0	254.9	2.8
All other					124,155	1.2	336.0	3.7
Other electric corporations					523,360	5.0	37.0	.4
	10,120,400	100.0	7,736.2	100.0	10,317,083	100.0	8,909.2	100.0

	1919				1920			
Lighting:								
Residence	637,800	4.7	2,172.9	20.5	837,814	4.8	2,852.9	24.0
Commercial	1,269,334	9.4	1,675.4	15.8	1,733,383	10.0	2,254.4	19.0
Municipal			101.9	1.0				
All other							890.4	7.6
Power:								
Industrial	10,267,802	76.1	5,948.3	56.1	12,154,885	70.0	5,358.5	45.2
Agricultural			11.3	.1				
Municipal	445,930	3.3	254.9	2.4	723,822	4.1	336.5	2.8
All other	190,098	1.4	372.0	3.5	460,628	2.6		
Other electric corporations	677,580	5.0	75.0	.6	1,487,420	8.5	165.0	1.4
	13,488,544	100.0	10,611.7	100.0	17,397,952	100.0	11,857.7	100.0

ELECTRIC SYSTEM.

EL CENTRO STEAM PLANT.

El Centro steam plant was constructed by Holton Power Co. and put into operation in 1908. The single 300-kilovolt-ampere unit installed at that time was replaced November, 1918, by a 350-kilovolt-ampere machine.

Buildings.—The two original buildings were constructed of brick, but in 1916 the generator room was wrecked by a severe earthquake and was replaced by a corrugated galvanized-iron building with wooden frame, built against the front of the boiler house. The composite building is L-shaped in plan, the generator house being approximately 80 feet long by 30 feet deep and the brick boiler house 50 feet long by 44 feet deep. The boiler house has a corrugated-iron roof supported on wooden trusses.

Mechanical equipment.—Two 250-horsepower Stirling water-tube boilers are installed in the back of the boiler room facing forward.

Pumps and other auxiliary equipment are installed in the space in front of the boilers. Feed water is supplied either by two duplex Worthington 6 by 4 by 6 inch or by two Fairbanks-Morse 7 by 4½ by 7 inch feed pumps. The feed-water heater was manufactured by Llewellyn Iron Works Co., of Los Angeles. The prime mover of the main unit is a St. Louis Iron & Machine Works noncondensing tandem Corliss engine.

Electrical equipment.—The main generator, a 350-kilovolt-ampere 2,400-volt 84.3-ampere 3-phase 60-cycle alternator, is operated at 450 revolutions per minute by a belt from the engine.

The exciter is a Bullock 15-kilowatt 120-volt 125-ampere direct-current generator driven at 1,500 revolutions per minute by a belt from one end of the main generator shaft.

The steam plant connects to the transmission system through the El Centro substation located on the same block.

EL CENTRO GAS-ENGINE PLANT.

The El Centro gas-engine electric plant was constructed by Holton Power Co. and began operating in April, 1912. It is located in El Centro on the same property with the El Centro steam plant and substation.

Building.—The entire station is housed in a single brick and reinforced-concrete building with steel roof system and galvanized corrugated-iron roof, measuring approximately 80 feet long by 50 feet wide.

A transverse wall divides the interior of the main floor into a generator room 64 feet long by 50 feet wide, and a gas producer and auxiliary space 16 feet in depth and extending the full 50-foot width of the plant. This space is further divided into an auxiliary [illegible] 16 by 10 feet and a producer room 16 by 40 feet.

Beneath the main floor there is a high basement most of which is taken up by the heavy foundations of the gas engines; sufficient room remains, however, for a machine and work shop. A large ventilator extends the entire length of the peak of the roof.

Mechanical equipment.—The single electric generator is driven by two 21 by 30 inch Allis-Chalmers twin tandem gas engines direct-connected to the ends of the generator shaft.

Producer gas is generated for the engines by three Allis-Chalmers oil gas producers, each having a normal capacity of 18,500 cubic feet of gas per hour, at 180 British thermal units per cubic foot. Each producer has a self-contained gas washer, and there is a small gas tank or accumulator immediately behind the station. The gas engines are started by compressed air supplied at 200 to 220 pounds pressure from an air tank.

A 10-horsepower gas engine operating a compressor raises the pressure in the air tank to 220 pounds, after which leakage is taken care of by connecting the compressor to a 7.5-horsepower alternating-current motor which is put into operation automatically when pressure in the tank drops to 200 pounds per square inch. Current for ignition is generated by an Allis-Chalmers 110-volt 6.36-ampere direct-current generator operated at 1,000 revolutions per minute, either by a Crocker-Wheeler 2-horsepower 220-volt 5.9-ampere 3-phase 60-cycle motor, or by a belt from the shaft of the compressor.

Electrical equipment.—The main generator is an Allis-Chalmers 950-kilovolt-ampere 2,400-volt 227-ampere 3-phase 60-cycle alternating-current machine, operated at 180 revolutions per minute. An Allis-Chalmers 22.5-kilowatt 120-volt 187.5-ampere exciter is operated at 925 revolutions per minute by a belt from the shaft of the main generator.

The station connects to the transmission and distribution system through the El Centro substation on the same lot.

TRANSMISSION AND DISTRIBUTION SYSTEM.

Tables 172 and 173 give detailed information concerning the company's transmission and distribution system as it stood at the end of 1920.

TABLE 172.—*High-tension transmission lines operated by Holton Power Co., Dec. 31 1920.*

District.	Miles constructed.	Voltage.	Circuits.
Brawley	15.18	15,000	1
Calexico	10.55	15,000	2
Calipatria	10.85	15,000	1
Dixieland	14.00	15,000	1
Holtville	.75	15,000	1
	51.33		

NOTE.—All lines are supported on 35-foot wooden poles.

TABLE 173.—*Rated capacity of substations operated by Holton Power Co., 1920.*

Substations.	Rated kilovolt-amperes.	Miles of primary distribution lines, all overhead.	Substations.	Rated kilovolt-amperes.	Miles of primary distribution lines, all overhead.
Brawley	1,125	10.50	Imperial	400	6.84
Calexico	1,700	11.18	Meloland	10	.5
Calipatria	150	3.43	Mexicali	600	
Dixieland	15	.5	Niland		1.0
El Centro		17.23	Seeley		.94
Heber	30	2.8			
Holtville	225	4.99		4,255	59.91

CHAPTER V.—NEVADA MARKET.

TERRITORY COVERED.

AREA AND POPULATION.

The transmission lines serving the Nevada market enter Douglas Lyon, Ormsby, Storey, and Washoe counties, all of which are in Nevada. The area and population of these counties are given in Table 174.

TABLE 174.—*Area and population of counties in Nevada market. (All served by Sierra Pacific Electric system.)*

County.	Area.	Population.			Class of population.					
					Urban.					
		1900	1910	1920	1900		1910		1920	
	Sq. mi.					*P. ct.*		*P. ct.*		*P. ct.*
Douglas	733	1,534	1,895	1,825						
Lyon	1,509	2,268	3,568	4,078						
Ormsby	156	2,893	3,415	2,453						
Storey	251	3,673	3,045	1,469	2,695	73.4				
Washoe	6,251	9,141	17,434	18,627	4,500	49.2	13,367	76.7	15,254	81.9
	8,900	19,509	29,357	28,452	7,195	36.8	13,367	45.5	15,254	53.5

County.	Class of population.					
	Rural.					
	1900		1910		1920	
		Per cent.		*Per cent.*		*Per cent.*
Douglas	1,534	100	1,895	100	1,825	100
Lyon	2,268	100	3,568	100	4,078	100
Ormsby	2,893	100	3,415	100	2,453	100
Storey	978	26.6	3,045	100	1,469	100
Washoe	4,641	50.8	4,067	23.3	3,373	18.1
	12,314	63.2	15,990	54.5	13,198	46.5

The population of the incorporated places in the market is shown in Table 175.

TABLE 175.—*Population of incorporated places in Nevada market.*

City or town.	County.	Population.			
		1890	1900	1910	1920
Carson	Ormsby	3,950	2,100	2,466	1,685
Reno	Washoe	3,563	4,500	10,867	12,016
Silver City	Lyon	342	307	337	100
Sparks	Washoe			2,500	3,238
Yerington	Lyon			682	1,169
		7,855	6,907	16,852	18,208

The following unincorporated places are also served:

Bluestone.
Dayton.
Floriston.
Ludwig.
Minden.
Verdi.
Como.
Empire.
Gardnerville.
Mason.
Thompson.
Virginia City.

PHYSICAL AND INDUSTRIAL FEATURES OF COUNTIES.

The physical and economic features are briefly described in the following paragraphs. It will be noted that the population in several parts of the territory showed a marked decrease between 1890 and 1900, which was in some counties offset by an increase in population between 1900 and 1910. These irregularities point distinctly to the periods of prosperity or depression in the mines.

Douglas County.—Douglas County is south of Ormsby County and along the western border of Nevada and the eastern edge of the Sierra. A small amount of mining, timbering, and agriculture is carried on. The demand for power is served by the Sierra Pacific Electric Co. (The Truckee River General Electric Co.).

Lyon County.—The country east of Storey, Ormsby, and Douglas counties including Walker River valley and the secondary ranges is in Lyon County. The chief users of power are mines and smelters, which are served by the Sierra Pacific Electric Co. (The Truckee River General Electric Co.).

Ormsby County.—Ormsby County is a small county just east of Lake Tahoe. It includes Carson City, the State capital, and part of Carson valley. The chief demand for power has come from mines, though the agricultural load is gradually increasing. The area is served by the Sierra Pacific Electric Co. (The Truckee River General Electric Co.).

Storey County.—Storey County is east of Ormsby and includes the Virginia City mining region, which for many years has been one of the chief load centers east of the mountains. It is served by the Sierra Pacific Electric Co. (The Truckee River General Electric Co.).

Washoe County.—Washoe County extends along the western boundary of Nevada from the vicinity of Reno northward to the Oregon line. In the long valleys at the eastern base of the Sierras agriculture is developed in varying degrees; elsewhere the country is arid. Mining is carried on in scattered districts and the mines, railway shops, and ranches furnish the market for power. Only the extreme south end of the county is reached by electric transmission lines, all of which are owned by the Sierra Pacific Electric Co. (The Truckee River General Electric Co. and Reno Power, Light & Water Co.).

SIERRA PACIFIC ELECTRIC CO.

HISTORY.

In 1909 Sierra Pacific Electric Co. was formed by Stone & Webster (then Stone & Webster Corporation) to acquire, among other properties, the various small hydroelectric systems along Truckee River, which were held either by purchase or option by San Francisco capitalists. The companies which passed into the control of Sierra Pacific Electric Co. on its formation included Truckee River General Electric Co., Union Light & Water Co., California-Nevada Electric Power Co., Loon Lake Water & Power Co., Carson City Coal Gas Co., and Reno Power, Light & Water Co.

The holding company later acquired the stocks of Washoe Power & Development Co. and Washoe Deep Well Water Co., and there have been certain changes in the component companies listed above. The system is often referred to as The Truckee River General Electric system, because that company was the first to establish itself on the river.

Sierra Pacific Electric Co. is the holding company, and The Truckee River General Electric Co. and Reno Power, Light & Water Co. are the operating organizations for the entire electric business of Reno, Sparks, Virginia City, Carson City, and the surrounding territory in western Nevada.

Truckee River General Electric Co., predecessor of The Truckee River General Electric Co., was incorporated August 31, 1899, under the laws of California and was financed on the strength of a contract entered into with the Comstock Pumping Association, by which that association agreed to buy power and advanced $100,000 toward the completion of the Farad plant. With this aid the company constructed the plant and a line to Virginia City. The plant was completed and went into operation in 1899.[1]

In 1905 the company installed another station at Fleish, just below Farad, and in 1911, after the stock control of the company had passed into the hands of Sierra Pacific Electric Co., it built a third plant at Verdi with money advanced by the latter corporation. In 1905 the

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[1] In Virginia City the company agreed to furnish 2,300-volt 3-phase service for a minimum of 1,500-horsepower, used for pumping operations in the mines. The rates charged were as follows:

	Per horsepower per month.
Less than 2,000 horsepower	$7.00
2,000 to 3,000 horsepower	6.50
3,000 to 4,000 horsepower	6.00
4,000 to 4,500 horsepower	5.50
4,500 to 7,000 horsepower	5.00
7,000 horsepower and over	4.00

These figures were based on a maximum demand for the highest reading for any time not exceeding five minutes. At the time that transmission began the operating expense of power supplied by steam was $34.13 per indicated horsepower per month in Virginia City. Wood cost $10 to $12 per cord and was of such quality that 1 cord would evaporate 10,670 pounds of water from and at 212°. See Eckart, W. R., Jour. Electricity, vol. 10, p. 97, 1908.

lines of Truckee River General Electric and Reno Power, Light & Water companies were interconnected and the Reno company began to receive power on an annual flat charge. The combined transmission now extends as far south as Yerington, Nev.

In 1912 Truckee River General Electric Co. was reincorporated as The Truckee River General Electric Co., under the laws of Maine, with the same authorized and issued stock as the old company, $3,000,000, all of which is owned by Sierra Pacific Electric Co.

In 1912 also all the properties and assets of Loon Lake Water & Power Co., consisting chiefly of undeveloped power sites on Rubicon Creek, a tributary of American River, and California-Nevada Electric Power Co. were transferred to The Truckee River General Electric Co. In addition to the properties referred to, the company owns $43,750 out of $50,000 of the stock of Carson Coal Gas Co., and the rest is owned by Sierra Pacific Electric Co. The Carson City Coal Gas Co. controls the entire gas business in Carson City.

California-Nevada Electric Power Co. was organized under the laws of California in 1907, and its entire issued capital stock of $5,000,000 was acquired by Sierra Pacific Electric Co. in 1909. The California-Nevada Electric Power Co. made no hydroelectric or other installations; its entire property consisted of lands, water rights, and undeveloped power sites.

Reno Power, Light & Water Co. was organized under the laws of California in 1904 as a successor of Nevada Power, Light & Water Co., and acquired all the property and assets of that company. The object of this reorganization was to facilitate obtaining additional money required to finance extensions. The company is an outgrowth of various electric, gas, and water companies, some of which dated as far back as 1870. All the stock was outstanding and was in 1909 acquired by Sierra Pacific Electric Co. The company owns $176,131 of the capital stock of the Washoe Power & Development Co. (organized under the laws of Nevada in 1902), of which $151,000 is subject to the mortgage and the rest is held by Sierra Pacific Electric Co. The Washoe company built the Washoe plant near Mogul above Reno, which it operated until 1905, when its system was leased to the Reno Power, Light & Water Co.

Reno Power, Light & Water Co. operates all the electric, gas, and water business of Reno and Sparks, either directly or through the lease of the plants of Washoe Power and Development Co., Washoe Deep Well Water Co., and Hunter Creek Water Co. The company owns in fee the entire electric, gas, and water distribution systems of Reno, and also owns the Highland ditch and two connected reservoirs, as well as the Reno hydroelectric and Reno gas plants.

The Hunter Creek Water Co. owns the reservoir in Hunter Creek and the 22-inch main to the southern limits of the city of Reno. The original records of the company, as well as those of the Washoe Power & Development Co. and the Washoe Deep Well Water Co., were lost in the San Francisco fire, so that a great deal of data regarding the early history of the company is not available.

MARKET.

TERRITORY AND POPULATION.

The Sierra Pacific Electric Co. is the only system serving the Nevada market. Its transmission lines enter Douglas, Lyon, Ormsby, Storey, and Washoe counties and a single short branch from Farad power house enters the extreme east end of Nevada County, Calif.

The area and population of the counties in Nevada are shown in Table 174 and the physical and industrial features are briefly described on page 833.

The population of communities served is shown in Table 175.

LOAD.

The highest demand ever reached by the combined companies on the system was in July, 1918, and amounted to 7,615 kilowatts It was estimated that this demand was made up as follows:

	Kilowatts.
Railway	250
Pumping	150
Mining	5,365
Manufacturing	1,350
Light and small power	500
	7,615

The comparatively small lighting demand is due to the fact that the system peak occurred at 11 a. m. and was due to mining and manufacturing power. Mining included pumping in the mines at Virginia City, amounting to 1,200 kilowatts, and also included a copper smelter with a demand of 1,000 kilowatts.

The connected load on the same date was estimated to be divided as follows:

	Kilowatts.
Light and heating	7,350
Railway	250
Pumping	300
Mining	6,000
Manufacturing	4,800
Wholesaling to companies and municipalities	150
	18,850

Fluctuations in load from year to year are caused chiefly by varying demands of mines and smelters. The mines at Virginia City decreased their pumping and mining operations by approximately 1,000 kilowatts in January, 1919, and the copper smelter with a demand varying normally from 750 to 1,000 kilowatts operated from November, 1911, to September, 1914, then closed until March, 1917, and then operated until February, 1919.

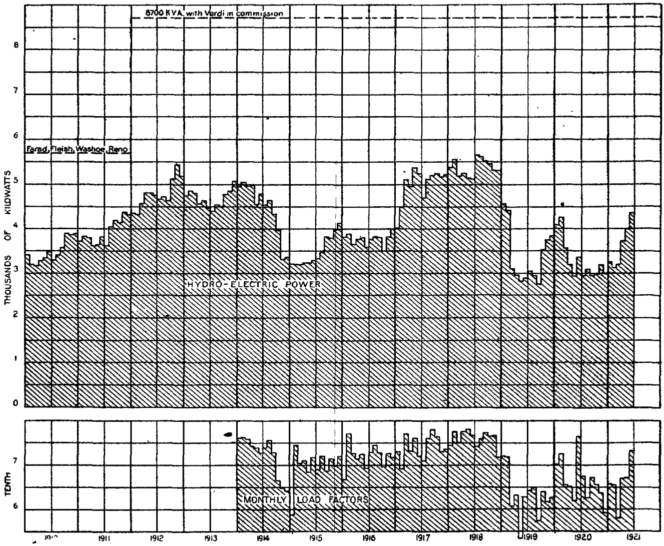

Figure 42.—Sierra Pacific Electric Co. (Truckee River system), mean monthly loads, 1910–1921, and load factors, 1914–1921.

Table 176 shows the growth of connected load on the system for years ending December 31, beginning with 1910.

Figure 42 shows the monthly output of the system beginning with January, 1910. The falling off in demand for power subsequent to 1912 is due to the closing of some of the mines and mills served by the company.

The daily load curves for the years 1914 to 1921, given in figure 43, show the very marked effect of the heavy mining load.

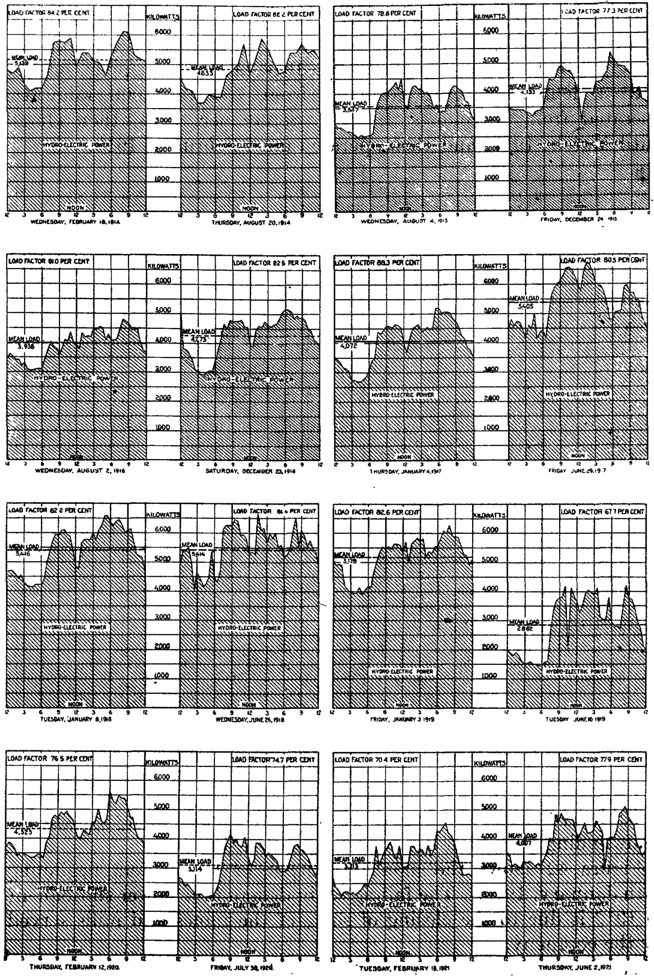

FIGURE 43.—Sierra-Pacific Electric Co. (Truckee River system), daily load curves, 1914–1921.

TABLE 176.—*Growth of load on lines of Sierra Pacific Electric Co., 1911–1920.*

	1911	1912	1913	1914	1915
Electric department:					
Connected load—					
Commercial arcs.....number..	111	102	106	104	103
Incandescent.......kilowatts..	4,032	4,346	3,462	4,731	4,897
Motors...........horsepower..	11,212	12,247	9,201	12,135	12,732
Miscellaneous......kilowatts..	300	358	579	462	533
Gas department:					
Meters.................number..	1,466	1,586	1,684	1,759	1,976
Mains.......................miles..	29.97	31.98	32.6	35.6	36.2
Output................cubic feet..	33,537,100	31,995,300	34,806,600	36,115,900	[a] 39,290,200
Water department:					
Customers...............number..	2,036	2,818	2,964	2,993	3,167
Reservoir capacity........gallons..	67,287,000	67,287,000	67,287,000	67,287,000	67,287,000
Water mains...............miles..	.53	56.79	57.67	58.1	59.3

	1916	1917	1918	1919	1920
Electric department:					
Connected load—					
Commercial arcs......number..	103	102	102	103	107
Incandescent........kilowatts..	5,340	5,542	5,462	5,611	6,018
Motors............horsepower..	13,011	13,597	13,668	14,685	16,955
Miscellaneous.......kilowatts..	845	1,813	1,529	929	1,171
Gas department:					
Meters..................number..	2,086	2,288	2,378	2,528	2,743
Mains........................miles..	37.75	38.16	38.34	39.35	40.04
Output.................cubic feet..	[a] 42,110,900	[a] 48,950,000	[a] 49,800,000	57,240,200	70,490,970
Water department:					
Customers................number..	3,373	3,451	3,470	3,965	3,893
Reservoir capacity.........gallons..	67,287,000	67,710,000	67,710,000	67,710,000	67,710,000
Water mains...............miles..	60.3	58.1	60.4	60.9	62.2

[a] Year ending Nov. 30.

TRUCKEE RIVER ELECTRIC SYSTEM.

SOURCE OF WATER SUPPLY.

The system of Sierra Pacific Electric Co. is supplied entirely from five hydroelectric plants on Truckee River. None of these plants are owned directly by the company, but all are the properties of subsidiaries controlled through stock ownership.

Truckee River drains an area lying immediately east of and along the main ridge of the Sierra in Eldorado, Placer, Nevada, and Sierra counties, Calif., and Douglas, Ormsby, and Washoe counties, Nev. The maximum length of the area north and south is about 60 miles, and its maximum width, east and west, in the neighborhood of 30 miles. (See Pl. LXXII, in pocket.) Lake Tahoe, 193 square miles in area, is in the south-central part of the basin.

Upper Truckee River, which drains the south end of the basin, rises near Stevens Peak and flows nearly due north into the south end of the lake. Truckee River proper flows out of the northwest side of the lake and runs northward through Truckee Canyon for about 15 miles. Near the town of Truckee it turns to the northeast and follows a tortuous canyon for about 24 miles to Verdi, where it turns east for 10 miles and emerges from the foothills near Reno.

As far north as Truckee, the entire basin drains directly into the main Truckee River or into Lake Tahoe, but in the area northwest of the town of Truckee the drainage from Weber and Independence lakes and minor streams has a general easterly trend into the Little Truckee. From its headwaters this branch first flows east and then south into the main river at Boca.

The drainage area at Farad, which is at the head of the series of power plants, comprises 922 square miles. At Fleish, next below in downstream order, the drainage area includes 937 square miles; at Verdi, 949; at Washoe, 993; and at Reno, 1,043 square miles. The intake of the Farad plant is 5,267 feet above sea level and that of the Reno plant 4,549 feet. Most of the drainage area of 1,043 square miles which lies above the Reno plant is between 6,000 and 7,000 feet in elevation. The elevation of Lake Tahoe, which is the dominating natural feature of the basin, is 6,225 feet above sea level. Along the western boundary of the basin the average elevation of the crest of the Sierra is between 8,000 and 9,000 feet, the maximum being about 10,000 feet on some of the peaks southwest of the lake. The eastern boundary, which follows the crest of the detached ridge running north and south between Lake Tahoe and the Great Basin, is almost equal in general elevation to the western boundary. In fact, Mount Rose (10,800 feet) and Freel Peak (10,900 feet) are higher than any of the peaks west of the lake.

In topographic form the southern two-thirds of the Truckee drainage basin is a rugged mountain region, whose slopes descend rapidly from the crest of the bounding ridges to the shores of Lake Tahoe. North of the lake, through the main Truckee Canyon, the ridges are high and broken and the courses of the tributary streams are very tortuous.

The rocks of the upper or southern part of the basin are chiefly granitic, but north of the lake slates and shales appear. The granite in the higher regions is in most places bare, and is only here and there, as in Upper Lake Valley, covered with good soil. In the northern half of the basin, except along the main ridges, the soil covering the rocks is fair.

The basin was once well forested, and extensive logging has probably been carried on in this region as long as at any other point in California, for the country around the lake supplied most of the timbers and lumber used in the mines along the Comstock Lode. Much of the higher region south of the lake is far too barren to support a good forest growth, but along the ridges north of the lake, except where cutting has thinned out the timber, the forest cover is excellent. In the lower canyon the timber is more scattered and on the hillsides is interspersed with a heavy growth of sage.

Long-term records of precipitation in the vicinity of Tahoe are not available but have been kept for long periods at Truckee, Boca, and Reno, and also at Summit, almost due west of Truckee. These records show that the highest precipitation for the four stations is along the backbone of the Sierra, and that as the storms proceed eastward they lose much of their moisture. At Summit the mean seasonal rainfall is about 48 inches, but the eastern side of the drainage basin gets only 9 inches.

Southwest of the lake, between its borders and the crest of the range, are numerous small lakes, among which Fallen Leaf and Cascade are the largest. This region probably yields from its melting snow and the natural regulative effect of its lakes the largest part of the low flow into Lake Tahoe or Truckee River.[2] The flow of the Truckee has been regulated for many years by artificial control of Tahoe outlet. The regulation of Tahoe, long the subject of dispute among private owners of land bordering the lake and the course of the Truckee, became of great importance to the Government when it undertook the construction of the Truckee-Carson reclamation project. After prolonged negotiations the Government obtained control of the outlet regulator on June 4, 1915.

RESERVOIRS.

The old dam at Tahoe outlet was a rock-filled timber-crib overflow regulator with plank covering 10 feet high, 196 feet long, and 14 feet wide on crest, with upstream slope of 1.1 horizontal to 1 vertical and its downstream face vertical. The flow past the dam into the river was controlled by five timber gates 5½ feet wide by 7 feet high. The floor of the gates was at a level of 6,223 feet above the sea and the crest of the dam at 6,230 feet.

The new Lake Tahoe concrete regulator was built very close to the old wooden structure. This new regulator has 17 gates and is 14 feet in maximum height, 11 feet high to spillway, 13 feet 6 inches wide on top, and 19 feet wide on bottom.

The maximum recorded variation in the lake level has been 8 feet, and prior to 1913 it was regulated through a maximum rise and fall of 6 feet, with corresponding storage of 741 acre-feet, or 32,300,000 cubic feet, gross, not allowing for loss by evaporation. Since control of the outlet was taken over by the Reclamation Service the lake level has been maintained between 6,224.8 and 6,229.8 feet. It is roughly estimated that a rise of 1 foot gives a storage of very nearly 120,000 acre-feet, so that the total regulation through 5 feet gives 600,000 acre-feet, of which the power company has right to the first 480,000

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[2] For records of lake level at Tahoe and discharge of Truckee River and its tributaries, see U. S. Geol. Survey Water-Supply Papers as follows: 300, pp. 71–155 (records to June 30, 1912); 330, pp. 193–219 (1911–12); 360, pp. 222–233, 287 (1912–13); 390, pp. 254–262 (1913–14); 410, pp. 174–184 (1914–15).

acre-feet and the Reclamation Service to the remaining 120,000 acre-feet. Under the operating agreement the Reclamation Service maintains a flow of not less than 500 second-feet from March 1 to September 30 each year and of 400 second-feet for the balance of the year. The company may, however, require that a maximum of 500 second-feet be discharged through the regulator at any time that it is actually needed, between October 1 and February 28.

The annual run-off measured at the outlet from 1901 to 1918 varied between a maximum of 704,000 and a minimum of 113,000 acre-feet, with a mean of 274,500 acre-feet.

FARAD PLANT.

LOCATION.

The intake for Farad plant, the oldest generating station on the system as well as on the river, is in sec. 30, T. 18 N., R. 18 E., Mount Diablo base and meridian; the conduit traverses secs. 12 and 13, T. 18 N., R. 17 E., and secs. 19 and 30, T. 18 N., R. 18 E.; the power house is in sec. 12, T. 18 N., R. 17 E. Work on the plant was begun by Truckee River General Electric Co. in 1899, immediately after its organization, and was completed in the same year.

CONDUITS.

Water from Truckee River is diverted into the Farad flume by means of a low dam in the edge of the town of Floriston, Calif. The dam is a rock-filled timber crib structure, 7 feet high and 142 feet long on the crest with rock-filled abutments at each end rising about 10 feet higher than the crest. The crest elevation of the dam is 5,267 feet (Southern Pacific Co. datum). The maximum flood which the structure has withstood was 15,300 second-feet March 18, 1907, when the water was 10 to 15 feet deep over the dam.

At the west end of the dam are five timber inlet gates, each 5 feet wide by 12 feet high, which slide in vertical grooves and are operated by screws and handwheels. The crib supporting the gates runs upstream at right angles to the axis of the dam. After passing through the gates the water enters a narrow settling basin which is about 500 feet long and was excavated in the loose material at the side of the river. At the lower end of this basin the water flows into the head of the flume through a set of inclined screens. The total length of the conduit from the dam to the power house is about 9,300 feet, and aside from the 500 feet occupied by the settling basin this entire line is pine flume 10 feet wide and 6 feet 8 inches deep, with a capacity of 400 second-feet when flowing 6 feet deep. Just above the power house the flume is enlarged into a timber penstock, and for about 200 feet above this penstock a spillway flume is built outside of the main flume. When the head gates of the pressure line are closed water discharges over the weir between the main and spillway flume to flow through the latter to its lower end, from which it discharges through a timber chute into the river just above the power house. The elevation of the water surface at the penstock is 5,259.5 feet, giving a total fall of 7.5 feet from the head of the flume and a grade of 0.0008. The floor of the power house is at an elevation of 5,179 feet. Water is admitted to the pressure pipes through sliding timber gates in the side of the penstock. Both of the wooden-stave pressure lines are 150 feet long and 72 inches in diameter, run straight to the power house, and give, with the aid of draft tubes, a working head of 85 feet.

GENERATING STATION.

Power house.—The power house is a brick building 88 feet 6 inches long parallel to the river and 31 feet deep and is roofed with corrugated iron supported on a steel frame. The building contains two units which discharge through draft tubes and separate arched tailraces into the main river. At one end of the building a lean-to addition has been built to house an exciter wheel and some auxiliary equipment. The generator room is spanned by a traveling crane.

The two horizontal turbine-driven units are arranged in line along the back wall of the single room in the building. The switchboard is parallel to the front wall and at its center. The transformers are near the end of the switchboard. The exciter equipment is in the upstream end of the room.

Hydraulic equipment.—Each pressure pipe passes through the rear wall of the building to a horizontal McCormick turbine, with double 27-inch runners, rated at 1,200 horsepower and regulated by two type B Lombard governors. Each turbine is connected to its generator by means of flexible rawhide couplings; the generator shafts of the two units are in line and may be connected to operate in unison.

Generators.—The generators are Westinghouse 750-kilovolt-ampere 500-volt 866-ampere 3-phase 60-cycle machines, operating at 400 revolutions per minute.

Exciters.—No. 1 exciter is a Westinghouse 22½-kilowatt 125-volt machine, operated by a turbine at 975 revolutions per minute. The second exciter unit consists of a Westinghouse induction motor belted to an impulse wheel and in turn to a duplicate exciter generator of the same type as exciter No. 1. The speeds of the wheel, motor, and exciter are, respectively, 165, 850, and 975 revolutions per minute. The set operates in the same manner as the ordinary direct-connected motor-generator exciter, which forms the usual equipment of California hydroelectric plants.

Transformers.—Six Westinghouse 1-phase 60-cycle water-cooled transformers, of 250-kilowatt capacity, step the potential up from the generator voltage of 500 to 23,000 volts. The high-tension side of the transformers is connected delta.

Wiring.—The switchboard contains one panel for each generator and one for the exciters; the low-tension switches are of the old 500-volt knife-blade type. From the transformers the high-tension leads run out through the end of the power house to a set of three Baum single-phase hand-operated tub oil-switches in a pole-top shelter a short distance from the main building. The transmission line runs down the Truckee to Fleish power house, where it branches, one line running on by way of Washoe plant and the other taking a more direct route toward Virginia City. These lines are shown on the transmission map. (See Pl. I, in pocket.)

Two sets of Westinghouse multigap lightning arresters are mounted overhead in the end of the power house.

FLEISH PLANT.

LOCATION.

Fleish, the second plant built by Truckee River General Electric Co., was put into commission in 1905, to take part of the mining load carried up to that time by Farad alone, and a line was run from Fleish to Reno in 1905 to connect with the system of the Reno Power, Light & Water Co.

The Fleish intake is in sec. 6, T. 18 N., R. 18 E.; the conduit traverses (secs. 29, 31, 32, T. 19 N., R. 18 E., and sec. 6, T. 18 N., R. 18 E.; the power house is in sec. 29, T. 19 N., R. 18 E.

CONDUITS.

The Fleish diversion dam is of the same type as all the other intakes—that is, it is a rock-filled timber crib with plank facing. It is located 3.2 miles down the river from Farad power house, at an elevation of 5,078 feet above sea level. The dam is 220 feet long, 10 feet in maximum height, and 20 feet wide on the crest. Both its upstream face and its downstream face are vertical, but erosion below the dam is prevented by an apron. The twelve canal headgates at the south end of the dam are 2½ feet wide by 10 feet high, and have a combined capacity of 400 second-feet. During the flood of March, 1907, the maximum head on the crest of the dam was about 15 feet and the discharge 15,300 second-feet.

Immediately below the gates the water enters a settling basin of the same type as that at Farad but about 1,000 feet long. At the lower end of the basin the supply enters the flume through a set of steel screens.

The total length of the conduit from the dam to the forebay is 11,526 feet. Of this, 2,736 feet is in ditch or settling basin and 8,763 feet is in flume. The total fall from head to tail of the line is

5.75 feet. The grade averages 0.0005 for the whole line and is the same in flume and ditch. The flume measures 10 feet wide by 6½ feet deep inside the box and carries water to a depth of 6 feet. The ditch is 24 feet wide at water surface, 12 feet wide on bottom, and 6 feet deep to normal water surface. The carrying capacity of the conduit is 315 second-feet. The forebay is simply an enlarged flume section (capacity 38,300 cubic feet) and the wasteway is in the flume several hundred feet above the penstock. The working head at the power house is 125.3 feet with draft tube in use. The single lap-riveted steel pressure pipe, 96 inches in diameter, is about 400 feet long and is covered for the entire length. The elevation of water surface at the power house is 4,947 feet.

GENERATING STATION.

Power house.—The Fleish power house (see Pl. LXXIII, *B*) is constructed of masonry. It extends along the river bank and has a lean-to addition at its back; at its upstream end, separated from the generator room by a court, is a separate building that contains the transformer cells. The generator room measures 56 by 36 feet, the addition back of it 9½ by 40 feet, the court 36 by 25 feet, and the transformer house 17 by 36 feet. The power house contains a single unit, which is set parallel to the main axis of the generator room, along its front wall, and discharges through a draft tube into a tailrace opening into the river. The switchboard is flush with the back wall of the generator room, so that the low-tension wiring and switches and the rheostats have to be accommodated in the lean-to at the back of the building. The parts of the lean-to not used for this purpose serve as an office. A large double door at the end of the generator room on the court affords a clear view of the transformer equipment except in cold weather when the doors have to be closed.

Hydraulic equipment.—A single horizontal Francis turbine with 43-inch runner direct-connected to the generator and governed by an old-style Lombard governor constitutes the hydraulic equipment.

Generator.—The generator now installed is a 2,500-kilovolt-ampere 2,200-volt 3-phase 60-cycle General Electric machine operating at 300 revolutions per minute.

Exciter.—Exciting current is furnished by a General Electric 35-kilowatt 125-volt 4-pole continuous-current generator with commutating poles, which is operated at 850 revolutions per minute by belt from the end of the generator shaft.

Transformers.—Four (one bank and a spare) Westinghouse 750-kilowatt single-phase 60-cycle oil-insulated water-cooled transformers step the potential up from 2,200 to 22,000 volts. The high-tension side of the bank is connected Y and the low-tension side connected delta.

Wiring.—Three separate outgoing circuits and the incoming circuit from Farad power house are controlled by 12 high-tension oil-tub switches set in pole-top shelters outside the main buildings.

One set of Westinghouse multigap lightning arresters is mounted in a cell back of the transformer compartments.

VERDI PLANT.

LOCATION.

The Verdi intake is in sec. 19, T. 19 N., R. 18 E.; the conduit traverses secs. 8, 17, 18, and 10, T. 19 N., R. 18 E; the power house is on the south side of Truckee River in sec. 8, T. 19 N., R. 18 E.

The Verdi plant is the fifth and most modern plant now operated on Truckee River. The canal, power house, and a new 60,000-volt wooden-tower line to Virginia City, Thompson, and Bluestone were built by Stone & Webster in 1910 and 1911, and the plant was turned over to the operating company January 15, 1912.

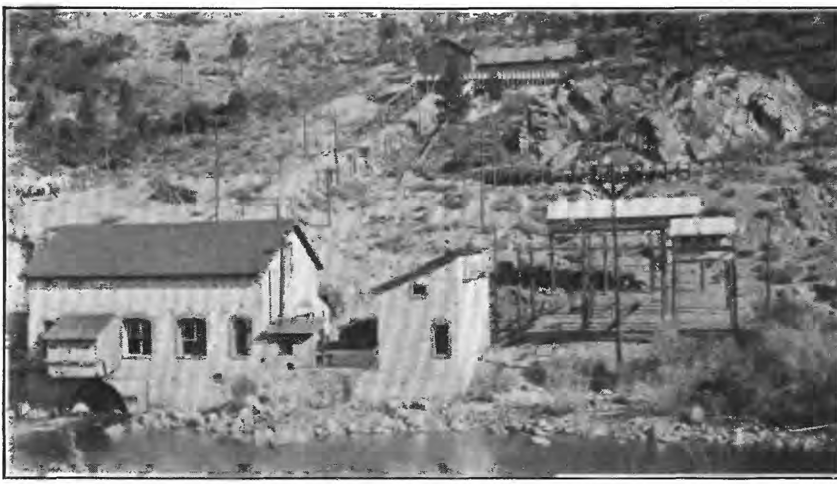
CONDUIT.

The Verdi intake is slightly less than a mile below Fleish power house and on the same side of the river. The diversion dam (see Pl. LXXIII, *C*) was completed late in 1911 and is a more pretentious structure than the dams of the older plants. It is a well-built crib structure filled with rock and gravel. On its east end it is flanked by a wing wall that extends downstream between the river and the head of the canal and by concrete intake works that extend upstream from the junction of the dam and wing wall. The elevation of the dam's crest is 4,899 feet. The dam is about 15 feet in maximum height, 8 feet wide on the crest, its upstream face is vertical, and its downstream face has three drops of 4 feet on 1 to 1 slopes. The spillway crest is 175 feet long, and the probable maximum flood which it will have to carry is 15,000 second-feet. The gatehouse is built on top of the concrete buttresses to which the guides for the sliding timber gates are bolted. There are eight gates, each 5 feet wide by 8 feet high, operated vertically by a hand-driven lifting mechanism. In front of the gates and extending the full length of the gatehouse is a single inclined steel trash rack or screen. Just at the lower end of this screen a section of the crest of the dam is depressed 2 feet below the ordinary level, so that when the flashboards fitted to it are removed ice and débris can be sluiced out over it and the pond in front of the trash racks thus kept clear. The total cost of the headworks was slightly over $60,000.

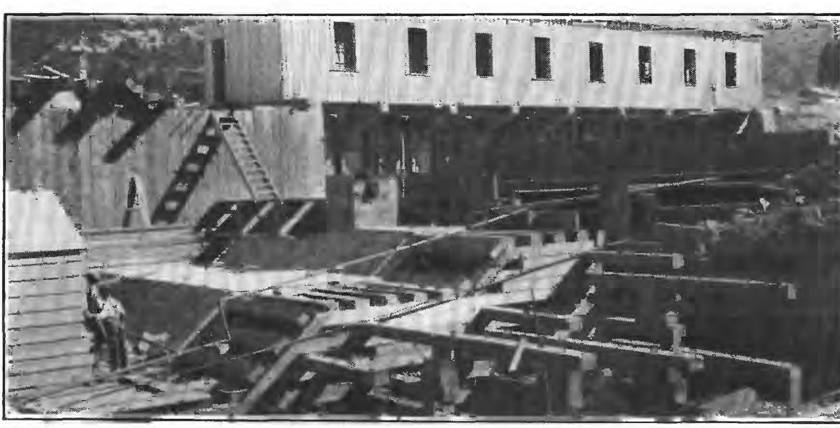
The total length of the Verdi conduit from the dam to the forebay is 10,962 feet, all of which is in ditch except the 600 feet of flume at the extreme lower end of the line. This flume connects the ditch with the timber forebay in the eastern outskirts of the town of Verdi.

A. WASHOE POWER HOUSE.

A low-head development typical of the Truckee River plants. Photograph by the company.



B. FLEISH POWER HOUSE.



C. HEAD DAM AND GATE HOUSE, VERDI PLANT.

During construction, November, 1911, showing type of structures.

HYDROELECTRIC SYSTEM OF SIERRA PACIFIC ELECTRIC CO.

The forebay is a timber structure carried on trestle work. The timber construction of the flume box and the bay is very heavy. The box bents are set about 32 inches apart and are formed by 6 by 8 inch upright posts set between two 4 by 8 inch beams which are supported on four 8 by 12 inch stringers carried on the trestles; the two caps of each belt course are 4 by 6 inch and are bolted to each side of the side posts. The forebay is 33 feet wide, 6½ feet deep to water surface, and 75 feet long, giving a capacity of about 16,100 cubic feet.

The ditch section measures 17 feet wide on the bottom and 30 feet at water surface, with 6½ feet depth of stream. The flume box is 10½ feet wide and carries a stream 6½ feet deep. The ditch grade is 0.0004 and the flume grade 0.0006. The elevation of normal water surface at the head of the conduit is 4,899 feet (construction datum) and in the forebay 4,895.5 feet, giving a total fall of 3.5 feet. The capacity of the conduit is 500 second-feet.

Extending back along the conduit several hundred feet from the forebay is a wasteway into which the water spills over the weir formed by the wall of the flume. From the lower end of this waste flume, near the head of the pressure pipe, water is discharged into a side flume leading to a gully that joins the main river below the power house. At the lower end of the forebay is a concrete heading for the pressure main. Additional trash racks and gates protect the upper end of the pipe.

The upper section of the pressure line is of wood-stave pipe, 108 inches in diameter, supported on a dry-laid stone and cobble wall. The last third of the 2,376 feet of the pipe is lap-riveted steel, 72 inches in diameter. The alinement of the main is on a tangent from the forebay to the powerhouse. The wood-stave section reaches only to the edge of the gentle slope of the mesa and at this point, where the ground begins to break away rapidly toward the river, the steel pipe begins. The static head from water surface in the forebay (4,895.5 feet) to tailwater at the power house (4,797.5 feet) is 98 feet, and the working head developed with draft tubes 92 feet.

GENERATING STATION.

Power house.—The power house is on the south side of the Truckee River; the elevation of the floor is 4,811 feet above sea level. The main building is divided into three rooms—an almost rectangular generator room on the river side, with transformer and lightning-arrester rooms opening into its back. The house is built of concrete and brick, and contains a single unit set across the generator room. The turbine operating the unit discharges through a draft tube into a concrete wasteway leading to the main river. On the downstream side of the main station there is a small separate switch house.

Hydraulic equipment.—The pressure pipe entering through the back wall of the power house passes under the floor of the lightning-arrester compartment and under the back of the generator room to a single horizontal Allis-Chalmers Francis turbine with a 45-inch runner. The wheel discharges through a draft tube into the tailrace under the power house. As a safeguard against water hammer the pressure pipe is fitted with an automatic by-pass and also with a safety disk which is set in the end of a Y near the turbine. This disk will be ruptured before the rise in pressure is great enough to wreck any of the hydraulic machinery. The turbine is rated at 3,200 horsepower, is regulated by a type Q Allis-Chalmers governor, and operates direct-connected to the generator at 277 revolutions per minute.

Generators.—The single generator is a General Electric ATB 26-pole 2,300-volt 754-ampere 3-phase 60-cycle machine, rated at 3,000 kilovolt-amperes.

Exciters.—Excitation is furnished by two General Electric DLC form A 35-kilowatt 125-volt 280-ampere generators, either of which can be belted to the end of the generator shaft and operated at 850 revolutions per minute.

Transformers.—Three General Electric single-phase water-cooled transformers, of 1,000-kilovolt amperes capacity each, are installed in one of the two small rooms back of the generator room. At present these raise the potential from 2,300 to 60,000 volts, connected delta, but they are fitted with the taps which will give 104,000 volts with Y connection.

Wiring.—The switchboard has only two panels—one for the generator and one for the exciter. The generator panel is fitted with three Thomson ammeters, one Thomson indicating wattmeter, one Thomson voltmeter, and one power-factor indicator. The exciter panel has one wattmeter, one voltmeter, and a synchronism indicator. A Thomson voltmeter is mounted on a swinging bracket beside the board.

The switch house contains a single set of Baum high-tension oil-tub switches.

One 3-phase 60,000-volt circuit of No. 4 copper, 65 miles long, extends from the power house southeastward past the Washoe plant to Virginia City, Thompson, and Bluestone. The route followed by the line is shown on the transmission map. (See Pl. I, in pocket.)

A single set of General Electric aluminum lightning arresters is installed back of the generator room on the opposite side of the partition from the transformers.

WASHOE PLANT.

LOCATION.

The Washoe intake is in sec. 16, T. 19 N., R. 18 E.; the conduit traverses secs. 14, 15, 16, and 22, T. 19 N., R. 18 E.; the power house is in sec. 14, T. 19 N., R. 18 E., on the south bank of the Truckee. The plant was constructed by the Washoe Power & Development Co. in 1903 and 1904 and put into operation in 1905.

CONDUIT.

The Washoe diversion dam and canal intake are little more than a mile below the Verdi power house. This dam also is of the rock-filled timber-crib type used in the Fleish and Verdi plants but consists of two overflow sections which have a crest elevation of 4,782.5 feet and are joined by a higher crib in the center of the stream. The first overflow section runs nearly south from the north bank of the river to a point about two-thirds across the channel. The second or high section runs from the end of the first directly downstream, nearly parallel to the bank. The third section, which is of the overflow type and on a level with the first, connects the lower end of the second section to the south bank just below the headgates. The first section is 30 feet long and the third 100 feet, so that the total length of spill is 130 feet.

The sliding wooden headgates of the canal are placed directly against the rocky bank and the supply is diverted into a tunnel through a sharp point putting out into the river. The three gates are 4 feet wide by 8 feet deep and are raised by screws. On the opposite side of the point a section of ditch several hundred feet long leads to a flume that is about three-fourths of a mile long and follows along the side of the mesa. From the lower end of this flume all the rest of the line is in ditch, except close to the power house. The total length of the conduit is 10,810 feet. Of this 7,510 feet is ditch and 3,300 feet flume. The ditch is 12 feet wide on the bottom and 24 feet wide at the surface, with 6-foot depth of water. The flume box measures 10 feet wide by 6½ feet deep. The uniform grade in both ditch and flume is 0.00045. The elevation of water surface in the head of the conduit is 4,782.5 and in the forebay 4,777 feet, giving a total drop of 5.5 feet in the line. The capacity of the conduit is 300 second-feet. Its lower end terminates in a section of flume leading to a small timber forebay or penstock, on the edge of the last terrace above the river. The forebay capacity is 50,000 cubic feet and from it two wooden-stave pressure lines, 72 inches in diameter, run to the power house. Both lines are uncovered. The elevation of water surface at the power house is 4,690 feet above sea level. The working head obtained is 86 feet with draft tubes in operation; the static head from water surface in the forebay to the center of turbines is 78 feet. A short distance above the power house an emergency waste flume leaves the main conduit and discharges over the edge of the bluff into the river.

GENERATING STATION.

Power house.—The Washoe power house (see Pl. LXXIII, *A*) is a stone and brick building 70 feet long by 28 feet wide. The generator room occupies the entire main building, and the transformers and switching apparatus are placed in a small house, 45 by 28 feet in plan, opposite its downstream end. The generating equipment consists of two units placed in line on the main axis of the generator room. The switchboard is set opposite the central part of the room and slightly out from the front wall. Behind it are the rheostats and low-tension switches. One exciter set is placed at each end of the board. The turbines discharge through draft tubes which pass just under the floor and out through the side of the building into a pool at the head of a short channel leading to the river.

Hydraulic equipment.—The hydraulic equipment consists of two "New American" Dayton Globe Iron Works double horizontal turbines, with 30-inch runners. Each turbine is connected to its generator by a flexible rawhide-link coupling. The wheels were originally regulated by two Sturgess governors but these are no longer in use.

Generators.—The two electric generators are Stanley revolving-field 750-kilovolt-ampere 2,300-volt 3-phase 60-cycle units, operated at 360 revolutions per minute.

Exciters.—Two turbine driven direct-current generators furnish excitation. Each set consists of a 30-horsepower wheel, direct-connected to a Stanley 20-kilowatt 120-volt 160-ampere direct-current generator, operating at 875 revolutions per minute. A 30-horsepower Stanley induction motor is coupled to one set.

Transformers.—To the old transformer equipment, consisting of three 300-kilowatt and three 250-kilowatt Stanley shell single-phase transformers, have been added three Westinghouse water-cooled 333-kilovolt-ampere single-phase transformers. The latter have a ratio of 2,300 to 60,000; the former a ratio of 2,300 to 22,000.

Wiring.—From the switchboard the leads are carried to the end of the power house and through the tile outlets to the transformer house. The high-tension leads from the transformers pass through three Baum tub oil switches. The transformer and switching equipment is arranged so that the power house can be connected to both the 23,000-volt line running from Farad and Fleish plants to Virginia City and the 60,000-volt line running from the Verdi plant to the same place. The switching equipment is also so arranged that the 60,000-

volt and 23,000-volt lines can feed into each other at the station. In addition to this connection a No. 4 copper line, operated at 23,000 volts, extends to the Reno plant.

RENO PLANT.

LOCATION.

The Reno intake is in sec. 16, T. 19 N., R. 19 E.; the conduit traverses secs. 10, 15, and 16, T. 19 N., R. 19 E.; the power house is in sec. 10, T. 19 N., R. 19 E.

The plant is the lowest and next to the oldest of the developments on the system. It was built by the Reno Power, Light & Water Co. in 1900 and began to generate power in 1901. It has since been equipped with new machinery and partly rebuilt.

CONDUIT.

The timber-crib diversion dam for the Reno plant is 3.5 miles below Washoe power house and at an elevation of 4,549 feet. The dam has a maximum height of 10 feet above the river bed and 15 feet above the lowest point in its foundations. Its crest length is 100 feet, crest width 8 feet, and thickness at the base 10 feet. The flood of March, 1907 (the highest on record since the building of the dam) put from 10 to 15 feet of water (15,300 second-feet) over its crest. The headgates are of simple timber construction. Water is diverted into a canal which runs across a low mesa, extending out into a bend on the east side of the river. The ditch is 12 feet wide on the bottom, 16 feet wide on the surface, and carries water to a depth of 8 feet. Its grade is 0.00125 and its carrying capacity is 360 second-feet. At the edge of the mesa the conduit is changed from ditch to flume carried on trestle and this flume continues to the timber penstock or forebay. The flume is 10 feet wide, 8 feet deep, and is constructed on a grade of 0.00125. The maximum height of trestle, at the lower end of the flume is 10 feet. The total length of ditch is 3,989 feet and the flume 1,657 feet, making a total of 5,646 feet from head to forebay. The total drop in the line is from 4,549 feet at the intake to 4,542 feet at water surface in the forebay, or 7 feet. The forebay, which is supported on the trestle, is 60 feet long by 20 feet wide and 10 feet deep. From it three wood-stave pressure pipes 700 feet long and 48 inches in diameter drop to the level of the mesa and then run along at a gentle slope to the power house, where they join the end of the steel pipe that leads through the wall to the turbine casing. Along the mesa they are supported on a dry-laid stone wall. The working head developed is 41 feet with draft tube in operation.

GENERATING STATION.

Power house.—The power house is a long stone building with hip roof. Only the north end of it is used strictly as a generating station. The central part is used as a substation for the Reno circuits and the south end as a workshop. On the main floor of the generator room is a motor-generator set for furnishing current for the Reno Street Railway. This set consists of a General Electric continuous-current type MPC class 6–500–720 form H 600-volt 833-ampere machine, coupled to a General Electric type AT 10-pole 700-horsepower 74-ampere 4,150-volt synchronous motor, operated at 720 revolutions per minute. Opposite this direct-current set is the transformer equipment for the Reno arc lighting load. The single generating unit and its turbine are placed in a concrete-lined pit at the north end of the room. All high-tension switching is done outside the power house, where the high-tension equipment is housed in pole-top shelters of corrugated iron.

Hydraulic equipment.—The station is equipped with a single horizontal double-inflow Allis-Chalmers turbine, with 33-inch runners, direct-connected to the generator.

Generators.—The electric unit is a 700-kilovolt-ampere 4,100-volt 98.7-ampere 3-phase 60-cycle Allis-Chalmers generator, operated at 360 revolutions per minute.

Exciter.—The single exciter is an 18-kilowatt 120-volt multipolar machine, belted to the generator shaft so as to operate at 1,450 revolutions per minute.

Transformers.—The transformer equipment comprises three General Electric type BI 750-kilowatt 1-phase 60-cycle oil-insulated water-cooled units.

Wiring.—The outgoing lines from the Reno power house and substation are: One 600-volt direct-current line feeding Nevada Interurban Railway Co., one 600-volt direct-current line feeding Reno Traction Co., three 1-phase circuits feeding Reno lighting, one 3-phase 4,000-volt circuit, feeding commercial power to Reno and Sparks, one 3-phase 4,000-volt circuit for Sparks supply, and three arc circuits lines for Reno.

TRANSMISSION AND DISTRIBUTION SYSTEM.

TABLE 177.—*High-tension transmission system, Sierra Pacific Electric Co., Sept. 30, 1921.*

Supporting structure.	Length.	Voltage.	Number of circuits.	Size of conductor.
	Miles.			
Twin poles and suspension insulators	75	60,000	1	No. 4 stranded copper.
Single poles with pin insulators	20	60,000	1	No. 6 stranded copper.
Do	184	23,000	1	Nos. 2, 4, and 6 copper.

TABLE 178.—*Substations operated by Sierra Pacific Electric Co. (The Truckee River General Electric Co. and Reno Power, Light & Water Co.), Sept. 30, 1921.*

District.	Substation.	Location.	Building.		Put into operation.	Voltage.		Capacity.	Service.
			Type.	Dimensions.		Incoming circuits.	Outgoing circuits.		
				Feet.		*Kilovolts.*	*Volts.*	*Kilovolt-amperes.*	
Reno	Reno	West of Reno.	Rubble masonry	46 by 125; hydraulic plant and transformer station.	1902	23	[a] 600 [b] 4,000	2,250 500	Serves light and power in Reno and Sparks.
Virginia	Virginia	Virginia City	Brick	37½ by 35½	1900	23 and 60	2,200	4,125	Lighting in Virginia City and Silver City and power for mines on the Comstock lode.
Carson	Carson	Carson City	Concrete	20 by 18	1910	23	2,200	750	Light and power in Carson and Empire.
Minden	Minden	Minden	Brick	11 by 11	1907	23	2,200	112.5	Light and power in Minden and Gardnerville.
Dayton	Dayton	Dayton	Corrugated iron	12 by 14	1912	23	2,200	125	Light and power in Dayton.
Yerington	Bluestone	4 miles from Yerington.	Wooden building destroyed by fire Aug 1, 1912; new building rubble masonry.	34 by 25½	1907	23 and 60	2,200	1,600	Lighting in Yerington and power for mines.
Fulstone-Genoa	Fulstone	3 miles from Minden.	Corrugated iron	14 by 16	1913	23	4,000	150	Light and power for Genoa, Sheridan, and surrounding farming district.

[a] Transformers; direct current.
[b] Motor generators; alternating current.

NOTE.—In addition to the above, company supplies 36 customers directly from its transmission lines through privately owned high-tension transformers, having a combined transformer capacity of 5,468 kilowatts.

CHAPTER VI.—CONSERVATION OF OIL THROUGH THE INCREASED USE OF HYDROELECTRIC POWER.

GENERAL CONSIDERATIONS.

California possesses only two sources of energy now commercially feasible, her streams and her oil fields. The State produces little marketable coal, and the day has not yet arrived for the profitable development of her supply of oil shale. Despite the widespread use of hydroelectric power, California oil now produces over 70 per cent of the total energy being utilized in the State.

Fuel oil has completely driven imported steam coals from the market. The small amount of coal now consumed is used exclusively for domestic purposes and is imported by water from foreign and eastern ports, by rail and water from the fields of British Columbia, Washington, and Oregon, and by rail from the Rocky Mountain States.

Statistics published by the California State Mining Bureau[1] show that the importations of coal into California increased steadily from 150,141 tons in 1865 to 1,889,128 tons in 1900, and then decreased rapidly, coal being driven out of the market by the growing supply of fuel oil. At the date of the report (1914) imports were less than 500,000 tons per annum. Fuel oil had therefore actually displaced 1,400,000 tons of coal on the basis of coal consumption in 1900, and estimating increase from 1900 to 1915 at the same rate (50,000 tons per year) as for the period 1865 to 1900, fuel oil was probably displacing 2,000,000 tons of coal each year.

The rapid increase in power demands within the State and the resulting increase in use for fuel of an oil supply that might obviously be put to higher uses gives particular interest to the question of substituting hydroelectric power.

In order to present the subject clearly to those unfamiliar with the local situation, the following pages give the best available information concerning developed and possible ultimate supply of hydroelectric power within the State, the past production and utilization of oil from California oil fields, the probable ultimate oil production that may be expected, and possible measures for its conservation.

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[1] McLaughlin, R. P., and Waring, G. A., Petroleum industry of California: California State Min. Bur., Bull. 69, p. 834, 1915.

WATER-POWER RESOURCES.

PAST PRODUCTION AND INSTALLED CAPACITY OF HYDRO-ELECTRIC PLANTS, CALIFORNIA SYSTEMS.

Figures 44, 45, and 42 show, respectively, the mean monthly loads carried by the hydroelectric systems of the northern California, southern California, and Nevada markets, from January 1, 1907, to June 30, 1921. The mean monthly loads in kilowatts shown in these curves were computed from the kilowatt-hour outputs of the various stations and include, therefore, not only power delivered but also transmission and distribution losses. The combined load for all systems in the State (including the load on outlying plants in southern Oregon and western Nevada) is given in figure 46, which is a combination of figures 44, 45, and 42. Electric power generated by steam plants not owned by hydroelectric corporations and by small isolated hydroelectric plants is small in comparison with the total loads shown.

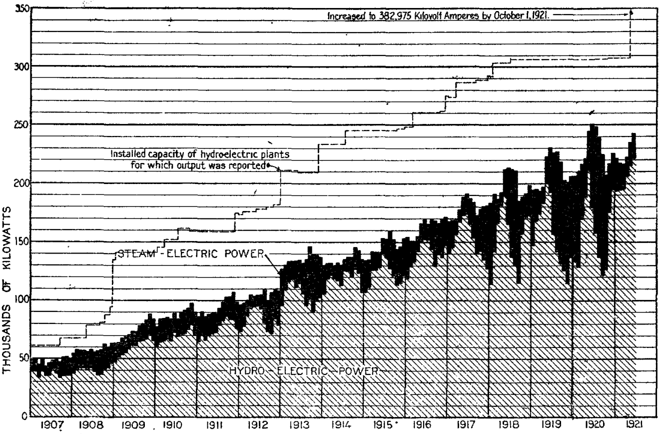

FIGURE 44.—Mean monthly loads on hydroelectric power systems of northern California market, 1907-1921.

Figure 44 includes the loads of the Pacific Gas & Electric Co. (and companies that it has absorbed), Sierra & San Francisco Power Co., and Great Western Power system for the entire period shown, and the loads carried by Western States Gas & Electric Co., The California Oregon Power Co., Snow Mountain Water & Power Co., Coast Counties Gas & Electric Co., Tuolumne Electric Co., and Yosemite Power Co., from January 1, 1913. The city of San Francisco municipal system was also included from the date on which it began to operate. The sudden rise in the curve at the beginning of 1913 is due to including these additional companies and not to a sudden increase in the load within the market. The mean load on the plants of these miscellaneous small companies for the year 1913 was, however, only 11,850 kilowatts hydroelectric and 510 kilowatts steam.

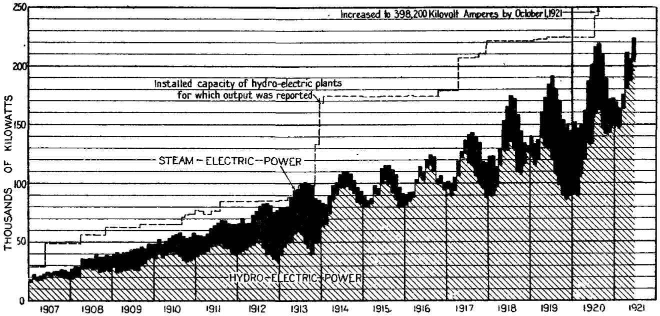

FIGURE 45.—Mean monthly loads on hydroelectric power systems of southern California market, 1907–1921.

Figure 45 was compiled similarly by combining the loads of The San Joaquin Light & Power Corporation and Southern California Edison Co. (including companies that it has absorbed) from January 1, 1907, to the end of record and includes also load carried by The Nevada-California system after April 1, 1908, Ontario Power Co. from November 1, 1910, to the end of record (except the year 1915), Pacific Power Co. (except 1915), and Holton Power Co. from January 1, 1913, to the end of the record or to date of absorption into The Nevada-California system.

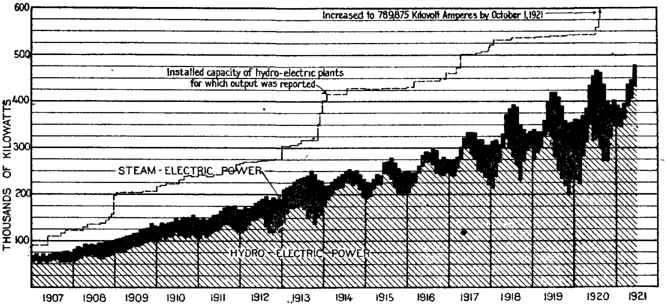

FIGURE 46.—Combined mean monthly loads on hydroelectric power systems of California (including plants in southern Oregon and western Nevada), 1907–1921.

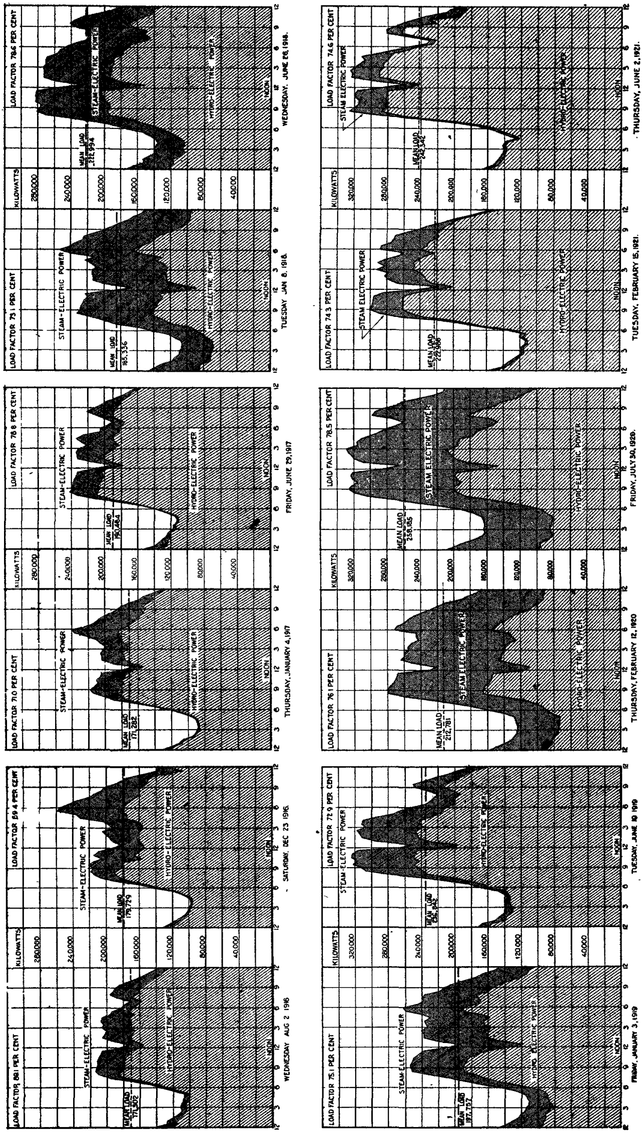

FIGURE 47.—Combined daily load on hydroelectric power systems of northern California market, 1916–1921.

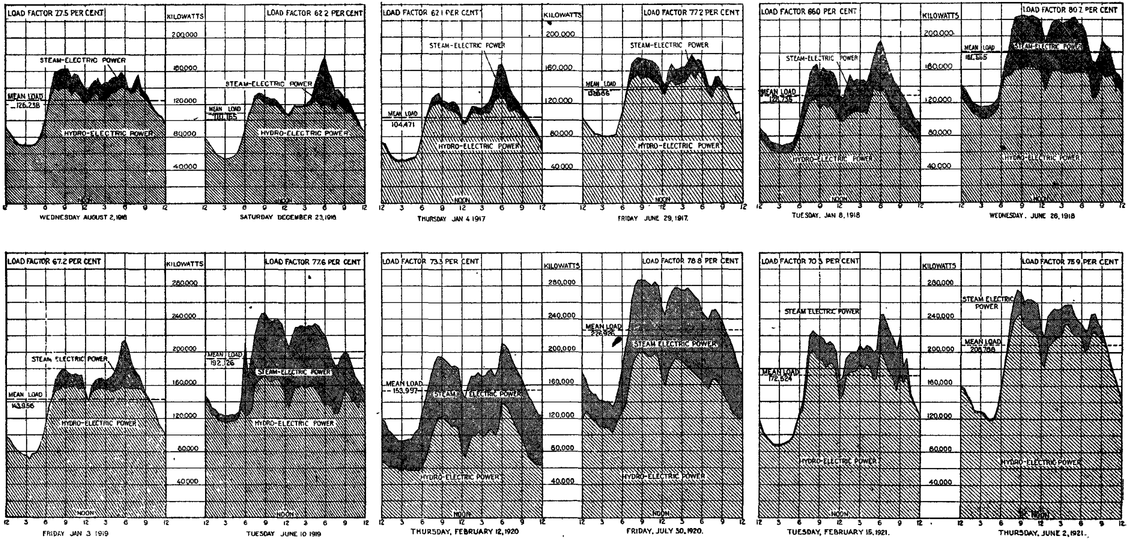

FIGURE 48.—Combined daily load on hydroelectric power systems of southern California market, 1916–1921.

The Los Angeles municipal system on the lower part of the aqueduct was also included from the date on which it began operation.

The load carried by Sierra Pacific Electric Co., the only company operating in the Nevada market, is shown separately in figure 42 (p. 837).

The installed capacity of generators in the hydroelectric plants in each market is shown by the broken line in each figure. The capacity of steam auxiliary stations is not shown.

Two daily load curves for the northern California market for each year from 1916 to 1921 are shown in figure 47. These curves were compiled from the separate curves of The California Oregon Power Co., Pacific Gas & Electric Co., Northern California Power Co. Consolidated, Sierra & San Francisco Power Co., Great Western Power system, and Western States Gas & Electric Co. They do not include the output of the Coast Counties Gas & Electric Co., Tuolumne Electric Co., and smaller or isolated companies. The output of the smaller companies is, however, of small importance in comparison with the total loads shown by the combined curves.

Two daily load curves for the southern California market for each year from 1916 to 1921 are shown in figure 48. These curves were compiled in a similar manner from the separate system curves of San Joaquin Light & Power Co., Mount Whitney Power & Electric Co., Pacific Light & Power Co., Southern California Edison Co., and The Nevada-California Power system.[2]

Two curves for each year from 1914 to 1921 for Sierra Pacific Electric Co., the only system serving the Nevada market, are given in figure 43 (p. 838).

Consolidated curves showing the loads on all of the principal hydroelectric systems serving the State, formed by combining the curves for corresponding days from figures 47, 48, and 43, are shown in figure 49.

Electric power generated in steam plants other than those owned by the hydroelectric companies is almost negligible in comparison with the total loads shown graphically in these figures.

Future reference to several of these curves will be made in connection with the detailed study of the conservation of fuel oil.

ULTIMATE WATER-POWER RESOURCES.

In the course of eleven years' work as engineer for the United States Forest Service, the writer has reported in detail upon projected hydroelectric developments in California aggregating more than 1,000,000 horsepower in proposed installed capacity and has examined

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[2] The 1916 curves also include Ontario Power Co. and the curves the Pacific Power Corporation (absorbed in 1917 by The Nevada-California system). The curve for June 29, 1917, and all curves for 1918 to 1921 include also the Los Angeles municipal system.

casually certain projects upon which no reports were prepared. The results of these investigations have, however, never been compiled, nor has there been opportunity to make the calculations necessary to round out a complete estimate of total potential power in the State. The only complete estimate of this kind is that prepared by the hydrographers of the United States Geological Survey, published first in the report of the National Conservation Commission and republished in Water-Supply Paper 234.[3] The estimate is of course only approximate, having been compiled in the following manner:

SOURCES OF DATA.

The data used in this report have been obtained from the following sources:

The records of flow are mainly from the reports and files of the water-resources branch of the United States Geological Survey. As the period over which these records extend varies in length, a 7-year period, extending from 1900 to 1906, inclusive, was taken as a basis and all values of flow are the mean for these years.

The profiles and elevations have been obtained as follows:

(*a*) River surveys made by the United States Geological Survey, United States Army Engineer Corps, and others.

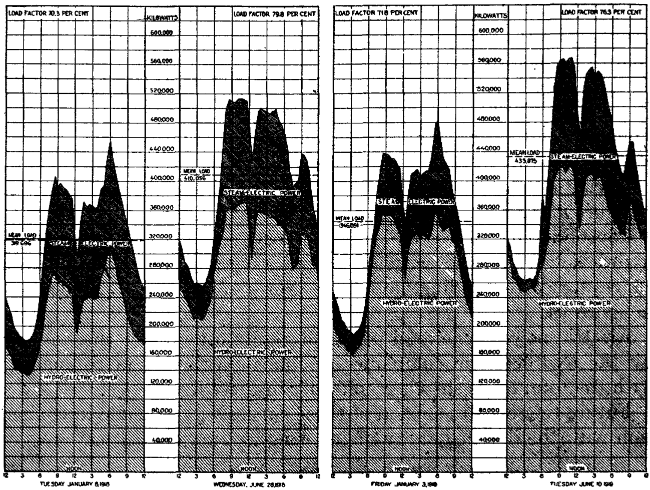

FIGURE 49.—Combined daily load on hydroelectric systems of California

(*b*) Elevations as given by railroad and other levels.

(*c*) Dictionary of altitudes, Bulletin No. 274, United States Geological Survey.

(*d*) United States Geological Survey topographic maps.

(*e*) Miscellaneous maps and reports of various State and other organizations.

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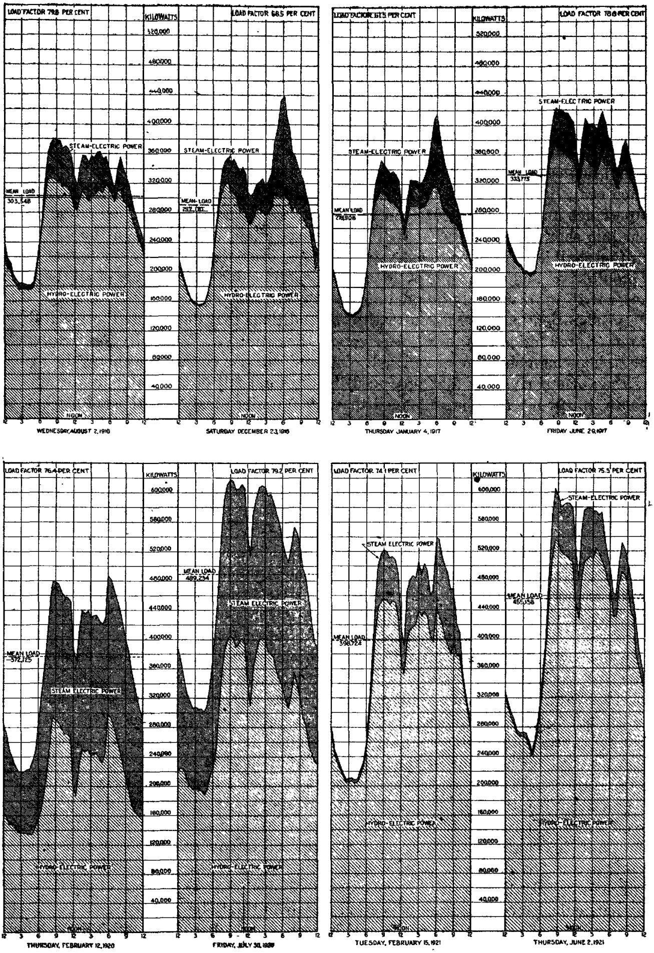
[3] Papers on the conservation of water resources: U. S. Geol. Survey Water-Supply Paper 234, pp. 46–49, 1909.



(including plants in southern Oregon and western Nevada), 1916–1921.

In the use of maps the following preferences have been given: (1) United States Geological Survey topographic sheets; (2) special detailed surveys; (3) General Land Office maps; (4) United States post-route maps; (5) Rand & McNally Atlas sheets.

WATER POWER.

The schedule presented in this report gives the amount of available water power according to three classifications—(1) that which may be produced by the minimum flow; (2) the assumed maximum development; and (3) the additional power that may be recovered by developing the available storage capacity in the upland basins and using stored water to compensate the low-water periods. The data as a whole have been considered without reference to the present practicability of development or present market. For the purposes of this report it has been assumed that all the power in the United States will some day be required. Such an interpretation is the logical one when natural resources are being considered. In other words, the schedule here presented must be interpreted for the future rather than for the present. The reader should not assume that all of the power here shown is economically available today. Much of it, indeed, would be too costly in development to render it of commercial importance under the present conditions of market and the price of fuel power. The schedule shows therefore what will be the maximum possibilities in the day when our fuel shall have become so exhausted that the price thereof for production of power is prohibitive, and the people of the country shall be driven to the use of all the water power that can reasonably be produced by the streams.

Consideration has been given to all the conditions that determine the possibilities of power production on the various rivers of the country. Especially has the slope of the stream channels been scrutinized. Theoretically, of course, the energy developed by the various rivers is that produced by the total fall of the water from source to mouth, but it has not been assumed that, even under ideal conditions of market, all this power will ever be commercially available. The flatter portions of the river channels can never be profitably developed for power, and they have not been included in the schedule. The rivers have been divided into sections of varying length, determined by channel slope, and the fall and flow of each section have been obtained from the best available source of information. The records of stream flow collected by the water-resources branch of the Geological Survey have almost uniformly been the only available resort, although acknowledgments should be made to * * * bodies and individuals, public and private, who in the past have maintained measurements in cooperation with the United States Geological Survey or independently. Use has also been made of certain river-gage records of the United States Weather Bureau and of the Corps of Engineers, United States Army.

In determining the flow for the various sections the data of flow per square mile, procured from the sources above enumerated, have been applied. The drainage areas above the upper and the lower limits of each section have been determined and a mean taken for the whole section. This has been used as a factor along with the flow per square mile in determining the minimum flow for that section. This figure, together with 90 per cent of the total fall from head to foot, has been used to determine theoretical horsepowers according to the usual formulas. It is obvious that in practice the entire fall along any stretch of river or at any power privilege can not be effectively utilized. In few places can even 90 per cent be utilized at the present time; but, inasmuch as these figures are supposed to cover future as well as present practice, and inasmuch as it may reasonably be assumed that future practice in water-power installation will improve, it is believed that 90 per cent of the fall along any particular power privilege or section may eventually be realized.

The results of calculations of theoretical power on 90 per cent total fall have been reduced 10 per cent to allow for inefficiency of wheels. It is recognized that 90 per cent efficiency is too high to be used in calculations of power at the present time, 75 or 80 per cent being the usual installation maximum. Here again, however, we are computing for future conditions, as well as present ones, and it may confidently be expected that, with the improvement of turbines, a greater percentage of the theoretical power will be realized on the shaft and improvements will before long render possible a 90 per cent efficiency.

In determining the minimum horsepower, the minimum flow for the lowest two consecutive seven-day periods in each year was determined and the mean of these values for the period of record was taken as the minimum flow. It is obvious that this is somewhat higher than the absolute minimum, but the latter is usually of so short duration that it does not equal the practicable minimum that may profitably be installed.

The assumed maximum economical development has been determined on the assumption that it is good commercial practice to develop wheel installation up to that amount the continuance of which can be assured during six months of the year on the assumption that the deficiency in power during the remainder of the year can be profitably provided by the installation of fuel power plants as auxiliaries. In many parts of the country it has been shown conclusively that it is economical to develop up to that amount which can be had continuously during the highest four months of the year, and, while it is probable that there are parts of the country where the limit should be the highest eight or ten months, it is believed that the period used in these schedules is a very conservative average. The minimum weekly flow for each month of the year has been arranged according to magnitude, and the sixth value has been taken as the basis for estimating the power, the mean of these values for the record period in each case being that used in the computation.

The potential power of the streams of California, some of which have already been partially developed by companies, as estimated on the above basis, is shown in Table 179.

As the mean load on the hydroelectric systems was only 508,000 horsepower for the first nine months of 1919, and has increased at the mean rate of about 47,000 horsepower per annum for the last three years, it appears that there not only will be an ample supply of potential power to take care of the normal rate of increase for many years to come, but that as rapidly as economic conditions demand hydroelectric power may be substituted for energy now generated by the consumption of fuel oil. It is therefore desirable to ascertain even approximately where such substitution may best begin and to what extent and how rapidly it may be carried forward.

The totals show a minimum of 4,291,400 and a maximum of 9,655,300 horsepower, which it should be remembered are on the basis of natural flows, unaided by storage but at an efficiency of 90 per cent. On a more conservative basis of 70 per cent efficiency, the minimum would be 3,338,000 horsepower, and the maximum 7,510,000 horsepower. The utilization of storage universally practiced by California power companies would act as a factor of safety in using the higher estimates.

TABLE 179.—*Estimate of potential water power on California streams.*

Stream.	Horsepower.	
	Minimum.	Maximum.
Klamath River and minor coast streams north of San Francisco Bay	680,000	1,240,000
San Francisco Bay drainage:		
Sacramento River	2,420,000	4,580,000
San Joaquin River	759,000	3,140,000
Coast streams south of San Francisco Bay	36,400	88,300
Interior Basin (including Los Angeles Aqueduct)	396,000	607,000
Total (90 per cent efficiency)	4,291,400	9,655,300
Total (70 per cent efficiency)	3,338,000	7,510,000

CALIFORNIA OIL PRODUCTION.

PAST PRODUCTION.

Fortunately complete and accurate figures covering production have been recorded almost from the beginning of the oil industry in the State. Among the most accurate and detailed records are those prepared by the Standard Oil Co. of California. These have been checked from time to time against figures prepared by the Federal and State governments and the Independent Producers' Agencies, and have been found to agree within a few per cent. These outputs are shown in Table 180.[4]

The production of 105,721,186 barrels from the California fields in 1920 exceeded that of 1914, the previous record year, by about 2 per cent, and the output of 60,663,417 barrels during the six months ending June 30, 1921, established a rate of production which if maintained for the full calendar year would far exceed the best previous record. A serious strike in the oil fields during the second half of 1921, however, resulted in a decreased rate, which in view of industrial conditions was probably not unwelcome to the operators.

The relation between total production, consumption, reserves in storage, and value of oil in cents per barrel is shown graphically in figure 50, which extends into 1921 similar curves published in Bulletin 69 of the California State Mining Bureau.

The relation of the California supply to the total supply for the United States and for the world is shown by the following comparative figures for 1918. The total petroleum production of the world for that year was 514,729,354 barrels, of which the United States produced 355,927,716 barrels, or 69.15 per cent, and Mexico, the nearest available field, 63,828,327 barrels, or 12.40 per cent. California produced 97,531,997 barrels, or 18.94 per cent of the total production of the world and 27.40 per cent of the total of the United States.[5]

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[4] Standard Oil Bulletins, p. 10, April, 1919; p. 11, January, 1920.

[5] Standard Oil Bulletin, January, 1920, p. 4. Tabulation of outputs compiled by U. S. Geological Survey.

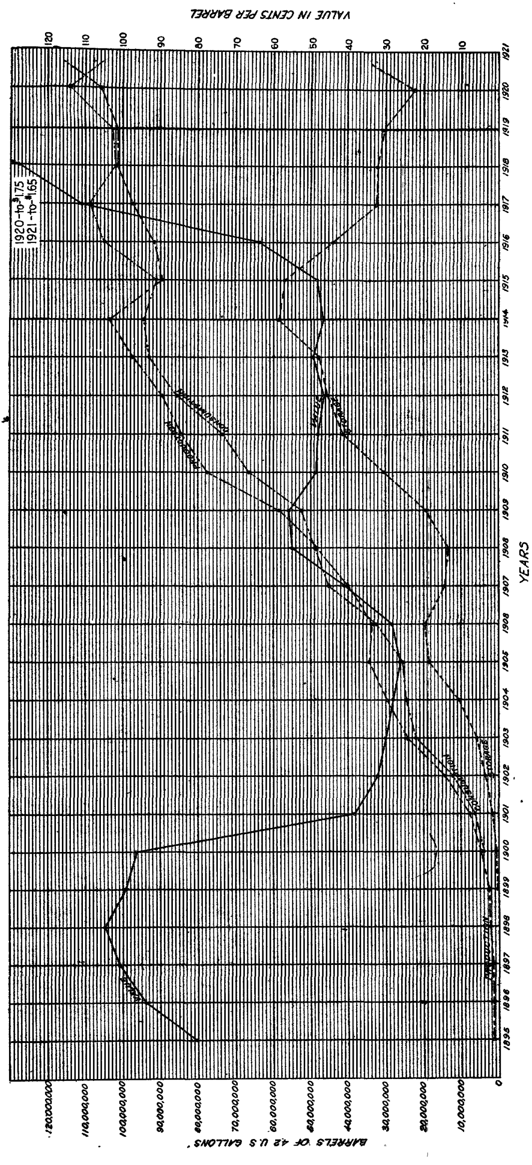

FIGURE 50.—Production, consumption, storage, and value of California oils, 1895-1921.

TABLE 180.—*Total production of crude oil in California from the beginning of the industry to Dec. 31, 1919, by fields, in barrels (42 U. S. gallons).*

[★shows first year of production.]

Year.	Kern River.	McKittrick.	Midway.	Sunset.	Coalinga.	Santa Maria-Lompoc.	Summerland.	Newhall and Ventura counties.	Los Angeles and Salt Lake.	Whittier-Fullerton.	Lost Hills-Belridge.	Miscellaneous.	Total.
Prior to 1876								175,000					175,000
1876								12,000					12,000
1877								13,000					13,000
1878								15,227					15,227
1879								19,858					19,858
1880								40,552		★			40,552
1881								99,862					99,862
1882								128,636					128,636
1883								142,857					142,857
1884								262,000					262,000
1885								325,000					325,000
1886								377,145					377,145
1887								678,572					678,572
1888								690,333					690,333
1889								303,220					303,220
1890					★		★	307,360					307,360
1891				★				323,600					323,600
1892		★						385,049	★				385,049
1893								470,179					470,179
1894							1,500	524,469	257,109				783,078
1895							16,904	476,490	751,945				1,245,339
1896					14,119		39,792	298,866	905,003				1,257,780
1897					70,140		130,136	368,282	1,327,011	12,000		4,000	1,911,569
1898		10,000			154,000		132,217	427,000	1,462,871	60,000		3,000	2,249,088
1899	★	15,000			439,372		208,370	496,200	1,409,356	108,077		1,500	2,677,875
1900	826,775	80,000	★	12,500	547,960		183,486	443,000	1,722,887	254,397		248,945	4,319,950
1901	3,278,840	430,450	4,235	188,600	525,433	★	203,616	472,057	2,304,432	302,652			7,710,315
1902	8,988,046	619,296	3,048	167,558	571,233	86,888	143,552	475,000	2,198,496	1,103,793			14,356,910
1903	16,342,099	1,353,206	27,305	352,565	2,138,058	204,890	131,125	682,185	793,765	2,305,613		3,670	24,334,481
1904	17,226,240	1,856,225	910	390,425	5,097,853	700,450	120,506	650,779	1,241,304	2,224,550		39,392	29,548,634
1905	15,253,845	1,373,030	18,530	419,212	8,882,125	3,402,800	96,871	476,898	2,226,768	2,118,312		29,650	34,298,041
1906	12,825,166	680,756	11,800	307,550	8,401,105	4,799,411	72,810	404,379	2,675,650	2,434,512		10,090	32,623,229
1907	12,346,014	2,415,840	149,944	704,805	8,996,268	8,249,236	69,060	435,584	3,372,465	3,294,206		69,090	40,102,512
1908	13,803,579	3,076,300	434,578	1,463,510	10,725,795	8,699,350	67,862	498,015	5,138,959	4,273,314		125,475	48,306,737
1909	14,508,242	5,807,360	2,234,455	1,999,701	15,406,619	8,017,455	66,338	516,628	4,350,898	5,157,252	★	126,775	58,191,723
1910	14,776,435	5,471,613	11,174,207	9,218,904	18,646,570	7,607,830	74,725	652,575	3,729,618	6,281,221	4,900	58,970	77,697,568
1911	14,078,890	5,477,532	21,584,602	5,559,069	18,311,251	7,465,074	71,255	661,785	3,223,661	7,081,165	168,410	61,350	83,744,044
1912	12,446,445	5.094,46	25,948,980	5,590,824	19,546,122	6,801,966	65,715	859,885	3,073,427	7,919,779	2,680,961	45,870	90,074,439

1913...........	9,980,940	4,496,842	33,040,129	5,984,651	18,604,626	5,817,711	62,406	1,022,052	2,898,846	10,657,053	5,274,553	27,375	97,867,184
1914...........	7,030,545	3,820,857	37,479,228	12,546,615	15,925,887	4,303,080	55,743	968,421	2,504,475	14,130,548	4,830,921	27,375	103,623,695
1915...........	8,034,974	3,552,801	33,311,486	6,006,607	13,548,159	4,536,840	53,000	1,036,305	2,110,133	13,030,549	4,318,550	27,375	89,566,779
1916...........	8,402,525	3,230,644	32,156,818	6,768,658	14,381,493	4,422,410	56,775	1,122,033	1,721,453	14,679,672	4,852,431	27,450	91,822,362
1917...........	8,495,610	3,252,544	29,487,812	7,072,333	15,938,543	5,789,070	56,570	1,186,407	1,501,799	18,155,440	6,295,329	27,375	97,267,832
1918...........	7,921,515	3,050,627	27,439,993	6,608,940	16,283,066	7,143,750	54,613	1,386,518	1,397,781	24,903,613	5,420,079	27,375	101,637,870
1919...........	7,563,025	2,810,848	32,003,952	(a)	16,385,610	6,030,910	53,680	1,792,465	1,341,415	28,657,683	4,554,821	27,375	101,221,784
	214,129,750	57,976,236	286,512,012	71,363,027	229,541,407	94,088,121	2,288,627	23,103,728	55,641,527	169,145,401	38,400,955	1,019,477	1,243,210,268

[a] For 1919 included in figures for Midway field.

That California can long maintain her relative importance as a producer is improbable. The annual outputs shown in Table 180 demonstrate conclusively that some of the fields are declining, that others are practically at their maximum production, and that in only two (the Whittier-Fullerton and Midway fields) is there any indication of a possible marked increase in production. Records of the numbers of producing wells show that the output of the State as a whole has probably nearly reached its peak, the total number of producing wells December 31, 1914, the year of maximum production, being 5,913, against a total of 9,127 on December 31, 1919. In other words, the number of producing wells at the end of 1919 was 55 per cent greater than at the end of 1914, but the production for the year was 2 per cent less.

Most specialists who have studied the subject agree that the peak of production has been reached in most of the California oil fields and that the present rate of production can be maintained in the future only by a most aggressive and constantly increasing drilling program.[5a]

ULTIMATE PRODUCTION.

Estimates of the ultimate production that may be expected from the oil fields of the State are necessarily approximate. Probably the most careful study of this subject has been made by the technologists of the United States Bureau of Mines. Carl H. Beal of that bureau has published the following:[6]

> An accurate inventory of the present undrilled locations in California has been taken by the State oil and gas supervisor, R. P. McLaughlin, and submitted to the petroleum committee of the California Council of Defense.[7] These locations were classified according to their probable productiveness the first year, and the writer has used the statistics in estimating the probable future production of the undrilled areas in the California fields.
>
> On the assumption that the average ultimate cumulative percentage[8] of the California wells is approximately 500, the undrilled wells in the State, provided they are drilled during the next few years, will ultimately produce about 1,300,000,000 barrels of oil. The probable future production of the producing wells has been estimated at approximately 1,000,000,000 barrels, so that the estimated total future production for California is about 2,300,000,000 barrels. The present proved territory * * * is 88,745 acres, but it includes only lands on which wells have been drilled. The undrilled areas comprise about 72,000 acres, making the total productive acreage 160,745 acres.

[5a] A drilling campaign of this nature increased the number of producing wells to 9,963 at the end of June, 1921, and through unusual success in the Elk Hills region greatly increased production. It is hardly to be expected that this success can be often repeated on a large scale.

[6] Beal, C. H., The decline and the ultimate production of oil wells, with notes on the valuation of oil properties: Bureau of Mines Bull. 177, pp. 200, 201, 1919.

[7] Report of Committee on Petroleum, California Council of Defense, pp. 131, 140, 141, 1917.

[8] The ultimate cumulative percentage is the total production of a well at the time of its exhaustion, expressed in terms of its first year's production, which is taken as 100 per cent.—F. H. F.

CHANGING MARKET CONDITIONS.

The oil produced by the more recently developed fields is generally of a much higher gravity than that from the fields developed from 1900 to 1905, and as the fields producing heavy oils have passed their peak of production there has been a marked rise in the percentage of lighter or refining oils. This rise in the proportion of the lighter oils began in 1912. In the years 1909, 1910, and 1911 the light oils (above 20° Baumé) ranged from 28 to 32 per cent of the total production, but beginning with 1912 there was a steady increase in this percentage until in 1914 about 58 per cent of the total yield was above 20° Baumé, a proportion that has remained approximately the same to date.

The rapidly increasing demand for gasoline, lubricants, and other refined products and improved methods of refining are rapidly changing the California oil industry from a fuel supply to one valuable chiefly for its refined products. When the Kern River fields were first exploited only a small percentage of their total output was even partially refined. The proportion of the total output of California fields subjected to at least partial refining increased at first gradually and then rapidly, until 60 per cent in 1917, 66 per cent in 1918, and 80 per cent of the entire output in 1919 was subjected to at least partial refining. There is every prospect that the demands for refined products on the Pacific coast will continue to increase, and in consequence of the release of shipping following the war there has been a growing exportation of such products to New York and other Atlantic ports through the Panama Canal. We may therefore anticipate that in future even a larger percentage of the California output will be subjected to partial refining and that the refining will be more complete.

That there is ample opportunity for much more complete refining than has hitherto been practiced is shown conclusively by the information contained in Table 181, which gives the properties of oils from the various California fields.

TABLE 181.—*Percentages of possible refined products, fuel oil, and asphalt and road oil in output of various California fields.*

[Résumé of possible results of refining, condensed from Table 18, California State Pet. Com. Rept.]

Field.	Degrees Baumé at 60° F.	Refined products.	Fuel oil.	Asphalt and road oil.
		Per cent.	*Per cent.*	*Per cent.*
Salt Lake	15.61	47	26	27
Fullerton	22.26	54	32	14
Whittier	19.20	51	30	19
Coyote Hills	24.68	60	20	20
Santa Maria	24.68	57	23	20
Coalinga	19.26	47	35	18
Midway	20.30	64	20	16
Sunset	18.67	28	36	26
Kern River	15.00	28	46.5	25.5

CLASSIFIED USES OF FUEL OIL IN CALIFORNIA.

In this chapter we are interested directly with but one phase of utilization of the output from California oil fields, namely, the amount that may be saved by the substitution of hydroelectric power within the territory that is or may be reached by California transmission systems.

The latest and most complete estimate of the use of fuel oil in California is that prepared by Mr. D. M. Folsom, petroleum director for the Pacific coast, and submitted to the United States Fuel Administration on August 27, 1918. A condensed tabulation prepared from this estimate, which covered the year ending May 31, 1919, is given in Table 182. The total consumption given in this estimate is considerably lower than that given in Table 19 of the Report of Committee on Petroleum, California State Council of Defense, owing chiefly to a reduction in the estimated use by railways and steamships, resulting from a more careful geographic segregation of these uses.

The table shows that about 33 per cent of the total California production is being burned as fuel within the State or by steamers plying from California ports, and affords the basis of a rough study of possible conservation of this part of the supply.

TABLE 182.—*Estimated use of fuel oil in California for the year ending May 31, 1919.*[a]

Class of use.	Average per month (barrels).	Total for year (barrels).	Per cent of total, excluding steamships.
Railways	954,400	11,453,000	39.66
Government and municipal	101,869	1,222,000	4.23
Public utilities	459,726	5,517,000	19.10
Heating	118,950	1,427,000	4.94
Agriculture	9,485	114,000	.40
Industrial	664,534	7,974,000	27.62
Miscellaneous	97,357	1,168,000	4.05
Total, exclusive of ships	2,406,321	28,875,000	100.00
Steamships	346,724	4,161,000	....
Grand total	2,753,045	33,037,000	....

[a] Condensed from a more detailed estimate prepared by D. M. Folsom, petroleum director for the Pacific coast, Aug. 27, 1918.

In preparing the table the use of oil for fuel on steamships was listed separately, as there is no possibility of hydroelectric substitution in this class and no higher use to which this particular form of fuel could be put. All percentages are therefore figured on the basis of the total use exclusive of the oil burned on steamers.

The estimated use of oil by steamers taking on their fuel supply at California ports was 4,161,000 barrels, or 12.6 per cent of the total fuel consumption including this class. With every indication of rapid increase in shipping on the Pacific, this use should grow correspondingly. Not only is a fuel-oil supply imperative for our Navy, but its manifold advantages recommend it in every way for use in the merchant marine. No more logical use exists for the fuel supply remaining after the extraction of lubricants and other high-grade refinery products.

Taking up, in order, the classified uses given in the table, we find the following opportunities for conservation:

RAILROADS.

Although the estimated consumption of approximately 11,453,000 barrels of oil on the railroads within the State amounts to 39.66 per cent of the total consumption for all purposes except ocean transportation, it is less than half of the total consumption of the railroads supplied from the California fields.

California oil has been used as fuel on the following important railroad systems in or radiating from the State: Southern Pacific, Pacific system to El Paso, Ogden, and Portland; Atchison, Topeka & Santa Fe from San Francisco to Winslow, Ariz.; Salt Lake & Los Angeles from Los Angeles to Milford, Utah; Western Pacific from San Francisco to Wendover, Utah; and Northwestern Pacific from San Francisco to Eureka, Calif. The following table shows the rapid increase in this use of fuel oil and the very large amount that is now burned under locomotive boilers. The annual consumption includes Western Pacific Railroad from 1913 and the other four roads from 1907 to the end of the tables.

TABLE 183.—*Consumption of California fuel oil by Pacific coast railroads, 1907-1917.*[9]

	Barrels.		Barrels.
1907	13,703,850	1913	20,194,778
1908	12,691,997	1914	18,514,799
1909	14,428,984	1915	19,382,801
1910	16,436,147	1916	21,844,351
1911	17,094,023	1917	[10] 24,361,914
1912	18,836,415		

It is obvious that much of this total consumption is on divisions that will never be reached by California hydroelectric power, and that even within the boundaries of California there are many miles of roads on which traffic conditions will probably never justify electrification. There are, however, three very important mountain divisions in or partly in California that offer opportunity for electrification—the Siskiyou and Sacramento divisions of the Southern Pacific lines and the San Joaquin division, part of which is operated

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[9] Condensed from Tables 22 and 29, Report of Committee on Petroleum, California State Council of Defense, pp. 109, 160, 1917.

[10] Estimated for year from actual consumption up to May 31, 1917.

jointly by the Southern Pacific and the Santa Fe. Careful estimates[11] show that the electrification of these three divisions would result in the saving of over 3,000,000 barrels of fuel oil with traffic conditions similar to those existing during 1917, the detailed amounts being as follows:

	Barrels.
Siskiyou division, Gerber to Ashland	907,300
Sacramento division, Roseville to Sparks	978,000
San Joaquin division, Bakersfield to Saugus	1,177,000
	3,062,300

GOVERNMENT AND MUNICIPAL USES.

The uses grouped under the heading Government and municipal are so varied that it is impossible to analyze them successfully with a view to effecting economies. Fortunately, however, the total of such uses amounts to only 1,222,000 barrels, or 4.23 per cent, of the grand total. Part of this use could undoubtedly be eliminated by substitution of hydroelectric power, but the exact amount is uncertain.

PUBLIC UTILITIES.

The estimated consumption of 5,517,000 barrels of oil, or 19.10 per cent of the total, by public utilities is one of the most important single uses in the schedule. Gas making and the generation of electric energy are the two largest single uses in the group, and the greater part of the latter use is in the stand-by plants of the hydroelectric companies. The extent to which these auxiliary steam stations were operated, particularly during the years 1918 and 1919, is not realized by the general public, and the writer has therefore collected the available statistics for these and preceding years in Table 184.

TABLE 184.—*Consumption of fuel oil by the more important electric systems in California.*

Company.	1907	1908	1909	1910	1911	1912
Western States Gas & Electric Co.:						
Eureka system	(a)	(a)	(a)	(a)	(a)	(a)
Stockton system	(a)	(a)	(a)	(a)	10,107	11,485
Pacific Gas & Electric Co	768,514	907,396	640,413	703,266	579,433	529,193
Sierra & San Francisco Power Co	....	....	....	16,404	17,795	96,764
Coast Valleys Gas & Electric Co	(a)	(a)	(a)	(a)	(a)	(a)
Great Western Power System	(a)	(a)	(a)	(a)	(a)	303,000
Coast Counties Gas & Electric Co	(a)	(a)	(a)	(a)	(a)	(a)
San Joaquin Light & Power Co	(a)	(a)	(a)	(a)	(a)	(a)
Mount Whitney Power & Electric Co	....	10,349	4,965	2,355	1,212	18,687
Pacific Light & Power Co	172,742	433,801	456,638	566,332	696,232	934,954
Southern California Edison Co	133,548	52,158	243,022	124,636	198,336	584,063
Southern Sierras Power Co	....	....	....	....	....	18,038
Los Angeles Gas & Electric Co	(a)	(a)	(a)	(a)	(a)	(a)
San Diego Consolidated Gas & Electric Co	(a)	(a)	(a)	(a)	(a)	(a)
Universal Gas & Electric Co	....	....	....	....	....	....
	1,074,804	1,463,704	1,345,038	1,412,993	1,503,115	2,496,184

[a] Steam plants in operation but oil consumption not available.

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[11] Dietrich, W. F., engineer, oil division, U. S. Fuel Administration, Report on mountain railroad electrification in California, Sept. 27, 1918.

TABLE 184.—*Consumption of fuel oil by the more important electric systems in California*—Continued.

Company.	1913	1914	1915	1916	1917	1918	1919
Western States Gas & Electric Co.:							
Eureka system	(a)	(a)	(a)	(a)	22,901	13,019	8,282
Stockton system	9,845	12,569	9,667	9,590	8,991	20,271	24,269
Pacific Gas & Electric Co.	809,700	549,451	786,073	777,707	945,275	1,165,170	1,614,871
Sierra & San Francisco Power Co.	148,402	56,969	133,178	63,422	130,055	413,265	525,910
Coast Valleys Gas & Electric Co.	[b] 4,000	[b] 1,930	[b] 1,900	[b] 4,050	[b] 4,153	12,587	15,500
Great Western Power System	352,000	220,000	218,209	317,584	363,077	510,863	[c] 358,165
Coast Counties Gas & Electric Co.	(a)	(a)	(a)	(a)	8,792	....	....
San Joaquin Light & Power Co.	(a)	(a)	(a)	[d] 10,600	[d] 83,200	297,074	419,723
Mount Whitney Power & Electric Co.	16,960	10,331	43,228	42,791	36,486	20,900	67,252
Pacific Light & Power Co.	912,528	173,892	88,575	81,791	[e] 25,692	....	....
Southern California Edison Co.	623,234	407,456	223,673	327,218	623,393	760,950	1,434,790
Southern Sierras Power Co.	55,429	20,713	18,561	8,834	55,945	49,690	[f] 39,083
Los Angeles Gas & Electric Co.	(a)	(a)	(a)	(a)	38,780	78,619	179,904
San Diego Consolidated Gas & Electric Co.	(a)	(a)	(a)	(a)	128,183	120,010	184,395
Universal Gas & Electric Co.	....	....	....	....	43,493	49,066	23,398
	2,932,098	1,453,311	1,523,064	1,643,587	2,518,416	3,511,484	4,895,542

[a] Steam plants in operation but oil consumption not available.
[b] Estimate.
[c] Includes 133,738 barrels burned at combined heating and steam-electric plants.
[d] Estimated from kilowatt-hours output.
[e] Five months ending May 31.
[f] Including Blythe plant and Holton power, steam, and gas engine plants.

Los Angeles Gas & Electric Co., San Diego Consolidated Gas & Electric Co., and Universal Gas & Electric Co., included in the table, are not hydroelectric systems but are connected to the hydroelectric transmission systems for the exchange of power. They are the most important consumers of oil outside of the companies covered in this report.

The table shows that the hydroelectric companies and three large steam-electric systems consumed 3,511,484 barrels of fuel oil in 1918, and 4,895,542 barrels in 1919. This large use of oil during the two years was due to three causes, two of which are shown clearly in figures 42, 44, and 45. First, there has been a nearly uniform increase in load; second, there has been no commensurate increase in the installation of hydroelectric plants; and, third (a factor not shown clearly by the charts), the water supply during 1918 and 1919 was considerably below normal. A detailed study of figure 45 shows a large increase in hydroelectric installation and a corresponding reduction in the use of steam power near the end of 1913. Figures 45 and 46 show that most of this increase in capacity was in the southern California market. Going still further back, the separate company curves show the increase due to the completion of the Big Creek plants on the Pacific Light & Power system (see Pl. L), each step back from State to market and from market to system curve showing more clearly the effect of the substitution of hydroelectric for steam power.

A detailed study of the Pacific Light & Power Corporation load diagram (see Pl. L) and the corporation's consumption of fuel oil, as shown in Table 184, is illuminating. From the completion of the Borel plant at the beginning of 1905 to the installation of the Big Creek plants late in 1913, the corporation made no important additions to its hydroelectric installations. Its load increased steadily, and this constant increase was carried by steam, all hydroplants on the system being operated to their full capacity with the water available during the period. The years 1912 and 1913 being unusually dry resulted in the consumption of over 900,000 barrels of oil per annum. The consumption in 1913 would doubtless have been larger than in 1912 had not the two Big Creek plants been in operation for a short time during the latter part of the year. The following year, 1914, was the first during which the full effect of the storage in Huntington Lake, above the plants, became fully effective, the use of oil being cut to about 174,000 barrels, and in 1915, a year of good run-off, oil consumption dropped to 88,575 barrels, or about 9.5 per cent of that used in 1912.

It is not unreasonable to suppose that as soon as an ample supply of developed hydroelectric power is available the use of oil throughout the State will be reduced in approximately the same ratio. Such reduction would have resulted in a saving of 3,180,000 barrels during 1918 and 4,430,000 during 1919.

The manufacture of gas from oil accounts for most of the remaining consumption by utilities. Very little gas is manufactured from coal, but natural gas piped from the oil fields is frequently mixed with the artificial gas manufactured from oil in the regions that are within range of the natural-gas pipe lines. This mixture has resulted in economy and a resulting decrease in gas rates. There are indications, however, that the natural-gas supply, like the oil supply, has reached its peak and will decline. Only a very detailed study would enable one to predict the rapidity with which gas, either natural or mixed, will be driven out by electricity, although it appears reasonably certain that such will be the ultimate result.

HEATING.

The estimated use of oil for heating, 1,427,000 barrels, amounts to 4.94 per cent of the total use, and it is problematic to what extent this consumption can be reduced. Combined steam-electric and steam-heating stations connected as auxiliaries to the hydroelectric lines may effect appreciable economies. The Bush Street plant of Great Western Power Co. of California (see pp. 375–376), operating two noncondensing turbo-generators and supplying the exhaust steam to a system of underground ducts that serve a number of buildings in San Francisco, is a plant of this type. It is obvious, however, that such central steam stations are of limited range and that there must continue to be a considerable use of oil in isolated heating installations.

AGRICULTURE.

The estimated use of 114,000 barrels, or 0.40 per cent of the total oil consumption, for agriculture represents the small remnant of agricultural power that has not already been taken over by the hydroelectric systems and agricultural uses where heat is necessary in addition to power. Complete substitution of electric energy in the small part of this field as yet unabsorbed would effect but little saving.

INDUSTRIAL USES.

The largest single use outside of the railways is included under the broad classification "industrial," with a total use of 7,974,000 barrels, or 27.62 per cent of the total consumption for the State. Here again a definite estimate of saving that may be effected by substitution of hydroelectric energy is impossible without the expenditure of a large amount of time and money. It is known positively, however, that we may still expect to invade all parts of this field where oil is consumed only to produce light or motive power and neither forms part of the articles manufactured nor is used for the production of heat. Electric heating has not yet reached that degree of perfection where it can economically be substituted for fuel.

A conservative estimate based on all data available shows a possible saving of 3,200,000 barrels.

MISCELLANEOUS.

The uses classed as miscellaneous, consuming 1,168,000 barrels, or 4.05 per cent of the total consumption, are so varied that no estimate of substitution is possible.

RECAPITULATION.

The numerous indeterminate factors noted in the preceding paragraphs make a complete statement of possible hydroelectric substitution out of the question. The approximate estimates of the more important savings may be summed up in round numbers as follows:

TABLE 185.—*Summary of possible fuel-oil conservation by substitution of hydroelectric power.*

	Barrels.
By electrification of three mountain railway divisions	3, 060, 000
By cutting down steam auxiliary operation	4, 430, 000
By substitution of additional hydropower in the industrial field	3, 200, 000
	10, 690, 000

These figures show that thoroughly justifiable economies would reduce the annual consumption of fuel oil in California by at least 10,690,000 barrels, leaving a total (exclusive of marine uses) of only 18,185,000 instead of 28,875,000 barrels.

In short, 37 per cent of the present oil consumption could be eliminated by the utilization of a readily available supply of water power, and probably an adequate development of the States' power sites would result in a far larger percentage of fuel-oil conservation.[12]

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[12] The estimate here given has not been revised in detail for the years 1920 and 1921, but an approximate review shows the following trend in the use of California oil: Industrial depression has tended to reduce the use of oil by public utilities, but this tendency was more than compensated by a water shortage, the use by utilities during 1920 being 5,312,194 barrels for the generation of electricity and steam stand-by plants and 3,253,757 barrels for the manufacture of gas, a total of 8,565,951 barrels, showing that the estimate for saving in this use is ultraconservative. Agricultural use increased in 1920 but returned to normal in 1921. Industrial use was reduced from 15 to 20 per cent in the last part of 1919 and in 1920, owing to the substitution of powdered coal in copper mining, and in 1921 was reduced 30 to 50 per cent, almost no oil being used for mining and smelting. The mercantile marine and Navy used 18,000,000 barrels of California oil in 1920 and will use 7,000,000 or more in 1921, of which 75 per cent will be in California or California coastwise trade.

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Success in long-distance transmission, by F. A. C. Perrine: Jour. Electricity, vol. 13, p. 47, January, 1903. A discussion of problems that arise in long-distance alternating-current work. 5,100 words.

The water and electric systems of the South Yuba, by Rudolph Warner Van Norden: Jour. Electricity, vol. 13, p. 57, January, 1903. An illustrated, detailed description of these systems, with tabulated engineering data. 13,600 words; 46 photographs; 1 map.

Some storage-battery applications: Jour. Electricity, vol. 13, p. 107, January, 1903. A general list of installations, several of which are on The Standard Electric Co.'s lines. 1,400 words.

The distribution of Bay Counties' power: Jour. Electricity, vol. 13, p. 125, January, 1903. A discussion of the gas and electric market conditions and developments in and around Marysville. 5,400 words; 8 photographs.

San Francisco's gas and electric industry: Jour. Electricity, vol. 13, p. 137, February, 1903. A financial note on the operating companies and their earnings for 1902.

Electric power for mining and milling by J. B. Tregolan: Jour. Electricity, vol. 13, p. 150, February, 1903. A discussion of the comparative cost of electricity versus steam or water, for the operation of mining pumps, blowers, compressors, etc. 2,700 words.

Butte County Gas & Electric system: Jour. Electricity, vol. 13, p. 170, March, 1903. History of Chico Gas Co. and its growth and absorption by Butte County Gas

& Electric system, followed by a description of the original installation and new 900-kilowatt unit at Centerville. 3,700 words; 9 photographs; plan and elevation.

An impulse water wheel governed by an induction motor by L. M. Hancock: Eng. News, vol. 49, p. 246, Mar. 19, 1903. Short abstract of a paper, published in Wisconsin Eng., which describes this form of governing at Colgate.

The organization of operative forces of a transmission plant by L. M. Hancock: Jour. Electricity, vol. 13, p. 277, August, 1903. A general discussion of the force needed to operate a hydroelectric plant. 2,800 words.

Electric power for mining purposes, by G. Scarfe: Jour. Electricity, vol. 13, p. 279, August, 1903. Review of power conditions in the Colgate region.

Bay Counties' Power Co.'s transmission system, by L. M. Hancock: Int. Electrical Cong. of St. Louis, September, 1904. An outline of general and controlling features, dealing more at length with the organization of the forces needed to operate a plant and to carry on construction and repairs of a long-distance transmission. 5,500 words.

High-potential long-distance transmission and control, by F. G. Baum: Int. Electrical Cong. of St. Louis, September, 1904. Gives the practice and results on California Gas & Electric system. 5,000 words.

The design of generators for electric-power transmission work, by David B. Rushman: Eng. News, vol. 52, p. 367, Oct. 27, 1904. A general discussion of generator construction and design, supplemented by a full description of No. 3 unit at De Sabla. 5,600 words; 3 photographs; 1 detail; characteristic curves of 4,000-kilowatt unit for De Sabla.

High-potential, long-distance transmission and control, by F. G. Baum: Jour. Electricity, vol. 14, p. 439, November, 1904. Reprint of paper which was read before Inter. Engineers' Cong. at St. Louis Fair. Prefaced by remarks by the editor. 6 photographs; 6 graphic charts; 9 details; 1 elevation of ideal power house.

American practice in long-distance high-tension line construction, by F. A. C. Perrine: Jour. Electricity, vol. 14, p. 452, November, 1904. Discussion of problems and best current practice in long-distance transmission, by designer of the Electra transmission. 5,700 words.

Long-distance, high tension in California: Eng. Rec., vol. 52, p. 122, July 29, 1905. An abstract of an article read before the Natl. Electric Light Assoc., by J. A. Britton. Outlines growth of Pacific Gas & Electric Co. General outline of changes in construction. 3,500 words.

Utilization of gas engines in connection with long-distance electric transmission, by John Martin: Electrical World, vol. 46, p. 220, Aug. 5, 1905. Outline of conditions that led California Gas & Electric Corporation to try gas engines at Martin station. 1,950 words.

Hydroelectric power station, California Gas & Electric Corporation, De Sabla, Calif., by J. D. Galloway: Eng. News, vol. 54, p. 131, Aug. 10, 1905. Detailed description of the station as it stood after the installation of the 5,000-kilowatt unit. 3,000 words; 5 photographs; 1 map; profile of pressure line; elevation of plant; flume section; switch details.

Towers for carrying electric-power transmission wires at Sacramento across Sacramento River, by J. D. Galloway: Eng. News, vol. 54, p. 377, Oct. 12, 1905. Short description. 1 photograph; 3 details.

The new electric light and power plant of Mutual Electric Light Co., by J. C. Hopp: Jour. Electricity, vol. 16, p. 221, May 12, 1906. Detailed description of Spear and Folsom streets plant of this company. 2,700 words.

How electricity was served to consumers and street car lines by San Francisco Gas & Electric Co. after the fire, by L. E. Reynolds: Jour. Electricity, vol. 17, p. 211, Sept. 22, 1906. A description of the system before the earthquake, its condition after the fire, and the steps taken to recommence service. 2,600 words.

Large gas engines for power purposes: Jour. Electricity, vol. 17, p. 256, Sept. 29, 1906. A description of large gas engines, among which are those for the Martin station. 1,750 words; 9 photographs.

The distribution of electric power in Oakland, Berkeley, and Piedmont: Jour. Electricity, vol. 18, p. 195, Mar. 16, 1907. A description of Pacific gas and electric distribution system in these cities. 3,300 words; 5 photographs; 2 wiring diagrams; 3 detail drawings.

The economy of electric power in quartz mining, by C. O. Poole: Jour. Electricity, vol. 18, p. 273, Apr. 13, 1907 (reprinted from the Jour. of July, 1902). A discussion of the various uses of electric power in quartz mining, and its efficiency as compared with other forms of power. 5,300 words; 5 photographs.

The recent fire in station A of San Francisco Gas & Electric Co.: Jour. Electricity, vol. 18, p. 293, Apr. 20, 1907. A description of the equipment of this station and the effects of the fire of Apr. 2, 1907. 2,100 words; 7 photographs; transverse section of the plant.

Some power-transmission economics, by Frank G. Baum: Proc. Am. Inst. Electrical Eng., vol. 26, pt. 2, May, 1907. A discussion of the economics of certain types of construction, illustrated by examples from practice of California Gas & Electric Corporation. 2,500 words; 4 photographs; 1 map; 12 details.

Recent practice in hydraulic-fill dam construction, by James D. Schuyler: Trans. Am. Soc. Civil Eng., vol. 58, p. 196, June, 1907. General paper on hydraulic-fill construction, containing full description of Lake Francis dam on Colgate system. 7,000 words on this dam; 26 photographs; plan and sections.

History of hydroelectric and gas development in central California, by John A. Britton: Jour. Electricity, vol. 19, p. 231, Sept. 21, 1907. An article covering the history and development of Pacific Gas & Electric system. A revision of this article is printed in the book published by the company in 1911. 1,100 words; 9 photographs; 3 transmission maps; 1 detail of Carquinez span.

Some California power stations: Jour. Electricity, vol. 19, p. 354, Oct. 26, 1907. A list of 106 hydroelectric plants operating in California. Great care should be taken in using this table, since a number of the plants are listed twice.

High-head Francis turbine at Centerville, by J. H. Wise: Jour. Electricity, vol. 20, p. 125, Feb. 29, 1908. (Reprint of summary of article before Am. Soc. of Civil Eng.) Short description of the installation. 2,500 words; 4 photographs; 1 transmission map; 1 plant elevation.

The Centerville canal: Jour. Electricity, vol. 20, p. 141, Mar. 7, 1908. An article describing details of canal and pipe line. 1,400 words; 8 photographs.

The Centerville installation: Jour. Electricity, vol. 20, p. 143, Mar. 7, 1908. Discussion of Mr. Wise's paper in Jour. Electricity, vol. 20, p. 125, by H. Homberger, in which the author advocates impulse wheels. 1,400 words.

The Centerville installation, by J. W. Wise: Jour. Electricity, vol. 20, p. 160, Mar. 14, 1908. Reply to H. Homberger's discussion. 700 words.

The highest-head Francis turbine, Centerville hydroelectric power installation of California Gas & Electric Corporation: Eng. News, vol. 59, p. 320, Mar. 19, 1908. Reprint of paper read before Am. Soc. Civil Eng. 4,400 words; 7 photographs; plan; elevation; 3 canal and flume sections; detail of settling basin.

A high-head reaction turbine installation, Centerville plant of California Gas & Electric Corporation: Eng. Rec., vol. 57, p. 334, Mar. 21, 1908. Short detailed description. 2,650 words; 3 photographs; plan; elevation detail.

An unusual turbine plant: Eng. Rec., vol. 57, p. 480, Apr. 11, 1908. A short comment on the economy of the Centerville plant. 1,000 words.

The San Anselmo substation, by R. B. Elder: Jour. Electricity, vol. 21, p. 96, Aug. 15, 1908. Description of Northwestern Pacific substation which receives power either from the railroad plant or from Pacific Gas & Electric Co. 1,200 words; 3 photographs.

Notes on high-tension transmission lines in California, by S. L. Foster: Eng. News, vol. 62, p. 540, Nov. 18, 1909. Sets forth conditions, phenomena, and construction used.

The application of the Pitot tube to the testing of impulse water wheels, by Wm. Rankin Eckart: Proc. Inst. Mechanical Eng., London. Jan. 7, 1910. Detailed description of methods used in testing the water wheel at Deer Creek power house and of the results obtained. 8,500 words; 38 photographs; 9 diagrams.

The Carquinez span: Jour. Electricity, Power and Gas, vol. 24, p. 74, Jan. 22, 1910. Reprint of data in issues of May and October, 1901. 3,000 words; 1 photograph; 3 views of towers; 1 profile of span; 1 diagram; 4 detail drawings.

The story of the Folsom power plant, by Archie Rice: Jour. Electricity, Power and Gas, vol. 24, p. 179, Feb. 26, 1910. Short description and full history of development. 4,300 words; 18 photographs; 1 detail plan of dam.

Rapid installation of a steam turbine at Oakland, by F. H. Varney: Jour. Electricity, Power and Gas, vol. 24, p. 208, Mar. 5, 1910. General description of the installation of the 9,000-kilowatt turbine at station C, Oakland. 1,550 words; 4 photographs.

Storage system of South Yuba Water Co., by H. M. Cooper: Jour. Electricity, Power and Gas, vol. 24, p. 223, Mar. 12, 1910. Detailed description of reservoirs. 1,800 words; 8 photographs.

Station A, San Francisco, by Edward Stepenson: Jour. Electricity, Power and Gas, vol. 24, p. 245, Mar. 19, 1910. General description of the original installation. 2,200 words; 4 photographs.

The story of the Nevada power plant, by Archie Rice: Jour. Electricity, Power and Gas, vol. 24, p. 267, Mar. 26, 1910. Detailed history and general description of development. 3,800 words; 18 photographs; 1 map.

The story of Colgate and Yuba power plants, by Archie Rice: Jour. Electricity, Power and Gas, vol. 24, p. 405, Apr. 30, 1910. Popular history. 2,300 words; 17 photographs; 1 map.

The developed high-tension network of a general power system, by Paul M. Downing: Jour. Electricity, Power and Gas, vol. 24, p. 427, May 7, 1910. General outline of Pacific Gas & Electric and connected systems, and detailed account of methods of operation. 3,600 words; 1 photograph; 1 map; plan and elevation of high-tension switch.

Ridge substation at Berkeley, by C. F. Adams: Jour. Electricity, vol. 25, p. 8, July 2, 1910. Note on the installation. 740 words; 1 photograph; 1 switching diagram; 1 plan; 2 sections.

De Sabla and Centerville power plants: Jour. Electricity, Power and Gas, vol. 25, p. 43, July 16, 1910. Popular description, valuable for its illustrations and for tabulation of data. 3,500 words; 15 photographs; 1 map; 1 table.

History of gas lighting in Marysville. Jour. Electricity, Power and Gas, vol. 25, p. 70, July 23, 1910. History of gas business from its inception in 1858. 2,000 words; 1 photograph.

Electric service of the peninsular towns: Jour. Electricity, vol. 25, p. 195, Aug. 27, 1910. An article on the substations and distributing mains in the country from Burlingame south to Sunnyvale. 2,700 words; 4 photographs.

The story of the Deer Creek power house, by Archie Rice: Jour. Electricity, vol. 25, p. 247, Sept. 17, 1910. A popular article, valuable only for short tabulated data at the end. 3,100 words; 13 photographs; 1 diagrammatic map.

Electric transmission troubles, by C. F. Adams: Jour. Electricity, vol. 25, p. 251, Sept. 17, 1910. Discussion of accidents to various types of apparatus. 4,100 words; 4 photographs.

The great power plant at Electra, by Archie Rice: Jour. Electricity, vol. 25, p. 417, Nov. 12, 1910. A popular discussion. Article valuable for its illustrations and tabulated data. 400 words; 12 excellent photographs; 2 maps.

Reconstruction of Oakland station, by C. F. Adams: Jour. Electricity, vol. 26, p. 41, Jan. 14, 1911. General note of the changes in stations A and B, Oakland. 1,250 words; 4 photographs.

The history of gas lighting in Vallejo, by E. C. Jones (chief engineer Pacific Gas & Electric Co., gas dept.): Jour. Electricity, vol. 26, p. 51, Jan. 14, 1911. History of town's gas supply from 1866 to 1911. 2,800 words; 4 photographs.

History of San Jose and its gas business, by E. C. Jones: Jour. Electricity, vol. 26, p. 68, Jan. 21, 1911. General history of the city's gas business from 1877 to 1911. 4,200 words; 6 photographs.

History of Napa and its gas business, by E. C. Jones: Jour. Electricity, vol. 26, p. 87, Jan. 28, 1911. History of town's gas business from 1867 to 1911. 3,600 words; 8 general photographs.

Transmission map of California, by Messrs. Baum and Wise: Jour. Electricity, vol. 26, p. 99, Jan. 28, 1911.

Fire-proof substations, by C. F. Adams, engineer of electrical construction, Pacific Gas & Electric Co. Jour. Electricity, vol. 26, p. 129, Feb. 11, 1911. Note on the two types—steel and concrete—of substations used on Pacific Gas & Electric system. 800 words; 7 photographs.

Depth of snow in the Sierra, by Prof. A. G. McAdie: Jour. Electricity, vol. 26, p. 270, Mar. 25, 1911. Note on snowfall conditions, which contains tabulations of snowfall at Summit (South Yuba drainage) from 1870 to 1911.

Electric equipment of Columbia Steel Co., by N. W. Hanscom: Jour. Electricity, vol. 26, p. 301, Apr. 8, 1911. Complete description of the plant of one of Pacific Gas & Electric Co.'s large consumers. 3,300 words; 6 photographs; 1 layout.

The Bear River reservoir, by Will T. Jones: Jour. Electricity, vol. 26, p. 367, Apr. 29, 1911. A general account of the construction work and engineering features of Bear River dam on the Electra system. 1,250 words; 4 photographs.

Station G, San Francisco, by C. F. Adams: Jour Electricity, vol. 26, p. 497, June 10, 1911. Note on the new substation. 400 words; 5 photographs.

The voltage regulator at North tower, by Geo. H. Bragg: Jour. Electricity, vol. 26, p. 503, June 10, 1911. A note on the use of an inductor alternator as a synchronous regulator at North tower. 780 words; 4 photographs; 2 diagrams.

Reconstruction of Fordyce dam, by E. L. Dodge: Jour. Electricity, vol. 28, p. 47, Jan. 20, 1912. A brief note in popular style. 850 words; 4 photographs.

Turbine and boiler efficiency tests in Oakland, by Robert Sibley and R. F. Chevalier: Jour. Electricity, vol. 28, p. 305, Apr. 6, 1912. An article on the results of tests of units in station C. Copy of a paper read before San Francisco Sec. Am. Inst. of Electrical Eng. 1,400 words; 5 photographs; 2 tables.

Hydroelectric power plants in California, by J. D. Galloway: Jour. Electricity, vol. 29, p. 313, October, 1912. A brief résumé of present developments. 5,300 words; 8 photographs.

Pacific Gas & Electric Co., by A. R. Maujer: Power, May 21, 1912. A general description of the system. 2,500 words; 8 photographs; 1 map; 1 diagram of Electra power house; 1 cross section of station A.

World's largest transmission system: Electrical World, June 1, 1912. An outline of the operating system and service conditions of Pacific Gas & Electric Co. 3,500 words; 11 photographs; 2 maps; and plans.

Argument for fair rate making, by A. F. Hockenbeamer: Jour. Electricity, vol. 28, Mar. 30, 1912, p. 295. Illustrates the income that will have to be allowed in order to yield a fair return on capital, based on conditions encountered by Pacific Gas & Electric Co. 1,260 words.

San Francisco substations of Pacific Gas & Electric Co., by J. P. Baloun: Western Eng., vol. 1, No. 1, p. 18, April, 1912. A complete description of the company's substations serving San Francisco, with wiring diagrams. 2,024 words; diagrams.

Enlarging the Bear River ditch, by Rudolph W. Van Norden: Jour. Electricity, vol. 30, pp. 241, Mar. 15, 270 (Mar. 22), 1913. Outline of history and description of methods used in enlarging the lower end of the South Yuba ditch system. 3,240 words, 4 photographs, 4 sections, 1 map, in first article; and 1,800 words, 2 photographs in second.

Accounting under utility regulation, by John A. Britton, general manager of Pacific Gas & Electric Co.: Jour. Electricity, vol. 30, p. 329 (Apr. 12); p. 357 (Apr. 19); p. 382 (Apr. 26), 1913. A lecture given at the University of California; 10,220 words (total).

Construction of the Spaulding dam: Eng. Rec., vol. 68, p. 150, Aug. 9, 1913. A detailed description of the dam and construction plant. 1,500 words; 4 photographs; profile and section of dam; map of reservoir.

Electric hoisting on the Mother Lode, by M. M. Boggess: Jour. Electricity, vol. 31, p. 211, Sept. 6, 1913. Descriptions of several notable installations, some of which are served by Pacific Gas & Electric Co. 1,560 words; 8 photographs.

South Yuba-Bear River power developments, by J. P. Jollyman: Eng. Rec., vol. 68, p. 573, Nov. 22, 1913. General description of the Drum project, with a detailed description of power house and electrical features. 1,334 words; 3 photographs; map of transmission system; profile of Bear River developments.

The Spaulding dam and South Yuba power developments of Pacific Gas & Electric Co., by H. C. Vensano: Eng. News, vol. 70, p. 1163, Dec. 11, 1913. A general description of the project, and a detailed description of dam and construction equipment. 2,100 words; 4 photographs; plan and section of dam; map of entire development.

Lake Spaulding-Drum power development, by R. W. Van Norden: Jour. Electricity, vol. 31, p. 525, Dec. 13, 1913. A general description of the entire Bear River development with a detailed description of the Drum system. 11,500 words; 18 photographs; map and profile of Bear River system; plan and section of Drum plant and Cordelia substation.

Station A, San Francisco district, by Frank H. Varney: Jour. Electricity, vol. 31, p. 553, Dec. 20, 1913. A description of the equipment of the largest steam-electric generating station of Pacific Gas & Electric Co. 1,100 words; 4 photographs.

World's concrete placing record: Eng. Rec., vol. 69, No. 8, p. 217, Feb. 21, 1914. Comparative records at Lake Spaulding and Kensico dams. 100 words; 1 table.

Hydroelectric developments on Bear River, by A. E. Chodzke: Western Eng., vol. 4, No. 3, p. 173, March, 1914. An outline of the Bear River developments and a detailed description of the portion of it covered by the Drum system. 5,500 words; 19 photographs; 2 ditch sections.

System of heating and lighting from gas, Panama-Pacific International Exposition, by Guy R. Kinsley: Jour. Electricity, vol. 32, No. 12, p. 241, Mar. 21, 1914. A description of the methods and layout of the gas system of the exposition. 1,900 words; 3 half-tones of architect's drawing.

Flat rates for light and power systems and territories, by Frank G. Baum, consulting engineer of Pacific Gas & Electric Co.: Proc. Am. Inst. Electrical Eng., vol. 34, No. 4, p. 485, April, 1915. An argument in favor of establishing uniform rates throughout a system of territory for different classes of electric service. 8,000 words; 4 diagrams.

Experience of Pacific Gas & Electric Co. with the grounded neutral, by J. P. Jollyman, P. M. Downing, and F. G. Baum: Trans. Am. Inst. Electrical Eng., vol. 33, p. 767, 1914. An outline of the operating experience of Pacific Gas & Electric system which has resulted favorably to the grounded neutral. 2,000 words.

The great luminous dome of the Palace of Horticulture: Electrical World, vol. 63, No. 15, p. 829, Apr. 11, 1914. Short description of opalescent lighting effect of the dome of Palace of Horticulture, Panama-Pacific Exposition, served by Pacific Gas & Electric system. 200 words; 1 diagram.

Public policy of public-utility corporations, by John A. Britton, general manager of Pacific Gas & Electric Co.: Jour. Electricity, vol. 32, No. 17, p. 356, Apr. 25, 1914. A discussion of the policy of public utility corporations. 4,000 words.

Progress in transmission line construction, by A. S. Kalenborn: Jour. Electricity, vol. 32, No. 19, p. 403, May 9, 1914. A short comparative description of three main transmission lines around the lower end of San Francisco Bay which typify the progress in electric transmission construction. 900 words; 1 half-tone.

Cost of financing utilities, by A. F. Hockenbeamer: Jour. Electricity, vol. 32, No. 20, p. 425, May 16, 1914. A discussion of the cost to public utilities of the capital necessary for their development, by the comptroller, vice president, and treasurer of Pacific Gas & Electric Co. An abstract of an affidavit filed in the U. S. District Court. 4,000 words; table of California utility bonds, showing approximate annual yield if held to maturity.

Cost of money for California utilities, by A. F. Hockenbeamer, vice president and comptroller of Pacific Gas & Electric Co.: Electrical World, vol. 63, No. 20, p. 1087, May 16, 1914. Abstracts of affidavits filed in the U. S. District Court, the northern district of California, 2d division, analyzing cost of capital to California utilities. 1,100 words.

Public policy of public-utility corporations. Advantages of commission control, by John A. Britton: Jour. Electricity, vol. 32, No. 26, p. 556, June 27, 1914. An article presented before the Civic Club of San Francisco on June 4, 1914. Reviews the history of the public-utilities development, and discusses some of the advantages of public control. 2,200 words.

Annual report of Pacific Gas & Electric Co.: Electrical World, vol. 63, No. 25, p. 1433. June 20, 1914. Short abstract of interesting information from annual report for 1913. 500 words.

Lake Spaulding development, power house No. 5, Pacific Gas & Electric Co., by J. W. Swaren: Western Eng., vol. 5, No. 6, p. 235, December, 1914. A brief description of the Bear River system of plants, and detailed description of plant 5, still under construction at the end of 1915. 3,500 words; 4 diagrams; 5 photographs; 1 map.

Mr. Britton on water-power bill: Electrical World, vol. 64, No. 26, p. 1236, Dec. 26, 1914. An outline of Mr. Britton's testimony before the U. S. Senate Committee on Public Lands, Dec. 11, 1914. 3,000 words.

Electrical equipment of Panama-Pacific Exposition: Electrical World, vol. 64, No 26, p. 1241, Dec. 26, 1914. A complete description of the electric system serving the exposition. 2,000 words; 10 diagrams; 10 photographs.

The electrochemical possibilities of the Pacific coast, by J. W. Beckman: Trans. Am. Electrochem. Soc., vol. 28, p. 169, 1915. 8,700 words with discussion; 7 photographs.

Illumination of Panama-Pacific Exposition, by G. L. Bayley: Electrical World, vol. 65, No. 7, p. 391, Feb. 13, 1915. A description of the flood-lighting and general lighting of the exposition. 1,500 words; 11 photographs.

Spaulding-Drum power development, by John A. Britton, general manager of Pacific Gas & Electric Co. Abstract of a description of the developments, presented before the society Sept. 10, 1914. 5,500 words; 2 diagrams; 4 photographs; plan and elevation of the power house.

Interconnected systems serving San Francisco: Electrical World, vol. 65, No. 22, p. 1357, May 29, 1915. Details of generating equipments and transmitting circuits tied in with system of Pacific Gas & Electric Co. 7,000 words; 9 diagrams; 32 photographs; 1 map; extensive tabulations of physical data for Pacific Gas & Electric, Great Western Power, Sierra & San Francisco Power, Northern California Power Co. Consolidated systems.

Irrigation pumping in the Coast States: Electrical World, vol. 65, No. 22, p. 1399, May 29, 1915. A résumé of irrigation pumping on the systems of several important hydroelectric companies. 4,800 words; 12 diagrams.

Illumination at the Panama-Pacific Exposition: Electrical World, vol. 65, No. 22, p. 1383, May 29, 1915. Description of the elaborate lighting, and use of concealed arc and incandescent units. 800 words; 6 photographs.

Electric developments on the Pacific coast: Electrical World, vol. 65, No. 22, p. 1387, May 29, 1915. General description of principal generating systems on the Pacific coast. 6,500 words; 1 diagram; 30 photographs.

Concreting the Spaulding dam: Engineering News, vol. 73, No. 22, p. 1057, June 3, 1915. Short description of concreting plant and conveyors. 900 words; 1 photograph.

Illumination of the Panama-Pacific Inter. Exposition, by W. D'A. Ryan, chief of illumination: General Electric Rev., vol. 18, No. 6, p. 579, June, 1915. Brief general description of the lighting methods employed. 3,000 words; 12 excellent photographs.

The Lake Spaulding-Drum power development of Pacific Gas & Electric Co.: Electrical Jour., vol. 12, p. 265, June, 1915. A brief description of Lake Spaulding dam and Drum power house. 2,500 words; 8 photographs; 2 maps; 2 diagrams.

Foundation for transmission line towers and tower erection, by P. M. Downing, chief engineer of hydroelectric section of Pacific Gas & Electric Co.: Proc. Am. Inst. of Electrical Eng., vol. 34, No. 6, p. 1193, June, 1915. Outline of the essentials of tower line design and construction. 1,600 words; 1 diagram; 4 photographs.

Features of the lighting of the Panama-Pacific Exposition, by W. D'A. Ryan, chief of illumination: Proc. of 38th Convention, Nat. Electric Light Assoc., San Francisco, June, 1915, Hydroelectrical vol., p. 257. An address delivered before the convention, in which the principal features of the lighting system are outlined. 3,000 words.

Report of subcommittee on water-power development on the Pacific coast: Proc. of 38th Convention, Nat. Electric Light Assoc., San Francisco, June, 1915, Hydroelectrical vol., p. 510. Complete description of the principal hydroelectric systems serving the Pacific States. 9,500 words; 40 photographs; extensive tabulations of physical, operating, and financial data.

Oil-burning stand-by plants, by C. H. Delaney, steam supt. of Pacific Gas & Electric Co.: Proc. of 38th Convention, Nat. Electric Light Assoc., San Francisco, June, 1915, Hydroelectrical vol., p. 494. Detailed description of methods of operation of steam stand-by plants on Pacific Gas & Electric Co.'s system. 4,000 words; 7 district load curves.

Idem, Jour. Electricity, vol. 34, No. 25, p. 529, June 19, 1915, No. 26, p. 543, June 26. Abstract of a paper, partially illustrated by conditions on Pacific Gas & Electric Co.'s system, describing methods and advantages of operating oil-burning stand-bys on hydroelectric systems. 2,900 words, 7 load curves.

Idem, Western Eng., vol. 6, No. 1, p. 24, July, 1915. Detailed description of methods of operation of steam stand-by plants on Pacific Gas & Electric Co.'s system. Paper read before 38th Convention, Nat. Electric Light Assoc. 4,000 words; 5 district load curves.

Idem, Jour. Electricity, vol. 34, No. 26, p. 543, June 26, 1915.

Practice in high-head hydraulic plants, by J. P. Jollyman, engineer of electrical construction, Pacific Gas & Electric Co.; Proc. 38th Convention, Nat. Electric Light Assoc., Hydroelectrical vol., p. 460. Outline of Pacific coast practice in design of pipe lines, gate valves, and water wheels for high-head plants. 3,000 words; 1 diagram.

Illumination of the Panama-Pacific Exposition, by W. D'A. Ryan, chief of illumination: Sci. Am. Suppl., vol. 79, No. 2058, p. 376, June 12, 1915. Reprint of article from General Electric Rev. 3,000 words; 5 photographs.

New Carquinez Straits high-tension crossing: Eng. News, vol. 74, No. 6, p. 248, Aug. 5, 1915. Brief notes on changes made in cable crossing. 600 words; 1 diagram; 6 photographs.

The Lake Spaulding hydroelectric development of Pacific Gas & Electric Co.: Sibley Jour. Eng., November, 1915. Outline of system and more detailed description of hydraulic features of Drum plant. 1,500 words; 18 photographs; 1 map.

The constant-angle arch dam: Canadian Engineer, Mar. 9, 1916. An article setting forth the principles of design. 4,500 words.

Examples of constant-angle arch dams—two important installations, by L. R. Jorgensen; Canadian Engineer, Mar. 23, 1916. Descriptions of Lake Spaulding and Salmon Creek dams. 2,500 words.

The constant-angle arch dam, by Lars R. Jorgensen: Trans. Am. Soc. Civil Eng., vol. 78, p. 685, 1915. Detailed mathematical discussion of this type of dam, with descriptions of Lake Spaulding and Salmon Creek dams, both of which were designed by the author. 14,000 words; 8 photographs; 9 diagrams; 3 plans; and elevations.

Illumination of the Panama-Pacific International Exposition, by W. D'A. Ryan, chief of illumination: Trans. Am. Inst. Elec. Eng., vol. 35, p. 757, 1916. Complete description of the lighting, with particular attention to the methods adopted and the results attained. 4,800 words; 2 tables; 21 diagrams; 12 photographs; 27 colored photographs.

Pacific coast hydroelectric development, by John Harrisberger: Jour. Electricity, vol. 36, p. 403, May 27, 1916. Summary—largely tabular—of operating conditions on various Pacific coast systems. 5,000 words; 3 photographs.

Spaulding dam to be raised from 225 to 260 feet, by F. G. Mudgett: Eng. News, vol. 76, p. 328, Aug. 17, 1916. General description of the power system, with notes on construction plant for new work. 900 words; 1 photograph.

The constant angle arch dam: The Eng., vol. 122, Sept. 22, 1916. Descriptions of Lake Spaulding and Salmon Creek dams. 2,500 words; 7 photographs; 2 diagrams; 2 plans.

Electric power for irrigation pumping, by S. B. Shaw: Jour. Electricity, vol. 37, p. 242, Sept. 23, 1916. Detailed study of the effect of rainfall on Pacific Gas & Electric Co.'s agricultural load in the San Jose district. 1,200 words; 4 diagrams; 2 tables.

The Halsey and Wise power plants, by Robert Sibley: Jour. Electricity, vol. 37, Sept. 30, 1916. General description of the two plants, with considerable detail regarding power houses. 1,850 words; 4 photographs; 1 map.

Characteristics of irrigation load on Pacific Gas & Elec. Co.'s system, by F. C. Piatt: Jour. Electricity, vol. 37, p. 302, Oct. 14, 1916. Detailed study of this type of load in the company's San Jose and Solano districts. 1,500 words; 3 diagrams; 5 tables.

The Bear River canal, by Robert Sibley: Jour. Electricity, vol. 37, Oct. 21, 1916. General description of the South Yuba-Bear River power system, and detailed notes on Halsey and Wise plants. 2,200 words; 6 photographs.

The constant angle arch dam, by L. R. Jorgenson: Jour. Electricity, vol. 38, No. 2, p. 33, Jan. 15, 1917. A development of the theory of the constant-angle arch dam, illustrated by two examples, one of which is the Spaulding dam of Pacific Gas & Electric Co. 2,500 words; 1 photograph; 5 diagrams and plans.

A new record for low-head development, by Rudolph W. Van Norden: Jour. Electricity, vol. 38, p. 65, No. 3, Feb. 1, 1917. Description of the plant installed on the Folsom canal, at Folsom prison. This plant, while not a part of the Pacific gas and electric system, is located on one of that company's conduits. 3,000 words; 5 photographs; cross section of power house.

How temperature varied in two dams while the cement was setting, by R. A. Monroe: Eng. News Rec., vol. 79, No. 6, p. 253, Aug. 9, 1917. Tabular data on the temperatures developed in the setting concrete of the Spaulding and Rock Creek dams of the South Yuba-Bear River system. 1,500 words; 1 photograph; 2 diagrams; 2 tables.

The putting in of the Wise power plant: Jour. Electricity, vol. 38, No. 6, p. 196; Mar. 15, 1917. Short description of the South Yuba-Bear River system, and the ceremony of putting the Wise plant into operation. 1,000 words; 4 photographs.

Experience with high-head Francis turbines, by J. P. Jollyman: Jour. Electricity, vol. 38, No. 8, p. 275, Apr. 15, 1917. General statement of the results obtained by Pacific Gas & Electric Co. in the operation of high head Francis turbines. 1,000 words; 2 photographs; 1 map.

Unusual details in power-house installation, by J. P. Jollyman: Jour. Electricity, vol. 38, No. 9, p. 321, May 1, 1917. An account of some of the economies effected in the design of the Wise and Halsey power houses, and an outline of certain construction methods. 2,500 words; 4 photographs.

Rock Creek multiple arch dam, by R. A. Monroe: Jour. Electricity, vol. 38, No. 11, p. 421, June 1, 1917. A general outline of the South Yuba-Bear River system, with a detailed description of Rock Creek dam. 1,500 words; 3 photographs; 1 map; 2 structural details.

Three major power possibilities in California, by F. H. Fowler: Jour. Electricity, vol. 41, No. 1, p. 12, July 1, 1918. A comprehensive statement of the growth in demand for power in California and a description of the proposed developments at Big Bend of the Pit, Feather River site No. 5, and on Big Creek of the San Joaquin. 3,000 words; 7 photographs; 7 diagrams.

Construction of a unique power plant: Jour. Electricity, vol. 39, No. 9, p. 392, Nov. 1, 1917. A description of the Spaulding power house of the South Yuba power system. 100 words; 4 photographs; plan and elevation; map of system.

Spaulding power plant completed, by J. P. Jollyman: Pacific Service Mag., vol. 9, No. 8, January, 1918. A concise description of this installation by its designer. 1,500 words; 7 photographs.

Double overhung Francis turbines, by Arnold Pfau: Jour. Electricity, vol. 40, No. 6, p. 279, Mar. 15, 1918. A discussion of this type of prime mover, illustrated by notes on White Salmon River and Halsey plants. 750 words; 4 photographs; plan; elevation and diagram map.

Interconnection and new power development, by P. M. Downing: Jour. Electricity, vol. 40, No. 6, p. 282, Mar. 15, 1918. A discussion of the effect of State and Federal regulation on power development; the relation of such regulation to the threatened fuel shortage; and the estimated power demands on the systems serving central California up to 1921. 2,000 words; 1 diagram.

Hydroelectric economies, by J. P. Jollyman: Jour. Electricity, vol. 40, No. 8, p. 384, Apr. 15, 1918. Details of efficiency tests of the pipe lines, water wheels, generа[illegible]nsformers, and entire installations at Drum, Wise, and Halsey plants. 1,800 [illegible] 4 photographs; 1 elevation; 1 tabulation.

[illegible]lowatt-hours per barrel of oil. What does it mean? by S. J. Lisberger: Jour. Electrici[illegible], vol. 42, p. 363, Apr. 15, 1919. Discussion of varying operating conditions, to show that "kilowatt-hours per barrel of oil" means nothing unless properly qualified. 2,500 words..

Note.—Pacific Service Mag.: In June, 1909, Pacific Gas & Electric Co. began the publication of a monthly magazine. The volumes which have appeared have contained many valuable illustrated descriptions of the company's system.

NORTHERN CALIFORNIA POWER CO. CONSOLIDATED.

[Absorbed by Pacific Gas & Electric Co. Oct. 3, 1919.]

Northern California Power Co.'s transmission: Jour. Electricity, vol. 12, p. 231, 1902. Description of first station at Volta, Kilarc plans, and transmission system. 4,000 words; 15 photographs.

Northern California Power Co.'s systems, Part 1. Electrical World, vol. 44, 1904; p. 407, Sept. 10. A detailed description of the first development at Volta. 3,500 words; 7 photographs, and 1 diagrammatic map.

Idem, Part 2. Electrical World, p. 455, Sept. 17. Detailed description of the Kilarc system. 6,000 words; 7 photographs; 1 diagrammatic map, 4 details and wiring diagrams.

Idem, Part 3. Electrical World, p. 503, Sept. 24. Detailed description of transmission system. 3,600 words; 5 photographs; 1 diagrammatic map.

Idem, Part 4. Electrical World, p. 559, Oct. 1. Detailed description of the dredges operated at Horsetown. 3,800 words; 2 photographs.

The water power plants of Northern California Power Co. Eng. Rec., p. 506, Oct. 29, 1904. An abridgment of the continued article beginning in the Electrical World of Sept. 10. This article covers the Volta and Kilarc stations, but does not give full data on transmission lines. 2,700 words; 5 photographs.

Northern California Power Co. Consolidated, by Rudolph W. Van Norden: Jour. Electricity, vol. 25, p. 5, Aug. 6, 1910. A minute description of the system. 11,150 words; 57 photographs; 1 general map; ground plans of Volta and Inskip; 5 details; and a tabulation of engineering and transmission data.

The Coleman plant, by R. W. Van Norden: Jour. Electricity, vol. 27, p. 411, Nov. 4, 1911. A detailed description of the plant and features of its construction, by its designer. 6,500 words; 24 photographs; and a map of the conduit line.

The Coleman hydroelectric development on Battle Creek, Calif.: Eng. Rec., vol. 64, p. 700, Dec. 16, 1911. Complete description of the Coleman hydraulic system, with short outline of the power house and its equipment. 3,000 words; 8 photographs; 1 map.

New hydroelectric plant of Northern California Power Co., by Rudolph W. Van Norden: Electrical World, vol. 59, p. 237, Feb. 3, 1912. General description of the four other Battle Creek plants of the system, and a detailed description of the Coleman plant. 2,500 words; 8 photographs; 1 map.

Pumping plants for rice irrigation, by C. F. Adams: Jour. Electricity, vol. 37, p. 117, Aug. 12, 1916. Description of an installation with a motor capacity of 950 horsepower. 1,000 words; 4 photographs; 1 map.

SIERRA & SAN FRANCISCO POWER CO., COAST VALLEYS GAS & ELECTRIC CO., AND SUBSIDIARIES.

The Bryant street steam plant: Jour. Electricity, vol. 4, p. 61, July, 1897. A history and general description of this plant. 2,000 words; 6 photographs; 3 plans and elevations.

The Monterey and Pacific Grove lighting plants, by Harry J. Bean: Jour. Electricity, vol. 7, p. 37, 1899. Description of equipment in first lighting plant in Monterey. 1,800 words; 6 diagrams.

The United Railroads of San Francisco: Jour. Electricity, vol. 14, p. 33, 1904. Description of system in general, and of original North Beach steam plant in detail. 6,500 words; 16 photographs; 10 plans; elevations; 1 map.

Electric-power development on Stanislaus River: Jour. Tech., p. 26, August, 1908. A general description of the Stanislaus plant. 1,200 words; photographs of diverting dam and power house.

High timber dams in California, by E. M. Chandler: Jour. Tech., p. 32, November, 1908. A brief description of Strawberry and Lyon's dams on South Fork of Stanislaus River. 800 words; 2 photographs; 1 section.

Monterey's new steam plant: Jour. Electricity, vol. 20, p. 217, 1908. Short detailed description of turbo-generator put in about 1906. 1,750 words; 4 photographs.

Stanislaus River electric-power development, by O. M. Boyle, jr.: California Jour. Tech., p. 12, April, 1909. A description of the work at Relief, on the conduit line, and at the power house, together with methods of tower-line calculations. It also describes mining line continuation of the pressure pipe. 3,500 words; 1 photograph of Relief; 1 of plant.

High timber dams in California: Jour. Electricity, vol. 22, p. 62, 1909. A reprint of article listed above which appeared in California Jour. Tech.

New steam plant of the United Railroads of San Francisco: Jour. Electricity, vol. 22, p. 55, 1909. Short note on installation of 5,000-kilowatt turbo-generator at North Beach steam plant. 500 words; 1 photograph.

The Stanislaus power development: Jour. Electricity, vol. 23, p. 147, Aug. 21, 1909. A detailed description of the Stanislaus plant, flume, and storage. 3,000 words; 18 photographs; transmission map; plan and three sections of Relief dam; plan of power house.

The Stanislaus transmission line: Jour. Electricity, vol. 23, p. 191, Sept. 4, 1909. A general description of the line and detailed description of insulators. 2,800 words; 7 photographs; 1 map; 3 diagrams.

The Bay Shore substation: Jour. Electricity, vol. 25, p. 207, 1910. Complete and detailed description of electrical features and general plan of receiving station at end of the Stanislaus tower line. 3,500 words; 5 photographs; 7 wiring diagrams; elevations; etc.

The construction of the Stanislaus line, by H. W. Crozier: Jour. Electricity, vol. 28, p. 87, Feb. 3, 1912. Excellent, detailed data on the construction of the transmission tower line. 4,100 words; 6 photographs.

Design of high-tension transmission line, by Otto E. Falch, jr.: Jour. Electricity, vol. 28, p. 107, Feb. 10, 1912. Outline of the methods used in designing the Stanislaus tower line. 2,950 words; 4 photographs; 2 graphic charts.

Suspension insulator failures on the lines of the Sierra and San Francisco, by J. E. Woodbridge: Jour. Electricity, vol. 34, No. 10, p. 185, Mar. 6, 1915. Reprint of paper read before the San Francisco November meeting of Am. Inst. of Electrical Eng., giving history of insular trouble on Sierra and San Francisco tower lines. 2,300 words; 1 photograph.

The Strawberry drop-filled dam: Jour. Electricity, vol. 37, p. 173, Sept. 2, 1916. General description of Lower Strawberry dam, on South Fork of Stanislaus River, and methods used in its construction. 1,500 words; 3 photographs; 1 diagram.

GREAT WESTERN POWER CO. OF CALIFORNIA.

The failure of a portion of a steel tower electric transmission line in California, by Edwin Duryea, jr.: Eng. News, vol. 61, p. 515, May 13, 1909. A description of the failure of 12 miles of Great Western Power Co.'s tower transmission line during a severe storm. 2,000 words; 3 photographs; 1 detailed drawing of standard tower; table of characteristics of 5 representative tower lines.

Hydroelectric generating station of Great Western Power Co. on Feather River: Electrical World, vol. 54, p. 471, Aug. 26, 1909. Detailed description of the development at Big Bend. 2,000 words; 9 photographs; 5 details, plans and sections; transmission map.

Electrical equipment of Great Western Power Co.: Electrical World, vol. 54, p. 657, Sept. 16, 1909. Detailed description of the electrical installations at Big Bend. 1,800 words; 6 photographs; 1 switch detail.

Steam auxiliary station for Great Western Power Co., Oakland, Calif.: Electrical World, vol. 54, p. 712, Sept. 23, 1909. Detailed description of the Oakland steam plant. 1,500 words; plan and transverse section.

Great Western Power Co.'s system, by Rudolph W. Van Norden: Jour. Electricity, vol. 24, p. 315, Apr. 9, 1910. Detailed description of entire system, including transmission lines and principal substations. 10,200 words; 25 photographs; 12 details; 1 transmission map; tabulation of engineering data.

Hydroelectric development of Great Western Power Co.: Eng. Rec., vol. 61, p. 746, June 11, 1910 (first part of serial). Detailed description of the entire system of the company. 3,000 words; 2 photographs; 2 tunnel and tower details; 1 map.

The construction of Great Western power plant: Eng. Rec., vol. 62, p. 74, July 16, 1910. Detailed description of the construction, methods, and features of the temporary intake dam, intake tower, and the tunnel at Big Bend. 2,500 words; 2 photographs; small map; and details of concrete forms.

The power system of City Electric Co., by J. G. DeRemer and Chas. W. Baker: Jour. Electricity, vol. 25, p. 163, Aug. 20, 1910. Detailed description of the North Beach plant of City Electric Co. 3,100 words; 9 photographs; 1 mechanical detail; 3 charts.

Motor drive in Cowell cement plant, by R. W. Van Norden: Jour. Electricity, vol. 26, p. 323, Apr. 15, 1911. Detailed account of the workings of the plant and of the electric installation of about 5,650 horsepower. 6,200 words; 13 photographs and 1 layout.

The Big Meadows dam: Jour. Electricity, vol. 27, p. 287, Sept. 30, 1911. General details of the proposed storage and dam at Big Meadows above the Big Bend plant. 1,000 words; 3 photographs; 1 map of reservoir.

The hydroelectric development of Great Western Power Co., by H. P. Rust: Pro Brooklyn Engineers' Club, January, 1912. An illustrated description of the Big Bend development with discussion. 12,500 words; map.

The Oakland & Antioch Railway: Jour. Electricity, vol. 28, p. 217, March, 1912. Detailed description of construction of railway system receiving power from Great Western Power Co. 2,900 words; 4 photographs; 1 map; 1 diagram.

Transbay cable of Great Western Power Co., by Samuel D. Naphtaly: Jour. Electricity, vol. 28, p. 239, March, 1912. Detailed account of cable crossing of Great Western Power Co. from Western Pacific pier to foot of Folsom Street. 2,550 words; 2 photographs; 1 map; 1 diagram; 1 cross section.

Cost of pumping water at Isleton, by A. F. Bridge and Ralph Reynolds: Jour. Electricity, vol. 30, p. 131, Feb. 8, 1913. Description of pumping conditions and costs in the lowlands of Sacramento River. 4,600 words; 8 photographs; 1 map.

Electrical hydraulic mining, by N. K. Cooper: Jour. Electricity, vol. 32, No. 5, p. 91, Jan. 31, 1914. A description of the method, equipment, and force of the motor-driven hydraulic outfit at Loomis supplied from the lines of Great Western Power Co. 750 words; 3 halftones.

Laying the largest submarine power cable, by John A. Koontz, jr.: Jour. Electricity, vol. 33, p. 1, July 4, 1914. A short description of the methods used in laying the second bay cable of Great Western Power Co. from Oakland to San Francisco. 1,300 words; 1 diagram; 1 photograph of barge; set of 8 photographs showing in order the various steps in splicing the cable.

Laying power cables across San Francisco Bay, by J. A. Koontz and L. P. Cornell: Jour. Electricity, vol. 36 p. 427, June 3, 1916. General notes on various submarine cables on Great Western system, with detailed description of second and third cables between Oakland and San Francisco. 2,250 words; 7 photographs.

Recent electrochemical development, by J. W. Beckman: Jour. Electricity, vol. 38, No. 1, p. 1. Jan. 1, 1917. Outline of progress of Great Western Electrochemical Co.

in the manufacture of caustic soda and bleaching powder. 2,000 words; 5 photographs; 2 diagrams.

A new advance in fuel-oil economy, by C. D. Stewart: Jour. Electricity, vol. 39, No. 2, p. 49, July 15, 1917. A description of automatic fuel oil and draft regulating devices at Bush Street steam electric and steam heating station of Great Western system, in San Francisco. 1,600 words; 3 photographs; 3 diagrams.

Three major power possibilities in California, by F. H. Fowler: Jour. Electricity, vol. 41, No. 1, p. 12, July 1, 1918. A comprehensive statement of the growth in demand for power in California and a description of the proposed developments at Big Bend of the Pit, Feather River site No. 5, and on Big Creek of the San Joaquin. 3,000 words; 7 photographs; 7 diagrams.

Electric manufacture of silico-manganese: Jour. Electricity, vol. 41, No. 2, p. 68, July 15, 1918. Short notes on the plant of Pacific Electro-Metals Co. served by Great Western Power Co. 500 words; 5 photographs.

District steam heating as related to fuel company conservation, by Harry S. Markey: Jour. Electricity, vol. 41, No. 6, p. 271, Sept. 15, 1918. Digest of operating figures for two central stations supplying heat to 56 city blocks in San Francisco, in connection with the development of power. 1,000 words.

WESTERN STATES GAS & ELECTRIC CO.

American Electric Co.'s plant on the South Fork of American River: Jour. Electricity, vol. 14, p. 77, February, 1904. A detailed description of the hydraulic development and general description of the transmission system. An extensive tabulation of data concerning the development is appended. 2,800 words; 11 photographs; transmission map; structural details.

American River Electric Co.'s system, by C. W. Whitney: Am. Electrician, p. 1, January, 1905. A complete description of the hydraulic developments of the transmission system and of the use of power in gold dredging. 8,900 words; 38 photographs; 6 structural details.

The Hydroelectric power plant of North Mountain Power Co., North Mountain, Calif.: Jour. Electricity, vol. 14, February, 1905. An illustrated, detailed description of the 25-cycle Junction City installation, which was being constructed to serve Humboldt Bay and Eureka in California. 3,000 words.

Trinity River plant of North Mountain Power Co., Trinity River, Calif.: Railroad Gazetteer, vol. 39, p. 618, 1905. Brief, illustrated description of an interesting power transmission system of the Pacific coast, and some of the difficulties of its construction. 1,200 words; 2 photographs.

North Mountain Power Co.'s plant near Junction City, Calif.: Eng. Rec., vol. 53, p. 26, January 6, 1906. Complete description of Junction City development. 3,000 words; 3 photographs.

Street railway systems of Stockton: Jour. Electricity. vol. 18, p. 121, February 16, 1907. An outline of the history and a description of the system, and of the Stockton lines of Central California Traction Co. 2,400 words; 3 photographs; 2 detail cuts.

Western States Gas & Electric Co. at Stockton, by Robert Sibley: Jour. Electricity, vol. 28, p. 371, Apr. 27, 1912. History and description of the company's system. 3,150 words; 6 photographs; 1 map.

Western States Gas & Electric Co.'s Richmond holdings: Jour. Electricity, vol. 28, p. 617, June 22, 1912. A brief note on the Richmond installation. 525 words; 4 photographs.

UTICA MINING CO.

The Utica mines plant: Jour. Electricity, vol. 2, p. 104, 1893.

The electrical transmission to the Utica mine, by J. Frank Gurney: Jour. Electricity vol. 9, p. 77, May, 1900. A general description of the Utica plant and transmission. 1,500 words; 6 photographs.

SAN JOAQUIN LIGHT & POWER CORPORATION.

The Bakersfield, Calif. long distance power transmission: Electrical Eng., p. 173. Aug. 21, 1895. A short description of the development of Power Transit and Light Co., at the mouth of Kern Canyon.

The Fresno transmission plant, by George P. Low. Jour. Electricity, Power and Gas, p. 79, April, 1896. A detailed description of the original San Joaquin No. 1. Development and transmission to Fresno. 6,600 words; 18 photographs.

A 35-mile, 3-phase transmission at Fresno, Calif.: Electrical Eng., p. 566, May 27, 1896. A description of original San Joaquin No. 1 plant. 700 words; 2 photographs.

A 35-mile power transmission at Fresno, Calif.: Electrical Eng., July 1, 1896. A description of the original San Joaquin plant No. 1. 1,800 words; 5 photographs.

The power plant at Fresno, Calif.: Eng. News, vol. 36, No. 1, p. 12, July 2, 1896. A short description of original San Joaquin No. 1 plant with costs. 300 words; 1 photograph.

A 35-mile electrical power transmission at Fresno, Calif.: Lord's Mag., July, 1896. An illustrated description of the original San Joaquin plant No. 1. 1,400 words.

Long-distance transmission plan at Fresno, Calif.: Sci. Am., vol. 76, p. 200, Mar. 27, 1897. An excellent description of San Joaquin plant No. 1 and earlier experiences in its operation. 2,500 words; 10 photographs.

Long-distance electrical transmission in California: Eng., London, Mar. 5, 1897. An illustrated description of the original San Joaquin No. 1 plant. 4,000 words.

Some details of the Fresno plant, by C. E. Dutcher: Jour. Electricity, Power and Gas, vol. 14, April, 1897, p. 1. Description of the details of the original San Joaquin No. 1 plant. 4,500 words; 5 photographs; 2 wiring diagrams.

The Bakersfield transmission: Jour. Electricty, Power, and Gas, August, 1897, p. 85. A detailed description of a plant of Power Development Co., at the mouth of Kern Canyon. 7,900 words; 15 excellent photographs; 3 diagrams; 1 tabulation of data.

The Bakersfield power plant, by J. D. Schuyler: Eng. News, vol. 38, No. 10, p. 150, Sept. 2, 1897. Description of the plant of Power Development Co. at the mouth of Kern Canyon. Detailed information on cost data, especially of the flume. 3,000 words; 6 photographs; 1 detail.

The San Joaquin Valley, by Clem A. Copeland: Jour. Electricity, Power, and Gas, Nov. 28, 1908, p. 345. Description of the developments and territory of San Joaquin Light & Power Co. 7,500 words; 40 photographs; 1 relief; 1 transmission map; 5 line-cut construction details.

Power development on the North Fork of San Joaquin River, by G. S. Hewins: Eng. Rec., vol. 63, No. 5, p. 124, Feb. 4, 1911. A detailed description of the enlargement of the North Fork plants of San Joaquin Light & Power Corporation. 5,000 words; 5 photographs; 1 outline map.

New station of San Joaquin Light & Power Co., by G. S. Hewins: Eng. Rec., vol. 63, No. 6, p. 156, Feb. 11, 1911. A detailed description of the new San Joaquin plant by its constructor. 1,600 words; 4 photographs.

Electric motors for oil-well service, by S. G. Gassaway: Jour. Electricity, vol. 28, p. 25, January, 1912. A review of the use of electricity in the south San Joaquin Valley oil fields. 1,950 words; 4 photographs.

San Joaquin Light & Power Corporation, by Rudolph W. Van Norden: Jour. Electricity, Power, and Gas, vol. 28, No. 19, p. 415, May 11, 1912. A description of the entire system of San Joaquin Light & Power Corporation as it stood at the date of publication. Interesting details on miscellaneous construction costs. Numerous typographical errors, for which the author was not responsible, appear in this article. These are corrected in a reprint published by Louis Sloss & Co., as a prospectus for a bond issue. 19,100 words; 83 photographs; plan and elevation of Fresno plant; wiring diagram of New San Joaquin plant; 5 construction details; map of transmission system.

Out-door substations in San Joaquin Valley, by Rudolph W. Van Norden: Jour. Electricity, Power, and Gas, vol. 28, No. 26, p. 633, June 29, 1912. A description of this type of substation with detail costs of installation. 1,500 words; 3 photographs.

San Joaquin hydroelectric power installation, by F. C. Perkins: Sci. Am. Suppl., vol. 74, p. 8, July 6, 1912. Description of developments Nos. 1 to 3. 1,500 words; 3 photographs.

New San Joaquin power plant, by Howard H. Bliss: Power, vol. 36, July 16, 1912. Description of new San Joaquin No. 1 plant, with results of efficiency tests of its units, and notes of the corporation's system. 1,200 words; 3 photographs; 1 efficiency curve.

Hydroelectric power in California oil fields, by Warren Aikens: Min. and Eng. World, vol. 37, No. 17, p. 751, Oct. 26, 1912. Detailed description of utilization of electric power in the fields. 4,000 words; photographs.

Electric energy in the oil fields, by A. E. Wishon: Jour. Electricity, Power, and Gas, vol. 30, p. 375, Apr. 26, 1913. Detailed figures on the costs and results of electric power in the oil fields. 3,400 words; 6 photographs.

Automatic electric operations of oil wells: Jour. Electricity, vol. 33, p. 75, July 25, 1914. A general description of electric oil well operating installations in Kern River fields. 1,700 words; 8 photographs.

Electric pumping of oil wells, by Ralph Arnold and V. R. Garfias: Jour. Electricity, vol. 33, p. 78, July 25, 1914. An abstract of technical paper No. 70, U. S. Bur. Mines on "Methods of oil recovery in California."

Bakersfield, Calif., steam power plant: Power, vol. 40, p. 476, Oct. 6, 1914. A comprehensive description of the plant, the conditions under which it operates, and the operating results. 2,500 words; 12 photographs; 3 details and diagrams.

Supervising 840 miles of lines, by L. J. Moore: Electrical World, vol. 65, p. 1422, May 29, 1915. Methods of operation of San Joaquin system. 2,200 words; 1 photograph; 2 daily load curves; map of transmission system.

Merced Falls low-head hydroelectric plant, by A. S. Kalenborn: Jour. Electricity, vol. 36, No. 24, p. 445, 1916. Detailed description of the plant built under the author's direction by San Joaquin Light & Power Corporation in 1915. 1,360 words; 10 photographs; 4 diagrams.

Unusual features of an irrigation pumping load, by G. R. Kenny: Jour. Electricity, vol. 38, No. 11, p. 448, June 1, 1917. An outline of pumping conditions on San Joaquin Light & Power system, with tabular data showing products, and operating conditions. 1,000 words; three tables; 2 load curves.

War service of electric energy, by Robert Sibley: Jour. Electricity, vol. 40, No. 3, p. 112, Feb. 1, 1918. Popular description of San Joaquin Light & Power system with detailed data on past and forecast of future operating conditions. 1,500 words; 11 photographs; 6 diagrams; 1 table.

Power resources in southern California, by H. A. Barre: Jour. Electricity, vol. 40, No. 7, p. 330, Apr. 1, 1918. A statement of the program of interconnection and extension adopted by the companies serving southern California, to insure a war-time power supply. 1,200 words; 1 photograph; 1 diagram; 1 map.

SOUTHERN CALIFORNIA EDISON CO.

A description of the system in successful operation at Redlands, Calif.: Street Railway Jour., December 1893. Describes Mill Creek No. 1 plant.

The utilization of water power in California, by George Hele: Electrical Eng., Feb. 13, 1895. Illustrated.

Industrial use of electrical power, Los Angeles, Calif., by G. H. Guy: Electrical Eng., Mar. 13, 1895. Illustrated.

The Riverside transmission, by W. A. Layman: Jour. Electricity, vol. 4, p. 21, May, 1897. Description of the first transmission line from Mill Creek No. 1 to Riverside, 22 miles. 3,000 words; 6 photographs.

The electrical development of hydraulic power, by F. C. Finkle: Eng. Mag., vol. 14, p. 1011, March 1898. Description of various southern California developments; covers Lytle Creek, Mill Creek No. 1, and Santa Ana No. 1 of this company. 4,100 words; 8 photographs; 2 maps; 4 cuts.

Water powers in southern California, by C. G. Baldwin: Jour. Electrictiy, vol. 7, p. 5, January 1899. A general discussion of some of the main questions in early hydroelectric development in the southern market. 4,000 words.

An 83-mile power transmission plant, by James A. Lighthipe. Cassiers Mag., vol. 17, p. 3, November, 1899. A description of the Santa Ana No. 1 to Los Angeles transmission. 2,800 words; 11 photographs; 2 cuts.

Water-power plants with long distance transmission in southern California by C. E. Fowler: Eng. News, vol. 41, p. 146, Mar. 9, 1899. p. 164, Mar. 16. Detailed descriptions of Santa Ana No. 1, Los Angeles, and Pasadena stations, and the main transmission line; Mill Creek No. 1 is also described. 8,500 words; 11 photographs; 1 transmission map. 7 details of plants.

The electric power transmissions of southern California: Jour. Electricity, vol. 9, p. 45, March, 1900. A résumé of developments then in operation. 2,300 words; map of all the systems.

The generating, transmission, and distributing system of Edison Electric Co., Los Angeles, Calif., by George P. Low: Jour. Electricity, vol 13, p. 9, January, 1903. Full description of the entire system; including Santa Ana No. 1, Mill Creek Nos. 1, 2, and 3, and preliminary work on Kern River No. 1; also, a general outline of the rest of the system, together with its history and a statement of its finances. 26,000 words; 60 photographs; 29 cuts; 2 maps.

The systems of United Electric Gas & Power Co.: Jour. Electricity, vol. 13, p. 86, January, 1903. Detailed description of entire system, with historical and financial notes. 4,000 words; 15 photographs; 4 plans; elevations and details; 1 map.

The new Mill Creek power plant of Edison Electric Co. near Redlands, Calif.: Eng. News, vol. 49, p. 133, Feb. 5, 1903. A good description of Mill Creek No. 3 development. 1,800 words; 6 photographs of construction work.

Power development in southern California, by L. R. Freeman: Rev. of Rev., vol. 28, p. 202, August, 1903. An article on the value of water power in California; contains a brief description of Mill Creek plant No. 3. 1,700 words; 7 photographs.

An efficient high pressure water power transmission plant, by Geo. J. Henry, jr., and Joseph N. Le Conte: Trans. of Am. Inst. Electrical Eng., vol. 22, p. 627, September, 1903. Description of the test of Mill Creek No. 3 installation. Extensive tables of results are given. 3,000 words; 7 photographs; 7 curves.

Medium span line construction, by C. A. Copeland: Eng. News, vol. 52, p. 143, Aug. 18, 1904. (Also published in Jour. Electricity.) An article giving the design of the distribution lines on Southern California Edison system (then Edison Electric Co.). 2,300 words; 2 cuts of pole-top construction.

The power plants of Edison Electric Co. of Los Angeles: Eng. Rec., vol. 51, p. 211, Feb. 25, 1905; p. 302, Mar. 11; p. 325, Mar. 18. A description of the system, including Santa Ana, Mill Creek, Lytle Creek, and Los Angeles No. 3 stations, and the construction work on Kern River No. 1. 12,600 words; 17 photographs; 7 cuts.

Edison Electric Co.'s system in southern California: Electrical World and Eng., vol. 45, p. 383, Feb. 25, 1905; p. 427, Mar. 4; p. 471, Mar. 11; and p. 583, Mar. 25. A general description of the entire system, including part of the construction work on

Kern River No. 1. 18,000 words; 15 photographs; 1 map of the transmission system; 18 cuts and details.

Hydroelectric power development and transmission in California, by Robert McF. Doble: Jour. Assoc. of Eng. Soc., vol. 34, p. 75, March, 1905. Description of numerous plants, among which are Mill Creek Nos. 1, 2, and 3, and Santa Ana No. 1 of this system. 9,500 words; 25 photographs; 1 map; 4 cuts.

Hydroelectric power plants of California, by C. W. Whitney: California Jour. Tech., vol. 7, p. 4, February, 1906. A review of some of the power plants in the State. 7,500 words; illustrations.

Cave-in of an incline shaft and the subsequent rescue of an entombed miner, by F. C. Finkle: Eng. News, vol. 57, p. 318, Mar. 21, 1907. A description of the cave-in at Kern River No. 1 during construction of the inclined pressure shaft. 2,500 words; 1 photograph; 3 cuts.

Kern River No. 1 station of Los Angeles Edison Electric Co.: Jour. Electricity, vol. 18, pp. 417 and 435, June 1 and 8, 1907. A description of Kern River No. 1 development and transmission line. The data given is part of that published in Eng. Rec. and Electrical World in August, 1907. 6,500 words; 9 photographs; 11 details and plans; 1 map.

Kern River No. 1 power plant of Edison Electric Co., Los Angeles, by C. W. Whitney: Eng. Rec., vol. 56, p. 140, Aug. 10, 1907; p. 175, Aug. 17. Description of Kern River No. 1. 6,500 words; 8 photographs; 9 cuts and sections.

Kern River No. 1 power plant of Edison Electric Co., Los Angeles: Electrical World, vol. 50, p. 277, Aug. 10, 1907; p. 317, Aug. 17; p. 359, Aug. 24; and p. 401, Aug. 31. A description of the hydraulic, electric and transmission systems of this development, together with the receiving station in Los Angeles. This article contains practically all the material printed in the serial beginning in Eng. Rec. of the same date, together with a more detailed description of the electrical features and transmission line. It is the most complete description of the installation available. 33,600 words; 25 photographs; 11 cuts.

Some problems in designing the Kern River No. 1 hydroelectric power plant, by F. C. Finkle: Eng. News, vol. 60, p. 701, Dec. 24, 1908. A detailed account of the problems encountered in the hydraulic development of this plant. 6,500 words; 10 photographs; 14 cuts; maps; sections.

The transmission of electrical energy in southern California: Electrical World, vol. 54, p. 1037, Oct. 28, 1909. A description of the transmission systems of Pacific Light & Power Co. and Southern California Edison Co. 3,000 words; 3 maps; 1 switching diagram; 1 load curve.

The power system of Southern California Edison Co., by W. V. Gump: Electrical Rev. and Western Electrician, vol. 58, pp. 583, 631, and 679, Mar. 25, 1911. Serial describing the Redlands, Mill Creek, Lytle Creek, Santa Ana River, and Kern River plants, also steam plants and substations. 14,700 words; 19 photographs; 11 wiring diagrams and details.

The new steam plant of Southern California Edison Co., by H. W. Dennis: Jour. Electricity, vol. 26, p. 309, Apr. 8, 1911. A description of the main features of the Long Beach station. 400 words; architect's sketch showing it as it will be when finally completed.

Southern California Edison system, by A. R. Maujer: Power, vol. 34, p. 352, Sept. 5, 1911. A general description of the plants of this system. 2,000 words; 7 photographs; 1 diagrammatic map.

Long Beach power plant, by A. H. Halloran: Jour. Electricity, vol. 27, p. 389, Oct. 28, 1911. Detailed description of this installation. 3,100 words; 8 photographs; 7 drawings and plans.

Auxiliary oil-burning station for southern California district: Electrical World, vol. 60, p. 535, Mar. 9, 1912. A detailed description of the installation at Long Beach.

Also a one-column editorial in the same issue, p. 522. 3,500 words; 7 photographs; 5 detailed drawings; plans; and sections.

Building a load factor on an electric system: Electrical World, vol. 63, No. 8, p. 424, Feb. 21, 1914. A review of load conditions in the various districts of Southern California Edison system for 1912–13. 1,700 words; 2 diagrams.

Rates and negotiations in California: Electrical World, vol. 62, No. 13, p. 694, Mar. 28, 1914. Editorial comment on change of rates on Southern California Edison system. 400 words.

Details of the transmission systems of the world, tabulated by Selby Haar: Electrical World, vol. 63, p. 926, Apr. 25, 1914. Large insert sheet giving very instructive, comparative data on 54 systems now operating at more than 50,000 volts.

Essentials of the modern distributing system, by R. E. Cunningham: Jour. Electricity, vol. 34, No. 12, p. 221, Mar. 20, 1915. Paper presented before the meeting of Los Angeles section of Am. Inst. of Electrical Eng., Feb. 16, 1915, giving a description of the distribution methods used on Southern California Edison system. 4,500 words; 3 photographs; 2 maps; 5 diagrams.

Irrigating "The land of little rain," by S. M. Kennedy, Electrical World, vol. 65, p. 1471, June 5, 1915. Description of installations and outline of schedules and operating conditions of irrigation pumping on Southern California Edison system. 2,000 words; 5 photographs; 2 diagrams.

Tests of irrigation pumping plants supplied by Southern California Edison Co., by R. H. Gates: Jour. Electricity, vol. 37, p. 360, Nov. 4, 1916. Description of methods used in testing the efficiency of consumer's pumping installations. 2,000 words; 1 photograph; 3 diagrams.

Tests of irrigation pumping plants, by R. H. Gates: Jour. Electricity, vol. 37, p. 394, Nov. 18, 1916. Detailed results of tests of over three hundred irrigation pumping plants on Southern California Edison system. 1,200 words; 2 tables.

Analysis of various types of irrigation pumps, by R. H. Gates: Jour. Electricity, vol. 37, p. 410, Nov. 25, 1916. Results of extensive tests of various types of pumps. Continuation of article begun in issue of Nov. 18, 1916. 1,700 words; 1 diagram; 3 tables.

Physical data of the highest voltage system, by H. A. Barre: Jour. Electricity, vol. 40, No. 6, p. 277, Mar. 1, 1918. A detailed but concise statement of the engineering and operating features of the Big Creek transmission system. 1,000 words.

Recent advances in transmission line construction, by L. M. Klauber: Jour. Electricity, vol. 40, No. 6, p. 272, Mar. 15, 1918. A detailed description of the engineering features of the tie line of San Diego Consolidated Gas & Electric Co., which connects its system to that of Southern California Edison Co. at San Juan Capistrano. 1,800 words; 13 photographs; 3 diagrams.

New Capistrano substation, by H. W. Dennis: Jour. Electricity, vol. 40, No. 6, p. 278, Mar. 15, 1918. Short description of the frequency changer station at San Juan Capistrano, connecting the systems of Southern California Edison and San Diego Consolidated Gas & Electric companies. 500 words.

Transmission and distribution losses, by R. E. Cunningham: Jour. Electricity, vol. 40, No. 7, p. 349, Apr. 1, 1918. An analysis of the transmission and distribution losses on Southern California Edison system between Jan. 1 and June 1, 1917, before the consolidation of Southern California Edison Co. and Pacific light and power systems. 1,500 words; 1 diagram.

Power-plant losses, by R. J. C. Wood: Jour. Electricity, vol. 40, No. 7, p. 344, Apr. 1, 1918. A description of the methods adopted by Southern California Edison Co. to increase the efficiency of its hydro and steam electric plants. 3,000 words; 6 photographs.

Power resources in southern California, by H. A. Barre: Jour. Electricity, vol. 40, No. 7, p. 330, Apr. 1, 1918. A statement of the program of interconnection and extension adopted by the companies serving southern California, to insure a war-time power supply. 1,200 words; 1 photograph; 1 diagram; 1 map.

Three major power possibilities in California, by F. H. Fowler: Jour. Electricity, vol. 41, No. 1, p. 12, July 1, 1918. A comprehensive statement of the growth in demand for power in California and a description of the proposed developments at Big Bend of the Pit, Feather River site No. 5, and on Big Creek of the San Joaquin. 3,000 words; 7 photographs; 7 diagrams.

PACIFIC LIGHT & POWER CORPORATION.

[Absorbed by Southern California Edison Co. May 31, 1917.]

A long-distance electric power transmission plant: Eng. News, vol. 28, No. 33, p. 137, Aug. 11, 1892. Short notes on the equipment of the San Antonio plant and general features of the transmission.

The San Antonio plant, by Geo. P. Low: Electrical Eng., New York, Aug. 2, 1893, p. 97. A description of the development, with a table of calculated efficiencies. 1,700 words; 4 photographs.

Long-distance transmission at 10,000 volts, by G. H. Winslow: Trans. Am. Inst. Electrical Eng. vol. 12, p. 405, 1895. A detailed description of the entire Pomona (or San Antonio) development written by the engineer who installed it. 11,500 words; 3 plans; 2 details; 1 diagram of transmission; 3 curves showing characteristics of operation.

A Pacific coast power and light station—Los Angeles Street Railway power plant: Power, May, 1898. Mechanical features of steam plant in Los Angeles. 2,000 words.

San Gabriel-Los Angeles transmission plant, by Geo. P. Low: Jour. Electricity, vol. 6, p. 81, November 1898. Complete description of the first installation at Azusa and transmission system to Los Angeles. 15,600 words; 21 photographs; 26 diagrams and details.

Water powers in southern California, by C. G. Baldwin: Jour. Electricity, vol. 7, p. 5, January, 1899. A general discussion of some of the main questions in hydroelectric developments in the southern market. 4,000 words.

Southern California power transmission systems, by C. E. Fowler: Eng. News, vol. 41, No. 11, p. 164, Mar. 16, 1899. Detailed descriptions of Azusa and Pomona (San Antonio) plants. 3,500 words; 6 photographs; and map of transmission system.

San Gabriel Electric Co.: Eng., Dec. 22, 1899, p. 781; Dec. 29, 1899, p. 813. Description of Azusa plant, transmission to Los Angeles, and distribution system. 4,000 words; 5 photographs; 2 wiring diagrams.

The electric power transmission of southern California: Jour. Electricity, vol. 9, p. 45, March, 1900. A résumé of developments then in operation. 2,300 words; map of all the systems.

A 16-mile 80,000-volt experimental electric transmission line, by A. C. Balch: Eng. News, vol. 44, p. 204, Sept. 8, 1900. (See also Jour. Electricity, Power, and Gas.) Detailed results of tests of wires and insulators on 16-mile line. 1,400 words.

Some heretofore unpublished facts on the Pomona case: Jour. Electricity, vol. 7, p. 23, January, 1901. An outline of the history of the Pomona design. 1,900 words.

Some relics of the Pomona plant: Jour. Electricity, vol. 13, p. 232, 1903. Short note on transformers. 500 words; 3 photographs.

Competitive boiler tests, Los Angeles: Jour. Electricity, vol. 14, p. 117, April, 1904. Report on boiler tests at Los Angeles steam plant operated by Pacific Light & Power Co. 10,000 words; 4 details; 3 diagrams of tests.

Kern River Co.'s hydroelectric power enterprise: Eng. News, vol. 52, p. 55, July 21, 1904. Complete description of Borel development. 900 words; 10 photographs, 7 plans and sections.

Los Angeles & Pacific Railway Co.: Jour. Electricity, vol. 14, p. 14, January, 1905. Complete description of interurban system supplied with power by Pacific Light & Power Co. 6,000 words; 41 photographs.

Los Angeles traction and California Pacific Electric Railroad, by Samuel B. Lenegan: Jour. Electricity, vol. 14, p. 23, January, 1905. Description of interurban railway served with power by Pacific Light & Power Co. 2,200 words; 5 photographs.

Kern River plant, Pacific Light & Power Co.: Jour. Electricity, vol. 18, p. 477, June 22, 1907. A general description of the Borel plant. 1,100 words; 7 photographs; map of canal line.

The Azusa plant: Jour. Electricity, vol. 18, p. 500, June 29, 1907. A short account of the development; incorrect in some respects. 700 words; 2 photographs; and cut of transmission line.

The Sierra and Mentone power houses of Pacific Light & Power Co.: Jour. Electricity, vol. 19, p. 1, July 6, 1907. A general description of the Sierra and Mentone plants. 700 words; 5 photographs.

Pacific Light & Power Co.'s plants and substations: Jour. Electricity, vol. 19, p. 19, July 13, 1907. A general description of San Bernardino Gas & Electric Co.'s Highgrove power house, Riverside power house, Kern River substation and Third Street steam plant; Hollywood, Sunnyslope, South Pasadena, and University substations. 3,000 words; 8 photographs.

Redondo power station of Pacific Light & Power Co: Electric Railway Rev., Nov. 2, 1907.

A 15,000-kilowatt oil-burning station power plant on which a bonus of $363,310 was earned: Eng. News, vol. 60, p. 302, Sept. 17, 1908. Detailed description of the original installation in the Redondo steam plant from information furnished by its constructors. 4,000 words; 5 photographs.

Fuel economy tests at a large oil-burning electric power plant having steam engine prime movers, by C. R. Weymouth, member Am. Soc. Mech. Eng.: Trans. Am. Soc. Mech. Eng., vol. 30, p. 775, December, 1908. 6,500 words; 3 diagrams; 2 tables.

Sixteen months' record at Redondo: Power; October, 1909. (Brief of paper published in Proc. Am. Soc. Mech. Eng., December, 1908). Operating results of the reciprocating engine installation. 1,200 words; table of efficiency record.

Operating record of the Redondo power station of Pacific Light & Power Co: Eng. News, vol. 62, p. 582; Nov. 25, 1909. (Transcribed from above article in Power.) Details of 16 months' operating record and discussion of previous tests. 600 words.

Southern California developments, by Del Reynolds: Progressive Age, June 15, 1910. Account of the work of the Huntington interests. (Pacific Light & Power Corporation and Los Angeles interurban railway systems in southern California.) 2,200 words.

Extension of Redondo Beach plant, by A. R. Maujer: Power, vol. 34, Aug. 8, 1911. Brief description of turbo-generator equipment added in 1911. 3,500 words; 6 photographs; lay-out of condenser-cooling system.

Pacific Light & Power system, by Robert Sibley: Jour. Electricity, vol. 28, p. 151, Feb. 24, 1911. Complete description of the system which was later reprinted as a prospectus for publicity use in financing the Big Creek developments. 11,600 words; 117 photographs; 1 general lay-out; 3 curves.

Pacific electric railway consolidation, by R. W. Van Norden: Jour. Electricity, vol. 28, p. 261, March, 1912. Complete account of the recent developments in the urban and interurban trolley systems centering at Los Angeles. These lines receive a large amount of power from Pacific Light & Power Corporation. 2,450 words; 9 photographs; 2 maps; 2 diagrams; 1 schedule.

Extension of the Redondo station of Pacific Light & Power Corporation: Electrical World, June 15, 1912, p. 1301. An account of the changes in the circulating system and additions to the generating station and boiler house at Redondo, made in 1911. 2,500 words; 9 photographs.

Hysteresis and eddy-current losses in transmission towers: Electrical World, vol. 62, p. 1108, Nov. 29, 1913. An outline of the experimental test to determine the losses due to eddy-currents in the transmission towers used on the Big Creek transmission. 950 words; 3 diagrams; and an elevation of the tower.

The 150,000 volt Big Creek development, pt. 1: Electrical World, vol. 63, p. 33, Jan. 3, 1914. Detailed description of the hydraulic development and power houses of the Big Creek project. 3,700 words; 10 photographs; 1 map; plan and elevation of power house No. 1.

World's longest transmission line: Electrical World, vol. 63, p. 71, Jan. 10, 1914. Editorial comment on chief features of the Big Creek transmission. 1,100 words.

The 150,000 volt Big Creek development, pt. 2: Electrical World, vol. 63, p. 85, Jan. 10, 1914. A detailed description of the Big Creek transmission line, and receiving substation at Los Angeles with synchronous regulating machinery. 3,100 words; 10 photographs.

Big Creek hydroelectric development: Eng. Rec., vol. 69, p. 47, Jan. 10, 1914. Description of construction methods on hydraulic system and plants of the Big Creek development. 3,500 words; 3 photographs; 1 map; plan and elevation of plants; 4 diagrams.

Valuation of the street railways in Los Angeles: Eng. News, vol. 71, p. 358, Feb. 12, 1914. An abstract of the valuation for rate-making purposes made by the city's Board of Public Utilities, covering a railway system which is supplied with power by Pacific Light & Power Corporation. 3,200 words; comparative table of street railway conditions in various cities.

World's longest transmission line: Electrical World, vol. 63, p. 493, Feb. 28, 1914. Letter and editorial comment giving reason for use of condensers at receiving station end of 150,000 volt. 400 words.

Inspecting, coating, and testing steel pipe for 112-mile high-pressure gas line from Taft to Los Angeles, Calif. Eng. and Contracting, vol. 41, p. 382, Apr. 1, 1914. An abstract of article by W. E. Barrett in Am. Gas Light Jour. A description of the shop and field methods. Gas system organized by Pacific Light & Power interests. 650 words.

Storm damage to a natural-gas pipe line in southern California: Eng. News, vol. 71, p. 774, Apr. 9, 1914. Account of damage to Southern California Gas Co.'s lines from the Midway field to Los Angeles, caused by the storm of February, 1914. 1,800 words; 8 photographs.

Details of the transmission systems of the world, tabulated by Selby Haar: Electrical World, vol. 63, p. 926, Apr. 25, 1914. Large insert sheet giving very instructive comparative data on 54 systems operating at more than 50,000 volts.

Suburban street lighting: Municipal Eng., vol. 46, No. 6, p. 514, June, 1914. A description of Los Angeles and other lighting systems. 2,000 words.

The 150-volt Big Creek scheme: The Electrician, London, Aug. 14, 1914, p. 762. Description of hydraulic features of the development and of the power houses. 3,500 words; 1 photograph; 2 power-house sections.

Idem, part 2, Aug. 21, 1914, p. 795. Description of the generating and switching equipment, lines, and receiving station. 4,000 words; 5 photographs.

The Big Creek development of Pacific Light & Power Co., by H. C. Hoyt: General Electric Rev., vol. 17, p. 828, August, 1914. Outline of conditions under which the development was made and general description of the system. 7,000 words; 10 photographs.

150,000-volt transmission system, by Edward Woodbury: Proc. Am. Inst. Electrical Eng., vol. 33, p. 1359, September, 1914. Description of operating conditions on the transmission line from Big Creek to Los Angeles, with detailed data for the entire development. 5,000 words; 7 photographs; 4 diagrams; tabulation of engineering data.

Some operating conditions of the 150,000-volt transmission system of the Big Creek development of Pacific Light & Power Corporation, by Edward Woodbury: Trans. Am. Inst. Electrical Eng., vol. 33, p. 1283, 1914. Description of operating conditions on the Big Creek lines, with notes on the development of Pacific Light & Power Corporation's system. 7 photographs; 3 diagrams; 5,000 words.

Long transmission lines, by R. A. Philip: Electrical World, vol. 64, p. 1147, Dec. 12, 1914. Comparison of electric-operating characteristics of the Keokuk-St. Louis and Big Creek-Los Angeles systems. 1,800 words; 1 diagram.

Problems and experiences in 150,000-volt power transmission, by Edward Woodbury: Electrical Jour., vol. 12, June, 1915. Practical observations on 18 months' operation of the Big Creek development. 2,500 words; 10 photographs; 2 diagrams.

The Big Creek hydroelectric development for Pacific Light & Power Corporation, by F. M. Thebo: U. S. Eng. Jour., March, 1916.

MOUNT WHITNEY POWER & ELECTRIC CO.

[Absorbed by Southern California Edison Co. June 15, 1920.]

Mount Whitney water power electric plant and light regulating device: Eng. News, vol. 2, p. 151, Sept. 7, 1899. Short detailed description of the plant and of a device for preventing consumers from burning too many lights. 1,800 words.

Mount Whitney, California, transmission plant, by Donald H. Fry: Electrical World, vol. 34, p. 648, Oct. 28, 1899. A short general description of Kaweah No. 1 plant. 1,200 words; 3 photographs.

Mount Whitney Power Co. Electrical Rev., vol. 25, p. 387, Dec. 20, 1899. Description of Kaweah No. 1 plant. 2,200 words; 3 photographs.

Mount Whitney Power transmission, by Robert McF. Doble: Jour. Electricity, Power, and Gas, January 1900, p. 3. A detailed description of the Kaweah No. 1 plant and of the transmission to Visalia, Tulare, and Porterville. 6,600 words; 28 photographs; plan and elevation of plant; and wiring diagram of transmission system. Tabulated data at the end of the article.

The auxiliary steam plant of the Mount Whitney Power Co. Jour. Electricity, Power, and Gas, January, 1907, p. 18. A description of the Visalia steam plant. 1,300 words; 3 photographs; plan and elevation of power house.

The Visalia Electric Railway, by A. H. Halloran: Jour. Electricity, vol. 19, p. 169, Aug. 31, 1907. A detailed description of an interurban electric railway supplied with power by Mount Whitney Power & Electric Co. 2,700 words; 9 photographs; 1 map.

Hydroelectric power as applied to irrigation, by John Coffee Hays: Part 1, Trans. Am. Inst. Electrical Eng., vol. 29, p. 731, April, 1910. Thorough description of the economic and operating conditions on the system of Mount Whitney Power & Electric Co., followed by discussion. 7,000 words; 11 photographs; 5 diagrams; 1 map.

Idem, Jour. Electricity, vol. 24, p. 513, June 4, 1910. Abstract of paper read before Am. Inst. Electrical Eng. 4,500 words; 11 photographs; 5 diagrams; 1 map.

Concrete-slab flume construction, in two parts, by S. L. Stovall: Western Eng., vol. 2, pp. 353 and 449, respectively, May and June, 1913. Description of engineering features and cost data on Tule River conduit, which led the author to adopt concrete slab construction on Kaweah No. 3. Detailed description of the latter conduit, with cost data. 9,000 words; 16 photographs.

System of Mount Whitney Power & Electric Co., by Rudolph W. Van Norden: Jour. Electricity, Power, and Gas, vol. 31, p. 575, Dec. 27, 1913. 17,400 words; 75

photographs; 1 chart; 1 discharge curve; 7 cross sections; 1 diagram; 1 map; 1 typical load curve.

Agricultural uses of power, Mount Whitney Power & Electric Co.'s system, by S. T. Harding: Jour. Electricity, vol. 37, p. 1, July 1, 1916. Detailed statistics on the agricultural power load on the system, compiled from exhibits in rate case before California Railroad Commission. 1,500 words; 8 photographs; 2 diagrams; 6 tables.

Power resources in southern California, by H. A. Barre: Jour. Electricity, vol. 40, No. 7, p. 330, Apr. 1, 1918. A statement of the program of interconnection and extension adopted by the companies serving southern California, to insure a war-time power supply. 1,200 words; 1 photograph; 1 diagram; 1 map.

ONTARIO POWER CO.

The irrigation system of Ontario, Calif., its development and cost, by F. E. Trask, member Am. Soc. Civil Eng.: Trans. Am. Soc. Civil Eng., vol. 55, p. 173, 1905. 6½ pages of text and 3½ pages of discussion. 10 halftones; 1 photograph of relief model.

LOS ANGELES MUNICIPAL POWER SYSTEM.

Investigation of surge phenomena by means of model experiments, by W. F. Durand: Western Eng., vol. 3, No. 6, p. 421, December, 1913. An extended discussion of surge phenomena and the feasibility of its experimental investigation by means of models. 4,000 words; 5 diagrams.

Surge tank at San Francisquito power station No. 1: Eng. Rec., vol. 69, No. 9, p. 263, Feb. 28, 1914. Letters to the editors from Roy Taylor and W. F. Durand, discussing article in Rec. of Sept. 13, 1913. 1,800 words; 2 diagrams.

Power bond election in Los Angeles, by E. F. Scattergood, chief electrical engineer of Los Angeles Power Bureau: Electrical World, vol. 63, No. 22, p. 1258, May 30, 1914. Letter to the editor. Sets forth city's side of power bond controversy. 1,600 words.

Power bond election in Los Angeles, by J. A. Lighthipe, Southern California Edison Co.: Electrical World, vol. 63, No. 26, p. 1501, June 27, 1914. Letter to the editor. Sets forth the company's side of bond controversy. 800 words.

Los Angeles power bond election on May 8, by Bert A. Heinly: Eng. News, vol. 71, p. 986, Apr. 30, 1914. Review of the controversy between city and companies. 1,700 words.

Progress on San Francisquito plant-Los Angeles power project: Jour. Electricity, vol. 36, p. 481, June 24, 1916. General description of the plant and work already completed. 1,200 words; 7 photographs; 4 diagrams.

Power resources in southern California, by H. A. Barre: Jour. Electricity, vol. 40, No. 7, p. 330, Apr. 1, 1918. A statement of the program of interconnection and extension adopted by the companies serving southern California, to insure a war-time power supply. 1,200 words; 1 photograph; 1 diagram; 1 map.

THE NEVADA-CALIFORNIA POWER SYSTEM.

Hydroelectric power plant of The Nevada Power Mining & Milling Co., by J. D. Galloway: Eng. Rec., vol. 53, p. 784, June, 1906. A detailed description of plant No. 4 on Bishop Creek and the first transmission line over the White Mountains to the mines around Goldfield and Tonopah. 2,500 words; 3 photographs; plan and elevation.

Test of Pelton impulse wheels for Bishop Creek No. 4: Jour. Electricity, vol. 16, p. 208, April, 1906. Notes on a test of the two 750-kilowatt units at plant 4. 500 words.

Bishop Creek hydroelectric power plant, by J. D. Galloway. Electrical World, vol. 47, p. 1535, June 30, 1906. Detailed description of the first three units and installation of plant 4, and first transmission line to Nevada mines. 2,500 words; 2 photographs; 2 details, plan and elevation.

The construction of the dam of The Nevada-California Power Co.: Eng. Rec., vol. 56, p. 133, Aug. 3, 1907. Description of tower and cable used in construction of Sabrina dam. 1,500 words; construction lay-out, and tower detail.

Hydroelectric developments of The Nevada-California Power Co., by H. D. Chapman: Eng. Rec., vol. 59, p. 256, Mar. 6, 1909. General description of Bishop Creek plants 2, 4, and 5, and detailed description of Sabrina and South Lake storage. 2,500 words; 3 photographs; diagram of developments; 4 details.

System of The Southern Sierras Power Co., by Rudolph W. Van Norden: Jour. Electricity, vol. 31, p. 1, July 5, 1913. First part describes in detail the hydroelectric and steam-electric stations of The Nevada-California Power Co. and The Southern Sierras Power Co. 11,800 words; 29 photographs; 9 plans, sections, and details; 2 maps.

Idem: p. 33, July 12, 1913. Second part covers the transmission systems of both companies. 10,600 words; 31 photographs; 7 diagrams; elevation, etc.

Hydroelectric development on Bishop Creek, Calif., by C. O. Poole: Electrical World, vol. 64, 1914; serial running through 10 numbers. No. 16, p. 757, Oct. 17. Short historical note and descriptions of storage dams and their construction. 1,900 words, 7 photographs, 2 plans and elevations.

Idem, No. 17, p. 805, Oct. 24: Description of reservoir outlet and future plant A and No. 1. 2,900 words, 2 photographs, 6 diagrams.

Idem, No. 18, p. 858, Oct. 31. Description of regulating reservoir and pressure system for plant 2, and repair of large Y casting at lower end of pressure pipe. 3,300 words; 10 photographs, including a set showing repairs; 4 diagrams.

Idem, No. 19, p. 903, Nov. 7, Description of powerhouse No. 2, and the entire plant at No. 3. 3,200 words; 12 photographs, 6 plans, elevations and details.

Idem, No. 20, p. 949, Nov. 14. Description of plants 4 and 5. 2,700 words; 5 photographs; 4 plans and details.

Idem, No. 21, p. 1001, Nov. 21. Description of plant 6. 1,000 words, 4 photographs, 2 diagrams.

Idem, No. 22, p. 1045, Nov. 28. Description of transmission system of The Nevada-California Power Co. 1,500 words; 3 photographs; 1 transmission map; 2 details.

Idem, No. 23, p. 1093, Dec. 5, Description of principal substations on The Nevada-California system. 1,600 words; 4 photographs.

Idem, No. 24, p. 1143, Dec. 12. Description of The Southern Sierras transmission system. 2,400 words; 8 photographs; 2 diagrams.

Idem, No. 25, p. 1193, Dec. 19. Description of San Bernardino steam plant and substations and Imperial Valley line. 2,000 words; 7 photographs.

Nevada transmission lines damaged by storm: Jour. Electricity, vol. 38, No. 3, p. 73, Feb. 1, 1917. Description of failures due to sleet storm in December, 1916. 400 words; 6 photographs.

Power resources in southern California, by H. A. Barre: Jour. Electricity, vol. 40, No. 7, p. 330, Apr. 1, 1918. A statement of the program of interconnection and extension adopted by the companies serving southern California, to insure a war-time power supply. 1,200 words; 1 photograph; 1 diagram; 1 map.

The Rush Creek controversy, by C. C. Hogan: Jour. Electricity, vol. 37, p. 407, Nov. 25, 1916.; Outline of controversy over proposed development of Rush and Leevining creeks. 1,400 words; 5 photographs.

New multiple-arch dams in the Sierra Nevada: Eng. News, vol. 76, p. 1157, Dec. 21, 1916; General descriptions of Gem and Agnew Lake dams. 950 words; 4 photographs; section of dam.

Multiple arch dams on Rush Creek: Jour. Electricity, vol. 37, p. 479, Dec. 23, 1916; Detailed description of Gem, and general description of Agnew Lake dam and power house. 1,200 words; 4 photographs; plan and elevation of Gem Lake dam.

SIERRA PACIFIC ELECTRIC SYSTEM.

The Truckee-Comstock transmission, by George P. Low: Jour. Electricity, vol. 10, p. 98, November, 1900. A general outline of the pumping conditions on the Comstock lode which led to the building of the Farad plant. Description of the plant, power house, and transmission system. Tabulated data at end of the article. 3,800 words; 9 photographs.

The Truckee River electric power plant: Eng. Rec., vol. 44, p. 562, Dec. 14, 1901. Description of the hydraulic station at Floriston, Calif., where electricity is generated for use in the Comstock mines, 30 miles distant. 1,500 words.

Electrical mining equipment on the Comstock lode, by Leon M. Hall: Electrical World, vol. 40, p. 285, Aug. 23, 1902. Describes in detail the electrical equipment of California Consolidated & Virginia mine. 1,800 words; 8 photographs; 4 diagrams of machine layout.

Washoe Power & Development Co.'s plant on Truckee River, by Wyatt H. Allen. Jour. Electricity, vol. 15, p. 467, November, 1905. Detailed description of a plant for supplying the towns of Reno and Sparks, Nev., with electric power and the final union of four companies, forming "Union Light & Water Co." 4,500 words.

Truckee River General Electric Co., by A. W. Clapp: Electrical Rev., vol. 49, p. 454, Sept. 22, 1906. Extract from a forthcoming volume. Description of the Farad, Fleish, and old Reno plant, and transmission lines. 2,400 words; 11 photographs.

Electrical equipment of a Nevada smelter, by R. N. Davidson: Jour. Electricity, vol. 28, p. 349, Apr. 20, 1912. Description of electrical equipment of smelter of Mason Valley Mines Co., at Thompson, Nev. Power supplied by Truckee River General Electric Co. 1,200 words; 3 photographs; 2 diagrams.

GENERAL ARTICLES.

A twelve-mile transmission of power by electricity, by Thomas H. Leggett: Eng. News-Rec., vol. 32, p. 74, July 26, 1894. Abstract of a paper read before Am. Inst. Min. Eng., giving detailed description of the Green Creek plant, with operating data. 3,000 words; 2 photographs; plan and elevation of dam; plan of power house.

A twelve-mile transmission of power by electricity, by Thomas H. Leggett: Trans. Am. Inst. Min. Eng., vol. 24, p. 315, 1894. Detailed description of the monophase transmission from Green Creek to the mines at Bodie. 7,500 words; 4 photographs; 1 map; 9 plans; elevations and details. For Bodie transmission, see also Trans. Tech. Soc. Pacific Coast, Vol. X, No. 4651.

A log dam for a mining power plant, by Robert Gilman Brown: Eng. and Min. Jour., vol. 62, Nov. 28, 1896. Description of additions to the system of Standard Consolidated Mining Co., Green Creek plant. 1,200 words.

Petroleum industry of California, by R. P. McLaughlin and C. A. Waring: Bulletin No. 69, accompanied by folio of 18 maps and plans. State Mining Bureau, 1914.

Economic devices in a small hydraulic system, by J. W. Swaren: Jour. Electricity, vol. 38, No. 10, p. 379, May 15, 1917. Description of improvements made in the small system of Quincy Light & Power Co. 1,500 words; 4 photographs.

Power resources in southern California, by H. A. Barre: Jour. Electricity, vol. 40, No. 7, p. 330, Apr. 1, 1918. A statement of the program of interconnection and extension adopted by the companies serving southern California, to insure a war-time power supply. 1,200 words; 1 photograph; 1 diagram; 1 map.

Three major possibilities in California, by F. H. Fowler: Jour. Electricity, vol. 41, No. 1, p. 12, July 1, 1918. A comprehensive statement of the growth in demand for power in California and a description of the proposed developments at Big Bend of the Pit, Feather River site No. 5, and on Big Creek of the San Joaquin. 3,000 words; 7 photographs; 7 diagrams.

Predicting stream flow in the Sierras, by Joseph N. LeConte: Jour. Electricity, vol. 41, No. 6, p. 248, Sept. 15, 1918. Outlines a rough method of predicting the summer flow of Sierran streams. 1,200 words; 21 diagrams; 1 table.

Statistical data on power companies, by W. F. Neiman: Jour. Electricity, vol. 41, No. 8, p. 350, Oct. 15, 1918. An extensive and valuable compilation of financial and operating data for California power companies for the years 1915–1917. 2,000 words; 3 tables.

Power possibilities in California, by F. H. Fowler: Jour. Electricity, vol. 41, No. 9, p. 393, Nov. 1, 1918. A general statement of the relative importance of the various California watersheds as sources of hydroelectric power. 2,500 words; 2 photographs.

Water power situation on the Pacific coast, by Maj. George F. Sever: A general statement of the war-time power supply in California, with detailed figures on interconnections, and possible extensions of existing systems. 2,500 words; tabulations.

APPENDIX A.—FINANCES.

Although no report on the hydroelectric systems of California would be complete without some statement of their finances, a thorough study of that particular subject would exceed both the scope and size of this paper. The financial resources and obligations of each company or system are therefore presented by four tables arranged in the following order:

1. Capitalization, outstanding stocks, and dividends.
2. Bonded indebtedness.
3. Earnings and expenses.
4. Comparative balance sheet.

The table of earnings and expenses shows not only the net revenues of the company but classifies electric revenues derived from diverse sources. It should be studied in connection with the tables of rates in Appendix B (Tables 292–314). Special tables have been added to present fully intercorporate finances within particular systems.

SOURCES OF INFORMATION.

Prior to 1913 each of the utilities operating in the State kept its accounts in such form as it saw fit, and no two companies used the same accounting system. The powers of the California Railroad Commission were extended on March 23, 1912, to include the regulation of electric utilities, and the companies were immediately required to file financial statements for the year ending December 31, 1911, prepared in accordance with their own systems of accounts. More complete financial returns in a partly standardized form of accounts were submitted for the year ending December 31, 1912, and all reports from 1913 to date have been kept and submitted according to a thoroughly standardized system.

The tables showing capitalization, amounts of stock outstanding, and the amount of dividends paid have been compiled from the articles of incorporation on file with the Secretary of State of California, from data furnished by the companies, from annual reports to the stockholders, and from annual reports to the California Railroad Commission.

Tables of bonded indebtedness have been prepared from information furnished by the companies and by the trustees of the various issues, from copies of the mortgages securing the issues, and from annual reports of the companies to the stockholders and to the California Railroad Commission.

Tables of earnings and expenses for years up to and including 1912 have been prepared from information furnished by the companies, or from their reports to their stockholders. The tables for 1913 to 1920 and the subtables showing classified electric earnings from various kinds of load are, except where noted, copied in full from the official reports submitted to the California Railroad Commission.

The comparative balance sheets for the years up to and including 1912 are likewise from the annual reports of the companies to their stockholders, and the sheets from 1913 to 1920 from the official reports submitted by the companies to the California Railroad Commission.

The sources of special tables are noted thereon.

In the preliminary studies of the histories and finances of the systems covered by this report all possible use was made of the various financial manuals, particularly "Walker's Manual of California Securities," "Moody's Manual of Corporations," and "Poor's and Moody's Manuals Consolidated." The form and contents of the bond tables were made to conform to the information usually given in these publications, and they have been found invaluable as a check on the completeness of information secured from variou sources which was later carefully compared with official figures or carefully checked by the auditing departments of the different companies.

GENERAL COMMENTS.

An incomplete analysis of the finances of the various systems would be both useless and misleading, and the writer has therefore purposely avoided anything more than the most general comments on the subject.

It is obvious that prior to 1912, when the systems came under a standard system of regulation of rates, practices, and accounts, there is no exact basis for comparison of finances of the different companies. Some of the systems were operated in close accord with present official standards, while the rates, practices, and systems of accounts of others but remotely approached the principles subsequently laid down by the commission. Greater changes and adjustments have been necessary in the finances of companies of the latter than those of the former class.

This lack of standard in financial practices and systems of accounting prior to 1912 is reflected in many of the earlier decisions of the California Railroad Commission. Commenting on conditions as they then stood, the president of the commission stated:[1] "Public utilities of this State know entirely too little about their own affairs.

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[1] Opinions and Orders, Railroad Commission of State of California, vol. 1, p. 295, Decision 268, July 11, 1912.

This, I believe, most of them admit." Probably the most radical departures from present-day practices were in the issuing of stock bonuses with the sale of bonds, capitalization of franchises and water rights, and lack of depreciation reserves. Commenting on stock bonuses, the following statement was made by the president of the commission in one of the early cases: [2]

> We do not believe that under the conditions which have existed heretofore in California the par value of the outstanding stocks and bonds bears any relation to the value of the property. To be sure, the Supreme Court of the United States has said that this is one of the relevant matters to be considered in a rate-fixing inquiry; and, further, the constitution of this State provides that no corporation shall issue stock or bonds except for money paid, labor done, or property actually received (sec. 11, art. 12). The provisions of the Civil Code (secs. 309 and 456) have heretofore prevented and do now, as to all except utility corporations, prevent the issuance of bonds in excess of the total subscribed capital stock. This provision has brought about a condition wherein it has been the practice to issue the stock of a corporation for the purpose of raising money by bond issues instead of issuing the stock and raising money by its sale, as is the design of the law. It is a matter of common knowledge that stock bonuses have heretofore been usual with bond issues, even up to the total amount of the bond issue. This has brought about a condition wherein the issued stock of the corporation ordinarily represents nothing except voting privilege. To be sure, high rates on the part of utilities and the extension of facilities from excessive profits have in some instances absorbed the water and have brought the value of the property up to a combined value of the stock and bond issues.

In regard to the capitalization of water rights the commissioner remarked: [3]

> Under the provisions of the constitution and statutes of this State it is legal for corporations and individuals to appropriate water for power or irrigation or other legitimate beneficial purposes, and so long as such water is devoted to beneficial purposes the appropriation is protected. The rule of "first in use, first in rights" prevails in this State. To be sure, the appropriator who has laid his plans and complied with the law and is prosecuting his enterprise with due diligence in proportion to the magnitude of his undertaking is protected, and by the doctrine of relation the time of his right dates from the time of the bona fide beginning of the work necessary to perfect his appropriation. Neither private nor public appropriators have heretofore been required initially to pay to the State anything for the right to appropriate. In other words, the State has held out as inducement to those who desire to develop power for irrigation that the first taker might hold in trust for the public, if it is a public appropriation, and during its continued use if it is a public appropriation, and that by expending money in legitimate development the public appropriator could be protected in his rates and the private appropriator protected by his right to continued use.
>
> But now the public appropriators of water for irrigation and power purposes are urging that they may capitalize their priority, and that although they have been required to pay nothing for the right to take the water, the generosity of the public in giving it to them instead of selling it to them shall be capitalized. To be sure, I realize that this is a very large question, and, of course, as to any private water rights which are required to be condemned or are purchased by these public agencies, there is no doubt that they should have consideration in a rate-fixing inquiry, but it is hard

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[2] Idem, p. 318, July 13, 1912.

[3] Idem, pp. 319–320. These remarks refer, of course, to appropriations under the old law.

for me to understand how we are going to place a value for rate-fixing purposes upon the generosity of the public, and if we place such a value, how we are to determine it.

During the intervening years a steady process of financial reorganization and standardization in the affairs of the various utilities has removed most of the causes of early criticism. The companies surrendered much of their independence of action and in return received protection from cutthroat competition and relief from regulations imposed by numerous local bodies.

TABLES.

FINANCIAL TABLES FOR THE CALIFORNIA OREGON POWER CO. AND PRINCIPAL SUBSIDIARIES.

TABLE 186.—*Capitalization, outstanding stock, and dividends of The California Oregon Power Co. and principal subsidiaries.*

Company.	Date of incorporation.	Capitalization.	Par.	Stock outstanding.		Dividends.
				Years (Dec. 31).	Par value.	
The California Oregon Power Co. (San Francisco).	Oct. 16, 1920	[a]$15,000,000	$100	1920	[b]$1,100	None.
California-Oregon Power Co. (San Francisco).	Dec. 15, 1911	10,000,000	100	1911–1918	[c]10,000,000	([d])
Siskiyou Electric Power & Light Co. (Yreka, Calif.)	Feb. 17, 1908	1,000,000	20	1908–1911	1,000,000	None.
Siskiyou Electric Power Co. (Yreka, Calif.)	Aug. 15, 1902	200,000	100	1907	200,000	None.
Rogue River Electric Co.[e] (Medford, Oreg.)	Nov. 11, 1907	700,000	100	1908–1920	564,000	None.
Klamath Power Co.[e] (Klamath Falls, Oreg.)	Mar. 28, 1911	500,000	20	1911–1920	500,000	None.
Ashland Electric Power & Light Co.[e] (Ashland, Oreg.)	May 27, 1899	35,000	100	1908–1916	35,000	None.

[a] $7,500,000 common and $7,500,000 preferred 7 per cent cumulative after 1924.

[b] Directors' qualifying shares only were outstanding Dec. 31, 1920, but on Apr. 15, 1921, $2,220,000 preferred and $4,441,100 common stock was issued.

[c] Capital stock in the par value of $992,000 was bought in by the company during 1915 on account of nonpayment of assessments, leaving $9,080,000 par value outstanding in hands of public. $725,000 par value was purchased in same manner during 1916, bringing total so purchased up to $1,717,000 and leaving $8,283,000 par value outstanding in hands of public. Stock purchased from nonpayment of assessments appears in balance sheets under head of "Treasury securities."

[d] Assessments were levied on the stock of California-Oregon Power Co. as follows during the years 1915–1918: No. 1, 30 cents per share, June 29, 1915; No. 2, $1 per share, Oct. 27, 1915; No. 3, 50 cents per share, Feb. 15, 1916; No. 4, 50 cents per share, Apr. 18, 1916; No. 5, $1 per share, June 20, 1916; No. 6, $3 per share, Sept. 25, 1917.

[e] All stock owned by California-Oregon Power Co.

NOTE.—On the formation of Siskiyou Electric Power & Light Co., in 1908, its stock was distributed pro rata among the stockholders of Siskiyou Electric Power Co. in exchange for the stock of that corporation. On the formation of California-Oregon Power Co., in 1911, its stock was exchanged in the same manner for that of Siskiyou Electric Power & Light Co.

TABLE 187.—*Bonds of The California Oregon Power Co.*

Issue.	Callable.	Sinking-fund deposits.	Trustee.	Bond denomination.	Authorized.	Year (Dec. 31).	Reserved for prior liens.	In sinking fund.	In hands of public.	Total authenticated.
1	2	3	4	5	6	7	8	9	10	11
1. The California Oregon Power Co. first and refunding mortgage gold bonds dated Feb. 1, 1921; due Feb 1, 1941; interest rate may be varied, with maximum of 8 per cent interest payable Feb. 1 and Aug. 1.	Callable at 110 as a whole or in part on any interest date up to and including Feb. 1, 1931; thereafter at a premium of 1 per cent for each year or fraction thereof to date of maturity.	Sinking fund. Commencing May 1, 1922, 2 per cent per annum of all bonds outstanding.	Mercantile Trust Co. (San Francisco).	$1,000, $500, and $100 coupon.[a]	$10,000,000	......	....	....	....	....
2. California-Oregon Power Co. first and refunding mortgage gold 5 per cent bonds dated Jan. 1, 1912; due Jan. 1, 1952; interest payable Jan. and July 1.	Callable at 105; can be exchanged for bonds of issues 3 to 6.	Sinking fund. Commencing May 15, 1917, provides for retirement on basis of percentage of bonds outstanding, the rate varying from 5/10 per cent in 1917-1921 to 10 4/10 in 1950-1951.	....do....	$1,000 coupon[b].	10,000,000	1912	[c]$2,082,000	....	$3,518,000	$5,600,000
						1913	[c] 2,082,000	....	3,518,000	[d]5,600,000
						1914	[c] 2,082,000	....	3,518,000	[d]5,600,000
						1915	1,193,000	....	4,407,000	[d]5,600,000
						1916	1,179,000	....	4,421,000	5,600,000
						1917	1,172,000	....	4,428,000	5,600,000
						1918	1,165,000	....	4,435,000	5,600,000
						1919	1,165,000	....	4,435,000	5,600,000
						1920	1,151,000	....	4,449,000	5,600,000
3. Siskiyou Electric Power & Light Co. first and refunding mortgage 5 per cent bonds dated May 1, 1908; due May 1, 1938; interest payable May and Nov. 1.	Callable at 105 and interest; could be exchanged for bonds of issue 3 up to date when closed under issue 2.	Sinking fund commences May 1, 1918, 2 per cent of bonds per annum.	....do....	....do....	1,000,000	1908	200,000	....	800,000	1,000,000
						1909	196,000	....	804,000	1,000,000
						1910	182,000	....	818,000	1,000,000
						1911	135,000	....	865,000	1,000,000
						1912	135,000	....	[e] 282,000	417,000
						1913	135,000	....	53,000	188,000
						1918	135,000	....	53,000	188,000
						1919	135,000	....	53,000	188,000
						1920	135,000	....	53,000	188,000
4. Siskiyou Electric Power Co. first-mortgage 6 per cent bonds dated Jan. 1, 1902; due Jan. 1, 1922; interest payable Jan. and July 1.	Not callable....	Sinking fund of 5 per cent, commencing in 1908.	....do....	....do....	200,000	1908	....	....	[f] 200,000	200,000
						1909	....	....	196,000	196,000
						1910	....	....	182,000	182,000
						1911-1920	....	....	135,000	135,000

TABLE 187.—*Bonds of The California Oregon Power Co.*—Continued.

Issue. 1	Callable. 2	Sinking-fund deposits. 3	Trustee. 4	Bond denomination. 5	Authorized. 6	Year (Dec. 31). 7	Reserved for prior liens. 8	In sinking fund. 9	In hands of public. 10	Total authenticated. 11
5. Rogue River Electric Co. first-mortgage 5 per cent bonds dated July 1, 1907; due July 1, 1937; interest payable Jan. and July 1.	Callable at 105 and interest.	Not less than $7,000 per annum beginning July 1, 1909.	Guaranty Trust Co. (New York).	$1,000 and $500 coupons.[b]	$700,000	1908			$557,000	$557,000
						1909			551,000	551,000
						1910			544,000	544,000
						1911			680,000	680,000
						1912			680,000	680,000
						1913			667,000	667,000
						1914			660,000	660,000
						1915			660,000	660,000
						1916			646,000	646,000
						1917			639,000	639,000
						1918			632,000	632,000
						1919			632,000	632,000
						1920			618,000	618,000
6. Klamath Power Co. first-mortgage 6 per cent bonds dated Apr. 1, 1911; due Apr. 1, 1931; interest payable June and Dec. 1.	Callable at 105 on any interest date.	Annual sinking fund beginning June 1, 1916, $10,500 and increasing to $52,750 June 1, 1926; thereafter without change until June 1, 1930.	Security Savings & Trust Co. (Portland, Oreg.).	$1,000 coupon[b].	500,000	1911			[e] 402,000	402,000
						1912			345,000	345,000
						1918–1920			345,000	345,000

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[a] Sold to syndicate which will take entire issue by Oct. 1, 1921.

[b] Principal may be registered.

[c] On the execution of this mortgage the $2,082,000 in bonds shown in column 8 were delivered to the trustee to be exchanged for underlying issues. Amounts outstanding under these issues on date of mortgage (Jan. 1, 1912) were:

Siskiyou Electric Power & Light Co. first and refunding 5 per cent bonds	$865,000
Siskiyou Electric Power Co. first 6 per cent bonds	135,000
Rogue River Electric Co. first 5 per cent bonds	680,000
Klamath Power Co. first 6 per cent bonds	402,000
	2,082,000

[d] Includes $1,229,000 deposited under contract; does not bear interest.

[e] Decrease in amounts outstanding is due to exchange of bonds for those of California-Oregon Power Co.

[f] Decrease in amounts outstanding is due to exchange of bonds for those of Siskiyou Electric Power & Light Co. and California-Oregon Power Co.

TABLE 188.—*Comparative balance sheet, The California Oregon Power Co., 1913–1920.*

	1913	1914	1915	1916
ASSETS.				
Total fixed capital	$15,811,842	$15,947,780	$15,992,452	$16,293,082
Cash and deposits:				
Cash	a 48,233	a 8,621	32,573	4,661
Notes receivable	1,443	1,685	2,895	1,426
Accounts receivable:				
Warrants				2,706
Due from consumers and agents	54,524	70,244	60,925	65,449
Miscellaneous accounts receivable	6,154	7,121	25,964	14,601
Total accounts receivable	60,678	77,365	86,889	80,050
Other current assets	15,099	3,269		
Investments in securities of other corporations	87,329	91,502	80,000	
Materials and supplies	27,644	32,375	23,914	66,078
Treasury securities			3,066	1,717,000
Prepaid expense:				
Prepaid taxes	2,039	2,652		100
Prepaid insurance	2,149	2,288	2,275	4,320
Other prepayments	265	162	3,519	
Total prepaid expenses	4,453	5,102	5,794	4,420
Other suspense	8,856	11,279	14,229	13,595
Construction work in progress	41,248	18,385	36,470	
Bond security deposit			b 1,193,000	1,179,000
Corporate deficit			140,439	365,586
Total assets	16,010,359	16,180,121	17,611,721	19,727,604
LIABILITIES.				
Capital stock	10,000,000	10,000,000	10,000,000	10,000,000
Funded debt	5,600,000	5,600,000	5,600,000	5,600,000
Notes payable	6,525	10,308		4,445
Accounts payable:				
Audited vouchers and wages unpaid	37,397	19,323	11,381	39,804
Consumers' deposits	14,502	20,691	3,326	4,109
Miscellaneous accounts payable	271,507	441,098	245,508	33,811
Total accounts payable	323,406	481,112	260,215	77,724
Interest accrued	3,981	2,216	202,467	443,566
Taxes accrued	8,654	13,004	13,666	16,209
Service billed in advance	37,359	30,323	37,747	58,501
Reserve for accrued depreciation	7,813	17,122	181,945	344,608
Casualty and insurance reserves				2,905
Other reserves from income or surplus	353	315	2,601	1,818
Underlying bonds			1,193,000	1,179,000
Insurance accrued				601
Assessment			120,080	289,740
Capital surplus (not available for distribution) adjustment to par value of capital stock purchased at delinquent sales				1,708,487
Corporate surplus unappropriated	22,268	25,721		
Total liabilities	16,010,359	16,180,121	17,611,721	19,727,604

	1917	1918	1919	1920
ASSETS.				
Total fixed capital	$16,462,769	$17,360,302	$17,467,793	$17,607,686
Cash and deposits:				
Cash	a 11,642	25,053	a 8,534	22.224
Special deposits		3,654		
Total cash and deposits	a 11,642	28,707	a 8,534	22,224
Notes receivable	1,393	1,148		
Accounts receivable:				
Warrants	623	2,433		
Due from consumers and agents	81,220	99,858	73,757	151,467
Miscellaneous accounts receivable	305,649	99,099	77,402	251,475
Total accounts receivable	387,492	201,390	151,159	402,942
Investments, miscellaneous			211,383	171,887
Materials and supplies	53,370	72,504	103,641	162,594
Treasury securities	1,717,000	1,717,000	1,717,000	1,717,000

a Credit item. b Bonds deposited to secure underlying bonds.

Table 188.—*Comparative balance sheet, The California Oregon Power Co., 1918–1920*—Continued.

	1917	1918	1919	1920
Prepaid expense:				
Prepaid rents	....	....	....	$167
Prepaid taxes	$100	$100	$150	150
Prepaid insurance	3,882	5,756	5,661	6,113
Other prepayments	....	162	....	....
Total prepaid expenses	3,982	6,018	5,811	6,429
Other suspense	2,720	12,827	7,539	33,706
Construction work in progress	....	....	....	136,432
Bond security deposits	1,172,000	1,165,000	1,165,000	1,151,000
Corporate deficit	589,230	759,128	801,238	762,453
Total assets	20,378,314	21,324,024	21,622,030	22,174,353
LIABILITIES.				
Capital stock	10,000,000	10,000,000	10,000,000	10,000,000
Funded debt	5,600,000	5,600,000	5,600,000	5,593,000
Notes payable	....	15,921	16,753	283,264
Accounts payable:				
Audited vouchers and wages unpaid	46,397	97,830	52,472	230,730
Consumers' deposits	5,248	5,627	7,627	11,206
Miscellaneous accounts payable	8,515	566,279	615,351	381,837
Total accounts payable	60,161	669,736	675,451	623,773
Interest accrued	664,742	894,850	1,108,321	1,410,253
Taxes accrued	19,476	20,778	21,477	29,136
Service billed in advance	61,968	51,430	35,326	32,207
Reserve for accrued depreciation	541,398	645,214	742,885	792,837
Casualty and insurance reserves	4,550	2,294	5,298	594
Other reserves from income or surplus	6,566	9,662	4,341	11,573
Underlying bonds	1,172,000	1,165,000	1,165,000	1,151,000
Insurance accrued	737	2,422	462	....
Assessment	538,230	538,230	583,230	538,230
Capital surplus (not available for distribution) adjustment to par value of capital stock purchased at delinquent sales	1,708,487	1,708,487	1,708,487	1,708,487
Total liabilities	20,378,314	21,324,024	21,622,030	22,174,353

Table 189.—*Earnings and expenses of The California Oregon Power Co., 1913–1920.*

	1913	1914	1915	1916
Electric operations:				
Operating revenues	$308,784	$343,655	$355,854	$388,298
Operating expenses	141,921	149,517	319,318	295,780
Net operating electric revenue	166,863	194,138	36,536	92,518
Water operations:				
Operating revenues	33,439	35,759	36,497	36,803
Operating expenses	6,279	9,961	13,088	24,106
Net operating water revenue	27,160	25,798	23,409	12,697
Total net operating revenue	194,023	219,936	59,945	105,215
Add:				
Nonoperating revenues—				
Rents from buildings, lands, etc., water	....	501	....	....
Miscellaneous rent revenues, electric	....	....	424	395
Miscellaneous interest revenue	1,391	1,225	320	610
Profits from operations of others	3,630	4,173	5,255	....
Miscellaneous nonoperating revenues	17	18	....	....
Total nonoperating revenues	5,038	5,917	5,999	1,005
Gross corporate income	199,061	225,853	65,944	106,220
Deduct:				
Uncollectible bills	3,360	3,731	3,897	4,221
Interest accrued on funded debt	181,561	203,516	213,064	284,800
Other interest deductions	....	1,286	681	404
Rent for lease of other electric plant	933	....	....	....
Contractual deductions from income	....	9,310	....	....
Total deductions	185,854	217,843	217,642	289,425
Balance of year carried to corporate surplus or deficit account	13,208	8,010	[a] 151,698	[a] 183,205

[a] Deficit.

TABLE 189.—*Earnings and expenses of The California Oregon Power Co., 1913–1920*—Continued.

	1917	1918	1919	1920
Electric operations:				
Operating revenues	$447,995	$460,698	$682,713	$896,395
Operating expenses	396,319	340,927	415,747	481,073
Net operating electric revenue	51,676	119,771	266,966	415,322
Water operations:				
Operating revenues	38,006	38,280	41,706	47,012
Operating expenses	25,038	29,321	36,409	53,202
Net operating water revenue	12,948	8,959	5,297	a 6,191
Total net operating revenues	64,624	128,730	272,263	409,131
Add:				
Nonoperating revenues—				
Rents from buildings, lands, etc., water	....	....	548	....
Miscellaneous rent revenues, electric	395	978	623	1,680
Miscellaneous interest revenue	1,520	2,312	489	3,190
Profits from operations of others	....	....	....	....
Miscellaneous nonoperating revenues	....	....	....	....
Total nonoperating revenues	1,915	3,290	1,660	4,870
Gross corporate income	66,539	132,020	273,923	414,001
Deduct:				
Uncollectible bills	4,817	4,902	6,019	7,052
Miscellaneous nonoperating expense	....	....	....	12
Interest accrued on funded debt	284,800	284,800	284,800	364,028
Other interest deductions	3,297	13,675	23,943	29,994
Rent for lease of other electric plant	....	....	....	....
Miscellaneous deductions from income	....	....	....	....
Contractural deductions from income	....	....	....	....
Total deductions	292,914	303,377	314,762	401,085
Balance of year carried to corporate surplus or deficit account	a 226,375	a 171,357	a 40,838	12,916

a Deficit.

TABLE 190.—*Classified electric revenues of The California Oregon Power Co., 1913–1920.*

Class of load.	1913		1914		1915	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc and incandescent	$20,252	6.5	$21,989	6.4	$21,092	5.9
Miscellaneous	....	....	....	....	778	.2
Municipal power	....	....	....	....	3,437	.9
Commercial lighting—						
Flat rate	94,455	30.6	108,914	31.7	88,307	24.8
Metered	92,105	29.7	94,397	27.5	92,290	25.9
Commercial power—						
Flat rate	31,448	10.4	25,994	7.5	54,144	15.4
Metered	61,270	19.8	80,976	23.6	87,853	24.7
Railway power	....	....	....	....	916	.3
Other electrical corporations	3,712	1.2	5,133	1.5	3,988	1.1
Miscellaneous electric revenue	....	....	....	....	29	....
Total operating revenue, electric	303,242	98.2	337,403	98.2	352,834	99.2
Electric merchandise and jobbing revenues	5,542	1.8	6,252	1.8	3,019	.8
Gross electric revenues	308,784	100	343,655	100	355,853	100

TABLE 190.—*Classified electric revenues of The California Oregon Power Co., 1913–1920*—Continued.

Class of load.	1916		1917		1918	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc and incandescent	$19,236	4.9	$20,051	4.5	$20,900	4.6
Miscellaneous	1,052	.3	741	.2	639	.1
Municipal power	5,209	1.3	4,835	1.1	4,204	.9
Commercial lighting—						
Flat rate	86,061	22.2	87,196	19.5	80,202	17.4
Metered	94,639	24.4	106,201	23.7	118,387	25.7
Commercial power—						
Flat rate	61,576	15.9	65,238	14.6	30,342	6.6
Metered	103,511	26.7	147,018	32.7	157,913	34.2
Railway power	1,321	.3	1,365	.3	1,296	.3
Other electrical corporations	12,671	3.3	11,153	2.5	9,503	2.1
Miscellaneous electric revenue	57				34,072	7.4
Total operating revenue, electric	385,334	99.3	443,798	99.1	457,458	99.3
Electric merchandise and jobbing revenues	2,965	.7	4,198	.9	3,240	.7
Gross electric revenues	388,299	100	447,996	100	460,698	100

Class of load.	1919		1920	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:				
Municipal street lighting—				
Arc and incandescent	$20,839	3.1	$21,031	2.3
Miscellaneous	638		602	
Municipal power	4,833	.7	4,169	.5
Commercial lighting—				
Flat rate	71,690	10.5	22,134	2.5
Metered	151,292	22.2	253,953	28.3
Commercial power—				
Flat rate	21,758	3.2	16,562	1.9
Metered	342,093	50.1	269,494	30.1
Railway power	1,215	.2	110	
Other electrical corporations	8,216	1.2	243,465	27.2
Miscellaneous electric revenue	54,248	7.9	60,192	6.7
Total operating revenue, electric	676,822	99.1	891,714	99.5
Electric merchandise and jobbing revenues	5,892	.9	4,681	.5
Gross electric revenues	682,714	100	896,395	100

FINANCIAL TABLES FOR PACIFIC GAS & ELECTRIC CO. AND PRINCIPAL SUBSIDIARIES.

Pacific Gas & Electric Co. acquired stock control of Northern California Power Co. Consolidated August 28, 1919, and purchased its properties October 3, 1919. Northern California properties were merged with Pacific Gas & Electric system upon their acquisition. Financial data for Northern California Co. will be found in Tables 201 to 205, inclusive. Financial data for Sierra & San Francisco Power Co., operated under a 15-year lease effective January 1, 1920, as well as for Coast Valleys Gas & Electric Co., Yosemite Power Co., and other systems owned or operated by the same interests as Sierra & San Francisco Power Co. but not leased to Pacific Gas & Electric Co., will be found in Tables 206 to 215, inclusive.

TABLE 191.—*Capitalization, outstanding stock, and dividends of Pacific Gas & Electric Co. and principal subsidiaries.*

[Term of incorporation uniformly 50 years. Unless otherwise stated in footnotes, par value of all stock is $100.]

Pacific Gas & Electric Co., San Francisco.

Company.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.			Dividends.[a]		
			First preferred.	Preferred.	Common.	On first preferred stock.	On preferred stock.	On common stock.
Pacific Gas & Electric Co., San Francisco, incorporated Oct. 10, 1905.	[b]$160,000,000	1905	....	$9,979,000	$20,000,000	....	....	....
		1906	....	9,979,000	20,000,000	....	$149,659.50	....
		1907	....	9,979,000	20,000,000	....	(c)	....
		1908	....	9,979,000	20,000,000	....	....	....
		1909	....	10,000,000	20,000,000	....	150,000.00	....
		1910	....	10,000,000	20,000,000	....	600,000.00	....
		1911	....	10,000,000	28,938,750	....	600,000.00	....
		1912	....	10,000,000	31,998,750	....	600,000.00	$1,520,434.88
		1913	....	10,000,000	[d] 32,109,300	....	600,000.00	398,848.00
		1914	$2,973,700	10,000,000	[d] 32,109,300	$14,983.37	600,000.00	....
		1915	12,206,200	10,000,000	[d] 34,035,858	400,716.70	600,000.00	1,930,073.60
		1916	23,467,430	302,800	[d] 34,035,858	1,374,637.73	....	1,708,168.29
		1917	24,721,992	76,300	[d] 34,004,058	1,471,105.00	....	1,281,372.00
		1918	24,881,305	75,800	[d] 34,004,058	1,490,463.23	....	....
		1919	29,976,780	72,800	[d] 34,004,058	1,528,961.46	....	1,708,094.60
		1920	33,628,230	56,800	[d] 34,004,058	1,777,933.03	....	1,700,845.85

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[a] The rate of dividends on preferred stock was 6 per cent, that on first preferred stock was 1½ per cent in 1914 and 6 per cent in other years. The rate of dividend paid on common stock was 5 per cent in 1912, 1¼ per cent in 1913, 6 per cent stock dividend in 1915, 5 per cent in 1916, and 3¾ per cent in 1917.

[b] Capitalized at $30,000,000, divided into $10,000,000 preferred and $20,000,000 common stock. Oct. 23, 1911, common stock was increased to $150,000,000; June 30, 1914, common stock was reduced *to* $100,000,000 and an issue *of* $50,000,000 first preferred stock was created.

[c] No dividends paid; assessment of $1,000,000 levied.

[d] $31,696,866.66 shares owned by subsidiary companies, making the total par value of stock outstanding $65,700,924.66.

TABLE 191.—*Capitalization, outstanding stock, and dividends of Pacific Gas & Electric Co. and principal subsidiaries*—Continued.

Subsidiary companies.[e]

Company.	Date of incorporation.	Capitalization.	Years (Dec. 31).	Stock outstanding (par value).	Dividends.	
					Rate.	Amount.[f]
					Per cent.	
California Gas & Electric Corporation, San Francisco	Dec. 6, 1901	[g] $50,000,000	1906–7	$15,000,000	...	...
			1908–1912	45,000,000	...	...
San Francisco Gas & Electric Co	Dec. 11, 1896	20,000,000	1905	15,848,433	5	$792,421.68
			1906	15,848,433	.428	226,315.63
			1907–1912	15,848,433	...	...
			1913	15,848,433	...	...
Bay Counties Power Co., San Francisco	June 4, 1900	5,000,000	1900	3,000,000	...	...
			1901	3,529,025	...	...
			1902–1913	3,600,000	...	...
Nevada County Electric Power Co., Grass Valley, Calif	Sept. 22, 1892	500,000	1900–1912	[h] 500,000	...	...
Yuba Electric Power Co., San Francisco	Jan. 30, 1899	1,000,000	1900–1912	1,000,000	...	...
Valley Counties Power Co., San Francisco	Jan. 25, 1902	2,500,000	1902–1913	2,500,000	...	...
Butte County Electric Power & Lighting Co., San Francisco	Apr. 12, 1899	500,000	1900–1909	5,000,000	...	...
Sacramento Electric Gas & Ry. Co	Apr. 4, 1896	2,500,000	1900	1,858,400	...	...
			1901	1,858,400	1.80	33,322.20
			1902	1,858,400	1.80	36,191.40
			1903	1,858,400	.60	11,150.40
			1904–1912	1,858,400	...	...
			1913	1,858,400	...	...
Central Electric Ry. Co., Sacramento, Calif. [i]	Apr. 20, 1891	500,000	1900–1913	...	...	...
Oakland Gas, Light & Heat Co. [i]	July 18, 1884	3,000,000	1900–1902	3,000,000	3.00	90,000.00
			1903	3,000,000	9.45	283,500.00
			1904–1913	3,000,000	...	...
Oakland Equitable Gas Co., San Francisco [i]	Jan. 13, 1899	1,500,000	1900–1908	[k] 1,043,600	...	...
Berkeley Electric Lighting Co	June 6, 1894	100,000	1900–1903	[k] 98,040	.24	2,352.96
			1904	[k] 98,040	.06	588.24
			1905–1913	[k] 98,040	...	...
California Central Gas & Electric Co., San Francisco	Mar. 25, 1901	1,500,000	1901	1,500,000	...	...
			1902	1,500,000	1.05	15,750.00
			1903–1912	1,500,000	.45	6,750.00
Fresno Gas & Electric Light Co. [i]	Dec. 14, 1888	500,000	1900	489,800	...	...
			1901	489,800	1.2	5,877.60
			1902	489,800	1.6	7,836.80
			1903	489,800	2.1	10,285.80
			1904–1908	489,800	...	...
Chico Gas & Electric Co., San Francisco [i]	Jan. 30, 1901	100,000	1901–1908	100,000	...	...
Colusa Gas & Electric Co., San Francisco [i]	July 31, 1901	100,000	1901–1908	100,000	...	...
Marysville Gas & Electric Co., Marysville, Calif., changed to San Francisco, 1904 [i]	Nov. 12, 1895	500,000	1900	100,000	2.50	2,500.00
			1901	100,000	6.00	6,000.00
			1902–1908	100,000	...	...

Napa Gas & Electric Co., San Francisco[i]	July 8, 1899	100,000	1900-1908	75,000		
Nevada County Gas & Electric Co., San Francisco [i]	May 28, 1901	100,000	1901-1908	500		
Petaluma Gas & Electric Co., Petaluma, Calif., changed to San Francisco Aug. 5, 1908 [i]	Apr. 15, 1899	300,000	1900-1908	140,000		
San Rafael Gas & Electric Light Co.[i]	Dec. 8, 1887	200,000	1900	162,700	4.8	7,809.60
			1901	162,700	3.2	5,206.40
			1902-1908	162,700		
Santa Rosa Lighting Co., San Francisco [i]	Sept. 15, 1888	100,000	1900-1908	100,000		
Woodland Gas & Electric Co., Woodland [i]	Jan. 15, 1901	100,000	1901-1908	100,000		
Vallejo Gas Co., San Francisco.[i]	Oct. 20, 1904	100,000	1904-1908	100,000		
The Standard Electric Co. of California, San Francisco [i]	Nov. 27, 1897	5,000,000	1900-1913	5,000,000		
Blue Lakes Water Co., Oakland	Apr. 17, 1890	10,000,000	1900-1912	10,000,000		
			1913	10,000,000		
Stockton Water Co.[i]	Oct. 25, 1890	500,000	1900-1913	500,000		
United Gas & Electric Co., San Francisco	Apr. 19, 1902	2,500,000	1902	2,228,600	.75	16,711.50
			1903	2,228,600	1.8	40,114.80
			1904	2,228,600	.3	6,685.80
			1905-1913	2,228,600		
San Mateo Power Co., San Francisco [i]	Jan. 26, 1905	1,000,000	1905-1913	1,000,000		
South Yuba Water Co., formerly South Yuba Water & Mining Co., New York City, N. Y.[i]	Apr. 1, 1880	2,000,000	1900-1904	[l]2,000,000		No records.
			1905	[l]2,000,000	6.25	250,000.00
			1906-1911	[l]2,000,000		
			1912	(m)		
Central California Electric Co., New York City, N. Y.[i]	June 13, 1895	100,000	1900-1910	10,000		
			1911	Dissolved.		
Edison Light & Power Co., San Francisco	July 1, 1891	3,000,000				
San Francisco Gas Light Co	Mar. 17, 1873	[n]300,000	1900	300,000	12	36,000.00
			1901	300,000	12	36,000.00
			1902	300,000	80	240,000.00
			1903			
Pacific Gas Improvement Co., San Francisco	Oct. 1, 1884	5,000,000	1900-02	3,500,000	Not known.	Books lost in fire 1906.
			1903-12	3,500,000		
Suburban Light & Power Co., San Leandro [j]	Mar. 11, 1908	[o]269,395	1908-13			
Mutual Electric Light Co., San Francisco	Dec. 15, 1894	500,000	1911-12	(k)		
			1913	500,000		
Metropolitan Gas Corporation, San Francisco [j]	Nov. 18, 1911	1,500,000	1911-13			
Livermore Water & Power Co., Oakland[j]	June 9, 1896	200,000	1912-13			

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[e] Companies are arranged in order indicated by the historical chart, Table 15, p. 106.

[f] Blanks in this column indicate that no dividends were paid.

[g] Originally capitalized at $30,000,000; diminished to $15,000,000 Dec. 11, 1902; increased to $50,000,000 Jan. 24, 1908.

[h] Par value of shares $5.

[i] Charter forfeited for nonpayment of State corporation license tax.

[j] Corporate powers not acquired by Pacific Gas & Electric Co.; only properties purchased.

[k] Par value of shares $10.

[l] Par value of shares $50.

[m] Dissolved Feb. 5, 1912.

[n] Capitalized at $10,000,000, with shares $100 par value; decreased to $300,000, with shares at par value of $3, Nov. 11, 1896. Inoperative since 1897. Most of stock canceled, leaving only a few shares outstanding from time to time. Disincorporated Dec. 7, 1903.

[o] Incorporated at $1,000,000, with par value of shares $10; par value of shares reduced to $5 and capitalization to $269,395, Jan. 25, 1911.

TABLE 191.—*Capitalization, outstanding stock, and dividends of Pacific Gas & Electric Co. and principal subsidiaries*—Continued.

Oro Electric Corporation.[p]

Company.	Year (Dec. 31).	Par value of stock outstanding.		Dividends.	
		First preferred.	Common.	On first preferred stock.	On common stock.
Oro Electric Corporation, San Francisco[j]	1911	$3,500,000	$6,500,000	See 1912	...
	1912	3,500,000	6,500,000	[q]$227,500	...
	1913	3,500,000	6,500,000	87,500	...
	1914	3,500,000	6,500,000	...	...
	1915	3,500,000	6,500,000	...	...
	1916	[r] 3,500,000	[s]6,500,000	...	...
Oro Development Co., San Francisco[j]	1911	...	1,000,000	...	...
	1916	...	...	...	...
Oro Water, Light & Power Co., San Francisco (entire outstanding capital stock owned by Oro Electric Corporation)[j]	1905	...	3,500,000	...	...
	1906	...	...	...	$125,891
	1907	...	...	...	179,844
	1908	...	...	...	179,844
	1909	...	...	...	179,844
	1910	...	...	...	189,072
	1911	...	...	...	196,250
	1912	...	...	...	300,625
	1913	...	...	...	...
	1914	...	...	...	...
	1915	...	...	...	...
	1916	...	...	...	...

[j] Corporate powers not acquired by Pacific Gas & Electric Co.; only properties purchased.

[p] No statement could be obtained from Oro Electric Corporation giving stock outstanding and dividends. The figures given for stock outstanding and dividends for the Oro Electric Corporation, Oro Development Co., and Oro Water, Light & Power Co. are the result of a comparative study of data published in all financial manuals available. The figures for 1912 and 1913 are from the records of the California State Railroad Commission.

[q] Fourteen months ending Dec. 31, 1912.

[r] $650,000 owned by Oro Water, Light & Power Co.

[s] $1,300,000 owned by Oro Water, Light & Power Co.

NOTE.—Table does not include Northern California Power Co. Consolidated, which became part of the system in September, 1919.

TABLE 192.—*Bonds of Pacific Gas & Electric Co. and principal subsidiaries.*

Issue.	Callable or convertible.	Sinking-fund deposits.	Trustee.	Denomination.	Authorized.
1	2	3	4	5	6
1. Pacific Gas & Electric Co. general and refunding mortgage 5 per cent bonds dated Dec. 1, 1911; due Jan. 1, 1912; interest payable July 1 and Jan. 1.	Jan. 1, 1937, at par and accrued interest; prior thereto on any interest date at $105 and interest in blocks of not less than $500,000; may be exchanged for retirement of underlying issues.	Sinking-fund deposits. 1 per cent per annum of face value of all underlying bonds and bonds of this issue.	Bankers' Trust Co., New York, and O. E. Ellinghouse, San Francisco.	$1,000, $500, $100, coupon; $1,000, $5,000, $10,000, registered.	$150,000,000
2. Pacific Gas & Electric Co. general mortgage and collateral trust 5 per cent bonds dated Jan. 2, 1906; due Jan. 2, 1936; interest payable July 2 and Jan. 2.	At 105 and interest	Sinking fund to be applied to purchase and cancellation of bonds of this issue; deposits began December, 1906.	Union Trust Co., San Francisco.	$1,000 coupon and registered.	10,350,000
3. Pacific Gas & Electric Co. general debenture mortgage 6 per cent bonds dated Dec. 15, 1905; due serially, $100,000 per year for 10 years and $500,000 in 11th year.	....	....	Trust Co. of America, New York.	....	4,500,000
4. Pacific Gas & Electric Co. debenture mortgage 6 per cent bonds dated Dec. 15, 1907; due Dec. 15, 1937; interest payable June 15 and Dec. 15.	At par and interest	$125,000 annually, Mar. 1, 1918, to 1927, inclusive; $250,000 annually, 1928 to 1937, inclusive.	....do	$100 and $1,000 coupon; principal may be registered.	
5. Pacific Gas & Electric Co. general lien 6 per cent bonds dated July 1, 1913; due July 1, 1923.	At 101 and interest	....	Guarantee Trust Co. and William C. Cox, New York.	....	5,000,000
6. California Gas & Electric Corporation's unifying and refunding 5 per cent bonds dated Nov. 1, 1907; due Nov. 1, 1937.	As a whole after Nov. 1, 1912, at $110 and interest on 60 days' notice only after retirement of issue No. 2; or by lot for sinking fund at 110. Could be exchanged for and used to retire underlying issues prior to Jan. 2, 1912, when mortgage was closed.	$150,000 per annum, 1912 to 1916[a]; $550,000 per annum, 1917 to 1921[a]; $700,000 per annum, 1922 to 1926[a]; $900,000 per annum, 1927 to 1936.[a]	Union Trust Co., San Francisco.	$1,000 coupon; principal may be registered; $1,000 and $10,000 registered.	45,000,000

[a] Payments to be applied first to redemption of bonds for sinking funds of all the underlying issues; balance to be applied to purchase of bonds of this issue. Bonds kept alive.

TABLE 192.—*Bonds of Pacific Gas & Electric Co. and principal subsidiaries*—Continued.

Issue. 1	Callable or convertible. 2	Sinking-fund deposits. 3	Trustee. 4	Denomination. 5	Authorized. 6
7. California Gas & Electric Corporation general mortgage collateral trust 5 per cent bonds dated Mar. 1, 1903; due Mar. 1, 1933; interest payable Mar. 1 and Sept. 1.	On any interest date at 110, on 4 weeks' notice.	The following amounts payable into fund Mar. 1, of each year: 1904–1908, $150,000; 1909–1913, $200,000; 1914–1918, $250,000; 1919–1923, $300,000; 1924–1928, $350,000; 1929–1933, $400,000.[b]	Mercantile Trust Co., San Francisco.	$1,000 coupon; principal may be registered.	$10,000,000
8. Bay Counties Power Co. first consolidated mortgage 5 per cent bonds dated Sept. 1, 1900; due Sept. 1, 1930; interest payable Mar. 1 and Sept. 1.	Not callable. May be issued to retire outstanding bonds of Nos. 9 and 10.	Annual payments, June 1, in percentage of total issue outstanding, as follows: 1905–1909, 1 per cent; 1910–1914, 1½ per cent; 1915–1919, 2 per cent; 1920–1924, 2½ per cent; 1925–1929, 3 per cent.	....do..............	$1,000 coupon........	2,250,000
9. Bay Counties Power Co. second mortgage 6 per cent bonds dated Apr. 1, 1901; due Apr. 1, 1931; interest payable Apr. 1 and Oct. 1.	Any time at 105..............	None............................	Union Trust Co., San Francisco.	.....do..............	750,000
10. Nevada County Electric Power Co. 6 per cent bonds dated Oct. 1, 1898; due Oct. 1, 1928; interest payable Apr. 1 and Oct. 1.	Not callable.................	.....do..........................	....do..............	.......do............	300,000
11. Yuba Electric Power Co. 6 per cent bonds dated June 1, 1899; due June 1, 1929; interest payable June 1 and Dec. 1.	.....do......................	.....do..........................	Mercantile Trust Co., San Francisco.	.....do.............	1,000,000
12. Valley Counties Power Co. first mortgage 5 per cent bonds dated May 1, 1902; due May 1, 1930; interest payable May 1 and Nov. 1.	.....do......................	Annual payments (Nov. 1 to Oct. 31), expressed in percentage of bonds outstanding, as follows: 1905–1909, 1 per cent; 1910–1914, 1½ per cent; 1915–1919, 2 per cent; 1920–1924, 2½ per cent; 1925–1929, 3 per cent.	....do.............	$1,000 coupon; may be registered.	2,500,000
13. California Central Gas & Electric Co. 5 per cent bonds dated Aug. 1, 1901; due Aug. 1, 1931; interest payable Feb. 1 and Aug. 1.	.....do......................	2 per cent of bonds outstanding, deposits beginning Aug. 1, 1902.	....do..............	$1,000 coupon.........	1,000,000

14. Oakland Gas, Light & Heat Co. 5 per cent bonds dated Mar. 16, 1891; due Mar. 16, 1916; interest payable Mar. 16 and Sept. 16.	do	None	California Safe Deposit & Trust Co., San Francisco.	do	1,000,000
15. Berkeley Electric Light Co. 6 per cent bonds dated July 1, 1896; due July 1, 1921; interest payable Jan. 1 and July 1.			do		30,000
16. Sacramento Electric Gas & Ry. Co. 5 per cent bonds dated Nov. 1, 1897; due Nov. 1, 1927; interest payable May 1 and Nov. 1.	For sinking fund at 103 and interest. May be issued to retire outstanding bonds of issue No. 17.	Annual payments (Nov. 1) as follows: 1902–1906, $5,000; 1907–1911, $10,000; 1912–1916, $20,000; 1917–1921, $30,000; 1922–1926, $40,000; 1927 to be paid off at 103.	Mercantile Trust Co., San Francisco.	$1,000 coupon	2,500,000
17. Central Electric Railway Co. 6 per cent bonds dated June 1, 1892; due serially 1912–1922; interest payable June 1 and Dec. 1.		6 per cent of par value of all bonds issued in excess of $250,000 to be paid to trustee annually after June 1, 1912, for redemption of bond at rate not to exceed 105.	do	$500 and $1,000 coupon; serial.	400,000
18. The Standard Electric Co. of California 5 per cent bonds dated Sept. 1, 1899, due Sept. 1, 1939; interest payable Mar. 1 and Sept. 1.		None	do	$1,000	5,000,000
19. Blue Lakes Water Co. 6 per cent bonds dated Mar. 1, 1893; supplement dated Apr. 24, 1905; due Mar. 15, 1938; interest payable Mar. 15 and Sept. 15.	Not callable	do	do	$1,000 coupon and registered.	5,000,000
20. Stockton Water Co. 6 per cent bonds dated Apr. 1, 1891; due Apr. 1, 1911; interest payable Apr. 1 and Oct. 1.	Callable; 105 and interest	15 per cent per annum of gross water rates.	Illinois Trust & Savings Bank, Chicago.	$1,000 coupon	500,000
21. United Gas & Electric Co. 5 per cent bonds dated July 1, 1902; due July 1, 1932; interest payable Jan. 1 and July 1.	Not callable	Annual payments (July 1) in percentage of total issued as follows: 1907–1911, 2 per cent; 1912–1916, 3 per cent; 1917–1921, 4 per cent; 1922–1926, 5 per cent; thereafter 6 per cent of bonds outstanding.	Mercantile Trust Co., San Francisco.	$1,000 coupon; may be registered.	2,000,000
22. South Yuba Water & Mining Co. first mortgage 6 per cent bonds dated Apr. 1, 1890; due Apr. 1, 1910; interest payable Apr. 1 and Oct. 1.	On any interest date at 110	Cumulative from Apr. 1, 1890; 2 per cent of total issued payable Oct. 1 and Apr. 1 each year.	Holland Trust Co., New York.	$1,000 coupon	550,000

[b] Payments to be applied first to redemption of bonds for sinking fund of Bay Counties Power Co., California Central Gas & Electric Co., Oakland Gas, Light, & Heat Co., Sacramento Electric, Gas & Railway Co., Fresno Gas & Electric Light Co., and Valley Counties Power Co.; remainder to be applied to creation of a sinking fund for issue No. 7.

TABLE 192.—*Bonds of Pacific Gas & Electric Co. and principal subsidiaries*—Continued.

Issue.	Callable or convertible.	Sinking-fund deposits.	Trustee.	Denomination.	Authorized.
1	2	3	4	5	6
23. South Yuba Water Co. consolidated 6 per cent bonds dated July 1, 1893; due July 1, 1923; interest payable Jan. 1 and July 1.	On any interest date at 110	None	Farmers Loan & Trust Co., New York.	$1,000 coupon	$1,500,000
24. Central California Electric Co. 5 per cent bonds dated May 1, 1903; due May 1, 1933; interest payable May 1 and Nov. 1.	do	do	Van Norden Trust Co., New York.	do	5,000,000
25. Suburban Light & Power Co. first gold 6 per cent bonds dated Aug. 1, 1908; due Aug. 1, 1938; interest payable Feb. 1 and Aug. 1.	Not callable	None	Oakland Bank of Savings, Oakland.	$500 coupon; principal may be registered.	250,000
26. Mutual Electric Light Co. 5 per cent bonds dated June 1, 1904; due June 1, 1934; interest payable June 1 and Dec. 1.	On any interest date at 110	2½ per cent per annum of bonds issued and outstanding after June 1, 1909.	Mercantile Trust Co., San Francisco.	$1,000 coupon	400,000
27. Metropolitan Gas Corporation 5 per cent bonds dated Nov. 25, 1911; due Dec. 1, 1941; interest payable June 1 and Dec. 1.	At par on any interest date	$25,000 per annum	do	$500 coupon; principal may be registered.	1,368,000
28. Livermore Water Power Co. 6 per cent bonds dated Sept. 1, 1897; due Sept. 1, 1922; interest payable Mar. 1 and Sept. 1.	Not callable	None	Union Trust Co., San Francisco.	$500 coupon	100,000
29. San Francisco Gas & Electric Co. general 4½ per cent bonds dated Nov. 1, 1903; due Nov. 1, 1933; interest payable May 1 and Nov. 1.	On any interest date at 105	Annual sinking fund of $105,000 beginning Nov. 1, 1906, to be used only in retiring bonds numbered 1 to 4,000, inclusive, at 105 and accrued interest. Bonds for sinking fund drawn by lot by board of directors on or before Sept. 1 of each year.	do	$1,000 coupon; principal may be registered.	10,000,000

30. Edison Light & Power Co. 6 per cent bonds dated Nov. 3, 1891; due Nov. 3, 1921; interest payable Feb. 3, May 3, Aug. 3, and Nov. 3.	Not callable.	Deposits to begin Nov. 3, 1901; first 5 years 4 per cent; next 5 years 6 per cent; and next 5 years 8 per cent of bonds outstanding; amounts to be paid annually from net income.	California Safe Deposit & Trust Co., San Francisco.	$1,000	800,000
31. Pacific Gas Improvement Co. 4 per cent bonds, dated Sept. 1, 1910; due Sept. 1, 1930; interest payable Mar. 1, June 1, Sept. 1, and Dec. 1.	By lot at option of company in eleventh year at 110, twelfth year at 109.50, and so on down to thirtieth year at 100.50.	$20,000 annually	Union Trust Co., San Francisco.	$1,000	1,250,000
32. Oro Electric Corporation first mortgage 6 per cent bonds, dated Oct. 1, 1911; due Oct. 1, 1951; interest payable Apr. 1 and Oct. 1.	At 105 and interest	Deposits beginning Oct. 1, 1921, for 5 years, 1 per cent of face value of bonds then outstanding; 1926 to 1930, 2 per cent; 1931 to 1935, 3 per cent; 1936 to 1940, 4 per cent; 1941 to 1950, 5 per cent.	First Federal Trust Co., San Francisco.	$1,000 coupon; principal may be registered.	10,000,000
33. Oro Water, Light & Power Co. first mortgage 6 per cent bonds, dated May 1, 1905; $85,000,000 due annually, Nov. 1, 1909, 1910, and 1911; $25,000 due Nov. 1, 1912; and remainder of issue May 1, 1925; interest payable May 1 and Nov. 1.		Sinking-fund deposits begun Nov. 1, 1907; provides cash payments to retire issue as in No. 32.	Union Trust Co., San Francisco.	$1,000 coupon	750,000
34. Oroville Light & Power Co. first mortgage 6 per cent bonds, dated Feb. 1, 1902; due Feb. 1, 1927; interest payable Feb. 1 and Oct. 1.			California Safe Deposit & Trust Co., San Francisco.	$500 coupon	50,000

NOTE.—In addition to the funded debt shown in Table 192, Pacific Gas & Electric Co. had outstanding Dec. 31, 1920, $10,000,000 par value 5-year 7 per cent convertible gold notes dated May 1, 1920. The company had also authorized $10,000,000 par value 20-year first and refunding mortgage 7 per cent series A gold bonds, but none of these were issued until 1921.

TABLE 192.—*Bonds of Pacific Gas & Electric Co. and principal subsidiaries*—Continued.

Issue.	Bonded debt.							Notes.
	Year (Dec. 31).	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total authenticated.a	
			Canceled.	Alive.				
1	7	8	9	10	11	12	13	14
1. Pacific Gas and Electric Co. general and refunding mortgage 5 per cent bonds dated Dec. 1, 1911; due Jan. 1, 1942; interest payable July 1 and Jan. 1.	1912	$64,404,502	$444,000			$24,986,000	$24,986,000	
	1913	50,499,800	444,000			24,986,000	28,558,000	Includes $3,572,000 pledged as collateral.
	1914	50,179,800	444,000		$135,000	24,976,000	30,986,000	Includes $5,875,000 pledged as collateral.
	1915	48,090,800	815,000		2,025,000	28,082,000	30,982,000	From 1915 to 1920 includes $875,000 deposited on account of rate cases.
	1916	47,214,800	815,000		125,000	29,982,000	30,982,000	
	1917	46,328,800	815,000		125,000	33,042,000	34,042,000	
	1918	45,329,800	815,000		125,000	36,542,000	37,542,000	
	1919	45,329,800	815,000		125,000	36,542,000	37,542,000	
	1920	49,216,600	815.000		125,000	36,542,000	37,542,000	
2. Pacific Gas & Electric Co. general mortgage and collateral trust 5 per cent bonds dated Jan. 2, 1906; due Jan. 2, 1936; interest payable July 2 and Jan. 2.	1906					9,982,700	9,982,700	
	1907		291,000			9,717,967	9,717,967	
	1908		620,245		4,000	9,384,722	9,388,722	
	1909		937,405		17,453	9,133,495	9,150,948	
	1910		1,324,405		1,028	8,817,975	8,819,003	
	1911		1,697,490		35,092	8,457,410	8,492,502	$8,492,502 retired in 1912 under Pacific Gas & Electric Co.'s general and refunding mortgage dated Dec. 1, 1911.
	1912		1,697,490					
3. Pacific Gas & Electric Co. general debenture mortgage 6 per cent bonds dated Dec. 15, 1905; due serially, $400,000 per year for 10 years and $500,000 in 11th year.	1906					4,500,000	4,500,000	
	1907					3,969,000	3,969,000	
	1908					233,000	233,000	Refunded from.
	1909					1,000	1,000	
4. Pacific Gas & Electric Co. debenture mortgage 6 per cent bonds dated Dec. 15, 1907; due Dec. 15, 1937; interest payable June 15 and Dec. 15.	1908	233,000			116,000	3,651,000	3,767,000	
	1909	1,000			116,000	3,883,000	3,999,000	
	1910				116,000	3,884,000	4,000,000	
	1911				116,000	3,884,000	4,000,000	
	1912							$4,000,000 retired in 1912 under Pacific Gas & Electric Co.'s general and refunding mortgage, dated Dec. 1, 1911.
5. Pacific Gas & Electric Co. general lien 6 per cent bonds dated July 1, 1913; due July 1, 1923.	1913						5,000,000	Pledged as collateral and deposited under trust agreement to secure gold notes due June 25, 1914, retired in 1915. $2,000,000 unissued.
	1914						5,000,000	

6. California Gas & Electric Corporation's unifying and refunding 5 per cent bonds dated Nov. 1, 1907; due Nov. 1, 1937.	1908				6,000	10,500,000	10,506,000	
	1909				495,000	13,140,000	13,635,000	
	1910				1,278,000	14,498,000	15,776,000	This mortgage is prior to Pacific Gas & Electric general mortgage and collateral trust of Jan. 2, 1906, but is not a prior lien on properties or stock of San Francisco Gas & Electric Co.
	1911					20,513,000	20,513,000	
	1912			$106,000		20,407,000	20,513,000	Par value of unissued bonds, $24,487,000.
	1913			106,000		20,407,000	20,513,000	Do.
	1914			196,000		20,317,000	20,513,000	Do.
	1915			815,000		19,698,000	20,513,000	Do.
	1916			765,000		19,748,000	20,513,000	Do.
	1917			1,008,000		19,505,000	20,513,000	Do.
	1918			1,339,000	44,000	19,130,000	20,513,000	Do.
	1919			1,633,000	36,000	18,844,000	20,513,000	Do.
	1920				56,000	18,531,000	20,513,000	Do.
7. California Gas & Electric Corporation general mortgage collateral trust 5 per cent bonds dated Mar. 1, 1903; due Mar. 1, 1933; interest payable Mar. 1 and Sept. 1.	1903					7,652,000	7,652,000	
	1904			136,000	11,000	8,603,000	8,750,000	
	1905			221,000	1,161,000	8,618,000	10,000,000	
	1906			316,000	400,000	9,284,000	10,000,000	
	1907			316,000	400,000	9,284,000	10,000,000	
	1908			418,000		6,327,000	6,745,000	
	1909			647,000		4,861,000	5,508,000	Dec. 31, 1908, $3,255,000 has been retired under California Gas & Electric Corporation unifying and refunding mortgage, dated Nov. 1, 1907, and by Dec. 31, 1909; the bonds retired under the same mortgage amounted to $4,492,000. There has been no increase since.
	1910			808,000		4,700,000	5,508,000	
	1911			912,000		4,596,000	5,508,000	
	1912			939,000		4,569,000	5,508,000	
	1913			939,000		4,569,000	5,508,000	
	1914			940,000		4,568,000	5,508,000	
	1915			991,000		4,517,000	5,508,000	
	1916			991,000		4,517,000	5,508,000	
	1917			1,001,000		4,507,000	5,508,000	
	1918			1,100,000	1,000	4,407,000	5,508,000	
	1919			1,194,000	138,000	4,176,000	5,508,000	
	1920			1,408,000	211,000	3,889,000	5,508,000	
8. Bay Counties Power Co. first consolidated mortgage 5 per cent bonds dated Sept. 1, 1900; due Sept. 1, 1930; interest payable Mar. 1 and Sept. 1.	1900	440,000				1,710,000	1,710,000	Bonds in sinking fund are alive but are marked nonnegotiable.
	1901	357,000				1,893,000	1,893,000	
	1902	357,000				1,893,000	1,893,000	
	1903	357,000				1,893,000	1,893,000	
	1904	357,000				1,893,000	1,893,000	
	1905	357,000				1,893,000	1,893,000	
	1906	357,000				1,893,000	1,893,000	
	1907	357,000		45,000		1,848,000	1,893,000	
	1908	357,000		93,000		1,800,000	1,893,000	
	1909	357,000		119,000		1,774,000	1,893,000	
	1910	357,000		158,000		1,735,000	1,893,000	
	1911	357,000		199,000		1,694,000	1,893,000	
	1912	357,000		240,000		1,653,000	1,893,000	
	1913	357,000		285,000		1,608,000	1,893,000	
	1914	357,000		319,000	19,000	1,555,000	1,893,000	

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[a] Not including bonds authenticated and later canceled by sinking fund or exchange.

TABLE 192.—*Bonds of Pacific Gas & Electric Co. and principal subsidiaries*—Continued.

Issue.	Bonded debt.							Notes.
	Year (Dec. 31).	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total authenticated.[a]	
			Canceled.	Alive.				
1	7	8	9	10	11	12	13	14
8. Bay Counties Power Co. first consolidated 5 per cent bonds, etc.—Continued.	1915	$357,000		$503,000	$82,000	$1,308,000	$1,893,000	
	1916	357,000		585,000		1,308,000	1,893,000	
	1917	357,000		676,000	1,000	1,216,000	1,893,000	
	1918	357,000		810,000	7,000	1,076,000	1,893,000	
	1919	357,000		850,000		1,043,000	1,893,000	
	1920	357,000		893,000		1,000,000	1,893,000	
9. Bay Counties Power Co. second mortgage 6 per cent bonds dated Apr. 1, 1901; due Apr. 1, 1931; interest payable Apr. 1 and Oct. 1.	1901					750,000	750,000	Bonds of this issue listed in column 10 are in California Gas & Electric Corporation sinking fund.
	1902					750,000	750,000	
	1903					750,000	750,000	
	1904					750,000	750,000	
	1905					750,000	750,000	
	1906					750,000	750,000	
	1907					750,000	750,000	
	1908			50,000		700,000	750,000	
	1909			50,000		700,000	750,000	
	1910			50,000		700,000	750,000	
	1911			64,000		686,000	750,000	
	1912			68,000		682,000	750,000	
	1913			68,000		682,000	750,000	
	1914			68,000		682,000	750,000	
	1915			68,000		682,000	750,000	
	1916			68,000		682,000	750,000	
	1917		$135,000	77,000	5,000	533,000	615,000	
	1918		135,000	82,000		533,000	615,000	
	1919		135,000	91,000		524,000	615,000	
	1920		135,000	93,000		522,000	615,000	
10. Nevada County Electric Power Co. 6 per cent bonds dated Oct. 1, 1898; due Oct. 1, 1928; interest payable Apr. 1 and Oct. 1.	1900					300,000	300,000	
	1901					300,000	300,000	
	1902					171,000	171,000	
	1903					171,000	171,000	
	1904					171,000	171,000	
	1905					171,000	171,000	
	1906					171,000	171,000	
	1907					171,000	171,000	

	1908					171,000	171,000
	1909					171,000	171,000
	1910					171,000	171,000
	1911					171,000	171,000
	1912					171,000	171,000
	1913					171,000	171,000
	1914					171,000	171,000
	1915					171,000	171,000
	1916					171,000	171,000
	1917					171,000	171,000
	1918				5,000	166,000	171,000
	1919				5,000	166,000	171,000
	1920				5,000	166,000	171,000
11 Yuba Electric Power Co. 6 per cent bonds dated June 1, 1899; due June 1, 1920; interest payable June 1 and Dec. 1.	1900					1,000,000	1,000,000
	1901					1,000,000	1,000,000
	1902					1,000,000	1,000,000
	1903					186,000	186,000
	1904					186,000	186,000
	1905					186,000	186,000
	1906					186,000	186,000
	1907					186,000	186,000
	1908					186,000	186,000
	1909					186,000	186,000
	1910					186,000	186,000
	1911					186,000	186,000
	1912					186,000	186,000
	1913					186,000	186,000
	1914					186,000	186,000
	1915					186,000	186,000
	1916			7,000		179,000	186,000
	1917			7,000		179,000	186,000
	1918			7,000		179,000	186,000
	1919			7,000		179,000	186,000
	1920			7,000		179,000	186,000
12. Valley Counties Power Co. first mortgage 5 per cent bonds dated May 1, 1902; due May 1, 1930; interest payable May 1 and Nov. 1.	1902					1,000,000	1,000,000
	1903				514,000	1,504,000	2,018,000
	1904				383,000	2,117,000	2,500,000
	1905			24,000		2,476,000	2,500,000
	1906			24,000		2,476,000	2,500,000
	1907			24,000		2,476,000	2,500,000
	1908			29,000		2,471,000	2,500,000
	1909			29,000		2,471,000	2,500,000
	1910			59,000		2,441,000	2,500,000
	1911			84,000		2,416,000	2,500,000
	1912			217,000		2,283,000	2,500,000
	1913			344,000		2,156,000	2,500,000
	1914			403,000	4,000	2,093,000	2,500,000
	1915			516,000	46,000	1,938,000	2,500,000
	1916			562,000		1,938,000	2,500,000
	1917			631,000		1,869,000	2,500,000

[a] Not including bonds authenticated and later canceled by sinking fund or exchange.

TABLE 192.—*Bonds of Pacific Gas & Electric Co. and principal subsidiaries*—Continued.

Issue.	Bonded debt.							Notes.
	Year (Dec. 31).	Reserved for prior lieus.	In sinking funds.		In treasury.	Held by public.	Total authenticated.[a]	
			Canceled.	Alive.				
1	7	8	9	10	11	12	13	14
12. Valley Counties Power Co. first mortgage 5 per cent bonds, etc.—Continued.	1918	....	....	$683,000	$11,000	$1,806,000	$2,500,000	
	1919	....	....	750,000	5,000	1,745,000	2,500,000	
	1920	....	....	800,000	....	1,700,000	2,500,000	
13. California Central Gas & Electric Co. 5 per cent bonds dated Aug. 1, 1901; due Aug 1, 1931; interest payable Feb. 1 and Aug. 1.	1901	....	....	....	....	750,000	750,000	
	1902	....	....	....	....	1,000,000	1,000,000	
	1903	....	....	38,000	....	962,000	1,000,000	
	1904	....	....	62,000	....	938,000	1,000,000	
	1905	....	....	85,000	....	915,000	1,000,000	
	1906	....	....	107,000	....	893,000	1,000,000	
	1907	....	....	107,000	....	893,000	1,000,000	
	1908	....	....	139,000	....	861,000	1,000,000	
	1909	....	....	186,000	....	814,000	1,000,000	
	1910	....	....	220,000	....	780,000	1,000,000	
	1911	....	....	220,000	....	780,000	1,000,000	
	1912	....	....	222,000	....	778,000	1,000,000	
	1913	....	....	233,000	....	767,000	1,000,000	
	1914	....	....	237,000	....	763,000	1,000,000	
	1915	....	....	245,000	26,000	729,000	1,000,000	
	1916	....	....	271,000	2,000	727,000	1,000,000	
	1917	....	....	325,000	....	675,000	1,000,000	
	1918	....	....	341,000	....	659,000	1,000,000	
	1919	....	....	361,000	....	639,000	1,000,000	
	1920	....	....	395,000	....	605,000	1,000,000	
14. Oakland Gas, Light & Heat Co. 5 per cent bonds dated Mar. 16, 1891; due Mar. 16, 1916; interest payable Mar. 16 and Sept. 16.	1900	....	....	....	....	1,000,000	1,000,000	
	1912							
	1913	....	....	11,000	....	989,000	1,000,000	
	1914	....	....	19,000	....	981,000	1,000,000	
	1915	....	....	312,000	....	688,000	1,000,000	Retired Mar. 16, 1916.

15. Berkeley Electric Light Co. 6 per cent bonds dated July 1, 1896; due July 1, 1921; interest payable Jan. 1 and July 1.	1900					26,000	26,000	Retired in 1908 under California Gas & Electric Corporation unifying and refunding mortgage of Nov. 1, 1907.
	1901					26,000	26,000	
	1902					26,000	26,000	
	1903					26,000	26,000	
	1904					26,000	26,000	
	1905					26,000	26,000	
	1906					26,000	26,000	
	1907					26,000	26,000	
	1908							
16. Sacramento Electric Gas & Ry. Co. 5 per cent bonds dated Nov. 1, 1897; due Nov. 1, 1927; interest payable May 1 and Nov. 1.	1900	$265,000				2,235,000	2,235,000	
	1901	265,000				2,235,000	2,235,000	
	1902	265,000	$5,000			2,230,000	2,230,000	
	1903	265,000	10,000			2,225,000	2,225,000	
	1904	265,000	15,000			2,220,000	2,220,000	
	1905	265,000	20,000			2,215,000	2,215,000	
	1906	265,000	25,000			2,210,000	2,210,000	
	1907	265,000	25,000			2,210,000	2,210,000	
	1908	265,000	25,000			2,210,000	2,210,000	
	1909	265,000	55,000			2,180,000	2,180,000	
	1910	265,000	65,000			2,170,000	2,170,000	
	1911	265,000	75,000			2,160,000	2,160,000	
	1912	240,000	95,000	4,000		2,161,000	2,165,000	
	1913	215,000	115,000	11,000		2,159,000	2,170,000	
	1914	190,000	135,000	19,000		2,156,000	2,175,000	
	1915	165,000	155,000	29,000	2,000	2,149,000	2,180,000	
	1916	140,000	175,000	36,000		2,149,000	2,185,000	
	1917	115,000	205,000	63,000		2,117,000	2,180,000	
	1918	90,000	235,000	118,000	10,000	2,047,000	2,175,000	
	1919	65,000	265,000	146,000		2,024,000	2,170,000	
	1920	40,000	295,000	177,000		1,988,000	2,165,000	
17. Central Electric Railway Co. 6 percent bonds dated June 1, 1892; due serially 1912–1922; interest payable June 1 and Dec. 1.	1903					265,000	265,000	$135,000 never issued.
	1904					265,000	265,000	
	1905					265,000	265,000	
	1906					265,000	265,000	
	1907					265,000	265,000	
	1908					265,000	265,000	
	1909					265,000	265,000	
	1910					265,000	265,000	$25,000 retired by issuing Sacramento Electric, Gas & Railway Co. mortgage bonds.
	1911					265,000	265,000	$1,000 retired under Pacific Gas & Electric Co. general and refunding mortgage dated Dec. 1, 1911.
	1912					239,000	239,000	
	1913					215,000	215,000	$50,000 Retired by issuing Sacramento Electric Gas & Ry Co. mortgage bonds..
	1914					190,000	190,000	75,000
	1915					165,000	165,000	100,000
	1916				1,000	139,000	140,000	125,000
	1917			1,000		114,000	115,000	150,000
	1918			3,500		86,500	90,000	175,000
	1919			11,000		54,000	65,000	200,000
	1920			1,000		39,000	50,000	225,000

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a Not including bonds authenticated and later canceled by sinking fund or exchange.

TABLE 192.—*Bonds of Pacific Gas & Electric Co. and principal subsidiaries*—Continued.

Issue.	Bonded debt.							Notes.	
	Year (Dec. 31).	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total authenticated.[a]		
			Canceled.	Alive.					
1	7	8	9	10	11	12	13	14	
18. The Standard Electric Co. of California 5 per cent bonds dated Sept. 1, 1899; due Sept. 1, 1939; interest payable Mar. 1 and Sept. 1.	1904				$1,750,000	$3,250,000	$5,000,000		
	1905				1,750,000	3,250,000	5,000,000		
	1906				1,750,000	3,250,000	5,000,000		
	1907				1,750,000	3,250,000	5,000,000		
	1908			$47,000		3,250,000	3,297,000	$1,703,000	Retired under California Gas & Electric Corporation unifying and refunding mortgage of Nov. 1, 1911.
	1909			47,000		2,711,000	2,758,000	2,242,000	
	1910			47,000		2,488,000	2,535,000	2,465,000	
	1911			47,000		2,401,000	2,401,000	2,599,000	
	1912			19,200		2,379,800	2,399,000	2,599,000	
	1913			21,200		2,377,800	2,399,000	2,000	Retired under Pacific Gas & Electric Co. general and refunding mortgage of Dec. 1, 1911.
	1914			24,200	48,500	2,326,300	2,399,000	2,000	
	1915			98,700	65,000	2,235,300	2,399,000	2,000	
	1916			261,700		2,137,300	2,399,000	2,000	
	1917			276,700		2,122,300	2,399,000	2,000	
	1918			286,700		2,112,300	2,399,000	2,000	
	1919			303,700	20,400	2,074,900	2,399,000	2,000	
	1920			327,100		2,071,900	2,399,000	2,000	
19. Blue Lakes Water Co. 6 per cent bonds dated Mar. 1, 1893; supplement dated Apr. 24, 1905; due Mar. 15, 1938; interest payable Mar. 15 and Sept. 15.	1900					725,000	725,000		
	1901					725,000	725,000		
	1902					725,000	725,000		
	1903					725,000	725,000		
	1904					725,000	725,000		
	1905					725,000	725,000		
	1906					725,000	725,000		
	1907					725,000	725,000		
	1908			11,000		714,000	725.000		
	1909			11,000		714,000	725,000		
	1910			11,000		714,000	725,000		
	1911			11,000		714,000	725,000		
	1912			11,000		714,000	725,000		
	1913			12,000		713,000	725,000		
	1914			12,000		713,000	725,000		
	1915			12,000		713,000	725,000		
	1916			12,000		713,000	725,000		
	1917			12,000		713,000	725.000		

	1918			12,000		713,000	725,000	
	1919			12,000		713,000	725,000	
	1920		$2,000	10,000		713,000	725,000	
20. Stockton Water Co. 6 per cent bonds dated Apr. 1, 1891; due Apr. 1, 1911; interest payable Apr. 1 and Oct. 1.	1900					350,000	350,000	
	1901					350,000	350,000	
	1902					350,000	350,000	
	1903					350,000	350,000	
	1904					350,000	350,000	
	1905					350,000	350,000	
	1906		36,000			314,000	314,000	
	1907		53,000			297,000	297,000	
	1908		80,000			270,000	270,000	
	1909		95,000			255,000	255,000	
	1910		112,000			238,000	238,000	
	1911							$238,000 bonds matured Apr. 1, 1911; all paid and retired under California Gas & Electric Corporation unifying and refunding mortgage, dated Nov. 1, 1907.
21. United Gas & Electric Co. 5 per cent bonds dated July 1, 1902; due July 1, 1932; interest payable Jan. 1 and July 1.	1904					1,150,000	1,150,000	
	1905					2,000,000	2,000,000	
	1906					2,000,000	2,000,000	
	1907					2,000,000	2,000,000	
	1908		40,000			1,960,000	1,960,000	
	1909		79,000			1,921,000	1,921,000	
	1910		119,000			1,881,000	1,881,000	
	1911		198,000			1,802,000	1,802,000	
	1912		251,000			1,749,000	1,749,000	
	1913		303,000			1,697,000	1,697,000	
	1914		303,000			1,697,000	1,697,000	
	1915		402,000		53,000	1,545,000	1,598,000	
	1916		450,000		5,000	1,545,000	1,550,000	
	1917		510,000	27,000	3,000	1,460,000	1,490,000	
	1918		563,000		7,000	1,430,000	1,437,000	
	1919		589,000	7,000		1,404,000	1,411,000	
	1920		651,000	135,000	11,000	1,203,000	1,349,000	
22. South Yuba Water & Mining Co. first mortgage 6 per cent bonds dated Apr. 1, 1890; due Apr. 1, 1910; interest payable Apr. 1 and Oct. 1.	1900					458,000	458,000	
	1901					439,000	439,000	
	1902					436,000	436,000	
	1903					436,000	436,000	
	1904					398,000	398,000	
	1905					387,000	387,000	
	1906					387,000	387,000	
	1907					327,000	327,000	
	1908					303,000	303,000	
	1909					199,000	199,000	
	1910							All bonds outstanding retired or exchanged for South Yuba Water & Mining Co. consolidated 6 per cent bonds early in 1910.

[a] Not including bonds authenticated and later canceled by sinking fund or exchange.

TABLE 192.—*Bonds of Pacific Gas & Electric Co. and principal subsidiaries*—Continued.

Issue.	Bonded debt.							Notes.
	Year (Dec. 31).	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total authenticated.[a]	
			Canceled.	Alive.				
1	7	8	9	10	11	12	13	14
23. South Yuba Water Co. consolidated 6 per cent bonds dated July 1, 1893; due July 1, 1923; interest payable Jan. 1 and July 1.	1900	$458,000				$942,000	$942,000	
	1901	439,000				1,061,000	1,061,000	
	1902	436,000				1,064,000	1,064,000	
	1903	436,000				1,064,000	1,064,000	
	1904	398,000				1,102,000	1,102,000	
	1905	387,000				1,113,000	1,113,000	
	1906	387,000				1,113,000	1,113,000	
	1907	327,000				1,173,000	1,173,000	
	1908	303,000				1,197,000	1,197,000	
	1909	199,000				1,301,000	1,301,000	
	1910					1,500,000	1,500,000	
	1911					1,500,000	1,500,000	
	1912					1,500,000	1,500,000	
	1913			$3,000		1,497,000	1,500,000	
	1914			3,000		1,497,000	1,500,000	
	1915			5,000		1,495,000	1,500,000	
	1916			5,000		1,495,000	1,500,000	
	1917			12,000		1,488,000	1,500,000	
	1918			24,000	$21,000	1,455,000	1,500,000	
	1919			45,000		1,455,000	1,500,000	
	1920			66,000		1,434,000	1,500,000	
24. Central California Electric Co., 5 per cent bonds dated May 1, 1903; due May 1, 1933; interest payable May 1 and Nov. 1.	1903					40,000		
	1904				60,000	40,000	850,000	$750,000 held by South Yuba Water Co., 1903–1906.
	1905				60,000	40,000	850,000	
	1906				60,000	40,000	850,000	
	1907				60,000	40,000	850,000	
	1908					40,000	40,000	Bonds amounting to $848,000 were retired under California Gas & Electric Corporation unifying and refunding mortgage, Nov. 1, 1907, between Dec. 31, 1907, and Dec. 31, 1912, and $1,000 Pacific Gas & Electric Co.'s general and refunding mortgage of Dec. 1, 1911, by Dec. 11, 1913.
	1909					40,000	40,000	
	1910					40,000	40,000	
	1911					2,000	2,000	
	1912					1,000	1,000	
	1913					1,000	1,000	
	1914					1,000	1,000	
	1915				1,000		1,000	
	1916				1,000		1,000	

	1917				1,000		1,000	
	1918				1,000		1,000	
	1919				1,000		1,000	
	1920				1,000		1,000	
25. Suburban Light & Power Co. first gold 6 per cent bonds dated Aug. 1, 1908; due Aug. 1, 1938; interest payable Feb. 1 and Aug. 1.	1908							
	1909					250,000	250,000	
	1910					250,000	250,000	
	1911					250,000	250,000	
	1912					250,000	250,000	
	1913			10,000		240,000	250,000	
	1914			10,000		240,000	250,000	
	1915			10,000	11,000	229,000	250,000	
	1916			26,000		224,000	250,000	
	1917			27,500		222,500	250,000	
	1918			28,000		222,000	250,000	
	1919			28,000		222,000	250,000	
	1920			28,500		221,500	250,000	
26. Mutual Electric Light Co. 5 per cent bonds dated June 1, 1904; due June 1, 1934; interest payable June 1 and Dec. 1.	1904					193,000	193,000	
	1905					250,000	250,000	$150,000 unissued.
	1906					250,000	250,000	
	1907					250,000	250,000	
	1908					250,000	250,000	
	1909		$6,000			244,000	244,000	
	1910		13,000			237,000	237,000	
	1911		19,000		3,000	228,000	231,000	
	1912		25,000	4,000		221,000	225,000	
	1913		31,000	4,000		215,000	219,000	
	1914		38,000	4,000		208,000	212,000	
	1915		44,000	18,000		188,000	206,000	
	1916		51,000	16,000		183,000	199,000	
	1917		57,000	10,000		183,000	193,000	
	1918		63,000	9,000		178,000	187,000	
	1919		70,000	7,000	5,000	168,000	180,000	
	1920		77,000	8,000		165,000	173,000	
27. Metropolitan Gas Corporation 5 per cent bonds dated Nov. 25, 1911; due Dec. 1, 1941; interest payable June 1 and Dec. 1.	1911					1,368,000	1,368,000	
	1912		25,000			1,343,000	1,343,000	
	1913		72,000			1,296,000	1,296,000	
	1914		75,000			1,293,000	1,293,000	
	1915		100,000	63,000		1,205,000	1,268,000	
	1916		125,000	38,000	18,500	1,186,500	1,243,000	
	1917		150,000	47,000		1,171,000	1,218,000	
	1918		175,000	44,500		1,148,500	1,193,000	
	1919		200,000	76,500		1,091,500	1,168,000	
	1920		225,000	90,500		1,052,500	1,143,000	

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[a] Not including bonds authenticated and later canceled by sinking fund or exchange.

TABLE 192.—*Bonds of Pacific Gas & Electric Co. and principal subsidiaries*—Continued.

Issue.	Bonded debt.							Notes.
	Year (Dec. 31).	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total authenticated.[a]	
			Canceled.	Alive.				
1	7	8	9	10	11	12	13	14
28. Livermore Water Power Co. 6 per cent bonds dated Sept. 1, 1897; due Sept. 1, 1922; interest payable Mar. 1 and Sept. 1.	1900					$100,000	$100,000	
	1901					100,000	100,000	
	1902					100,000	100,000	
	1903					100,000	100,000	
	1904					100,000	100,000	
	1905					100,000	100,000	
	1906					100,000	100,000	
	1907					100,000	100,000	
	1908					100,000	100,000	
	1909					100,000	100,000	
	1910					100,000	100,000	
	1911					100,000	100,000	
	1912					100,000	100,000	
	1913			$6,000		94,000	100,000	
	1914			10,000	$3,000	87,000	100,000	
	1915			43,500	27,000	29,500	100,000	
	1916			76,500		23,500	100,000	
	1917			78,000	1,500	20,500	100,000	
	1918			79,000	500	20,500	100,000	
	1919			82,500		17,500	100,000	
	1920			82,500		17,500	100,000	
29. San Francisco Gas & Electric Co. general 4½ per cent bonds dated Nov. 1, 1903; due Nov. 1, 1933; interest payable May 1 and Nov. 1.	1903	$1,813,000			(b)	(b)	8,000,000	
	1904	1,792,000			(b)	(b)	8,021,000	
	1905	1,772,000			1,091,000	6,950,000	8,041,000	
	1906	1,772,000			1,064,000	6,977,000	8,041,000	
	1907	1,772,000	$200,000			7,800,000	8,028,000	
	1908	1,772,000	300,000	69,000	970,000	6,889,000	7,928,000	
	1909	1,687,000	400,000	70,000	485,000	7,358,000	7,913,000	
	1910	1,661,000	500,000	133,000	393,000	7,313,000	7,839,000	
	1911	1,639,000	600,000	222,000	154,000	7,385,000	7,761,000	
	1912	1,639,000	700,000	206,000		7,350,000	7,556,000	$105,000 retired in 1912 under Pacific Gas & Electric Co. general and refunding mortgage of Dec. 1, 1911.
	1913	1,639,000	800,000	219,000		7,237,000	7,456,000	
	1914	1,639,000	900,000	207,000		7,149,000	7,356,000	
	1915	1,639,000	1,000,000	171,000		7,085,000	7,256,000	
	1916	1,639,000	1,100,000	137,000		7,019,000	7,156,000	

	1917	1,639,000	1,200,000	115,000		6,941,000	7,056,000	
	1918	1,639,000	1,300,000	117,000		6,839,000	6,956,000	
	1919	1,639,000	1,400,000	103,000		6,753,000	6,856,000	
	1920	1,639,000	1,500,000	95,000	4,000	6,657,000	6,756,000	
30. Edison Light & Power Co. 6 per cent bonds dated Nov. 3, 1891; due Nov. 3, 1921; interest payable Feb. 3, May 3, Aug. 3, and Nov. 3.	1900					623,000	623,000	$177,000 exchanged in 1900 for capital stock of San Francisco Gas & Electric Co.
	1901					623,000	623,000	
	1902					623,000	623,000	
	1903					623,000	623,000	
	1904					623,000	623,000	
	1905					623,000	623,000	
	1906					623,000	623,000	
	1907					623,000	623,000	
	1908					623,000	623,000	
	1909					623,000	623,000	
	1910					623,000	623,000	
	1911					623,000	623,000	
	1912					623,000	623,000	
	1913					623,000	623,000	
	1914					623,000	623,000	
	1915					623,000	623,000	
	1916		29,000			623,000	623,000	
	1917		29,000			623,000	623,000	
	1918		29,000			623,000	623,000	
	1919		29,000			623,000	623,000	
	1920		29,000	17,000		606,000	623,000	
31. Pacific Gas Improvement Co. 4 per cent bonds, dated Sept. 1, 1910; due Sept. 1, 1930; interest payable Mar. 1, June 1, Sept. 1, and Dec. 1.	1900					1,250,000	1,250,000	
	1901		20,000			1,230,000	1,230,000	
	1902		40,000			1,210,000	1,210,000	
	1903		60,000			1,190,000	1,190,000	
	1904		81,000			1,169,000	1,169,000	
	1905		101,000			1,149,000	1,149,000	
	1906		101,000			1,149,000	1,149,000	
	1907		101,000			1,149,000	1,149,000	
	1908		101,000			1,149,000	1,149,000	
	1909		190,000		33,000	1,027,000	1,060,000	
	1910		212,000		11,000	1,027,000	1,038,000	
	1911		234,000			1,016,000	1,016,000	
	1912		256,000	10,000		663,000	673,000	$321,000 retired in 1912 under Pacific Gas & Electric Co. general and refunding mortgage, dated Dec. 1, 1911.
	1913		279,000	50,000		600,000	650,000	
	1914		279,000	50,000	5,000	595,000	650,000	
	1915		324,000	16,000	72,000	517,000	605,000	
	1916		346,000	74,000		509,000	583,000	
	1917		368,000	62,000		499,000	561,000	
	1918		390,000	40,000		499,000	539,000	
	1919		412,000	24,000		493,000	517,000	
	1920		435,000	5,000		489,000	494,000	

[a] Not including bonds authenticated and later canceled by sinking fund or exchange.

[b] Not known; records destroyed.

TABLE 192.—*Bonds of Pacific Gas & Electric Co. and principal subsidiaries*—Continued.

Issue.	Bonded debt.							Notes.
	Year (Dec. 31).	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total authenticated.[a]	
			Canceled.	Alive.				
1	7	8	9	10	11	12	13	14
32. Oro Electric Corporation first mortgage 6 per cent bonds, dated Oct. 1, 1911; due Oct. 1, 1951; interest payable Apr. 1 and Oct. 1.	1911					$1,000,000	$10,000,000	$5,550,000 owned by Oro Development Co., $3,450,000 owned by Oro Water, Light & Power Co.
	1912					1,500,000	10,000,000	$8,500,000 owned by subsidiary companies.
	1913				$8,170,000	1,830,000	10,000,000	
	1914				8,170,000	1,830,000	10,000,000	
	1915				7,990,000	1,830,000	10,000,000	$180,000 pledged to secure $60,000 in notes.
	1916				8,170,000	1,830,000	10,000,000	Company purchased by Pacific Gas & Electric Co., 1917, and canceled.
33. Oro Water, Light & Power Co. first mortgage 6 per cent bonds, dated May 1, 1905; $85,000,000 due annually, Nov. 1, 1909, 1910, and 1911; $25,000 due Nov. 1, 1912; and remainder of issue May 1, 1925; interest payable May 1 and Nov. 1.	1906					750,000	750,000	
	1907		$85,000			665,000	665,000	
	1908		170,000			580,000	580,000	
	1909		255,000			495,000	495,000	
	1910		340,000			410,000	410,000	
	1911		425,000			325,000	325,000	
	1912		425,000			325,000	325,000	
	1913		450,000			300,000	300,000	
	1914		450,000			300,000	300,000	
	1915		450,000			300,000	300,000	
	1916		450,000			300,000	300,000	Oro Water, Light & Power Co. purchased by Pacific Gas & Electric Co. in 1917 and canceled.
34. Oroville Light & Power Co. first mortgage 6 per cent bonds, dated Feb. 1, 1902; due Feb. 1, 1927; interest payable Feb. 1 and Oct. 1.	1905							Data for years prior to 1911 not available.
	1906							
	1907							
	1908							
	1909							
	1910							
	1911		4,000			33,000	46,000	$13,000 owned by Oro Water, Light & Power Co.
	1912		4,000			33,000	46,000	
	1913		4,000			33,000	46,000	

1914	....	4,000	....	....	33,000	46,000	
1915	....	4,000	....	....	33,000	46,000	
1916	....	....	....	....	....	....	
1917	....	....	....	....	....	....	
1918	....	4,000	....	42,500	3,500	46,000	Sold with other properties of Oro Electric Corporation to Pacific Gas & Electric Co. in 1917.
1919	....	4,000	$42,500	....	3,500	46,000	
1920	....	4,000	42,500	....	3,500	46,000	

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[a] Not including bonds authenticated and later canceled by sinking fund or exchange.

TABLE 193.—*Summary of bonds in hands of public, Pacific Gas & Electric Co., 1900–1920.*

Bond issues.	1900	1901	1902	1903	1904
7. California Gas & Electric Corporation general mortgage and collateral trust 5's	....	....	....	$7,652,000	$8,603,000
8. Bay Counties Power Co. first consolidated mortgage 5's	$1,710,000	$1,893,000	$1,893,000	1,893,000	1,893,000
9. Bay Counties Power Co. second mortgage 6's	....	750,000	750,000	750,000	750,000
10. Nevada County Electric Power Co. 6's	300,000	300,000	171,000	171,000	171,000
11. Yuba Electric Power Co. 6's	1,000,000	1,000,000	1,000,000	186,000	186,000
12. Valleys County Power Co. first mortgage 5's	....	....	1,000,000	1,504,000	2,117,000
13. California Central Gas & Electric Co. 5's	....	750,000	1,000,000	962,000	938,000
14. Oakland Gas, Light & Heat Co. 5's	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
15. Berkeley Electric Lighting Co. 6's	26,000	26,000	26,000	26,000	26,000
16. Sacramento Electric, Gas & Railway Co. 5's	2,235,000	2,235,000	2,230,000	2,225,000	2,220,000
17. Central Electric Railway Co. 6's	....	....	....	265,000	265,000
18. The Standard Electric Co. of California 5's	....	....	....	....	3,250,000
19. Blue Lakes Water Co. 6's	725,000	725,000	725,000	725,000	725,000
20. Stockton Water Co. 6's	350,000	350,000	350,000	350,000	350,000
21. United Gas & Electric Co. 5's	....	....	....	....	1,150,000
22. South Yuba Water & Mining Co. first mortgage 6's	458,000	439,000	436,000	436,000	398,000
23. South Yuba Water Co. consolidated 6's	942,000	1,061,000	1,064,000	1,064,000	1,102,000
24. Central California Electric Co. 5's	....	....	....	40,000	40,000
26. Mutual Electric Light Co. 5's	....	....	....	....	193,000
28. Livermore Water & Power Co. 6's	100,000	100,000	100,000	100,000	100,000
29. San Francisco Gas & Electric Co. general 4½'s	....	....	....	[a] 8,000,000	[a] 8,021,000
30. Edison Light & Power Co. 6's	623,000	623,000	623,000	623,000	623,000
31. Pacific Gas Improvement Co. 4's	1,250,000	1,230,000	1,210,000	1,190,000	1,169,000
	10,719,000	12,482,000	13,578,000	29,162,000	35,209,000

Bond issues.	1905	1906	1907	1908	1909
2. Pacific Gas & Electric Co. general mortgage and collateral trust 5's	....	$9,982,700	$9,717,967	$9,384,722	$9,133,495
3. Pacific Gas & Electric Co. general debenture mortgage 6's	....	4,500,000	3,969,000	233,000	1,000
4. Pacific Gas & Electric Co. debenture mortgage 6's	....	....	....	3,651,000	3,883,000
6. California Gas & Electric Corporation unifying and refunding 5's	....	....	....	10,500,000	13,140,000
7. California Gas & Electric Corporation general mortgage and collateral trust 5's	$8,618,000	9,284,000	9,284,000	6,327,000	4,861,000
8. Bay Counties Power Co. first consolidated mortgage 5's	1,893,000	1,893,000	1,848,000	1,800,000	1,774,000
9. Bay Counties Power Co. second mortgage 6's	750,000	750,000	750,000	700,000	700,000
10. Nevada County Electric Power Co. 6's	171,000	171,000	171,000	171,000	171,000
11. Yuba Electric Power Co. 6's	186,000	186,000	186,000	186,000	186,000
12. Valleys County Power Co. first mortgage 5's	2,476,000	2,476,000	2,476,000	2,471,000	2,471,000
13. California Central Gas & Electric Co. 5's	915,000	893,000	893,000	861,000	814,000
14. Oakland Gas, Light & Heat Co. 5's	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
15. Berkeley Electric Light Co. 6's	26,000	26,000	26,000	....	....
16. Sacramento Electric, Gas & Railway Co. 5's	2,215,000	2,210,000	2,210,000	2,210,000	2,180,000
17. Central Electric Railway Co. 6's	265,000	265,000	265,000	265,000	265,000
18. The Standard Electric Co. of California 5's	3,250,000	3,250,000	3,250,000	3,250,000	2,711,000
19. Blue Lakes Water Co. 6's	725,000	725,000	725,000	714,000	714,000
20. Stockton Water Co. 6's	350,000	314,000	297,000	270,000	255,000
21. United Gas & Electric Co. 5's	2,000,000	2,000,000	2,000,000	1,960,000	1,921,000
22. South Yuba Water & Mining Co. first mortgage 6's	387,000	387,000	327,000	303,000	199,000
23. South Yuba Water Co. consolidated 6's	1,113,000	1,113,000	1,173,000	1,197,000	1,301,000
24. Central California Electric Co. 5's	40,000,	40,000	40,000	40,000	40,000
25. Suburban Light & Power Co. first gold 6's	....	....	....	250,000	250,000
26. Mutual Electric Light Co. 5's	250,000	250,000	250,000	250,000	244,000
28. Livermore Water & Power Co. 6's	100,000	100,000	100,000	100,000	100,000
29. San Francisco Gas & Electric Co. general 4½'s	6,950,000	6,977,000	7,800,000	6,889,000	7,358,000
30. Edison Light & Power Co. 6's	623,000	623,000	623,000	623,000	623,000
31. Pacific Gas Improvement Co. 4's	1,149,000	1,149,000	1,149,000	1,149,000	1,027,000
33. Oro Water, Light & Power Co. first mortgage 6's	....	750,000	665,000	580,000	495,000
	35,452,000	50,564,700	50,529,967	56,754,722	57,822,495

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[a] Total authenticated.

TABLE 193.—*Summary of bonds in hands of public, Pacific Gas & Electric Co., 1900–1920*—Continued.

Bond issues.	1910	1911	1912	1913	1914
1. Pacific Gas & Electric Co. general and refunding mortgage 5's	...	...	$24,986,000	$24,986,000	$24,976,000
2. Pacific Gas & Electric Co. general mortgage and collateral trust 5's	$8,817,975	$8,457,410	...	...	...
4. Pacific Gas & Electric Co. debenture mortgage 6's	3,884,000	3,884,000	...	...	...
6. California Gas & Electric Corporation unifying and refunding 5's	14,498,000	20,513,000	20,407,000	20,407,000	20,317,000
7. California Gas & Electric Corporation general mortgage and collateral trust 5's	4,700,000	4,596,000	4,569,000	4,569,000	4,568,000
8. Bay Counties Power Co. first consolidated mortgage 5's	1,735,000	1,694,000	1,653,000	1,608,000	1,555,000
9. Bay Counties Power Co. second mortgage 6's	700,000	686,000	682,000	682,000	682,000
10. Nevada County Electric Power Co. 6's	171,000	171,000	171,000	171,000	171,000
11. Yuba Electric Power Co. 6's	186,000	186,000	186,000	186,000	186,000
12. Valleys County Power Co. first mortgage 5's	2,441,000	2,416,000	2,283,000	2,156,000	2,093,000
13. California Central Gas & Electric Co. 5's	780,000	780,000	778,000	767,000	763,000
14. Oakland Gas, Light & Heat Co. 5's	1,000,000	1,000,000	1,000,000	989,000	981,000
16. Sacramento Electric, Gas & Railway Co. 5's	2,170,000	2,160,000	2,161,000	2,159,000	2,156,000
17. Central Electric Railway Co. 6's	265,000	265,000	239,000	215,000	190,000
18. The Standard Electric Co. of California 5's	2,488,000	2,401,000	2,379,800	2,377,800	2,326,300
19. Blue Lakes Water Co. 6's	714,000	714,000	714,000	713,000	713,000
20. Stockton Water Co. 6's	238,000	...	...	...	...
21. United Gas & Electric Co. 5's	1,881,000	1,802,000	1,749,000	1,697,000	1,697,000
23. South Yuba Water Co. consolidated 6's	1,500,000	1,500,000	1,500,000	1,497,000	1,497,000
24. Central California Electric Co. 5's	40,000	2,000	1,000	1,000	1,000
25. Suburban Light & Power Co. first gold 6's	250,000	250,000	250,000	240,000	229,000
26. Mutual Electric Light Co. 5's	237,000	228,000	221,000	215,000	208,000
27. Metropolitan Gas Corporation 5's	...	1,368,000	1,343,000	1,296,000	1,293,000
28. Livermore Water & Power Co. 6's	100,000	100,000	100,000	94,000	87,000
29. San Francisco Gas & Electric Co. general 4½'s	7,313,000	7,385,000	7,350,000	7,237,000	7,149,000
30. Edison Light & Power Co 6's	623,000	623,000	623,000	623,000	623,000
31. Pacific Gas Improvement Co. 4's	1,027,000	1,016,000	663,000	600,000	595,000
32. Oro Electric Corporation first mortgage 6's	...	1,000,000	1,500,000	1,830,000	1,830,000
33. Oro Water, Light & Power Co. first mortgage 6's	410,000	325,000	325,000	300,000	300,000
34. Oroville Water, Light & Power Co.	...	33,000	33,000	33,000	33,000
	57,758,975	64,197,410	77,866,800	77,648,800	75,056,300

Bond issues.	1915	1916	1917
1. Pacific Gas & Electric Co. general and refunding mortgage 5's	$28,082,000	$29,982,000	$33,042,000
6. California Gas & Electric Corporation unifying and refunding 5's	19,698,000	19,748,000	19,505,000
7. California Gas & Electric Corporation general mortgage and collateral trust 5's	4,517,000	4,517,000	4,507,000
8. Bay Counties Power Co. first consolidated mortgage 5's	1,308,000	1,308,000	1,216,000
9. Bay Counties Power Co. second mortgage 6's	682,000	682,000	533,000
10. Nevada County Electric Power Co. 6's	171,000	171,000	171,000
11. Yuba Electric Power Co. 6's	186,000	179,000	179,009
12. Valley County Power Co. first mortgage 5's	1,938,000	1,938,000	1,869,000
13. California Central Gas & Electric Co. 5's	729,000	727,000	675,000
14. Oakland Gas, Light & Heat Co. 5's	688,000	Retired.	Retired.
16. Sacramento Electric, Gas & Railway Co. 5's	2,149,000	2,149,000	2,117,000
17. Central Electric Railway Co. 6's	165,000	139,000	114,000
18. The Standard Electric Co. of California 5's	2,235,300	2,137,300	2,122,300
19. Blue Lakes Water Co. 6's	713,000	713,000	713,000
21. United Gas & Electric Co. 5's	1,545,000	1,545,000	1,460,000
23. South Yuba Water Co. consolidated 6's	1,495,000	1,495,000	1,488,000
25. Suburban Light & Power Co. first gold 6's	224,000	222,500	222,000
26. Mutual Electric Light Co. 5's	188,000	183,000	183,000
27. Metropolitan Gas Corporation 5's	1,205,000	1,186,500	1,171,000
28. Livermore Water & Power Co. 6's	29,500	23,500	20,500
29. San Francisco Gas & Electric Co. general 4½'s	7,085,000	7,019,000	6,941,000
30. Edison Light & Power Co. 6's	623,000	623,000	623,000
31. Pacific Gas Improvement Co. 4's	517,000	509,000	499,000
32. Oro Electric Corporation first mortgage 6's	1,830,000	1,830,000	Retired.
33. Oro Water, Light & Power Co. first mortgage 6's	300,000	300,000	Retired.
34. Oroville Water, Light & Power Co.	33,000	33,000	33,000
	78,335,800	79,359,800	79,403,800

TABLE 193.—*Summary of bonds in hands of public, Pacific Gas & Electric Co., 1900–1920*—Continued.

Bond issues.	1918	1919	1920
Pacific Gas & Electric Co. collateral trust gold notes 7's[b]		$36,542,000	$10,000,000
1. Pacific Gas & Electric Co. general and refunding mortgage 5's	$36,542,000	10,130,000	36,542,000
6. California Gas & Electric Corporation unifying and refunding 5's	19,130,000	18,844,000	18,531,000
7. California Gas & Electric Corporation general mortgage and collateral trust 5's	4,407,000	4,176,000	3,889,000
8. Bay Counties Power Co. first consolidated mortgage 5's	1,076,000	1,043,000	1,000,000
9. Bay Counties Power Co. second mortgage 6's	533,000	524,000	522,000
10. Nevada County Electric Power Co. 6's	166,000	166,000	166,000
11. Yuba Electric Power Co. 6's	179,000	179,000	179,000
12. Valley County Power Co. first mortgage 5's	1,806,000	1,745,000	1,700,000
13. California Central Gas & Electric Co. 5's	659,000	639,000	605,000
14. Oakland Gas, Light & Heat Co. 5's	Retired.	Retired.	Retired.
16. Sacramento Electric, Gas & Railway Co. 5's	2,047,000	2,024,000	1,988,000
17. Central Electric Railway Co. 6's	86,500	54,000	39,000
18. The Standard Electric Co. of California 5's	2,112,300	2,074,900	2,071,900
19. Blue Lakes Water Co. 6's	713,000	713,000	713,000
21. United Gas & Electric Co. 5's	1,430,000	1,404,000	1,203,000
23. South Yuba Water Co. consolidated 6's	1,455,000	1,455,000	1,434,000
25. Suburban Light & Power Co. first gold 6's	222,000	222,000	221,500
26. Mutual Electric Light Co. 5's	178,000	168,000	165,000
27. Metropolitan Gas Corporation 5's	1,148,500	1,091,500	1,052,500
28. Livermore Water & Power Co. 6's	20,500	17,500	17,500
29. San Francisco Gas & Electric Co. general 4½'s	6,839,000	6,753,000	6,657,000
30. Edison Light & Power Co. 6's	623,000	623,000	606,000
31. Pacific Gas Improvement Co. 4's	499,000	493,000	489,000
32. Oro Electric Corporation first mortgage 6's	Retired.	Retired.	Retired.
33. Oro Water, Light & Power Co. first mortgage 6's	Retired.	Retired.	Retired.
34. Oroville Water, Light & Power Co.	3,500	3,500	3,500
Northern California Power Co. Consolidated refunding and consolidating 5's[a]		3,849,000	4,199,000
Northern California Power Co. first mortgage 5's[b]		808,000	798,000
Keswick Electric Power Co. first mortgage 5's[b]		22,000	22,000
Battle Creek Power Co. first mortgage 5's[b]		84,000	84,000
The Redding Water Co. first mortgage 5's[b]		10,000	10,000
Sacramento Valley Power Co. first mortgage 6's[b]		396,000	372,700
The Sacramento Valley Power Co. first and refunding 6's[b]		497,000	478,000
Northern California Power Co. Consolidated series A gold debentures 6's[b]		382,206	Retired.
	81,875,300	87,002,406	95,758,600

[b] This issue not included in Table 192 but in Table 202.

TABLE 194.—*Comparative balance sheet of Pacific Gas & Electric Co., 1910–1920.*

Form of report of company's accountants, 1910–1912.

	Dec. 31, 1910.	Dec. 31, 1911.	Dec. 31, 1912.
ASSETS.			
Capital assets:			
Plant and properties	$109,570,941	$108,791,049	$116,677,072
Special construction funds and construction in progress	...	1,076,563	1,657,753
Cash and alive bonds in hands of trustees of sinking funds	1,504,326	1,713,875	2,219,755
Stocks of subsidiary companies representing cash equities	...	35,729,265	34,177,282
	111,075,267	147,310,752	154,731,862
Current assets:			
Free treasury securities	2,099,616	1,308,071	24,220
Material and supplies	1,162,477	1,483,552	1,723,042
Notes and accounts receivable	1,112,777	1,471,719	1,418,588
Advances on contracts	...	32,434	...
Cash and deposits	410,431	416,418	1,224,879
	4,785,301	4,712,194	4,390,729
Deferred and contingent assets:			
Cash in bank to cover refunds due consumers account of San Francisco gas rate cases	759,048	125,378	76,619
Water-front property (City of Oakland Exchange)	...	148,168	155,693
	759,048	273,546	232,312
Deferred charges:			
Unamortized debt, discount and expense	[a] 1,260,060	171,522	5,623,859
Prepaid taxes	[b] 85,797	11,245	5,135
Sinking funds accrued, not yet due	...	184,233	186,284
Unadjusted items	6,809	28,789	88,501
	1,352,666	395,789	5,903,779
Total assets	117,972,282	152,692,281	165,258,682
LIABILITIES.			
Capital liabilities:			
Common stock issued—in hands of public	20,000,000	28,938,750	31,998,750
Owned by subsidiary companies	...	32,697,817	31,696,867
Preferred stock issued—in hands of public	10,000,000	10,000,000	10,000,000
Due subsidiary companies	...	3,378,622	2,666,844
Bonds outstanding—in hands of public	61,093,004	64,097,410	75,898,800
Bonds held alive in sinking funds	...	1,712,000	2,056,200
Bonds held in treasury	...	308,092	...
Bonds due treasury from trustees for construction	...	1,805,397	...
	91,093,004	142,938,088	154,317,461
Current liabilities:			
Consumer's deposits	312,895	326,497	309,274
Notes payable	1,811,667	750,000	509,006
Current obligations for material and supplies, pay rolls, and other items	908,555	1,404,021	2,120,407
	3,033,117	2,480,518	2,938,687
Deferred liabilities:			
Charges accrued but not yet due—			
Bond interest	870,969	828,109	1,183,504
Sinking funds		184,233	186,284
	870,969	1,012,342	1,369,788
Contingent liabilities:			
San Francisco rate cases—refunds due consumers	821,462	125,378	76,619
Bonds called but not redeemed	...	...	86,480
Dividends declared	...	...	398,877
Notes payable in escrow (City of Oakland Exchange)	...	138,918	138,918
	821,462	264,296	700,894
Surplus and reserves	21,998,812	5,997,037	5,931,852
Other liabilities	154,918	...	...
Total liabilities	117,972,282	152,692,281	165,258,682

[a] Bond discount and expense.

[b] Includes insurance.

TABLE 194.—*Comparative balance sheet of Pacific Gas & Electric Co., 1910–1920*—Continued.

Standard form adopted by Railroad Commission of California.

	1913	1914	1915	1916
ASSETS.				
Total fixed capital	$121,929,414	$124,372,653	$125,856,629	$128,283,859
Cash and deposits:				
Cash	973,566	1,711,968	4,254,303	2,481,394
Special deposits	4,685	45,569	65,510	64,020
Total cash and deposits	978,251	1,757,537	4,319,813	2,545,414
Notes receivable	207,210	443,856	305,873	264,801
Accounts receivable:				
Due from consumers and agents	1,531,898	1,701,999	1,769,585	1,851,214
Miscellaneous accounts receivable	4,770	2,777,381	135,033	179,900
Total accounts receivable	1,536,668	4,479,380	1,904,618	2,031,114
Interest and dividends receivable	3,430	8,743	9,156	16,629
Other current assets	163,368	170,445	....	....
Miscellaneous investments	28,320	14,320	16,320	1,812,938
Materials and supplies	1,271,896	1,500,697	1,419,442	1,620,252
Sinking funds	2,367,918	2,813,355	3,832,398	3,981,029
Other special funds	76,573	....	....	....
Treasury securities	8,572,000	[a]11,109,500	[b]3,441,000	[b]1,080,500
Prepaid expenses:				
Prepaid taxes	4,732	378,517	434,457	482,826
Other prepayments	14,344	....	....	....
Total prepaid expenses	19,076	378,517	434,457	482,826
Unamortized discount on securities and expenses:				
Stocks	35,552,909	2,955,251	3,603,917	3,942,937
Bonds	4,158,648	4,016,423	4,283,526	4,330,150
Miscellaneous	141,902	91,963	....	....
Total	39,853,459	7,063,637	7,887,443	8,273,087
Other suspense	21,958	16,388	8,314	[c]11,467
Construction work in progress	2,474,692	2,765,402	3,424,731	4,656,247
Advance on construction	2,723,312			
Bonds due treasury		....	....	....
Sinking fund accretions not due	33,217	35,132	....	....
Total assets	182,260,762	156,929,562	152,860,194	155,037,230
LIABILITIES.				
Capital stock	73,806,167	45,083,000	56,242,058	57,806,088
Installments on stock subscription	....	5,827,600	380,200	181,700
Funded debt	86,402,000	88,678,000	83,379,000	82,157,000
Bonds due treasury for construction	2,723,312	....	....	52,571
Notes payable	7,699,186	5,606,968	....	1,319,313
Accounts payable:				
Accounts with system corporations	2,666,844	185,371	72,571	356,970
Audited vouchers and wages unpaid	1,369,444	1,356,985	1,140,139	4,250
Consumers' deposits	320,256	396,130	501,392	1,733,104
Miscellaneous accounts payable	10,249	150,712	20,409	1,288,111
Total accounts payable	4,366,793	2,089,198	1,734,511	496,133
Interest accrued	1,343,751	1,262,458	1,251,329	427,275
Taxes accrued	2,190	385,319	446,760	3,002,898
Dividends	651	2,608	2,437	87,590
Reserve for accrued depreciation	2,433,493	2,471,862	2,772,848	1,886,313
Casualty and insurance reserves	52,353	49,538	63,940	1,565,931
Reserves invested in sinking funds [d]	475,954	1,077,914	1,077,914	4,910
Other reserves from income or surplus [e]	261,733	816,096	1,214,384	60,670
Bonds called for redemption	24,355	8,105	910	132,240
Coupons due and unpaid	62,478	60,150	63,748	54,466
Bad debts reserve	34,162	130,000	132,853	....
Returns due consumers	76,573	54,653	54,539	....
Corporate surplus unappropriated	2,495,611	3,326,093	4,042,763	4,152,801
Total liabilities	182,260,762	156,929,562	152,860,194	155,037,230

[a] $10,875,000 hypothecated.
[b] $875,000 hypothecated.
[c] Credit item.
[d] Corporate surplus.
[e] Rate case surplus.

TABLE 194.—*Comparative balance sheet of Pacific Gas & Electric Co., 1910–1920*—Continued.

	1917	1918	1919	1920
ASSETS.				
Total fixed capital	$134,109,345	$135,859,739	[f]$151,030,721	$155,154,712
Cash and deposits:				
Cash	1,700,680	4,950,141	2,027,700	2,078,402
Special deposits	157,012	105,634	174,051	73,081
Total cash and deposits	1,857,692	5,055,775	2,201,751	2,151,483
Notes receivable	258,024	164,585	54,100	186,459
Accounts receivable:				
Accounts with system corporations	2,994	266,120	341,361	
Due from consumers and agents	1,853,084	2,345,450	2,327,763	3,384,691
Miscellaneous accounts receivable	209,266	308,637	1,174,902	854,169
Total accounts receivable	2,065,344	2,920,207	3,844,026	4,238,860
Interest and dividends receivable	38,779	21,548	14,343	40,098
Other current assets			42,858	42,909
Investments:				
Securities of other corporations	259,171	259,821	260,122	261,327
Advances to system corporation for construction, equipment and betterments	3,502	3,878	4,236	3,450,667
Miscellaneous investments	852,660	982,820	768,456	1,762,614
Total investments	1,115,333	1,246,519	1,032,814	5,474,607
Materials and supplies	2,094,097	2,178,889	2,708,677	4,514,627
Sinking funds	4,527,548	5,279,352	6,118,214	7,303,850
Treasury securities	1,024,500	1,150,000	1,358,952	17,341,300
Prepaid expenses:				
Prepaid rents				4,604
Prepaid taxes	14,763	5,092	29,186	30,020
Total prepaid expenses	14,763	5,092	29,186	34,624
Unamortized discount on securities and expenses:				
Stocks	4,017,070	4,032,250	4,762,281	5,534,649
Bonds	4,442,808	4,782,539	4,574,943	5,088,239
Total	8,459,878	8,814,789	9,337,224	10,622,888
Other suspense	34,262	64,287	168,293	132,072
Construction work in progress	3,143,686	2,926,438	2,417,765	6,487,067
Total assets	158,743,251	165,687,220	180,358,925	213,725,555
LIABILITIES.				
Capital stock	58,802,351	58,961,163	62,801,138	66,437,688
Installments on stock subscription	49,300	46,500	1,252,500	1,251,400
Funded debt	81,885,000	88,149,000	94,140,558	119,937,000
Notes payable			240,283	196,827
Accounts payable:				
Accounts with system corporations	52,093	22,093	250,012	49,242
Audited vouchers and wages unpaid	1,394,590	1,068,299	1,536,511	2,389,041
Consumers' deposits	354,933	432,854	687,497	831,003
Miscellaneous accounts payable	80,066	96,019	75,054	205,789
Total accounts payable	1,881,682	1,619,265	2,549,074	3,475,075
Interest accrued	1,360,278	1,442,815	1,474,970	1,581,818
Taxes accrued	215,135	682,795	912,421	1,339,928
Dividends			427,029	425,217
Reserve for accrued depreciation	3,154,219	3,990,261	2,834,717	3,909,829
Casualty and insurance reserves	106,527	150,639	155,591	204,727
Reserves invested in sinking funds [d]	1,077,914	1,077,914	1,077,914	1,077,914
Other reserves from income or surplus [e]	1,849,322	1,849,322	1,849,322	1,820,134
Bonds called for redemption	5,910	3,410	1,410	4,410
Coupons due and unpaid	72,232	123,290	121,065	130,368
Bad debts reserve	155,165	130,539	130,939	160,811
Returns due consumers	54,439			
Reserve for accrued depreciation, special	1,800,000	2,800,000	3,800,000	4,800,000
Reserve for Northern California Power Co. plant adjustment and accrued depreciation			1,799,577	1,648,137
Corporate surplus unappropriated	3,273,777	4,660,307	4,790,417	5,439,923
Reserve for maintenance of electric department capital as per railroad decision 7823				[g]115,651
Total liabilities	158,743,251	165,687,220	180,358,925	213,725,554

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[d] Corporate surplus.
[e] Rate case surplus.
[f] Includes Northern California Power Co.
[g] Debit item.

TABLE 195.—*Comparative balance sheet of Oro Electric Corporation and subsidiary, 1912–1916.*

[Capitalization and bonds included in Pacific Gas & Electric Co. tables.]

	1912		
	Oro Electric Corporation.	Oro Water, Light & Power Co.	Total.
ASSETS.			
Fixed capital: Cost of plant, buildings, and lands	$16,846,411.00	$1,037,971.00	$17,884,382.00
Other investments	6,700,000.00	3,807,564.00	10,507,564.00
Current assets:			
Cash	40,842.00		40,842.00
Notes and bills receivable	26,673.00		26,673.00
Materials and supplies	29,983.00		29,983.00
Miscellaneous	1,012.00		1,012.00
Total	98,510.00		98,510.00
Total assets	23,644,921.00	4,845,535.00	28,490,456.00
LIABILITIES.			
Capital stock	10,000,000.00	3,250,000.00	13,250,000.00
Funded debt	10,000,000.00	333,000.00	10,333,000.00
Current liabilities:			
Loans and notes payable	68,239.00		68,239.00
Accounts payable	23,452.00		23,452.00
Miscellaneous	146,370.00		146,370.00
	238,061.00		238,061.00
Accrued liabilities not due: Unmatured interest	23,175.00		23,175.00
Deferred credit items:			
Reserves	3,250,000.00	716,710.00	3,966,710.00
Profit and loss	133,685.00	545,825.00	679,510.00
	3,383,685.00	1,262,535.00	4,646,220.00
Total liabilities	23,644,921.00	4,845,535.00	28,490,456.00

TABLE 195.—*Comparative balance sheet of Oro Electric Corporation and subsidiary, 1912–1916*—Continued.

Account.	1913			1914		
	Oro Electric Corporation.	Oro Water, Light & Power Co.	Total.	Oro Electric Corporation.	Oro Water, Light & Power Co.	Total.
ASSETS.						
Fixed capital	$11,657,625	$1,046,871	$12,704,496	$2,025,799	$1,009,675	$3,035,474
Cash and deposits:						
Cash	5,561	....	5,561	4,416	....	4,416
Special deposits	1,000	....	1,000	....	....	....
Total cash and deposits	6,561	1,046,871	6,561	4,416	....	4,416
Accounts receivable:						
Accounts with system corporations	....	1,080	1,080	10,007	....	10,007
Due from consumers and agents	24,966	....	24,966	[a] 25,818	([b])	25,818
Miscellaneous accounts receivable	8,021	....	8,021	1,064	....	1,064
Total accounts receivable	32,987	1,080	34,067	36,889	....	36,889
Investments:						
Securities of other corporations	3,250,000	263,000	3,513,000	3,250,000	263,000	3,513,000
Miscellaneous investments	....	[c] 3,558,510	3,558,510	....	3,507,814	3,507,814
Total investments	3,250,000	3,821,510	7,071,510	3,250,000	3,770,814	7,020,814
Materials and supplies	84,338	....	84,338	66,203	....	66,203
Treasury securities	[d] 8,170,000	....	8,170,000	8,170,000	....	8,170,000
Prepaid expenses:						
Prepaid taxes	555	....	555	382	....	382
Prepaid insurance	11	....	11	484	....	484
Other	....	....	....	....	....	....
Total prepaid expenses	566	....	566	866	....	86
Unamortized discount on securities and expenses:						
Stocks	....	....	....	6,467,383	....	6,467,383
Bonds	149,194	....	149,194	192,704	....	192,704
	149,194	....	149,194	6,660,087	....	6,660,087
Construction work in progress	326,003	....	326,003	328,408	....	328,408
Total assets	23,677,274	4,869,461	28,546,735	20,542,668	4,780,488	25,323,157
LIABILITIES.						
Capital stock	10,000,000	3,250,000	13,250,000	10,000,000	3,250,000	13,250,000
Funded debt	10,000,000	346,000	10,346,000	10,000,000	346,000	10,346,000
Advance from system corporations	....	....	....	192,443	....	192,443
Notes payable	174,487	....	174,487	99,735	....	99,735
Accounts payable:						
Accounts with system corporations	46,556	....	46,556	....	10,007	10,007
Audited vouchers and wages unpaid	31,166	....	31,166	28,471	....	28,471
Consumers' deposits	294	....	294	2,557	....	2,557
Miscellaneous accounts payable	20,885	....	20,885	24,574	....	24,574
Total accounts payable	98,901	....	98,901	55,602	10,007	65,609
Interest accrued	[e] 35,544	....	35,544	33,375	....	33,375
Service billed in advance	....	....	....	....	....	....
Reserves for accrued depreciation	591	4,375	4,966	4,014	5,828	9,842
Other reserves from income or surplus	3,250,000	716,710	3,966,710	....	671,922	671,922
Corporate surplus unappropriated	117,751	552,376	670,127	157,499	496,732	654,231
Total liabilities	23,677,274	4,869,461	28,546,735	20,542,668	4,780,488	25,323,157

[a] Of own and subsidiary companies.
[b] See Oro Electric Corporation.
[c] Net, not public utility.
[d] Oro Electric Corporation bonds.
[e] On notes of own and subsidiary companies.

TABLE 195.—*Comparative balance sheet of Oro Electric Corporation and subsidiary, 1912–1916*—Continued.

Account.	1915			1916		
	Oro Electric Corporation.	Oro Water, Light & Power Co.	Total.	Oro Electric Corporation.	Oro Water, Light & Power Co.	Total.
ASSETS.						
Fixed capital	$2,020,225	$1,011,524	$3,031,749	$2,036,270.28	$1,016,349.20	$3,052,619.48
Cash and deposits:						
Cash	4,414	....	4,414	2,254.04	....	2,254.04
Special deposits	....	....	....	....	....	....
Total cash and deposits	4,414	....	4,414	2,254.04	....	2,254.04
Accounts receivable:						
Accounts with system corporations	10,380	....	10,380	9,299.04	....	9,299.04
Due from consumers and agents	23,199	....	23,199	26,870.58	....	26,870.58
Miscellaneous accounts receivable	910	....	910	1,699.10	....	1,699.10
Total accounts receivable	34,489	....	34,489	37,868.72	....	37,868.72
Investments:						
Securities of other corporations	3,250,000	263,000	3,513,000	3,250,000.00	263,000.00	3,513,000.00
Miscellaneous investments	....	[a]3,492,593	3,492,593	....	[a]3,515,432.97	3,515,432.97
Total investments	3,250,000	3,755,593	7,005,593	3,250,000.00	3,778,432.97	7,028,432.97
Materials and supplies	62,034	....	62,034	60,628.69	....	60,628.69
Treasury securities	3,630,000	....	3,630,000	....	....	....
Prepaid expenses:						
Prepaid taxes	886	....	886	555.07	....	555.07
Prepaid insurance	770	....	770	733.48	....	733.48
Other	15	....	15	2,177.30	....	2,177.30
Total prepaid expenses	1,671	....	1,671	3,465.85	....	3,465.85
Unamortized discount on securities and expenses:						
Stocks	6,467,383	....	6,467,383	6,467,382.63	....	6,467,382.63
Bonds	188,418	....	188,418	183,184.62	....	183,184.62
	6,655,801	....	6,655,801	6,650,567.25	....	6,650,567.25
Construction work in progress	294,563	....	294,563	292,760.89	....	292,760.89
Total assets	15,953,197	4,767,117	20,720,314	12,333,815.72	4,794,782.17	17,128,597.89
LIABILITIES.						
Capital stock	10,000,000	3,250,000	13,250,000	10,000,000.00	3,250,000.00	13,250,000.00
Funded debt	5,460,000	346,000	5,806,000	1,830,000.00	346,000.00	2,176,000.00
Advance from system corporations	147,148	10,380	157,528	....	....	....
Notes payable	120,643	....	120,643	194,500.00	....	194,500.00
Accounts payable:						
Accounts with system corporations	....	....	....	32,716.37	9,299.09	42,015.46
Audited vouchers and wages unpaid	39,712	....	39,712	6,785.60	....	6,785.60
Consumer's deposits	2,760	....	2,760	3,974.71	....	3,974.71
Miscellaneous accounts payable	50,180	....	50,180	73,153.20	....	73,153.20
Total accounts payable	92,652	....	92,652	116,629.88	9,299.09	125,928.97
Interest accrued	32,879	....	32,879	139,005.00	....	139,005.00
Service billed in advance	1,450	....	1,450	....	....	....
Reserves for accrued depreciation	28,764	11,827	40,591	53,514.00	17,827.63	71,341.63
Other reserves from income or surplus	....	671,922	671,922	....	671,921.74	671,921.74
Corporate surplus unappropriated	69,661	476,988	546,649	166.84	499,733.71	499,900.55
Total liabilities	15,953,197	4,767,117	20,720,314	12,333,815.72	4,794,782.17	17,128,597.89

[a] Net, not public utility.

TABLE 196.—*Earnings and expenses of Pacific Gas & Electric Co., 1906–1920.*

Form used by accountants of company, 1906-1912.

	1906	1907	1908	1909
Gross revenue from operation	$8,742,495	$11,193,325	$12,474,746	$13,298,308
Maintenance	673,067	1,057,163	1,219,492	1,210,506
Operating expenses, taxes, and reserves for uncollectible accounts, casualties, etc	3,750,052	5,169,066	5,573,227	6,321,070
Total expenses	4,423,119	6,226,229	6,792,719	7,531,576
Net revenue from operation	4,319,376	4,967,096	5,682,027	5,766,732
Merchandise sales and miscellaneous income	204,667	148,815	182,559	192,980
Total net revenue	4,524,043	5,115,911	5,864,586	5,959,712
Interest (including interest in unifying and refunding bonds and on all other funded and unfunded debt)	2,784,908	2,854,264	3,021,722	2,988,521
Balance	1,739,135	2,261,647	2,842,864	2,971,191
Deductions:				
Accrued dividends on preferred stock	600,000	600,000	600,000	600,000
Sinking funds	581,448	578,858	621,063	667,210
Bond discount and expense	....	....	44,259	42,237
Total deductions	1,181,448	1,178,858	1,265,322	1,309,447
Balance	557,687	1,082,789	1,577,542	1,661,744

	1910	1911	1912
Gross revenue from operation	$13,829,972	$14,426,259	$14,473,526
Maintenance	1,243,859	1,398,404	1,085,959
Operating expenses, taxes, and reserves for uncollectible accounts, casualties, etc	6,677,482	6,815,668	7,345,602
Total expenses	7,921,341	8,214,072	8,431,561
Net revenue from operation	5,908,631	6,212,187	6,041,965
Merchandise sales and miscellaneous income	214,624	178,350	271,126
Total net revenue	6,123,255	6,390,537	6,313,091
Interest (including interest in unifying and refunding bonds and on all other funded and unfunded debt)	3,006,256	3,254,133	3,568,944
Balance	3,116,999	3,136,404	2,744,147
Deductions:			
Accrued dividends on common stock	....	....	1,520,435
Accrued dividends on preferred stock	600,000	600,000	600,000
Sinking funds	733,402	773,226	....
Bond discount and expense	47,220	75,672	127,871
Total deductions	1,380,622	1,448,898	2,248,306
Balance	1,736,377	1,687,506	495,841
Sundry accretions	....	....	25,380
Balance	1,736,377	1,687,506	521,221

TABLE 196.—*Earnings and expenses of Pacific Gas & Electric Co., 1906–1920*—Contd.

Standard form prescribed by Railroad Commission of California, 1913–1920.

Account.	1913	1914	1915	1916
Electric operations:				
Operating revenues	$8,362,540	$8,930,950	$10,124,560	$10,307,424
Operating expenses	4,787,450	5,053,256	5,505,686	5,522,730
Net operating electric revenue	3,575,090	3,877,694	4,618,874	4,784,694
Gas operations:				
Operating revenues	6,547,595	7,015,408	7,560,185	7,438,255
Operating expenses	3,960,308	4,077,501	4,400,597	4,556,672
Net operating gas revenue	2,587,287	2,937,907	3,159,588	2,881,583
Water operations:				
Operating revenues	385,958	409,422	420,217	427,516
Operating expenses	204,747	200,641	208,204	231,565
Net operating water revenue	181,211	208,781	212,013	195,951
Railway operations:				
Gross operating revenues	572,913	556,908	425,338	442,303
Expenses	317,624	404,955	333,990	349,973
Net operating railway revenue	255,289	151,953	91,348	92,330
Total operating revenues	6,598,877	7,176,335	8,081,823	7,954,558
Depreciation of plant and equipment [a]	1,462,462	....	....	....
Total net operating revenue	5,136,415	7,176,335	8,081,823	7,954,558
Add:				
Miscellaneous rent revenues—electric	18,710	21,214	20,919	19,004
Miscellaneous rent revenues	14,407	....	....	....
Interest and dividend revenues—				
Interest on funded debt owned	....	....	....	....
Miscellaneous interest revenues	9,140	38,318	51,562	42,156
Dividend revenues	....	496	512	639
Total interest and dividend revenues	9,140	38,814	52,074	42,795
Sinking and reserve fund accretions	138,201	119,969	165,734	183,956
Profits from operations of others	....	....	....	97,234
Miscellaneous nonoperating revenues	[b] 147,466	[b] 65,689	[b] 151,640	135,005
Total nonoperating revenues	327,924	185,658	390,367	477,994
Gross corporate income	5,464,339	7,422,021	8,472,190	8,432,552
Deduct:				
Uncollectible bills	48,000	108,000	108,000	108,000
Nonoperating revenue deductions—				
Miscellaneous nonoperating expenses	....	....	....	....
Nonoperating taxes	13,078	11,459	10,035	10,567
Total nonoperating revenue deductions	13,078	11,459	10,035	10,567
Interest accrued on funded debt	3,680,266	3,748,330	3,808,507	3,836,006
Other interest deductions	221,779	443,071	176,903	8,928
Rent for conduits, poles, and other supports—electric	[c] 5,407	[c] 4,020	[c] 4,431	[c] 2,517
Amortization of debt discount and expense	246,042	469,515	160,410	173,186
Total deductions	4,203,758	4,776,355	4,259,424	4,134,170
Balance of year carried to corporate account	1,260,581	2,645,266	4,212,766	4,298,382

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[a] Subsequent to 1913 depreciation is included in "Operating expenses," the following amounts being distributed among the various activities: 1914, $1,000,000; 1915, $1,380,000; 1916, $1,250,000; 1917, $1,259,000; 1918, $1,700,000; 1919, 1,500,000; 1920, $2,788,302. In addition to these amounts taken from current revenues, $1,000,000 was appropriated each year from 1916 to 1920 from "surplus"; these appropriations from "surplus" are not included in the table.

[b] Net.

[c] Credit item.

TABLE 196.—*Earnings and expenses of Pacific Gas & Electric Co., 1906–1920*—Contd.

Account.	1917	1918	1919	1920
Electric operations:				
Operating revenues	$11,075,968	$12,628,692	$14,793,326	$22,764,493
Operating expenses	6,417,666	7,698,836	9,170,516	15,359,288
Net operating electric revenue	4,658,302	4,929,856	5,622,810	7,405,204
Gas operations:				
Operating revenues	7,771,058	8,923,484	9,933,334	11,284,177
Operating expenses	5,541,881	6,374,887	7,542,461	9,551,965
Net operating gas revenue	2,229,177	2,548,597	2,390,873	1,732,212
Water operations:				
Operating revenues	475,332	509,273	540,607	643,871
Operating expenses	263,708	273,059	315,791	485,709
Net operating water revenue	211,624	236,214	224,817	158,161
Railway operations:				
Gross operating revenues	491,021	534,067	671,105	753,028
Expenses	438,818	463,136	549,495	736,357
Net operating railway revenue	52,203	70,931	121,610	16,671
Total operating revenues	7,151,306	7,785,598	8,360,110	9,312,249
Depreciation of plant and equipment[a]	...	...	...	...
Total net operating revenue	7,151,306	7,785,598	8,360,110	9,312,249
Add:				
Miscellaneous rent revenues—electric	27,226	41,030	37,634	35,873
Miscellaneous rent revenues	...	...	...	...
Interest and dividend revenues—				
Interest on funded debt owned	35,576	52,634	60,026	62,399
Miscellaneous interest revenues	83,244	28,587	130,559	242,638
Dividend revenues	723	583	762	1,240
Total interest and dividend revenues	119,543	81,804	191,347	306,277
Sinking and reserve fund accretions	202,738	235,887	277,621	321,809
Profits from operations of others	...	...	...	...
Miscellaneous nonoperating revenues	80,816	72,391	77,248	230,046
Total nonoperating revenues	430,323	431,112	683,849	894,006
Gross corporate income	7,581,629	8,216,710	8,943,959	10,206,255
Deduct:				
Uncollectible bills	120,000	180,000	90,000	99,000
Nonoperating revenue deductions—				
Miscellaneous nonoperating expenses	...	...	...	...
Nonoperating taxes	14,116	19,940	21,765	27,371
Total nonoperating revenue deductions.	14,116	19,940	21,765	27,371
Interest accrued on funded debt	4,098,072	4,116,219	4,279,744	4,900,109
Other interest deductions	2,835	848	5,513	20,327
Rent from lease of other electric plant	...	...	...	943,296
Rent for conduits, poles, and other supports—electric	[c] 19,524	[c] 9,899	[c] 1,366	[c] 10,344
Amortization of debt discount and expense	185,051	187,019	207,951	306,538
Total deductions	4,400,550	4,494,127	4,603,606	6,286,297
Balance of year carried to corporate account.	3,181,079	3,722,583	4,340,353	3,919,959

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[a] Subsequent to 1913 depreciation is included in "Operating expenses," the following amounts being distributed among the various activities: 1914, $1,000,000; 1915, $1,380,000; 1916, $1,250,000; 1917, $1,250,000; 1918, $1,700,000; 1919, $1,500,000; 1920, $2,788,302. In addition to these amounts taken from current revenues, $1,000,000 was appropriated each year from 1916 to 1920 from "surplus"; these appropriations from "surplus" are not included in the table.

[c] Credit item.

TABLE 197.—*Earnings and expenses of Oro Electric Corporation and Oro Water, Light & Power Co., 1912–1916.*

	1912			1913		
	Oro Electric Corporation.	Oro Water, Light & Power Co.	Total.	Oro Electric Corporation.	Oro Water, Light & Power Co.	Total.
Electric operations:						
Operating revenue	$169,545	$128,324	$297,869	$196,918	$37,429	$234,347
Operating expenses	91,989	82,548	174,537	100,158	27,948	128,106
Net operating electric revenue	77,556	45,776	123,332	96,760	9,481	106,241
Gas operations:						
Operating revenue					19,078	19,078
Operating expenses					15,517	15,517
Net operating gas revenue					3,561	3,561
Water operations:						
Operating revenue					35,547	35,547
Operating expenses					32,819	32,819
Net operating water revenue					2,728	2,728
Total net operating revenue	77,556	45,776	123,332	96,760	15,770	112,530
Add:						
Nonoperating revenues—						
Miscellaneous rent revenues—						
Gas					12	12
Interest and dividend revenues—						
Interest revenue on funded debt					780	11,852
Miscellaneous interest revenues				11,072	7,138	7,138
Dividend revenues					6,250	6,250
Total interest and dividend revenues	300,625	39,502	340,127	11,072	14,168	25,240
Miscellaneous nonoperating revenues	30	100,941	100,971	13,904	275,580	289,484
Total nonoperating revenues	300,655	140,443	441,098	24,976	289,760	314,736
Gross corporate income	378,211	186,219	564,430	121,736	305,530	427,266
Deduct:						
Uncollectible bills				1,626	631	2,257
Interest accrued on funded debt	37,500	21,230	58,730	42,767	20,760	63,527
Other interest deductions		6,888	6,888	5,122		5,122
Amortization of debt, discount, and expenses				654		654
Total deductions	37,500	28,118	65,618	50,169	21,391	71,560
Surplus for year	340,711	158,101	498,812	71,567	284,139	355,706
Dividends	210,000	[a] 300,625	510,625	[a] 87,500		[a] 87,500
Balance	130,711	[b] 142,524	11,813	[b] 15,933	284,139	268,206

[a] Dividends probably paid out of surplus for preceding year.
[b] Deficit.

TABLE 197.—*Earnings and expenses of Oro Electric Corporation and Oro Water, Light & Power Co., 1912–1916*—Continued.

	1914			1915		
	Oro Electric Corporation.	Oro Water, Light & Power Co.	Total.	Oro Electric Corporation.	Oro Water, Light & Power Co.	Total.
Electric operations:						
Operating revenue	$191,436	$32,836	$224,272	$183,078	$34,992	$218,070
Operating expenses	101,010	23,993	125,003	116,192	22,541	138,733
Net operating electric revenue	90,426	8,843	99,269	66,886	12,451	79,337
Gas operations:						
Operating revenue	...	20,345	20,345	...	20,578	20,578
Operating expenses	...	15,930	15,930	...	17,099	17,099
Net operating gas revenue	...	4,415	4,415	...	3,479	3,479
Water operations:						
Operating revenue	...	34,828	34,828	...	34,636	34,636
Operating expenses	...	32,625	32,625	...	34,160	34,160
Net operating water revenue	...	2,203	2,203	...	476	476
Total net operating revenue	90,426	15,461	105,887	66,886	16,406	83,292
Add:						
Nonoperating revenues—						
Miscellaneous rent revenues—						
Electric	...	...	...	2,700	...	2,700
Gas	...	12	12	...	12	12
Interest and dividend revenues—						
Interest revenue on funded debt	...	780	780	...	780	780
Miscellaneous interest revenues	...	2,595	2,595	...	...	...
Total interest and dividend revenues	...	3,375	3,375	...	780	780
Miscellaneous nonoperating revenues	[c]24,158	[d]198,123	223,381	...	69,146	69,146
Total nonoperating revenues	24,158	201,510	225,668	2,700	69,938	72,638
Gross corporate income	114,584	216,971	331,555	69,586	86,344	155,930
Deduct:						
Uncollectible bills	750	441	1,191	4,917	961	5,878
Nonoperating revenue deductions—						
Rent expenses	...	...	...	1,518	...	1,518
Miscellaneous nonoperating expenses	...	...	...	3,971	...	3,971
Nonoperating taxes	...	...	...	1,787	...	1,787
Total nonoperating deductions	...	...	...	7,276	...	7,276
Interest accrued on funded debt	54,000	20,760	74,760	109,800	20,760	130,560
Other interest deductions	9,234	...	9,234	8,301	...	8,301
Rent deductions for instruments and equipment (electric)	865	...	865	556	...	556
Amortization of debt discount and expenses	2,986	...	2,986	5,285	...	5,285
Total deductions	67,835	21,201	89,036	136,135	21,721	157,856
Surplus for year	46,749	195,770	242,519	...	64,622	64,622
Deficit for year	...	...	...	66,549	...	66,549

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[c] Includes $23,564.38 net loss in operating Stockton division after interest on investment charged to development expense.

[d] Net gain, not from public utilities.

TABLE 197.—*Earnings and expenses of Oro Electric Corporation and Oro Water, Light & Power Co., 1912–1916*—Continued.

	1916		
	Oro Electric Corporation.	Oro Water, Light & Power Co.	Total.
Electric operations:			
Operating revenue	$174,207.66	$36,429.17	$210,636.83
Operating expenses	111,320.06	22,781.80	134,101.86
Net operating revenue	62,887.60	13,647.37	76,534.97
Gas operations:			
Operating revenue	....	20,385.19	20,385.19
Operating expenses	....	16,818.07	16,818.07
Net operating revenue	....	3,567.12	3,567.12
Water operations:			
Operating revenue	....	35,252.22	35,252.22
Operating expenses	....	32,640.93	32,640.93
Net operating revenue	....	2,611.29	2,611.29
Total net operating revenue	62,887.60	19,825.78	82,713.38
Add:			
Nonoperating revenues—			
Miscellaneous rent revenues—			
Electric	2,930.00	....	2,930.00
Gas	....	13.00	13.00
Interest and dividend revenues—			
Interest revenue on funded debt	....	780.00	780.00
Total interest and dividend revenues	....	780.00	780.00
Miscellaneous nonoperating revenues	280.75	161,258.30	161,539.05
Total nonoperating revenues	3,210.75	162,051.30	165,262.05
Gross corporate income	66,098.35	181,877.08	247,975.43
Deduct:			
Uncollectible bills	158.85	193.55	352.40
Nonoperating revenue deductions—			
Rent expenses	1,624.94	....	1,624.94
Miscellaneous nonoperating expenses	3,510.79	....	3,510.79
Nonoperating taxes	2,166.82	....	2,166.82
Total nonoperating deductions	7,302.55	....	7,302.55
Interest accrued on funded debt	109,800.00	20,760.00	130,560.00
Other interest deductions	12,467.14	....	12,467.14
Rent deductions for instruments and equipment (electric)	630.33	....	630.33
Amortization of debt discount and expenses	5,233.84	....	5,233.84
Total deductions	135,592.71	20,953.55	156,546.26
Surplus for year	....	160,923.53	160,923.53
Deficit for year	69,494.36	....	69,494.36

NOTE.—Capitalization and bonds included in Pacific Gas & Electric tables.

TABLE 198.—*Classified electric revenues, Pacific Gas & Electric Co., 1907–1920.*

Classification.	1907			1908		
	Revenue.	Per cent of total electric revenue for 1907.	Per cent of revenue of same class for 1907.	Revenue.	Per cent of total electric revenue for 1908.	Per cent of revenue of same class for 1907.
Commercial and residential business...	$3,686,972	58.4	100	$4,122,587	58.5	111.8
State, county, and municipal business.	365,794	5.8	100	424,024	6.0	115.9
Sales of power:						
Manufacturing....................	2,262,050	35.8	100	2,509,736	35.5	110.8
Temporary light and power.......	1,813	....	100	2,741	....	151.1
	6,316,629	100.0	100	7,059,088	100.0	111.8

Classification.	1909			1910		
	Revenue.	Per cent of total electric revenue for 1909.	Per cent of revenue of same class for 1907.	Revenue.	Per cent of total electric revenue for 1910.	Per cent of revenue of same class for 1907.
Commercial and residential business...	$3,457,955	45.0	93.8	$3,588,005	45.5	97.4
State, county, and municipal business.	474,121	6.2	129.5	527,944	6.7	144.4
Sales of power:						
Manufacturing....................	3,711,665	48.4	163.7	3,743,266	47.4	165.4
Commercial miscellaneous.........	32,492	.4	....	35,087	.4	[a]108.0
Temporary light and power.......	2,432	....	134.0	4,922	....	270.6
	7,678,665	100.0	121.5	7,899,224	100.0	125.0

Classification.	1911			1912		
	Revenue.	Per cent of total electric revenue for 1911.	Per cent of revenue of same class for 1907.	Revenue.	Per cent of total electric revenue for 1912.	Per cent of revenue of same class for 1912.
Commercial and residential business...	$3,712,797	47.5	100.6	$3,457,065	45.1	100.0
State, county, and municipal business.	583,852	7.5	159.6	680,339	8.9	100.0
Sales of power:						
Agricultural.....................	....	....	....	195,884	2.5	100.0
Mining...........................	....	....	....	576,785	7.5	100.0
Transportation...................	....	....	....	627,763	8.2	100.0
Manufacturing....................	3,492,410	44.6	154,0	1,436,644	18.7	100.0
Other companies..................	....	....	....	305,163	4.0	100.0
Commercial miscellaneous.........	34,113	.4	[a]105.0	391,567	5.1	100.0
Temporary light and power.......	731	....	40.3	1,361	....	100.0
	7,823,903	100.0	123.8	7,672,571	100.0	100.0

Classification.	1913			1914		
	Revenue.	Per cent of total electric revenue for 1913.	Per cent of revenue of same class for 1912.	Revenue.	Per cent of total electric revenue for 1914.	Per cent of revenue of same class for 1912.
Commercial and residential business...	$3,642,837	44.3	105.4	$3,973,012	45.3	115.0
State, county, and municipal business.	662,566	8.0	97.5	739,083	8.4	108.6
Sales of power:						
Agricultural.....................	419,093	5.1	214.0	350,551	4.0	179.1
Mining...........................	557,462	6.8	96.6	591,314	6.8	102.5
Transportation...................	696,324	8.5	111.0	756,343	8.6	120.7
Manufacturing....................	1,476,105	17.9	102.7	1,553,640	17.8	108.1
Other companies..................	343,430	4.2	112.5	304,031	3.5	99.8
Commercial miscellaneous.........	431,337	5.2	110.2	487,714	5.6	[a]124.6
Temporary light and power.......	1,628	....	119.5	3,761	....	276.0
	8,230,782	100.0	107.2	8,759,449	100.0	114.1

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[a] Per cent of revenue of same class for 1909.

TABLE 198.—*Classified electric revenues, Pacific Gas & Electric Co., 1907–1920*—Contd.

Classification.	1915			1916		
	Revenue.	Per cent of total electric revenue for 1915.	Per cent of revenue of same class for 1912.	Revenue.	Per cent of total electric revenue for 1915.	Per cent of revenue of same class for 1912.
Commercial and residential business	$4,486,451	46.6	130.0	$4,355,221	43.2	125.9
State, county, and municipal business	787,612	8.2	115.7	832,741	8.3	122.4
Sales of power:						
Agricultural	354,171	3.6	180.8	584,301	5.8	298.2
Mining	650,740	6.8	112.8	700,950	6.9	121.5
Transportation	870,326	9.0	138.6	822,220	8.1	130.9
Manufacturing	1,663,099	17.3	115.8	1,883,630	18.7	131.1
Other companies	306,059	3.2	100.3	301,421	3.0	98.7
Commercial miscellaneous	513,460	5.3	131.1	606,356	6.0	154.8
Temporary light and power	1,418	....	104.2	6,142	....	451.2
	[b] 9,633,336	100.0	125.5	10,092,982	100.0	131.5

Classification.	1917			1918		
	Revenue.	Per cent of total electric revenue for 1917.	Per cent of revenue of same class for 1912.	Revenue.	Per cent of total electric revenue for 1918.	Per cent of revenue of same class for 1912.
Commercial and residential business	$4,485,697	41.3	129.7	$5,009,287	40.8	145.0
State, county, and municipal business	867,708	8.0	127.5	896,824	7.2	131.8
Sales of power:						
Agricultural	661,117	6.1	337.7	836,759	6.7	427.2
Mining	849,775	7.8	147.3	851,466	6.8	147.6
Transportation	867,891	8.0	138.3	922,361	7.3	147.0
Manufacturing	2,152,836	19.8	149.8	2,521,140	20.4	175.5
Other companies	330,135	3.1	108.2	370,358	3.0	121.4
Commercial miscellaneous	642,575	5.9	164.1	974,752	7.8	249.0
Temporary light and power	2,051	....	150.7	1,552	....	114.0
	10,859,785	100.0	141.6	12,384,499	100.0	161.5

Classification.	1919			1920		
	Revenue.	Per cent of total electric revenue for 1919.	Per cent of revenue of same class for 1912.	Revenue.	Per cent of total electric revenue for 1919.	Per cent of revenue of same class for 1912.
Commercial and residential business	$6,082,949	42.0	175.9	$8,207,868	38.0	237.4
State, county, and municipal business	962,068	6.6	141.4	1,186,789	5.5	174.4
Sales of power:						
Agricultural	1,094,092	7.6	558.5	2,246,697	10.4	1,146.9
Mining	949,678	6.6	164.6	1,110,322	5.1	192.5
Transportation	1,021,145	7.1	162.6	2,257,636	11.9	207.4
Manufacturing	2,682,785	18.5	186.7	3,526,059	16.4	245.4
Other companies	498,480	3.4	163.3	1,196,295	5.6	392.0
Commercial miscellaneous	1,181,488	8.2	301.7	1,518,392	7.0	387.7
Temporary light and power	2,199	....	161.5	21,263	.1	156.2
	14,474,884	100.0	188.6	21,571,321	100.0	281.1

[b] Includes $291,146 for light and power furnished to Panama-Pacific International Exposition.

TABLE 198.—*Classified electric revenues, Pacific Gas & Electric Co., 1907–1920*—Contd.

Classified electric revenues according to classification of Railroad Commission of California, 1913-1920.

Class of load.	1913		1914	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Municipal street lighting:				
Arc	$379,527	4.6	$418,535	4.7
Incandescent	126,807	1.5	153,277	1.7
Municipal lighting, miscellaneous	36,367	.4	37,470	.4
Municipal power	33,679	.4	51,902	.6
Commercial lighting:				
Flat rate	259,363	3.1	212,236	2.4
Metered	3,202,358	38.3	3,523,587	39.6
Commercial power:				
Flat rate	23,042	.3	18,159	.2
Metered	2,861,600	34.2	2,966,504	33.2
Railway power	696,324	8.3	756,343	8.5
Other electrical corporations	343,430	4.1	304,031	3.4
Breakdown service	1,628	....	3,761	....
Miscellaneous electric revenues	265,785	3.2	312,545	3.5
Total operating revenues, electric	8,229,910	98.4	8,758,350	98.1
Rent of electric appliances	873	....	1,100	....
Steam sales, revenues	131,759	1.6	171,501	1.9
Total other operating revenues	132,632	1.6	172,601	1.9
Gross electric revenues[c]	8,362,542	100.0	8,930,951	100.0

Class of load.	1915		1916	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Municipal street lighting:				
Arc	416,917	4.1	$410,173	4.0
Incandescent	196,834	1.9	213,567	2.1
Municipal lighting, miscellaneous	48,598	.5	62,933	.6
Municipal power	48,283	.5	59,497	.6
Commercial lighting:				
Flat rate	109,134	1.1	62,331	.6
Metered	4,298,854	42.5	4,287,121	41.6
Commercial power:				
Flat rate	13,241	.1	9,168	....
Metered	3,170,360	31.3	3,776,572	36.7
Railway power	870,326	8.6	822,220	8.1
Other electrical corporations	306,059	3.0	301,421	....
Breakdown service	1,417	....	6,142	....
Miscellaneous electric revenues	442,114	4.4	86,620	.8
Total operating revenues, electric	9,922,137	98.0	10,097,765	98.0
Rent of electric appliances	2,344	....	2,267	....
Steam sales, revenues	200,079	2.0	207,391	2.0
Total other operating revenues	202,423	2.0	209,658	2.0
Gross electric revenues[c]	10,124,560	100.0	10,307,423	100.0

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[c] These entries less steam sales equal totals for same years given in form on pp. 955–956.

TABLE 198.—*Classified electric revenues, Pacific Gas & Electric Co., 1907–1920*—Contd.

Class of load.	1917		1918	
	Revenue.	Per cent of gross revenues.	Revenue.	Per cent of gross revenues.
Municipal street lighting:				
Arc	$345,653.67	3.13	$266,434.84	2.1
Incandescent	307,764.12	2.78	383,086.02	3.0
Municipal lighting, miscellaneous	59,134.15	.53	69,084.78	.5
Municipal power	61,159.40	.55	66,489.98	.5
Commercial lighting:				
Flat rate	72,169.94	.65	56,992.91	.4
Metered	4,378,822.18	39.53	4,903,296.03	38.8
Commercial power:				
Flat rate	9,122.75	.8	4,617.66	.0
Metered	4,329,601.39	39.09	5,223,340.58	41.3
Railway power	867,890.74	7.84	922,361.07	7.3
Other electrical corporations	330,135.36	2.98	370,358.27	2.9
Breakdown service	2,050.97	.02	1,551.68	.0
Miscellaneous electric revenues	94,002.40	.85	111,728.57	.9
Total operating revenues, electric	10,857,507.07	98.03	12,379,342.39	97.7
Rent of electric appliances	2,278.21	.02	5,156.47	.4
Steam sales, revenues	216,183.34	1.95	244,192.85	1.9
Total other operating revenues	218,461.55	1.97	249,349.32	2.3
Gross electric revenues[c]	11,075,968.62	100.00	12,628,691.71	100.0

Class of load.	1919		1920	
	Revenue.	Per cent of gross revenues.	Revenue.	Per cent of gross revenues.
Municipal street lighting:				
Arc	$242,477	1.7	$279,225	1.3
Incandescent	440,174	2.9	518,134	2.3
Municipal lighting, miscellaneous	82,326	.6	99,997	.5
Municipal power	74,213	.5	129,663	.6
Commercial lighting:				
Flat rate	92,775	.7	71,203	.3
Metered	5,930,732	40.0	8,023,701	35.3
Commercial power:				
Flat rate	6,112	....	148,846	.7
Metered	5,958,690	40.3	8,361,202	36.7
Railway power	1,021,145	6.9	2,557,636	11.3
Other electrical corporations	498,480	3.4	1,196,295	4.9
Breakdown service	2,199	....	3,574	....
Miscellaneous electric revenues	122,880	.8	1,019,626	4.5
Total operating revenues, electric	14,472,201	97.8	22,409,101	98.4
Rent of electric appliances	2,683	....	4,387	....
Steam sales, revenues	318,442	2.2	351,006	1.6
Total other operating revenues	321,125	2.2	355,392	1.6
Gross electric revenues	14,793,326	100.0	22,764,493	100.0

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[c] These entries less steam sales equal totals for same years given in form on pp. 955–956.

NOTE—In addition to $9,633,336 for electric revenues from its regular market, the company earned during 1915 $291,146 from sales of electricity for lighting and power to the Panama-Pacific International Exposition, making a total of $9,924,482 for all electric revenues. In 1916 the sales to the Panama-Pacific International Exposition amounted to $7,050, making a total of $10,100,032.

TABLE 199.—*Classified electric revenues (according to classification of Railroad Commission of California) of Oro Electric Corporation and Oro Water, Light & Power Co., 1913–1916.*

Oro Electric Corporation.

Class of load.	1913		1914	
	Revenue.	Per cent of total gross electric revenues.	Revenue.	Per cent of total gross electric revenues
Operating revenue, electric:				
Municipal lighting, miscellaneous	$62	....	$31	....
Municipal power	11	....	49	....
Commercial lighting, metered	1,630	0.8	5,585	2.9
Commercial power, metered	176,589	89.7	171,122	89.5
Other electrical corporations	15,076	7.7	11,350	5.9
Total operating revenues, electric	193,368	98.2	188,137	98.3
Other operating revenues:				
Electric merchandise and jobbing revenues	1,160	.6	58	....
Sale of by-products	2,391	1.2	3,241	1.7
Total other operating revenues	3,551	1.8	3,299	1.7
Gross electric revenues	196,919	100.0	191,436	100.0

Class of load.	1915		1916	
	Revenue.	Per cent of total gross electric revenues.	Revenue.	Per cent of total gross electric revenues.
Operating revenue, electric:				
Municipal lighting, miscellaneous	$13	....	$42	0.0
Municipal power	21	....	29	.0
Commercial lighting, metered	7,326	4.0	9,661	5.5
Commercial power, metered	160,452	88.1	148,310	85.2
Other electrical corporations	11,579	6.2	12,054	6.9
Total operating revenues, electric	179,391	98.3	170,096	97.6
Other operating revenues:				
Electric merchandise and jobbing revenues	243	....	534	.3
Sale of by-products	3,444	1.7	3,578	2.1
Total other operating revenues	3,687	1.7	4,112	2.4
Gross electric revenues	183,078	100.0	174,208	100.0

NOTE.—No gas plant operated by Oro Electric Corporation.

TABLE 199.—*Classified electric revenues (according to classification of Railroad Commission of California) of Oro Electric Corporation and Oro Water, Light & Power Co., 1913–1916*—Continued.

Oro Water, Light & Power Co.

Class of load.	1913		1914	
	Revenue.	Per cent of total gross electric revenues.	Revenue.	Per cent of total gross electric revenues.
Operating revenue, electric:				
Municipal street lighting—				
Arc	$832	2.2	$792	2.4
Incandescent	1,788	4.7	1,819	5.5
Municipal lighting, miscellaneous	1,460	3.9	1,419	4.3
Municipal power	344	.9	392	1.2
Commercial lighting—				
Flat rate	5,489	14.7	....	....
Metered	21,839	58.5	23,922	72.9
Commercial power—				
Flat rate	454	1.2	....	....
Metered	4,075	10.9	3,809	11.6
Miscellaneous electric	488	1.3	34	....
Total operating revenues, electric	36,769	98.5	32,187	98.0
Electric merchandise and jobbing revenues	660	1.5	649	2.0
Gross electric revenues	37,429	100.0	32,836	100.0

Class of load.	1915		1916	
	Revenue.	Per cent of total gross electric revenues.	Revenue.	Per cent of total gross electric revenues.
Operating revenue, electric:				
Municipal street lighting—				
Arc	$792	2.3	$792	2.2
Incandescent	1,860	5.3	2,010	5.5
Municipal lighting, miscellaneous	1,453	4.2	1,455	4.0
Municipal power	378	1.1	357	1.0
Commercial lighting—				
Flat rate	....	....	....	....
Metered	25,521	73.0	26,864	73.7
Commercial power—				
Flat rate	....	....	....	....
Metered	4,565	13.1	4,411	12.1
Miscellaneous electric	55	....	49	.1
Total operating revenues, electric	34,624	99.0	35,938	98.6
Electric merchandise and jobbing revenues	368	1.0	492	1.4
Gross electric revenues	34,992	100.0	36,430	100.0

Combined income statement of Oro Electric Corporation and Oro Water, Light & Power Co., 1914-1915, including dredge earnings.

	1914			1915		
	Public utility.	Dredges.	Total.	Public utility.	Dredges.	Total.
Gross earnings	$268,348	$445,321	$713,669	$261,705	$387,639	$649,344
Nonoperating revenue	1,374	....	1,374	3,492	....	3,492
Total earnings	269,722	445,321	715,043	265,197	387,639	652,836
Operating expenses	167,492	247,198	414,690	178,413	316,647	495,060
Gross income	102,230	198,123	300,353	86,784	70,992	157,776
Deductions from income:						
Interest on bonds and all other indebtedness.	....	....	137,199	138,861	1,846	140,708
Uncollectible bills	....	....	....	5,879	....	5,879
Miscellaneous nonoperating expenses	....	....	....	7,832	....	7,831
Amortization debt discount	....	....	....	5,285	....	5,285
Total deductions	....	....	137,199	157,857	1,846	159,703
Net income	....	....	163,154	[a]71,073	69,146	[a]1,927

[a] Deficit.

TABLE 200.—*Sources of gross revenues, Pacific Gas & Electric Co., 1906–1920.*

Year.		Electricity.	Gas.	Railway.	Water.	Steam.	All other operating and nonoperating revenues.	Total.
1907....	Revenue........	$6,316,629	$4,086,372	$431,800	....	....	$507,339	$11,342,140
	Per cent........	56	36	4	....	....	4	100
1908....	Revenue........	$7,059,088	$4,494,945	$414,326	....	....	$688,946	$12,657,305
	Per cent........	56	36	3	....	....	5	100
1909....	Revenue........	$7,678,665	$4,860,034	$452,396	....	....	$500,193	$13,491,288
	Per cent........	57	36	3	....	....	4	100
1910....	Revenue........	$7,899,224	$5,202,284	$509,152	....	....	$433,936	$14,044,596
	Per cent........	56	37	4	....	....	3	100
1911....	Revenue........	$7,823,903	$5,735,219	$533,520	....	....	$511,967	$14,604,609
	Per cent........	54	39	4	....	....	3	100
1912....	Revenue........	$7,672,570	$5,805,865	$547,187	....	....	$719,029	$14,744,651
	Per cent........	52	39	4	....	....	5	100
1913....	Revenue........	$8,230,782	$6,547,595	$572,913	$385,958	$131,758	$333,331	$16,202,337
	Per cent........	51	40	4	2	1	2	100
1914....	Revenue........	$8,759,449	$7,015,408	$556,908	$409,422	$171,501	$307,815	$17,220,503
	Per cent........	51	41	3	2	1	2	100
1915....	Revenue........	$9,924,482	$7,560,185	$425,338	$420,217	$200,079	$413,878	$18,944,179
	Per cent........	53	40	2	2	1	2	100
1916....	Revenue........	$10,100,032	$7,438,255	$442,303	$427,516	$207,391	$509,886	$19,125,384
	Per cent........	53	39	2	2	1	3	100
1917....	Revenue........	$10,859,785	$7,771,058	$491,021	$475,333	$216,184	$508,347	$20,321,728
	Per cent........	54	38	2	2	1	3	100
1918....	Revenue........	$12,384,499	$8,923,484	$534,068	$509,273	$244,193	$510,200	$23,105,717
	Per cent........	54	39	2	2	1	2	100
1919....	Revenue........	$14,474,884	$9,933,334	$671,105	$540,607	$318,442	$644,316	$26,582,688
	Per cent........	55	37	3	2	1	2	100
1920....	Revenue........	$21,571,321	$11,161,682	$753,028	$638,336	$351,005	$910,462	$35,385,834
	Per cent........	61	31	2	2	1	3	100

FINANCIAL TABLES FOR NORTHERN CALIFORNIA POWER CO. CONSOLIDATED AND PRINCIPAL SUBSIDIARIES.

TABLE 201.—*Capitalization, outstanding stock, and dividends of Northern California Power Co. Consolidated and principal subsidiaries.*

[Term of incorporation, uniformly 50 years.]

Northern California Power Co., San Francisco.

Company.	Capitalization.	Stock outstanding.			Dividends on common stock.[a]
		Year (Dec. 31).	Par value per share.	Common.	
Northern California Power Co. Consolidated, San Francisco (incorporated Aug. 28, 1908)..	[b] $10,000,000	[c] 1908	$100	$10,000,000	....
		[c] 1909		10,000,000	[d] $110,000
		[c] 1910		10,000,000	[d] 210,000
		[c] 1911		10,000,000	[d] 100,000
		[c] 1912		10,000,000	....
		[c] 1913		10,000,000	....
		1918–1919		10,000,000	....
Northern California Power Co., San Francisco (incorporated Mar. 13, 1902).................	2,000,000	[e] 1903–4	20	2,000,000	....
		1905–1907		2,000,000	[f] 60,000
		1908		[g] 2,000,000	[h] 40,000

[a] No preferred stock had been issued up to Dec. 31, 1915.

[b] Authorized capitalization increased July 17, 1914, to $12,000,000; $2,000,000 being 6 per cent cumulative preferred as to assets and dividends. No preferred stock ever issued.

[c] Years ending Oct. 31.

[d] Rate of dividends on common stock, December, 1908, to January, 1910, 10 cents per share per month; February, 1910, to March, 1911, 20 cents per share per month; then discontinued.

[e] Years ending Feb. 28.

[f] Rate of dividend on common stock in 1905–1907, 3 per cent.

[g] In 1909 exchanged for stock of Northern California Power Co. Consolidated. None in hands of public.

[h] Rate of dividend on common stock in 1908, 2 per cent.

NOTES.—Assessments: No. 1 of $2 per share was levied Sept. 30, 1914; No. 2 of $2 per share was levied Jan. 21, 1915; No. 3 of $2 per share was levied Oct. 7, 1915; No. 4 of $1 per share was levied Oct. 18, 1916; No. 5 of $2 per share was levied Mar. 6, 1917; No. 6 of $2 per share was levied Apr. 25, 1917; No. 7 of $1.50 per share was levied Mar. 27, 1918; No. 8 of $1.50 per share was levied Aug. 28, 1918.

TABLE 201.—*Capitalization, outstanding stock, and dividends of Northern California Power Co. Consolidated and principal subsidiaries*—Continued.

Subsidiary companies.

Company.	Date of incorporation.	Capitalization.	Stock outstanding.		
			Year (Dec. 31).	Par value per share.	Common stock.
Sacramento Valley Power Co., San Francisco	Mar. 17, 1909	$800,000	1912–1916	$2	[a]$765,626
			1917	......	765,000
			1918	......	765,000
Willows Water & Electric Light Co., Willows, Calif.	May 28, 1887	100,000	....	20	(b)
The Red Bluff Electric Light & Gas Co., Red Bluff, Calif.	May 10, 1889	100,000	....	100	(c)
Tehama Electric Co., San Francisco	June 8, 1899	50,000	....	1	(d)
Redding Electric Light & Power Co., Redding, Calif.	Jan. 7, 1891	50,000	....	1	(e)
The Redding Gas Co., Redding, Calif.	May 14, 1886	50,000	....	50	(f)
Belle Vue Irrigation Co., Anderson, Shasta County, Calif.	Mar. 23, 1899	10,000	....	10	(f)
The Redding Water Co., Redding, Calif.	Dec. 30, 1886	100,000	1901	1	(g)
Battle Creek Power Co., San Francisco	Mar. 6, 1905	1,000,000	1906	20	(h)
Keswick Electric Power Co., San Francisco	Aug. 30, 1900	200,000	1901	2	[i]200,000
The Sacramento Valley Power Co., San Francisco	Dec. 17, 1910	2,000,000	1910–1918	20	[j]1,314,000

[a] Held in escrow under purchase agreement with Northern California Power Co. Consoldated. No dividends ever paid.

[b] No dividends paid since acquisition by Northern California Power Co., about 1907. No record of transactions prior to that time. Corporation out of existence.

[c] No dividends paid since acquisition by Northern California Power Co., about 1903. No record of transactions prior to that time. Corporation out of existence.

[d] No dividends paid since acquisition by Northern California Power Co., about 1902. No record of transactions prior to that time. Corporation out of existence.

[e] No dividends paid since acquisition by Northern California Power Co., about 1901. No record of transactions prior to that time. Corporation out of existence.

[f] No dividends paid. Corporation out of existence.

[g] No dividends paid since acquisition by Northern California Power Co., about 1901. No record of transactions prior to that time. Corporate existence maintained for protection of outstanding bonds only. No stock in hands of public.

[h] Corporate existence maintained for protection of outstanding bonds only. No stock in hands of public.

[i] All stock exchanged in 1902 for stock of Northern California Power Co. Corporate existence maintained only for protection of outstanding bonds. No stock in hands of public.

[j] All stock in escrow under purchase agreement with Northern California Power Co. Consolidated.

TABLE 202.—*Bonds of Northern California Power Co. Consolidated.*

Issue.	Callable or convertible.	Sinking-fund deposits.	Trustee.	Denomination.	Authorized.
1	2	3	4	5	6
Keswick Electric Power Co. first mortgage 5 per cent bonds dated June 1, 1901; due June 1, 1931; interest payable June and Dec. 1.	Not callable or convertible......	Sinking fund, $5,000 per annum.	Mercantile Trust Co., San Francisco.	$1,000 coupon.........	$200,000
Northern California Power Co. first mortgage 5 per cent bonds dated June 1, 1902; due June 1, 1932; interest payable June and Dec. 1.	.....do.........................	From June 1, 1902 to 1907, 3½ per cent gross earnings; from 1908 to 1917, 4 per cent; from 1918 to 1931, 4½ per cent annually.	Union Trust Co., San Francisco.	$1,000 coupon; principal may be registered.	1,000,000
Battle Creek Power Co. first mortgage 5 per cent bonds dated Feb. 2, 1906; due Feb. 2, 1936; interest payable Feb. and Aug. 1.	.....do.........................	Commencing in 1911, $20,000 per annum if total is outstanding, if less pro rata.	Mercantile Trust Co., San Francisco.	.....do................	1,000,000
Northern California Power Co. Consolidated refunding and consolidating mortgage 5 per cent bonds dated Dec. 1, 1908; due Dec. 1, 1948; interest payable June and Dec. 1.	Callable at 110 on and after Dec. 1, 1915. Not convertible.	Commencing Dec. 1, 1913, 1 per cent of bonds outstanding. Bonds to be kept alive.	Union Trust Co., San Francisco.	$1,000 coupon.........	10,000,000
Series A debenture 6 per cent bonds dated Feb. 1, 1912; due Feb. 1, 1915, but extended to Feb. 1, 1920. Interest payable Feb. and Aug. 1.	Callable before maturity in cash at par or in Northern California Power Co. (Cons.) refunding and consolidated mortgage 5 per cent bonds at 96.	....	....	$100, $250, $500, and $1,000 coupon.	860,500
Series B debenture 6 per cent bonds dated July 15, 1912; due July 15, 1917; interest payable Jan. and July 15.	Callable on any interest date at par plus one-half of 1 per cent premium for each year the issue has to run.	....	....	$1,000 coupon.........	500,000
Sacramento Valley Power Co. first mortgage 6 per cent bonds dated May 1, 1909; due May 1, 1929; interest payable May and Nov. 1.	Callable at 105 after May 1, 1919. Not convertible.	Commencing May 1, 1912, 2½ per cent of par value of bonds outstanding to be kept alive.	Anglo-California Trust Co., San Francisco.	$100 and $500 coupon..	500,000
The Sacramento Valley Power Co. first and refunding 6 per cent bonds dated July 1, 1911; due July 1, 1941; interest payable Jan. and July 1.	Callable at 105 after July 1, 1914. Not convertible.	From 1917 to 1921, 1 per cent annually of bonds outstanding; from 1922 to 1926, 1½ per cent; from 1927 to 1936, 2 per cent; from 1937 to 1941, 2½ per cent.	.....do................	$1,000 coupon.........	2,000,000
The Redding Water Co. first mortgage 5 per cent bonds dated Mar. 1, 1907; due Mar. 1, 1936; interest payable Mar. and Sept. 1.	Not callable or convertible......	$2,000 per annum...............	Mercantile Trust Co., San Francisco.	$500 coupon..........	60,000

TABLE 202.—*Bonds of Northern California Power Co. Consolidated*—Continued.

Issue.	Year.	Reserved for prior liens.	Bonded debt.					Notes.
			In sinking funds.		In treasury.	Held by public.	Total authenticated.	
			Canceled.	Alive.				
1	7	8	9	10	11	12	13	14
Keswick Electric Power Co. first mortgage 5 per cent bonds dated June 1, 1901; due June 1, 1931; interest payable June and Dec. 1.	Feb. 28, 1901							Bonds in column 9 canceled by sinking fund or exchanged for Northern California Power Co. first mortgage 5's and canceled.
	Feb. 28, 1902							
	Feb. 28, 1903		$5,000.00			$195,000.00	$195,000.00	
	Feb. 28, 1904		10,000.00			190,000.00	190,000.00	
	Feb. 28, 1905		45,000.00			155,000.00	155,000.00	
	Feb. 28, 1906		45,000.00			155,000.00	155,000.00	
	Feb. 28, 1907		66,000.00			134,000.00	134,000.00	
	Feb. 28, 1908		66,000.00			134,000.00	134,000.00	
	Oct. 31, 1909		97,000.00			103,000.00	103,000.00	
	Oct. 31, 1910		155,000.00			45,000.00	45,000.00	
	Oct. 31, 1911		157,000.00			43,000.00	43,000.00	
	Oct. 31, 1912		157,000.00			43,000.00	43,000.00	
	Dec. 31, 1913		157,000.00			43,000.00	43,000.00	
	Dec. 31, 1914-15		177,000.00			23,000.00	23,000.00	
	Dec. 31, 1916-1920		178,000.00			22,000.00	22,000.00	
Northern California Power Co. first mortgage 5 per cent bonds dated June 1, 1902; due June 1, 1932; interest payable June and Dec. 1.	Feb. 28, 1903	$195,000				300,000.00	300,000.00	Reserved bonds not certified until exchanged.
	Feb. 28, 1904	190,000				665,000.00	665,000.00	Bonds in column 9 canceled by sinking fund.
	Feb. 28, 1905	155,000				775,000.00	775,000.00	
	Feb. 28, 1906	155,000	30,000.00			825,000.00	825,000.00	
	Feb. 28, 1907	134,000	25,000.00			841,000.00	841,000.00	
	Feb. 28, 1908	134,000	25,000.00			841,000.00	841,000.00	
	Oct. 31, 1909	103,000	64,000.00			833,000.00	833,000.00	
	Oct. 31, 1910	45,000	89,000.00			866,000.00	866,000.00	
	Oct. 31, 1911	43,000	91,000.00			866,000.00	866,000.00	
	Oct. 31, 1912	43,000	91,000.00			866,000 00	866,000.00	
	Dec. 31, 1913	43,000	91,000.00			866,000.00	866,000.00	
	Dec. 31, 1914	23,000	130,000.00			847,000.00	847,000.00	Bonds in column 9 for 1914 to 1920 include $53,000 exchanged for Northern California Power Co., Consolidated, refunding and consolidating mortgage 5's.
	Dec. 31, 1915	23,000	151,000.00			826,000.00	826,000.00	
	Dec. 31, 1916	23,000	151,000.00			826,000.00	826,000.00	
	Dec. 31, 1917	22,000	152,000.00			826,000.00	826,000.00	
	Dec. 31, 1918	22,000	152,000.00		$5,000.00	821,000.00	826,000.00	
	Dec. 31, 1919	22,000	152,000.00		18,000.00	808,000.00	826,000.00	
	Dec. 31, 1920	22,000	179,000.00		1,000.00	798,000.00	799,000.00	

Battle Creek Power Co. fir-t mortgage 5 per cent bonds dated Feb. 2, 1906; due Feb. 2, 1936; interest pay ble Feb. and Aug. 1.	Oct. 31, 1906–1908							$423,000 actually sold. Entries in column 9 show bonds exchanged for Northern California Power Co., Consolidated, refunding and consolidated mortgage 5's and $577,000 in bonds that were never issued.
	Oct. 31, 1909		719,000.00			281,000.00	281,000.00	
	Oct. 31, 1910		911,000.00			89,000.00	89,000.00	
	Oct. 31, 1911		916,000.00			84,000.00	84,000.00	
	Oct. 31, 1912		916,000.00			84,000.00	84,000.00	
	Dec. 31, 1913–1920		916,000.00			84,000.00	84,000.00	
Northern California Power Co. (Cons.) refunding and consolidating mortgage 5 per cent bonds dated Dec. 1, 1908; due Dec. 1, 1948; interest payable June and Dec. 1.	Oct. 31, 1909	1,227,000				1,377,000.00		Entries in column 9 show sinking fund credits established for this issue by retirement of underlying issues.
	Oct. 31, 1910	1,010,000				2,295,000.00	2,295,000.00	
	Oct. 31, 1911	1,003,000	33,000.00			3,964,000.00	3,964,000.00	
	Oct. 31, 1912	1,003,000	33,000.00			3,964,000.00	3,964,000.00	
	Dec. 31, 1913	1,003,000	33,000.00			3,964,000.00	3,964,000.00	
	Dec. 31, 1914	964,000	72,000.00			3,964,000.00	3,964,000.00	
	Dec. 31, 1915	943,000	93,000.00			3,964,000.00	3,964,000.00	
	Dec. 31, 1916	943,000	93,000.00			3,964,000.00	3,964,000.00	
	Dec. 31, 1917	942,000	93,000.00			3,964,000.00	3,964,000.00	
	Dec. 31, 1918	942,000	93,000.00			3,964,000.00	3,964,000.00	
	Dec. 31, 1919	942,000	115,000.00			3,849,000.00	3,964,000.00	
	Dec. 31, 1920	915,000	225,000.00		8,000.00	4,199,000.00	4,432,000.00	
Series A debenture 6 per cent bonds dated Feb. 1, 1912; due Feb. 1, 1915, but extended to Feb. 1, 1920. Interest payable Feb. and Aug. 1.	Oct. 31, 1912		60,300.00			800,200.00	800,200.00	Entries in column 9 show amounts retired by cash expenditures.
	Dec. 31, 1913		60,300.00			800,200.00	800,200.00	
	Dec. 31, 1914		150,300.00			710,200.00	710,200.00	
	Dec. 31, 1915		226,148.08			634,351.92	634,351.92	
	Dec. 31, 1916		303,536.09			556,963.91	556,963.91	
	Dec. 31, 1917		362,262.77			498,237.23	498,237.23	
	Dec. 31, 1918		420,377.50			440,122.50	440,122.50	
	Dec. 31, 1919		478,494.20		12,552.35	382,005.80	394,558.15	
Series B debenture 6 per cent bonds dated July 15, 1912; due July 15, 1917: interest payable Jan. and July 15.	Oct. 31, 1912					500,000.00	500,000.00	
	Dec. 31, 1913–1916					500,000.00	500,000.00	
Sacramento Valley Power Co. first mortgage 6 per cent bonds dated May 1, 1909; due May 1, 1929: interest payable May and Nov. 1.	Oct. 31, 1909–1911							$100,000 in bonds shown in column 9 were never issued.
	Oct. 31, 1912		100,000.00			400,000.00	400,000.00	
	Dec. 31, 1913–1918		100,000.00			400,000.00	400,000.00	
	Dec. 31, 1919				4,000.00	396,000.00	400,000.00	
	Dec. 31, 1920				27,300.00	372,700.00	400,000.00	
The Sacramento Valley Power Co. first and refunding 6 per cent bonds dated July 1, 1911; due July 1, 1941; interest payable Jan. and July 1.	Oct. 31, 1912	400,000	1,100,000.00			500,000.00	500,000.00	$1,100,000 in bonds shown in column 9 were never issued.
	Dec. 31, 1913–1918	400,000	1,100,000.00			500,000.00	500,000.00	
	Dec. 31, 1919				3,000.00	497,000.00	500,000.00	
	Dec. 31, 1920				22,000.00	478,000.00	500,000.00	
The Redding Water Co. first mortgage 5 per cent bonds dated Mar. 1, 1907; due Mar. 1, 1936; interest payable Mar. and Sept. 1.	Oct. 31, 1909–1912		50,000.00			10,000.00	10,000.00	
	Dec. 31, 1913–1920		50,000.00			10,000.00	10,000.00	

TABLE 203.—*Comparative balance sheet of Northern California Power Co. Consolidated, 1911–1919.*

Form used by company's accountants, 1911–1913.

	Oct. 31, 1911.	Oct. 31, 1912.	Oct. 31, 1913.
ASSETS.			
Plant account	$15,555,170	$17,649,751	$17,798,562
Sundry supplies and material on hand	45,452	84,447	108,564
Cash on hand and in bank	35,582	47,449	20,589
Bills receivable	2,323	3,498	2,079
Taxes paid in advance		3,123	4,592
Accounts receivable	84,422	150,053	180,171
Treasury bonds—sale negotiated for future delivery	336,000		
Balance in sinking fund		32,843	32,843
Other assets			26,417
Total assets	16,058,949	17,971,164	18,173,817
LIABILITIES.			
Capital stock, 100,000 shares, par $100 per share	10,000,000	10,000,000	10,000,000
Refunding and consolidating bonds	3,964,000	3,964,000	3,964,000
First-mortgage bonds, Northern California Power Co	866,000	866,000	866,000
First-mortgage bonds, Keswick Electric Power Co	43,000	43,000	43,000
First-mortgage bonds, Battle Creek Power Co	84,000	84,000	84,000
First-mortgage bonds, The Redding Water Co	10,000	10,000	10,000
First-mortgage bonds, Sacramento Valley Power Co		400,000	400,000
First and refund mortgage bonds, The Sacramento Valley Power Co		500,000	500,000
Series A debentures		800,200	800,200
Series B debentures		500,000	500,000
Bills payable	425,824	85,684	85,670
Accounts payable	231,515	106,609	105,170
Accrued bond interest, taxes, etc	96,759	144,554	148,873
Maintenance and depreciation reserve	13,933	38,742	100,412
Surplus, reinvested	323,917	428,375	566,093
Ranch rentals collected in advance			399
Total liabilities	16,058,949	17,971,164	18,173,817

TABLE 203.—*Comparative balance sheet of Northern California Power Co. Consolidated, 1911–1919*—Continued.

Standard form adopted by Railroad Commission of California, 1913–1919.

	1913	1914	1915
ASSETS.			
Total fixed capital	$9,801,461	$9,920,065	$9,995,227
Cash and deposits:			
Cash	10,997	47,243	96,804
Special deposits	....	737	....
Total cash and deposits	10,997	47,980	96,804
Notes receivable	3,384	2,639	12,995
Accounts receivable:			
Due from consumers and agents	176,080	145,500	103,121
Miscellaneous accounts receivable	408	407	538
Total accounts receivable	176,488	145,907	103,659
Interest and dividends receivable	273	156	....
Investments—Securities of other corporations	1,250	1,250	250
Materials and supplies	111,450	78,874	95,800
Sinking funds	32,843	6,894	15,612
Prepaid expenses:			
Prepaid rents	....	115	....
Prepaid taxes	722	891	579
Prepaid insurance	50	48	22
Total prepaid expenses	772	1,054	601
Unamortized discount on securities and expenses:			
Stocks	8,000,000	8,000,000	8,000,000
Bonds	1,639	628	1,698
Total	8,001,639	8,000,628	8,001,698
Other suspense	2,436	23,788	51,933
Construction work in progress	34,702	54,232	64,862
Total assets	18,177,695	18,283,467	18,439,441
LIABILITIES.			
Assessment No. 1	....	200,000	200,000
Assessment No. 2	....	....	200,000
Assessment No. 3	....	....	200,000
Capital stock	10,000,000	10,000,000	10,000,000
Funded debt	7,167,200	7,038,200	6,941,352
Notes payable	115,527	149,220	....
Accounts payable:			
Audited vouchers and wages unpaid	81,639	75,419	42,313
Consumers' deposits	189	737	2,146
Miscellaneous accounts payable	33,937	17,931	12,575
Total accounts payable	115,765	94,087	57,034
Interest accrued	74,976	57,752	60,624
Rents accrued	....	....	10
Service billed in advance	649	275	1,120
Reserve for accrued depreciation	111,761	118,679	122,892
Reserves invested in sinking funds	....	161,194	326,763
Other reserves from income or surplus	....	....	89,931
Suspense:			
Noble Electric Steel Co	....	924	....
Profit on series A debentures	....	....	75
Renewals on contract signs	....	....	37
Corporate surplus unappropriated	591,817	463,136	239,603
Total liabilities	18,177,695	18,283,467	18,439,441

TABLE 203.—*Comparative balance sheet of Northern California Power Co. Consolidated, 1911–1919*—Continued.

	1916	1917	1918	1919 (to Sept. 30).
ASSETS.				
Total fixed capital	$10,188,161	$10,513,773	$10,760,051	$11,357,934
Cash and deposits:				
Cash	72,783	38,232	24,359	30,312
Special deposits				
Total cash and deposits	72,783	38,232	24,359	30,312
Notes receivable	21,384	291	1,993	48
Accounts receivable:				
Due from consumers and agents	120,212	139,642	164,360	206,648
Miscellaneous accounts receivable	224	199	2,066	2,675
Total accounts receivable	120,436	139,841	166,426	209,323
Interest and dividends receivable				57
Investments:				
Securities of other corporations	250	250	250	250
Miscellaneous investments			2,450	7,998
Total investments	250	250	2,700	8,248
Materials and supplies	113,952	166,713	214,460	247,602
Sinking funds	19,996	19,613	19,627	8,956
Prepaid expenses:				
Prepaid rents	1			
Prepaid taxes	936	988	369	6,491
Prepaid insurance			6	92
Total prepaid expenses	937	988	375	6,584
Unamortized discount on securities and expenses:				
Stocks	7,300,000	6,900,000	6,600,000	6,600,000
Bonds	1,181	719	374	115
Total	7,301,181	6,900,719	6,600,374	6,600,115
Other suspense	4,347	925		
Construction work in progress	82,884	113,092	370,993	165,989
Ranch, live stock, etc				41,344
Suspense, general				565
Miscellaneous		26,492	35,743	
Total assets	17,926,311	17,920,929	18,197,101	18,677,075
LIABILITIES.				
Capital stock	10,000,000	10,000,000	10,000,000	10,000,000
Funded debt	6,862,964	6,304,237	6,241,122	6,187,334
Notes payable		335,000	214,250	375,633
Accounts payable:				
Audited vouchers and wages unpaid	42,897	51,362	78,505	58,086
Consumers' deposits	2,543	4,243	4,908	5,151
Miscellaneous accounts payable	24,700	21,925	16,900	4,975
Total accounts payable	70,140	77,530	100,313	68,212
Interest accrued	58,716	38,495	43,297	109,117
Taxes accrued		69		
Rents accrued			189	254
Service billed in advance	642	11,380	53,172	132,432
Reserve for accrued depreciation	126,403	113,702	159,205	167,508
Reserves invested in sinking funds	406,697	464,391	528,418	571,536
Other reserves from income or surplus	164,260	200,212	258,854	303,021
Suspense, general				33,093
Corporate surplus unappropriated	236,489	351,224	584,851	728,935
Miscellaneous		24,689	13,430	
Total liabilities	17,926,311	17,920,929	18,197,101	18,677,075

TABLE 204.—*Earnings and expenses of Northern California Power Co. Consolidated, 1903–1919.*

Form used by company's accountants, 1902-1912.

	Northern California Power Co.					
	[a] 1903	[a] 1904	[a] 1905	[a] 1906	[a] 1907	[a] 1908
Gross earnings:						
Electric light and power	$72,228.23	$128,560.95	$148,956.26	$150,397.86	$180,515.94	$254,173.17
Redding waterworks	13,354.12	14,492.10	14,749.11	15,474.76	15,546.72	19,264.35
Redding gas works	....	666.91	2,892.94	4,199.62	5,542.40	9,562.03
Red Bluff gas works	....	7,204.60	8,685.05	8,862.15	9,916.35	10,891.40
Willows waterworks	....	....	....	....	....	1,454.00
Willows gas works	....	....	....	....	....	....
Miscellaneous	....	....	3,289.23	6,090.01	3,308.59	1,716.95
Total gross earnings	85,582.35	150,924.56	178,572.59	185,024.40	214,830.00	297,061.90
Operating expenses:						
Light and power service	14,943.78	18,599.08	18,825.00	21,100.27	29,649.33	39,660.27
Redding waterworks	10,170.14	12,789.23	13,721.77	14,440.14	14,844.75	17,947.98
Redding gas works	....	457.27	1,376.72	1,607.29	2,549.59	3,982.40
Red Bluff gas works	....	3,295.90	4,031.70	3,611.53	3,861.77	4,410.96
Willows waterworks	....	....	....	....	....	1,291.31
Willows gas works	....	....	....	....	....	....
Less undistributed adjustments	....	....	....	....	....	....
Total operating expenses	25,113.92	35,141.48	37,955.19	40,759.23	50,905.44	67,292.92
Maintenance:						
Electric generating and distributing	1,856.21	2,514.28	4,084.00	5,380.38	3,388.58	9,408.91
Redding waterworks	....	....	....	....	....	....
Redding gas works	....	....	58.54	396.45	242.46	754.41
Red Bluff gas works	....	....	180.38	65.85	78.09	53.16
Willows waterworks	....	....	....	....	....	....
Willows gas works	....	....	....	....	....	....
Total maintenance	1,856.21	2,514.28	4,322.92	5,842.68	3,709.13	10,216.48
Carried to maintenance	....	....	....	....	....	....
General expenses	15,283.43	16,490.14	17,647.32	19,159.72	25,084.89	38,839.59
Amortization of debt, discount, and expenses	....	....	....	....	....	....
Total to reserve, general and amortization	15,283.43	16,490.14	17,647.32	19,159.72	25,084.89	38,839.59
Grand total expenses	42,253.56	54,145.90	59,925.43	65,761.63	79,699.46	116,348.99
Net earnings from operation	43,328.79	96,778.66	118,647.16	119,262.77	135,130.54	180,712.91
Miscellaneous earnings:						
Store	....	1,277.76	4,391.07	3,346.29	9,759.61	3,239.08
Shop	....	....	13.93	592.84	353.22	276.83
Commissary	....	....	....	....	....	....
Ranch	....	....	....	....	....	....
Total miscellaneous earnings	....	1,277.76	4,405.00	3,939.13	10,112.83	3,515.91
Grand total net earnings	43,328.79	98,056.42	123,052.16	123,201.90	145,243.37	184,228.82
Profit and loss	....	....	....	....	....	....
Interest on funded debt	15,500.00	28,773.98	43,981.70	47,787.50	49,000.00	48,750.00
Dividends	....	....	60,000.00	60,000.00	60,000.00	40,000.00
	27,828.79	28,773.98	103,981.70	107,787.50	109,000.00	88,750.00
Surplus for year	27,828.79	69,282.44	19,070.46	15,414.40	36,243.37	95,478.82
Surplus on hand	....	27,828.79	97,111.23	116,181.69	131,596.09	167,839.46
Total surplus	27,828.79	97,111.23	116,181,69	131,596.09	167,839,46	263,318.28

[a] Years 1902–1907, inclusive, end on Feb. 28.

TABLE 204.—*Earnings and expenses of Northern California Power Co. Consolidated, 1903–1919*—Continued.

	Northern California Power Co. Consolidated.				
	[b] 1908	[c] 1909	[c] 1910	[c] 1911	[c] 1912
Gross earnings:					
Electric light and power	....	$370,454.96	$506,958.66	$582,612.22	$642,331.53
Redding waterworks	....	22,231.85	23,543.03	24,610.43	23,940.50
Redding gas works	....	10,504.19	9,736.85	9,346.35	9,457.15
Red Bluff gas works	....	11,404.70	11,088.36	9,652.30	9,067.17
Willows waterworks	....	6,378.85	8,662.70	11,871.22	14,954.72
Willows gas works	....	....	....	1,135.55	7,182.25
Miscellaneous	....	11,740.50	18,092.77	475.00	....
Total gross earnings	$245,375.56	432,715.05	578,082.37	639,702.07	706,933.32
Operating expenses:					
Light and power service	....	36,741.21	49,251.50	59,698.71	71,303.03
Redding waterworks	....	13,791.32	12,535.88	11,835.54	11,878.05
Redding gas works	....	5,209.66	5,362.40	4,701.14	4,249.96
Red Bluff gas works	....	4,652.24	5,228.12	4,881.89	4,980.89
Willows waterworks	....	4,719.19	4,767.58	7,287.10	7,192.59
Willows gas works	....	....	....	619.05	3,942.20
Less undistributed adjustments	....	....	....	....	....
Total operating expenses	66,998.14	65,113.62	77,145.48	89,023.43	103,546.72
Maintenance:					
Electric generating and distributing	....	26,472.22	26,070.56	42,738.97	73,418.16
Redding waterworks	....	1,598.22	2,282.00	2,650.15	2,579.59
Redding gas works	....	1,201.66	1,246.30	674.21	751.13
Red Bluff gas works	....	143.63	383.60	217.75	1,037.50
Willows waterworks	....	788.97	690.11	640.15	617.72
Willows gas works	....	....	....	266.23	319.98
Total maintenance	([d])	30,204.70	30,672.57	47,187.46	78,724.08
Carried to maintenance	....	....	....	13,933.23	24,809.04
General expenses	....	55,842.55	73,793.52	81,328.26	105,026.43
Amortization of debt, discount, and expenses	....	....	....	....	....
Total to reserve, general and amortization	([d])	55,842.55	73,793.52	95,261.49	129,835.47
Grand total expenses	....	151,160.87	181,611.57	231,472.38	312,106.27
Net earnings from operation	178,377.42	281,554.18	396,470.80	408,229.69	394,827.05
Miscellaneous earnings:					
Store	....	1,114.63	9,712.71	11,162.96	18,723.39
Shop	....	....	339.41	1,819.49	1,764.09
Commissary	....	....	320.47	2,069.92	....
Ranch	....	....	....	143.59	141.26
Total miscellaneous earnings	....	1,114.63	10,372.59	15,195.96	20,628.74
Grand total net earnings	178,377.42	282,668.81	406,843.39	423,425.65	415,455.79
Profit and loss	....	13,387.72	[e]20,393.45	2,134.79	28,209.47
Interest on funded debt	38,537.50	94,653.62	122,834.93	156,402.81	282,788.46
Dividends	....	110,000.00	210,000.00	100,000.00	....
	38,537.50	218,041.34	312,441.48	258,537.60	310,997.93
Surplus for year	139,839.92	64,627.47	94,401.91	164,888.05	104,457.86
Surplus on hand	263,318.28	....	64,627.47	159,029.38	323,917.43
Total surplus	403,158.20	64,627.47	159,029.38	323,917.43	428,375.29

Combined surplus of both companies, 1902 to 1912, $831,533.49.

[b] Eight months, Mar. 1–Oct. 31.
[c] Years 1909–1912, inclusive, end on Oct. 31.
[d] Included in operating expenses.
[e] Miscellaneous addition to surplus.

TABLE 204.—*Earnings and expenses of Northern California Power Co. Consolidated, 1903–1919*—Continued.

Standard form adopted by Railroad Commission of California.

Account.	1913	1914	1915	1916	1917	1918	1919 (to Sept. 30).
Electric operations:							
Operating revenues	$760,346	$698,873	$710,257	$775,687	$889,428	$1,075,130	$855,495
Operating expenses	270,568	292,809	303,187	310,260	345,987	417,891	385,464
Net operating revenue	489,778	406,064	407,070	465,427	543,441	657,239	470,031
Gas operations:							
Operating revenue	28,953	31,800	31,257	35,505	37,720	44,386	36,575
Operating expenses	23,710	24,676	23,814	27,867	29,585	40,991	36,833
Net operating revenue	5,243	7,124	7,443	7,638	8,135	3,395	a 259
Water operations:							
Operating revenue	39,727	40,514	41,083	41,934	46,092	44,151	33,557
Operating expenses	27,849	28,963	30,435	33,575	32,801	33,577	28,816
Net operating revenue	11,878	11,551	10,648	8,359	13,291	10,574	4,741
Total net operating revenue	506,899	424,739	425,161	481,424	564,867	671,208	474,513
Add:							
Nonoperating revenues: Miscellaneous rent revenues—Electric	843	....	1,147	920	607	1,099	704
Interest and dividend revenues:							
Interest revenue on funded debt owned	1,679	....	....	....	....	....	....
Miscellaneous interest revenues	1,129	....	1,162	2,504	3,236	1,041	150
Total interest and dividend revenue	2,808	....	1,162	2,504	3,236	1,041	854
Miscellaneous nonoperating revenue	5,904	7,654	1,030	3,126	9,016	3,102	....
Total nonoperating revenues	9,555	7,654	3,339	6,550	12,859	5,242	854
Gross corporate income	516,454	432,393	428,500	487,974	577,727	676,450	475,367
Deduct:							
Uncollectible bills	4,144	8,905	2,693	4,087	3,125	1,364	....
Nonoperating revenue deductions:							
Rent expenses	2	....	....	....	....	....	....
Miscellaneous nonoperating expenses	3,477	1,051	451	....	....	....	....
Nonoperating taxes	....	....	....	2,228	2,439	2,787	2,552
Total nonoperating revenue deduction	3,479	1,051	451	2,228	2,439	2,787	2,552
Interest accrued on funded debt	351,586	361,179	359,189	352,920	334,626	311,313	242,406
Other interest deductions	....	2,820	3,708	....	....	12,464	12,561
Interest charged to construction	....	....	....	....	....	....	a 19,140
Rent deductions:							
Rent for lease of other electric plants	....	....	....	....	3,080	3,504	2,204
Rent for conduits, poles, and other supports (electric)	34	....	....	....	....	....	....
Miscellaneous rent deductions	120	....	....	....	....	....	....
Total rent deductions	154	....	....	....	3,080	3,504	2,204
Amortization of debt discount and expense	1,361	1,011	656	517	462	345	259
Miscellaneous deductions from income (contractual deductions)	....	....	49	....	66	....	....
Total deductions	360,724	374,966	366,746	359,752	343,798	331,777	240,842
Balance of year carried to corporate surplus or deficit account	155,730	57,427	61,754	128,222	233,928	344,673	234,525

a Deficit.

TABLE 205.—*Classified electric revenues (according to classification of Railroad Commission of California), Northern California Power Co. Consolidated, 1913–1919.*

Class of load.	1913		1914		1915	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$9,173	1.2	$9,747	1.4	$9,444	1.3
Incandescent	5,639	.7	5,715	.8	6,868	1.0
Municipal lighting, miscellaneous	2,648	.3	3,167	.5	3,283	.5
Municipal power	3,248	.4	4,413	.6	6,227	.9
Commercial lighting—						
Flat rate	24,003	3.2	11,885	1.7	8,629	1.2
Metered	105,198	13.9	118,247	16.9	124,346	17.5
Commercial power—						
Flat rate	16,632	2.2	4,722	.7	3,815	.5
Metered	343,516	45.2	296,804	42.5	328,966	46.3
Other electrical corporations	243,424	32.1	213,561	30.5	212,667	29.9
Breakdown service	674	....	640	.1	362	.1
Miscellaneous electric revenues	51	....	23,831	3.4	26	....
Total operating revenues, electric	754,206	99.2	692,733	99.1	704,633	99.2
Other operating revenues:						
Rent of electrical appliances	15	.8	687	.1	607	.1
Electric merchandise and jobbing revenue	6,124	.8	5,452	.8	5,017	.7
Total other operating revenues	6,139	.8	6,139	.9	5,624	.8
Gross electric revenues	760,346	100.0	698,873	100.0	710,257	100.0

Class of load.	1916		1917		1918		1919 (to Sept. 30)	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:								
Municipal street lighting—								
Arc	$9,718	1.3	$7,204	0.8	$8,610	0.8	$5,870	0.7
Incandescent	9,317	1.2	9,918	1.1	11,435	1.1	9,263	1.1
Municipal lighting, miscellaneous	3,238	.4	3,032	.3	3,449	.3	2,272	.3
Municipal power	6,623	.9	6,419	.7	6,398	.6	5,865	.7
Commercial lighting—								
Flat rate	8,408	1.1	4,338	.5	3,289	.3	2,162	.3
Metered	125,482	16.3	133,609	15.1	140,926	13.1	110,314	12.9
Commercial power—								
Flat rate	1,830	.2	8,155	.9	10,851	1.0	71,651	8.4
Metered	390,155	50.3	497,748	56.0	704,653	65.6	471,281	55.1
Other electrical corporations	213,481	27.5	210,840	23.8	176,109	16.4	172,245	20.1
Breakdown service	420	....	574	....	521	....	316	....
Miscellaneous electric revenues	116	....	265	....	154	....	114	....
Total operating revenues, electric	768,788	99.2	882,102	99.2	1,066,395	99.2	851,354	99.6
Other operating revenues:								
Rent of electric appliances	1,026	.1	350	....	47	....	24	....
Electric merchandise and jobbing revenue	5,873	.7	6,976	.8	8,688	.8	4,116	.4
Total other operating revenues	6,899	.8	7,326	.8	78,35	.8	4,140	.4
Gross electric revenues	775,687	100.0	889,428	100.0	1,075,130	100.0	855,495	100.0

FINANCIAL TABLES FOR SIERRA & SAN FRANCISCO POWER CO., COAST VALLEYS GAS & ELECTRIC CO., AND SUBSIDIARY COMPANIES.

TABLE 206.—*Capitalization, outstanding stock, and dividends of Sierra & San Francisco Power Co., Coast Valleys Gas & Electric Co., and subsidiaries.*

[Term of incorporation, uniformly 50 years.]

Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co.

[System of Sierra & San Francisco Power Co. was leased to Pacific Gas & Electric Co. Jan. 1, 1920, but system of Coast Valleys Gas & Electric Co. was not included in the lease.]

Company.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.			Dividends.	
			Per share.	Preferred.	Common.	On preferred stock.	On common stock.
Sierra & San Francisco Power Co., Millbrae, Calif., incorporated May 28, 1909.	$20,000,000	1909–1920	$100	....	$20,000,000	....	....
Coast Valleys Gas & Electric Co., San Francisco, incorporated Mar. 18, 1912.	5,000,000	1912–1920	100	$2,000,000	3,000,000	....	....

Subsidiary companies and predecessors of Sierra & San Francisco Power Co.

Company.	Date of incorporation.	Capitalization.	Years (Dec. 31).	Par value of stock outstanding.			Dividends.	
				Per share.	Preferred.	Common.	On preferred stock.	On common stock.
The Stanislaus Electric Power Co. (acquired by Sierra & San Francisco Power Co., Sept. 1, 1909), Hartford, Conn.	Dec. 20, 1905	[a]$10,000,000	1904–1914	$100	....	$10,000,000	....	....
Tuolumne Water Power Co. (acquired by Sierra & San Francisco Power Co. Sept., 1909), San Francisco.	Dec. 30, 1907	[b] 1,000,000	1904–1912	100	....	1,000,000	....	....
Consolidated Stanislaus Water & Power Co. (properties purchased in 1910 from San Joaquin Canal & Irrigation Co., which had taken over old company in 1908), San Francisco.	Nov. 18, 1904	1,000,000	1904–1908	10	$3,000,000	10,000,000	....	....
Mount Diablo Light & Power Co. (controlled by Sierra & San Francisco Power Co., acquired Jan. 2, 1912), San Leandro, Calif.	Oct. 13, 1904	[c] 50,000	1904	5	....	11,280	....	....
			1905	......	....	23,000	....	800
			1906	......	....	25,000	....	1,900
			1907–1908	......	....	25,000	....	2,000
			1909	......	....	30,000	....	2,215
			1910–1911	......	....	30,375	....	2,430

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[a] Company disincorporated in 1915.
[b] State license tax not paid in 1913.
[c] State license tax not paid in 1912.

TABLE 206.—*Capitalization, outstanding stock, and dividends of Sierra & San Francisco Power Co., Coast Valleys Gas & Electric Co., and subsidiaries*—Continued.

Subsidiary companies and predecessors of Coast Valleys Gas & Electric Co.

Company.	Date of incorporation.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.			Dividends.	
				Per share.	Preferred.	Common.	On preferred stock.	On common stock.
Salinas Valley Water Co. (controlled by Coast Valleys Gas & Electric Co. Acquired Mar. 19, 1912), King City, Calif).	Dec. 15, 1896	[d]$2,000,000	1911	$100		$1,000,000		
Monterey Gas & Electric Co. (properties purchased), Los Angeles, Calif.	May 6, 1902	200,000	1904	100		200,000		[e]$10,000
			1905–1915			200,000		
Monterey & Pacific Grove Street Railway & Electric Power Co. (name changed to Monterey & Pacific Grove Railway Co. in 1907, Monterey, Calif.	June 2, 1893	[f]180,000	1904–1907	30		97,160		
			1908–1912			[g]600,000		
			1913–1915			300,000		
Monterey County Gas & Electric Co. (controlled by Coast Valleys Gas & Electric Co.), Los Angeles, Calif.	Aug. 3, 1903	750,000	1904–1915	100		750,000		
California Consolidated Light & Power Co. (controlled by Coast Valleys Gas & Electric Co., acquired Mar. 19, 1912).	July 7, 1911	([h])	1911		2,000,000	3,000,000		
King City Water, Light & Power Co. (controlled by Coast Valleys Gas & Electric Co., acquired May 18, 1912), King City, Calif.	July 17, 1908	[i]50,000	1908	25	([j])			
			1909		([j])			
			1910			15,975		
			1911			15,975		
			1912			23,525		
Salinas Water, Light & Power Co. (controlled by Coast Valleys Gas & Electric Co.), Los Angeles, Calif.	Nov. 27, 1901	[k]200,000	1904–1907	100		200,000		

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[d] State license tax not paid in 1912 and charter lapsed.

[e] The rate of dividends on common stock was 5 per cent.

[f] Capitalization increased to $600,000 on change of name in 1907.

[g] The $600,000 shown by ledger 1908 to 1912 was reduced to $300,000 in 1913 on recheck of minute book. All owned by Coast Valleys Gas & Electric Co.

[h] Stock retired and company dead in 1912.

[i] State license tax not paid in 1913.

[j] No information.

[k] Merged in 1907 with Monterey County Gas & Electric Co.

TABLE 207.—*Bonds of Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co.*

[System of Sierra & San Francisco Power Co. was leased to Pacific Gas & Electric Co. Jan. 1, 1920, but system of Coast Valleys Gas & Electric Co. was not included in the lease.]

Issue. 1	Callable or convertible. 2	Sinking-fund deposits. 3	Trustee. 4	Denomination. 5	Authorized. 6
1. Sierra & San Francisco Power Co. first-mortgage gold 5 per cent bonds dated Aug. 1, 1909; due Aug. 1, 1949; interest payable Feb. 1 and Aug. 1.	On any interest date at 110.	None	U. S. Mortgage & Trust Co., New York.	$1,000 coupon.	$10,500,000
2. Sierra & San Francisco Power Co. second-mortgage gold 6 per cent bonds, series A, dated Jan. 1, 1909; due Jan. 1, 1949; interest payable Jan. 1 and July 1.	On any interest date at 105.	do	Columbia Trust Co., successor to Knickerbocker Trust Co., New York.	do	1,000,000
3. Sierra & San Francisco Power Co. second-mortgage gold 5 per cent bonds, series B, dated Jan. 1, 1909; due Jan. 1, 1949; interest payable Jan. 1 and July 1.	do	do	do	$1,000	8,500,000
4. Stanislaus Electric Power Co. first-mortgage 5 per cent bonds dated Jan. 8, 1906; due Jan. 1, 1946; interest payable Jan. 1 and July 1.	At 110 and interest after Jan. 1, 1913.		do	$1,000 coupon.	10,000,000
5. Coast Valleys Gas & Electric Co. first-mortgage gold 6 per cent bonds dated Mar. 1, 1912; due Mar. 1, 1952: interest payable Mar. 1 and Sept. 1.[a]	At 105 and interest	None	Mercantile Trust Co., San Francisco, or U. S. Mortgage & Trust Co., New York (trustee, Mercantile Trust Co., San Francisco).	$1,000 coupon; principal may be registered.	10,000,000
6. Salinas Water, Light & Power Co. (controlled by Coast Valleys Gas & Electric Co.) first-mortgage gold 5½ per cent bonds dated Jan. 1, 1902; due Jan. 1, 1922; interest payable Jan. 1 and July 1.	After Jan. 1, 1912, at premium of $18.75.		Citizens Trust & Savings Bank, Los Angeles (trustee, Title Insurance & Trust Co., Los Angeles).		150,000
7. Monterey Gas & Electric Co. (controlled by Coast Valleys Gas & Electric Co.) first-mortgage gold 5 per cent bonds dated July 1, 1902; due July 1, 1922; interest payable July 1 and Jan. 1.	After July 1, 1912, at premium of $16.25.		Citizens Trust & Savings Bank, Los Angeles.		180,000
8. Monterey County Gas & Electric Co. (controlled by Coast Valleys Gas & Electric Co.) first-mortgage 5 per cent bonds dated Oct. 1, 1903; due Oct. 1, 1933; interest payable Apr. 1 and Oct. 1.	After Oct. 1, 1913, at 103½ and interest.	From Oct. 1, 1908 to 1913, 1 per cent of par value of bonds outstanding to be set aside each year from net earnings and paid to trustee, to be used in purchase of bonds from 1914 to 1919, 1½ per cent from 1920 to 1933; 2 per cent to be set aside as above.	Citizens Trust & Savings Bank (trustee, Title Insurance & Trust Co., Los Angeles, secured by deed of trust).	$500 coupon	500,000

[a] See note *a*, p. 977

TABLE 207.—*Bonds of Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co.*—Continued.

Issue.	Callable or convertible.	Sinking-fund deposits.	Trustee.	Denomination.	Authorized.
1	2	3	4	5	6
9. Monterey & Pacific Grove Ry. Co. (controlled by Coast Valleys Gas & Electric Co.) first-mortgage gold 6 per cent bonds dated July 1, 1907; due July 1, 1937; interest payable Jan. 1 and July 1.	At 110 and interest....	Three per cent annually of bonds outstanding drom Feb. 1, 1913, to 1923; 4 per cent annually from 1924 to 1937.	Mercantile Trust Co., San Francisco.	$1,000 coupon.	$300,000
10. Yosemite Power Co. first-mortgage sinking-fund 6 per cent bonds dated Jan. 1, 1911; due Jan. 1, 1951; interest payable Jan. 1 and July 1. (See note.)	....	....	....	....	10,000

Issue.	Bonded debt.					Notes.
	Year (Dec. 31).	Reserved for prior liens.	In sinking fund.	In hands of public.	Total.	
1	7	8	9	10	11	12
1. Sierra & San Francisco Power Co. first-mortgage gold 5 per cent bonds dated Aug. 1, 1909; due Aug. 1, 1949; interest payable Feb. 1 and Aug. 1.	1909	None.	None.	....	$6,500,000	May be increased from time to time to an aggregate of $30,000,000 by certain provisions of the mortgage. Above $7,500,000, the unissued bonds are available for betterments, improvements, extensions, and additions at not to exceed 80 per cent of the cost of replacement value thereof, or for the acquisition, to an amount not to exceed 80 per cent of the actual cost thereof, either of first-mortgage bonds or the entire capital stock and indebtedness of other companies. None of such unissued bonds shall be issued, however, except when the property covered by the mortgage (excluding receipts from the San Domingo mine) for the preceding 12 months shows a net income, over operating expenses and taxes, of twice the interest on the first-mortgage bonds then actually outstanding or to be issued.
	1910–1915	None.	None.	$6,500,000	6,500,000	
	1916–1920	None.	None.	7,500,000	7,500,000	
2. Sierra & San Francisco Power Co. second-mortgage gold 6 per cent bonds, series A, dated Jan. 1, 1909; due Jan. 1, 1949; interest payable Jan. 1 and July 1.	1909	None.	None.	....	....	
	1910	None.	None.	600,000	1,000,000	$400,000 in escrow Sold under contract which provided for deferred payments, the bonds in escrow to be delivered by escrow agents as payments are made as provided in the contract.
	1911	None.	None.	800,000	1,000,000	200,000 in escrow
	1912	None.	None.	900,000	1,000,000	100,000 in escrow
	1913–1920	None.	None.	1,000,000	1,000,000	
3. Sierra & San Francisco Power Co. second-mortgage gold 5 per cent bonds, series B, dated Jan. 1, 1909; due Jan. 1, 1949; interest payable Jan. 1 and July 1.	1909	None.	None.	6,000,000	6,000,000	
	1910	None.	None.	6,648,250	6,648,250	
	1911	None.	None.	6,983,000	6,983,000	
	1912	None.	None.	7,335,000	7,335,000	
	1913	None.	None.	7,704,023	7,704,023	
	1914–1920	None.	None.	8,463,000	8,463,000	$37,000 in treasury.

4. Stanislaus Electric Power Co. first-mortgage 5 per cent bonds dated Jan. 8, 1906; due Jan. 1, 1946; interest payable Jan. 1, and July 1.	1906	....	....	....	....	No data received from company for this issue, but financial manuals report $5,250,000 outstanding in 1906 and $6,000,000 in 1908. The latter amount is covered by the exchange agreement noted in the text of this report.
	1907	....	....	....	....	
	1908	....	....	....	....	
	1909	....	....	....	....	
5. Coast Valleys Gas & Electric Co. first-mortgage gold 6 per cent bonds dated Mar. 1, 1912; due Mar. 1, 1952; interest payable Mar. 1 and Sept. 1.[a]	1912	None.	None.	786, 000	786, 000	Bonds to a total par value of $1,000,000[a] may be issued for full value of improvements when net earnings for 12 months preceding equal one and three-fourths times the interest on bonds outstanding and to be issued. On the remaining $9,000,000 directors are to fix a rate of interest not to exceed 6 per cent; can be issued for only 80 per cent of cost of further additions and extensions, subject to the above requirements as to earnings. The $786,000 in bonds of this issue outstanding in 1912 were used in retiring bonds of companies purchased.
	1913	None.	None.	900, 000	900, 000	
	1914	None.	None.	900, 000	900, 000	
	1915	None.	None.	900, 000	900, 000	
	1916	None.	None.	900, 000	900, 000	
	1917	None.	None.	900, 000	900, 000	
	1918	None.	[b] $11, 000	889, 000	900, 000	
6. Salinas Water, Light & Power Co. (controlled by Coast Valleys Gas & Electric Co.) first-mortgage gold 5½ per cent bonds dated Jan. 1, 1902; due Jan. 1, 1922; interest payable Jan. 1 and July 1.	1902–1911	None.	None.	150, 000	150, 000	
	1912	None.	None.	22, 500	22, 500	All bonds outstanding retired in 1913.
7. Monterey Gas & Electric Co. (controlled by Coast Valleys Gas & Electric Co.) first-mortgage gold 5 per cent bonds dated July 1, 1902; due July 1, 1922; interest payable July 1 and Jan. 1.	1902	None.	None.	75, 500	75, 500	
	1903–1911	None.	None.	180, 000	180, 000	
	1912	None.	None.	5, 500	5, 500	
	1913	None.	None.	1, 000	1, 000	Cash deposited with trustee to retire bonds apparently lost, and mortgage discharged.
8. Monterey County Gas & Electric Co. (controlled by Coast Valleys Gas & Electric Co.) first-mortgage 5 per cent bonds dated Oct. 1, 1903; due Oct. 1, 1933; interest payable Apr. 1 and Oct. 1.	1903	....	None.	....	....	
	1904	$330, 000	None.	13, 500	343, 500	$330, 000 retained by trustee to retire Salinas Water, Light & Power Co. and Monterey Gas & Electric Co. bonds.
	1905–1911	330, 000	None.	170, 000	500, 000	
	1912	330, 000	None.	9, 000	9, 000	
	1913	....	....	0	0	
9. Monterey & Pacific Grove Ry. Co. (controlled by Coast Valleys Gas & Electric Co.) first-mortgage gold 6 per cent bonds dated July 1, 1907; due July 1, 1937; interest payable Jan. 1 and July 1.	1907	None.	None.	79, 000	79, 000	
	1908	None.	None.	112, 000	112, 000	
	1909	None.	None.	157, 000	157, 000	$102,000 in the treasury, 1909.
	1910	None.	None.	198, 000	198, 000	
	1911	None.	None.	288, 000	288, 000	$12,000 in the treasury, 1911–1918. Interest on the outstanding bonds of this issue has been in default since Jan. 1, 1915.
	1912	None.	None.	288, 000	288, 000	
	1913–1918	None.	[c] $18, 000	270, 000	270, 000	
10. Yosemite Power Co. first-mortgage sinking-fund 6 per cent bonds dated Jan. 1, 1911; due Jan. 1, 1951; interest payable Jan. 1 and July 1. (See note.)	1911–1917	None.	None.	....	1, 700, 000	$8,292,000 unissued.
	1918	None.	None.	....	1, 500, 000	Sierra & San Francisco Power Co. purchased all electric operating properties of this company in 1917.

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[a] During 1920 Coast Valleys Gas & Electric Co. also authorized $400,000 par value in $1,000 coupon 8 per cent gold notes dated Nov. 1, 1920, due Nov. 1, 1930, subject to call at 105 and interest up to and including Dec. 31, 1926, and thereafter at a premium of 1 per cent for each year of unexpired term; Anglo California Trust Co., San Francisco, trustees. As of Dec. 31, 1920, only $57,000 par value ad interim certificates for these notes had been issued. The notes were not issued in final form until February, 1921.

[b] Includes $2,000 in treasury.

[c] Canceled.

TABLE 208.—*Comparative balance sheet of Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co., 1913–1920.*

Sierra & San Francisco Power Co.

	1913	1914	1915	1916
ASSETS.				
Total fixed capital	$34,540,033	$34,805,227	$35,263,785	$35,502,474
Cash and deposits:				
Cash	64,259	77,650	102,791	958,499
Special deposits	379,696	532,391	670,449	324,319
Total cash and deposits	443,955	610,041	773,240	1,282,818
Notes receivable	26,658	34,116	20,150	20,225
Accounts receivable:				
Due from consumers and agents	412,647	254,810	365,029	420,491
Miscellaneous accounts receivable	33,347	76,891	5,929	10,576
Total accounts receivable	445,994	331,701	370,958	431,067
Materials and supplies	135,454	119,922	115,963	159,501
Treasury securities	37,000	37,000	37,000	37,000
Prepaid expenses:				
Prepaid rents	[a] 10	[a] 22	[a] 17	84
Prepaid insurance	1,858	2,219	2,238	1,947
Other prepayments			[a] 5,760	[a] 3,840
Total prepaid expenses	1,848	2,197	[a] 3,539	[a] 1,809
Unamortized discount on bonds				147,607
Other suspense	45,558	[a] 34,655	4,739	24,906
Construction work in progress	3,141			
Corporate deficit	281,525	390,539	384,720	290,498
Reclamation and irrigation district warrants		1,472	2,048	2,872
Reserve for extra maintenance			1,051	
Miscellaneous				
Total assets	35,961,166	36,297,560	36,970,115	37,897,159
LIABILITIES.				
Capital stock	20,000,000	20,000,000	20,000,000	20,000,000
Funded debt	15,204,023	15,592,166	16,000,000	17,000,000
Accounts payable:				
Audited vouchers and wages unpaid	187,942	69,806	92,229	103,649
Consumers' deposits	2,747	2,871	2,671	2,778
Miscellaneous accounts payable	2,340	3,555	34,067	31,871
Total accounts payable	193,029	76,232	128,967	138,298
Interest accrued	513,912	501,608	135,417	156,250
Taxes accrued	22,142	27,460	33,628	36,021
Reserve for accrued depreciation	14,948	82,854	145,187	222,292
Casualty and insurance reserves	12,342	17,240	18,967	19,979
Reserve for extraordinary repairs	770			
Interest matured			507,949	324,319
Miscellaneous				
Corporate surplus unappropriated				
Total liabilities	35,961,166	36,297,560	36,970,115	37,897,159

	1917	1918	1919	1920
ASSETS.				
Total fixed capital	$36,397,509	$36,659,914	$36,735,206	$37,101,460
Cash and deposits:				
Cash	175,334	52,823	162,970	23,260
Special deposits	320,849	325,019	481,365	285,980
Total cash and deposits	496,183	377,842	644,335	309,240
Notes receivable	223			10,125
Accounts receivable:				
Due from consumers and agents	432,944	384,555	140,620	
Miscellaneous accounts receivable	17,589	36,210	211,726	67,543
Total accounts receivable	450,533	420,765	352,346	67,543
Interest and dividends receivable			2,850	2,795
Investments:				
Securities of other corporations			89,250	89,250
Miscellaneous investments			50	50
Total investments			89,300	89,300

[a] Credit item.

TABLE 208.—*Comparative balance sheet of Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co., 1913–1920*—Continued.

Sierra & San Francisco Power Co.—Continued.

	1917	1918	1919	1920
ASSETS—continued.				
Materials and supplies	$201,194	$247,542	$326,891	$12,034
Treasury securities	37,000	37,000	37,000	43,775
Prepaid expenses:				
Prepaid rents	*a* 17	....	....	....
Prepaid taxes	....	....	196	....
Prepaid insurance	2,320	2,697	4,166	101
Other prepayments	47,339	42,332	2,625	....
Total prepaid expenses	49,642	45,029	6,987	101
Unamortized discount on bonds	143,142	139,684	135,184	108,802
Other suspense	3,757	19,070	....	....
Construction work in progress	....	....	....	....
Corporate deficit	215,885	....	205,413	....
Reclamation and irrigation district warrants	....	....	....	....
Reserve for extra maintenance	....	....	....	....
Miscellaneous	249	....	....	....
Total assets	37,995,317	37,946,846	38,535,513	37,745,174
LIABILITIES.				
Capital stock	20,000,000	20,000,000	20,000,000	20,000,000
Funded debt	17,000,000	17,000,000	17,000,000	17,000,000
Notes payable	....	....	4,079	3,600
Accounts payable:				
Audited vouchers and wages unpaid	154,104	249,062	666,972	....
Consumer's deposits	5,220	11,352	64,598	....
Miscellaneous accounts payable	12,318	7,025	19,495	242,651
Total accounts payable	171,642	267,439	751,066	242,651
Interest accrued	156,250	156,250	157,223	181
Taxes accrued	40,004	*a* 3,399	18,665	5,776
Reserve for accrued depreciation	294,210	171,965	241,324	141,323
Casualty and insurance reserves	19,337	21,436	3,000	2,669
Reserve for extraordinary repairs	....	....	53,358	10,649
Other reserves from income or surplus	....	....	....	....
Interest matured	....	....	285,928	284,318
Miscellaneous	313,874	317,744	....	....
Corporate surplus unappropriated	....	15,411	....	32,241
Unadjusted credit, United R. R. Co. deficiency	....	....	20,870	20,870
Deferred credit item	....	....	....	894
Total liabilities	37,995,317	37,946,846	38,535,513	37,745,174

a Credit item.

Coast Valleys Gas & Electric Co.

	1913	1914	1915	1916
ASSETS.				
Total fixed capital	$5,682,100	$5,758,470	$5,769,993	$5,789,281
Cash and deposits:				
Cash	689	1,536	22,161	22,182
Special deposits	1,930	365	1,425	540
Total cash and deposits	2,619	1,901	23,586	22,722
Notes receivable	22,030	37,130	1,546	....
Accounts receivable:				
Accounts with system corporations	16,120	16,120	16,075	....
Due from consumers and agents	26,894	30,278	27,193	31,593
Miscellaneous accounts receivable	3,848	6,941	1,361	1,241
Total accounts receivable	46,862	53,339	44,629	32,834
Interest and dividends receivable	....	....	....	....
Investments:				
Securities of other corporations	216,901	207,901	207,901	....
Miscellaneous investments	....	....	....	....
Total investments	216,901	207,901	207,901	....
Materials and supplies	31,377	26,346	25,854	26,171
Sinking funds	....	....	....	....
Treasury securities	....	....	....	....
Prepaid expenses:				
Prepaid insurance	1,215	936	997	1,368
Other prepayments	....	....	....	723
Total prepaid expenses	1,215	936	997	2,091

TABLE 208.—*Comparative balance sheet of Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co., 1913–1920*—Continued.

Coast Valleys Gas & Electric Co.—Continued.

	1913	1914	1915	1916
ASSETS—continued.				
Unamortized discount on securities and expenses:				
Stocks	....	....	....	$223,976
Bonds	$46,710	$19,754	$19,222	23,833
Miscellaneous	8,015	....	....	....
Total unamortized discount on securities and expenses	54,725	19,754	19,222	247,809
Other suspense	314	10,282	8,097	22,430
Construction work in progress	4,824	....	....	....
Total assets	6,062,967	6,116,059	6,101,825	6,143,338
LIABILITIES.				
Capital stock	5,000,000	5,000,000	5,000,000	5,000,000
Funded debt	901,000	900,000	900,000	900,000
Notes payable	51,993	51,897	40,000	40,000
Accounts payable:				
Audited vouchers and wages unpaid	25,435	33,211	37,860	39,569
Consumers' deposits	1,778	2,290	1,990	2,208
Total accounts payable	27,213	35,501	39,850	41,777
Interest accrued	18,146	18,365	19,425	18,540
Taxes accrued	3,330	4,477	7,077	8,854
Service billed in advance	....	....	....	750
Reserve for accrued depreciation	2,152	17,959	33,054	51,046
Casualty and insurance reserves	....	1,415	2,631	4,166
Corporate surplus unappropriated	59,133	86,445	59,788	78,205
Miscellaneous	....	....	....	....
Total liabilities	6,062,967	6,116,059	6,101,825	6,143,338

	1917	1918	1919	1920
ASSETS.				
Total fixed capital	$1,232,083	$1,289,507	$1,418,556	$1,618,223
Cash and deposits:				
Cash	19,972	37,865	74,101	28,312
Special deposits	180	4,664	1,620	74,828
Total cash deposits	20,152	42,529	75,721	103,140
Notes receivable	....	....	....	....
Accounts receivable:				
Accounts with system corporations	....	....	....	....
Due from consumers and agents	29,558	34,000	48,289	49,849
Miscellaneous accounts receivable	5,492	5,861	2,391	16,660
Total accounts receivable	35,050	39,861	50,680	66,509
Interest and dividends receivable	....	1,020	960	620
Investments:				
Securities of other corporations	....	....	....	....
Borrowed	....	....	....	1
Miscellaneous investments	11,378	11,378	11,378	11,378
Total investments	11,378	11,378	11,378	11,379
Materials and supplies	25,278	32,907	39,269	45,706
Sinking funds	....	9,270	19,080	31,152
Treasury securities	....	2,000	3,000	6,000
Prepaid expenses:				
Prepaid insurance	1,237	1,947	1,948	1,419
Other prepayments	13,017	7,657	3,313	....
Total prepaid expenses	14,254	9,604	5,261	1,419
Unamortized discount on securities and expenses:				
Stocks	4,808,971	4,808,971	4,808,970	4,808,907
Bonds	23,028	22,354	40,369	44,363
Total unamortized discount on securities and expenses	4,831,999	4,831,325	4,849,340	4,853,270
Other suspense	647	1,982	604	....
Construction work in progress	....	....	....	....
Total assets	6,170,841	6,271,383	6,473,849	6,737,418

TABLE 208.—*Comparative balance sheet of Sierra & San Francisco Power Co. and Coast Valleys Gas & Electric Co., 1913–1920*—Continued.

Coast Valleys Gas & Electric Co.—Continued.

	1917	1918	1919	1920
LIABILITIES.				
Capital stock	$5,000,000	$5,000,000	$5,000,000	$5,000,000
Collateral trust notes				57,000
Funded debt	900,000	900,000	1,025,000	1,025,000
Securities borrowed				1
Notes payable			1,753	61,804
Accounts payable:				
Audited vouchers and wages unpaid	63,874	116,567	49,168	73,295
Consumers' deposits	2,765	8,246	15,965	35,428
Miscellaneous accounts payable			618	17,696
Total accounts payable	66,639	124,813	65,751	126,419
Interest accrued	18,000	18,000	20,566	21,542
Taxes accrued	12,491	5,017	15,494	14,107
Service billed in advance	750	750		
Reserve for accrued depreciation	67,378	91,524	114,772	134,156
Casualty and insurance reserves	4,587	2,009	2,237	1,107
Other reserves from income or surplus				15,390
Bond interest matured			1,620	960
Customers' accounts receivable—prepaid			24,309	23,320
Donated capital reserve			25,000	25,000
Corporate surplus unappropriated	100,816	128,250	177,347	231,612
Miscellaneous	180	1,020		
Total liabilities	6,170,841	6,271,383	6,473,849	6,737,418

TABLE 209.—*Earnings and expenses, Sierra & San Francisco Power Co., 1910–1920.*

	1910	1911	1912	1913	1914	1915
Electric operations:						
Operating revenue	[a] $434,277	[a] $834,324	[a] $945,937	$1,031,621	$1,087,239	$1,227,826
Operating expenses	[b] 146,852	[b] 230,654	[b] 388,552	477,790	479,779	489,593
Net operating electric revenue	287,425	603,670	557,385	553,831	607,460	738,233
Water operations:						
Operating revenue				42,598	38,487	37,282
Operating expenses				27,470	26,812	23,105
Net operating water revenue				15,128	11,675	14,177
Total net operating revenue				568,959	619,135	752,410
Add:						
Nonoperating revenues—						
Rents from buildings, land (water)				201	323	
Rents accrued from lease of electric plant						
Rents accrued from lease of gas plant						
Miscellaneous rent revenues (electric)				1,799	404	339
Interest and dividend revenues—						
Interest during construction						13,532
Miscellaneous interest revenues				12,468	12,839	
Total interest and dividend revenues				12,468	12,839	13,532
Miscellaneous nonoperating revenue				88		2,617
Total nonoperating revenue				14,556	13,566	16,488
Gross corporate income	287,425	603,670	557,385	583,515	632,701	768,898

[a] Includes water and nonoperating revenues.

[b] Includes water operating expenses.

TABLE 209.—*Earnings and expenses, Sierra & San Francisco Power Co., 1910–1920*—Continued.

	1910	1911	1912	1913	1914	1919
Deduct:						
Uncollectible bills and nonoperating revenue deductions	$17,981	$24,464	$36,287	$668	$1,357	$3,806
Interest on funded debt	197,641	662,999	697,363	743,034	752,907	764,289
Amortization of debt discount and expense	....	....	....	....	....	....
Miscellaneous deductions	....	....	....	....	....	....
Total deductions	215,622	687,463	733,650	743,702	754,264	....
Balance of year carried to corporate surplus or deficit account	71,803	c 83,793	c 176,265	c 160,187	c 121,563	803

	1916	1917	1918	1919	1920
Electric operations:					
Operating revenue	$1,366,809.86	$1,475,028.43	$1,897,169.00	$2,434,944	....
Operating expenses	481,186.59	582,109.21	1,011,233.46	1,852,643	....
Net operating electric revenue	885,623.27	892,919.22	885,935.54	582,301	....
Water operations:					
Operating revenue	39,018.50	42,365.93	51,887.87	59,058	....
Operating expenses	24,963.32	25,385.25	27,668.95	24,621	....
Net operating water revenue	14,055.18	16,980.68	24,218.92	34,437	....
Total net operating revenue	899,678.45	909,899.90	910,154.46	616,738	....
Add:					
Nonoperating revenues—					
Rents from buildings, land (water)	....	....	65.00	315	....
Rents accrued from lease of electric plant	158.00	155.50	....	....	$50,000
Miscellaneous rent revenues (electric)	1,767.50	1,565.00	3,100.00	3,000	....
Interest and dividend revenues—					
Interest during construction	....	....	....	....	....
Interest revenue and funded debt owned	....	....	....	3,938	6,600
Miscellaneous interest revenues	15,589.01	29,017.72	3,580.19	9,366	1,809
Total interest and dividend revenues	15,589.01	29,017.72	3,580.19	13,304	8,409
Miscellaneous nonoperating revenue	3,302.96	2,086.49	3,919.35	1,868	1,343
Total nonoperating revenue	20,817.47	32,824.71	10,664.54	18,486	59,751
Gross corporate income	920,495.92	942,724.61	920,819.00	635,224	59,751
Deduct:					
Uncollectible bills and nonoperating revenue deductions	805.75	3,907.19	1,654.43	28,032	....
Interest on funded debt	816,483.34	858,150.00	858,150.00	858,150	....
Interest expenses	....	....	....	....	994
Dividend expenses	....	....	....	....	1,588
Miscellaneous nonoperating expenses	....	....	....	....	30,991
Nonoperating taxes	....	....	....	....	1,257
Amortization of debt discount and expense	....	4,700.00	4,700.00	4,700	....
Other interest deductions	c 20,891.76	....	....	12,089	....
Total deductions	796,397.33	866,757.19	864,504.43	902,971	34,831
Balance of year carried to corporate surplus or deficit account	124,098.59	75,967.42	56,314.57	c 267,747	24,920

c Deficit.

TABLE 210.—*Earnings and expenses, Coast Valleys Gas & Electric Co., 1912–1920.*

	1912	1913 [a]	1914	1915	1916	1917	1918	1919	1920
Electric operations:									
Operating revenue	[b]$181,558	$157,263	$197,363	$160,714	$177,470	$214,793	$343,414	$345,144	$430,962
Operating expense	[c]98,965	81,099	97,299	92,980	108,261	137,037	171,043	244,861	320,344
Net operating electric revenue	82,593	76,164	82,364	67,734	69,209	77,756	72,371	100,283	110,618
Gas operations:									
Operating revenue	....	42,104	45,561	46,098	52,978	55,299	71,462	86,167	112,875
Operating expense	....	35,135	40,569	44,218	45,409	56,746	66,428	82,773	109,535
Net operating gas revenue	....	6,969	4,992	1,880	7,569	[d]1,447	5,034	3,394	3,341
Water operations:									
Operating revenue	....	21,315	21,323	21,990	23,003	23,463	24,766	26,882	29,694
Operating expense	....	16,780	20,562	21,910	22,003	20,945	19,934	23,755	28,131
Net operating water revenue	....	4,535	761	80	1,000	2,518	4,832	3,127	1,563
Total operating revenue	82,593	87,668	88,117	69,694	77,778	78,827	82,237	106,804	115,522
Add:									
Nonoperating revenues—									
Rent from buildings, land, apparatus	....	....	938	947	827	869	....	....	....
Miscellaneous rent revenues	....	928	....	....	....	....	804	....	....
Interest and dividend revenues—									
Interest revenue on funded debt owned	....	4,905	4,365	2,160	....	....	330	810	875
Miscellaneous interest revenues	....	1,381	2,320	1,243	44	155	369	....	....
Total interest and dividend revenue	....	6,286	6,685	3,403	44	155	699	810	875
Miscellaneous nonoperating revenue	....	....	....	....	142	160	160	2,744	2,405
Sinking and reserve fund	....	....	....	....	....	....	270	....	....
Total nonoperating revenue	....	7,214	7,623	4,350	1,013	1,184	1,933	3,554	3,280
Gross corporate income	82,593	94,882	95,740	74,044	78,791	80,011	84,170	110,358	118,802
Deduct:									
Uncollectible bills	....	887	1,021	281	223	411	410	450	180
Nonoperating revenue deductions	....	192	....	....	....	....	....	....	....
Rent expenses	....	....	3	....	....	....	....	11	....
Nonoperating taxes	....	87	....	....	....	....	106	110	39
Miscellaneous nonoperating expenses	....	....	167	391	157	156	100	....	119
Total nonoperating revenue deductions	....	1,166	1,191	672	380	567	616	571	338
Interest accrued on funded debt	....	47,836	54,000	54,000	54,000	54,000	54,000	58,426	61,502
Other inrerest deductions	45,938	9,984	5,022	4,743	4,138	3,904	3,385	2,733	589
Amortization of debt discount and expense	....	....	1,506	532	698	805	674	1,035	1,265
Miscellaneous deductions from income	7,354	....	....	....	....	....	....	....	308
Total miscellaneous deductions	53,292	58,986	61,719	59,947	59,216	59,276	58,675	62,766	64,001
Balance of year carried to surplus	29,301	35,896	34,021	14,097	19,575	20,735	25,495	47,592	54,801

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[a] General expense has been apportioned to electric, gas and water departments upon a basis determined by the company's rate engineer.

[b] Includes electric, water, and gas revenues.

[c] Includes electric, water, and gas expenses.

[d] Loss.

TABLE 211.—*Classified electric revenues of Sierra & San Francisco Power Co. according to classification of Railroad Commission of California, 1913–1919.*

Class of load.	1913		1914		1915	
	Gross receipts.	Per cent of gross electric income.	Gross receipts.	Per cent of gross electric income.	Gross receipts.	Per cent of gross electric income.
Municipal street lighting—arc and incandescent	$3,814	0.37	$4,369	0.4	$5,210	0.43
Municipal lighting	678	.07	717	.1	787	.06
Municipal power	10,711	1.04	10,112	.9	10,748	.87
Commercial lighting:						
Flat rate	1,868	.18	2,686	.2	1,613	.12
Metered	78,021	7.56	89,468	8.2	96,211	7.84
Commercial power:						
Flat rate	563	.05	334		1,564	.13
Metered	128,896	12.40	132,592	12.2	155,677	12.68
Railway power	716,183	69.50	735,595	67.7	821,603	67.00
Other electrical corporations	88,890	8.64	106,138	9.8	106,074	8.57
Miscellaneous electric revenue	50		54			
Breakdown service					25,000	2.03
Rent of electric appliances	294	.03	392	.1	175	.01
Electric merchandising and jobbing revenues	1,653	.16	4,782	.4	3,164	.26
Total operating revenue, electric	1,031,621	100.00	1,087,239	100.00	1,227,826	100.00

Class of load.	1916		1917		1918		1919 [a]	
	Gross receipts.	Per cent of gross electric income.	Gross receipts.	Per cent of gross electric income.	Gross receipts.	Per cent of gross electric income.	Gross receipts.	Per cent of gross electric income.
Municipal street lighting—arc and incandescent	$6,216	0.45	$7,682	0.5	$12,967	0.68	$14,699	0.6
Municipal lighting	915	.06	963	.1	1,240	.07	1,281	
Municipal power	9,960	.72	11,624	.8	17,075	.95	23,475	1.0
Commercial lighting:								
Flat rate	3,349	.24	4,136	.3	1,494	.08	405	
Metered	102,902	7.53	123,336	8.4	167,147	8.81	230,985	9.5
Commercial power:								
Flat rate	2,056	.15	2,625	.2	949	.05	642	
Metered	196,270	14.36	199,295	13.5	271,967	14.33	396,164	16.3
Railway power	900,937	65.94	922,134	62.5	1,174,548	61.91	1,291,166	53.0
Other electrical corporations	138,296	10.12	196,060	13.2	248,820	13.11	475,356	19.6
Miscellaneous electric revenue								
Breakdown service								
Rent of electrical appliances	314	.02	179		168			
Electric merchandising and jobbing revenues	5,595	.41	6,994	.5	793	.01	782	
Total operating revenue, electric	1,366,810	100.00	1,475,028	100.00	1,897,169	100.00	2,434,955	100.0

[a] Last year reported separately; system leased to Pacific Gas & Electric Co. Jan. 1, 1920.

TABLE 212.—*Classified electric revenues of Coast Valleys Gas & Electric Co. according to classification of Railroad Commission of California, 1913–1920.*

Class of load.	1913		1914		1915	
	Gross receipts.	Per cent of gross electric income.	Gross receipts.	Per cent of gross electric income.	Gross receipts.	Per cent of gross electric income.
Municipal street lighting:						
Arc			$10,308	5.7	$5,469	3.40
Incandescent	$13,637	8.66	3,698	2.1	5,271	3.28
Municipal lighting	1,315	.83	1,243	.7	1,058	.66
Municipal power	99	.06	103		243	.02
Commercial lighting:						
Flat rate	1,692	1.08	4,006	2.2	3,228	2.01
Metered	80,872	51.45	85,352	47.5	74,449	46.43
Commercial power:						
Flat rate	6,946	4.41	10,413	5.8	8,365	5.21
Metered	45,239	28.75	58,820	32.8	58,053	36.14
Railway power	4,767	3.05	5,031	2.8	3,777	2.35
Miscellaneous electric revenues			1			
Electric merchandising and jobbing revenues	2,696	1.71	688	.4	801	.50
Total electric revenue	157,263	100.00	179,663	100.0	160,714	100.00

Class of load.	1916		1917		1918	
	Gross receipts.	Per cent of gross electric income.	Gross receipts.	Per cent of gross electric income.	Gross receipts.	Per cent of gross electric income.
Municipal street lighting:						
Arc	$3,899	2.20	$3,895	1.80	$3,658	1.27
Incandescent	6,525	3.68	6,483	3.01	7,763	3.00
Municipal lighting	1,298	.73	1,256	.05	1,201	.49
Municipal power	345	.20	292	.01	184	.07
Commercial lighting:						
Flat rate	2,933	1.65	2,860	1.33	1,625	.66
Metered	82,313	46.38	88,317	41.00	92,462	37.98
Commercial power:						
Flat rate	9,347	5.26	11,199	5.20	478	.19
Metered	64,881	36.56	93,725	44.60	127,530	53.00
Railway power	4,506	2.54	4,230	1.90	5,651	2.32
Miscellaneous electric revenues					54	.02
Electric merchandising and jobbing revenues	1,422	.80	2,535	1.10	2,808	1.00
Total electric revenue	177,469	100.00	214,792	100.00	243,414	100.00

Class of load.	1919		1920	
	Gross receipts.	Per cent of gross electric income.	Gross receipts.	Per cent of gross electric income.
Municipal street lighting:				
Arc	$5,066	1.4	$4,363	1.0
Incandescent	8,529	2.5	9,487	2.2
Municipal lighting	1,965	.7	1,935	.4
Municipal power	237		258	
Commercial lighting:				
Flat rate	208		25	
Metered	121,149	35.1	151,889	35.3
Commercial power:				
Flat rate	15		97	
Metered	198,815	57.6	253,765	58.9
Railway power	7,997	2.3	8,052	1.8
Miscellaneous electric revenues				
Electric merchandise and jobbing revenue	1,162	.4	1,093	.4
Total operating revenue, electric	345,144	100.0	430,962	100.0

TABLE 213.—*Comparative balance sheet of Yosemite Power Co., 1912–1916.*

[Electric operative properties sold to Sierra & San Francisco Power Co. in 1917.]

	1912	1913	1914	1915	1916
ASSETS.					
Total fixed capital	$3,808,249	$3,882,972	$3,949,828	$3,966,180	$4,017,257
Cash and deposits:					
Cash	1,577	6,030	16,660	6,361	2,882
Special deposits	....	....	....	270	150
	1,577	6,030	16,660	6,631	3,032
Notes receivable	28	....	....	1,108	....
Accounts receivable:					
Due from consumers and agents	....	15,696	12,336	9,317	9,444
Miscellaneous accounts receivable	....	8,998	1,688	945	890
	....	24,694	14,024	10,262	10,334
Other current assets	22,383	....	500	....	....
Miscellaneous investments	....	....	....	....	....
Materials and supplies	10,323	12,018	7,123	10,202	8,473
Sinking funds	....	....	....	....	....
Prepaid expenses:					
Prepaid taxes	....	....	193	80	325
Prepaid insurance	....	[a] 203	33	94	119
Other prepayments	....	....	1,345	249	440
	....	[a] 203	1,571	423	884
Other suspense	....	2,250	....	....	....
Construction work in progress	....	1,260	2,623	1,430	31
Corporate deficit	....	....	63,347	178,830	269,181
Total assets	3,842,560	3,929,021	4,055,676	4,175,066	4,309,191
LIABILITIES.					
Capital stock	2,050,300	2,050,300	2,050,300	2,050,300	2,050,300
Funded debt	1,708,000	1,708,000	1,708,000	1,708,000	1,708,000
Notes payable	....	3,843	109,000	111,000	119,300
Accounts payable:					
Audited vouchers and wages unpaid	7,864	7,951	24,652	7,708	7,470
Consumers' deposits	....	878	672	270	359
Miscellaneous	66,116	93,806	5,040	840	1,801
	73,980	102,635	30,364	8,818	9,630
Interest accrued	....	43,876	145,980	256,936	367,224
Reserve for accrued depreciation	....	11,224	11,159	39,299	53,654
Other reserves from income or surplus	664	868	873	713	1,083
Corporate surplus unappropriated	9,616	8,275	....	....	....
Total liabilities	3,842,560	3,929,021	4,055,676	4,175,066	4,309,191

[a] Credit item.

TABLE 214.—*Earnings and expenses of Yosemite Power Co., 1912–1916.*

[Electric operative properties sold to Sierra & San Francisco Power Co. in 1917.]

	1912	1913	1914	1915	1916
Operating revenues	$50,520	$65,554	$71,792	$65,930	$71,677
Operating expenses	27,984	46,355	35,275	66,654	50,249
Net operating revenue	22,536	19,199	36,517	[a] 724	21,428
Nonoperating revenues:					
Rents from buildings, land, and apparatus	686				
Miscellaneous interest revenues	56	176	2	44	39
Miscellaneous nonoperating revenues			932		
Total nonoperating revenues	742		934	44	39
Gross corporate income	23,278	19,375	37,451	[a] 680	21,467
Deductions:					
Uncollectible bills		834	801	684	647
Miscellaneous nonoperating expenses			3,468	749	
Uncollectible nonoperating revenues		961	2,203	2,276	
Total nonoperating revenue deductions		1,795	6,472	3,709	647
Interest accrued on funded debt	18,497	18,480	102,480	102,480	102,480
Other interest deductions	33	441	121	8,614	7,982
Total miscellaneous deductions	18,530	20,716	109,073	114,803	111,109
Surplus for year	4,748				
Deficit for year		1,341	71,622	115,483	89,642

[a] Deficit.

TABLE 215.—*Classified electric revenues of Yosemite Power Co. according to classification of Railroad Commission of California, 1913–1916.*

Class of load.	1913		1914		1915		1916	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:								
Municipal street lighting—								
Arc	$3,809	5.8	$3,508	4.9	$3,903	5.9	$3,397	4.8
Incandescent	317	.5	2,358	3.3	1,154	1.8	2,072	2.9
Municipal lighting, miscellaneous	115	.2	134	.2	127	.2	210	.2
Municipal power	2,760	4.2	4,421	6.2	4,567	6.9	4,710	6.6
Commercial lighting—								
Flat rate	554	.8	744	1.0	821	1.2	815	1.1
Metered	21,093	32.2	24,228	33.7	26,666	40.5	29,952	41.9
Commercial power—								
Flat rate	15		107	.1	116	.2	116	.1
Metered	18,474	28.2	26,799	37.4	24,570	37.3	29,833	41.8
Railway power								
Other electrical corporations	6,611	10.1	8,028	11.2	3,068	4.6		
Miscellaneous electric revenue	9,256	14.1			6		9	
Total operating revenues, electric	63,004	96.1	70,327	98.0	64,998	98.6	71,114	99.4
Other operating revenues:								
Electric merchandise and jobbing revenues	2,550	3.9	818	1.1	323	.5	64	
Sale of by-products			647	.9	609	.9	499	.6
Total other operating revenues	2,550	3.9	1,465	2.0	932	1.4	563	.6
Total operating revenues, electric	63,004	96.1	70,327	98.0	64,998	98.6	71,114	99.4
Total electric revenues	65,554	100.0	71,792	100.0	65,930	100.0	71,677	100.0

FINANCIAL TABLES FOR GREAT WESTERN POWER SYSTEM.

TABLE 216.—*Capitalization, stock outstanding, and dividends of Great Western Power system.*

[Term of incorporation 50 years, unless otherwise noted. Unless stated in footnotes, par value of all stock is $100.]

Company.	Date of incorporation.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.		Dividends.[a]				Notes.
						Preferred.		Common.		
				Preferred.	Common.	Rate.	Amount.	Rate.	Amount.	
						P. ct.		*P. ct.*		
Western Power Corporation, New York.	[b] June 5, 1915	$7,813,500	1915	$7,035,396	[c] $140,823	......	....	......	....	First dividend, $1.20 per share on preferred stock, paid Oct. 16, 1916. Western Power Corporation of New York is a holding company controlling through ownership of the specified amounts of common stock (as of Dec. 31, 1918), the following companies: Western Power Co. of New Jersey, $14,660,900; Great Western Power Co. of California, $27,498,600.
			1916	7,067,492	146,316	4	$281,575	......	....	
			1917	7,067,492	146,316	4	282,452	......	....	
			1918	7,076,932	146,614	4	282,697	......	....	
			1919	7,079,882	146,615	......	353,672	......	....	
			1920	7,079,882	146,615	......	424,512	......	....	
Great Western Power Co. of California, San Francisco.	Nov. 22, 1915	60,000,000	1915	....	....	......	....	......	....	Only director's qualifying shares of Great Western Power Co. of California had been issued on Dec. 31, 1915. The company was organized as an operating company, to take over the properties and business of Great Western Power Co., City Electric Co., California Electric Generating Co., and Consolidated Electric Co. The properties of the above were finally acquired June 1, 1919. As of Dec. 31, 1918, Great Western Power Co. of California was controlled by Western Power Corporation of New York through ownership of stock. All but 13 director's qualifying shares and 1 share of common stock held by Western Power Co. of New Jersey. Great Western Power Co. of California controlled (as of Dec. 31, 1918) through the ownership of the specified amounts of common stock: Great Western Power Co., $27,498,600; City Electric Co., $4,997,100.
			1916	....	27,500,000	......	....	......	$275,000	
			1917	10,211	27,500,000	1 1/16	....	1.11	305,250	
			1918	173,684	27,500,000	7	8,831	1.11	305,250	
			1919	1,338,526	27,500,000	7	34,222	1.28	352,000	
			1920	1,916,084	27,500,000	7	120,172	1.74	478,500	
Western Power Co., Jersey City, N. J.	Aug. 21, 1906	[d] 18,000,000	1906	....	....	......	....	......	....	Entire capital stock Western Power Co. of New Jersey owned by Western Power Corporation of New York, with exception of a few shares still in hands of public. Western Power Co. of New Jersey was organized originally as a holding company to control the various operating companies of the Great Western system; it has completed transfer of all stock control and assets to Western Power Corporation of New York.
			1907–1910	6,000,000	12,000,000	......	....	......	....	
			1911–1915	6,000,000	14,670,000	......	....	......	....	
			1916	6,000,000	14,670,000	......	1,344	......	....	
			1917	6,000,000	14,670,000	......	512	......	....	
			1918	6,000,000	14,670,000	......	197	......	....	
			1919	6,000,000	14,670,000	......	....	......	....	
			1920	6,000,000	14,670,000	......	....	......	....	

Great Western Power Co., San Francisco.	Sept. 18, 1906	[c]25,000,000	1906							Controlled by Great Western Power Co. of California through ownership of entire capital stock, with the exception of 13 director's qualifying shares and 1 share held by Western Power Co. of New Jersey. Controlled (as of Dec. 31, 1918) following companies through ownership of the specified amounts of common stock: California Electric Generating Co., $4,998,700; Consolidated Electric Co., $9,700. Exchanged for stock of Great Western Power Co. of California.
			1907–1910		25,000,000					
			1911–1915		27,500,000					
			1916		27,500,000				357,500	
			1917		27,500,000			2.25	618,750	
			1918		27,500,000			2.21	607,750	
			[f]1919		27,500,000			.60	165,000	
California Electric Generating Co., Oakland, Calif.	Nov. 23, 1908	7,500,000	1908–1911	2,500,000	5,000,000					Controlled, as of Dec. 31, 1918, by Great Western Power Co. through ownership of all but 13 directors' qualifying shares of common stock.
			1912–1920	2,500,000	5,000,000	6	150,000			
City Electric Co., San Francisco.	Jan. 14, 1907	5,000,000	1907		5,000,000					Controlled, as of Dec. 31, 1918, by Great Western Power Co. of California through ownership of entire capital stock with the exception of 9 director's qualifying shares and 20 shares held by public.
			1908		5,000,000					
			1909		5,000,000			3	12,500	
			1910		5,000,000			3, 3.6	165,000	
			1911		5,000,000			3.6	90,000	
			1912–1919[f]		5,000,000					
Western Power Co., Los Angeles, Calif.	Mar. 24, 1902	5,000,000								
Consolidated Electric Co., San Francisco.	Feb. 2, 1915	10,000	1915–1919[f]		10,000					Controlled, as of Dec. 31, 1918, by Great Western Power Co. through ownership of entire capital stock with the exception of 3 director's qualifying shares.
United Light & Power Co. of New Jersey, Jersey City, N. J.[g]	Jan. 6, 1911	3,000,000	1911–1914		3,000,000					Combined to form Consolidated Electric Co.
United Light & Power Co. of California, San Francisco.[g]	[h]May 2, 1910	[i]6,000,000	1910							
			1911	1,941,260	3,811,732					
			1912–1914	1,996,100	3,982,130					
Consumers Light & Power Co., San Francisco.[g]	Feb. 26, 1908	[i]100,000	1908–1910							
			1911–1914		100,000					
Southside Light & Power Co., San Francisco.[g]	May 3, 1910	[i]1,000,000	1910							
			1911–1914	250,000	750,000					
Equitable Light & Power Co., San Francisco.[g]	Mar. 22, 1909	[i]750,000	1909							
			1910							
			1911–1914	250,000	500,000					
Central Oakland Light & Power Co., San Francisco.[g]	Jan. 25, 1909	[i]1,250,000	1909							
			1910							
			1911–1914	230,200	964,100					

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[a] Blanks in columns indicate that no dividends were paid or rates given.
[b] Term of incorporation perpetual.
[c] Stated in number of shares; no par value given.
[d] Capitalized at $18,000,000, divided into $6,000,000 preferred and $12,000,000 common stock; October, 1911, common stock was increased to $14,670,000.
[e] Capitalized at $25,000,000 common stock. On Oct. 26, 1911, common stock was increased to $27,500,000.
[f] May 31.
[g] Properties of this company acquired by Consolidated Electric Co. in 1915. No other information available concerning stock outstanding and dividends paid.
[h] Term of incorporation perpetual.
[i] Par value of shares $10.

NOTE.—See footnote 75a, p. 342.

TABLE 217.—*Bonds of Great Western Power Co. and subsidiaries.*

Issue.	Callable or convertible.	Sinking-fund provisions.	Trustee.	Denomination.	Authorized.
1	2	3	4	5	6
1. Western Power Co. (of New Jersey) 2-year 6 per cent collateral trust notes. Bonds dated July 18, 1913; due July 18, 1915; interest payable Jan. 18 and July 18.	Callable at 101 and interest on any interest date on 30 days' notice.	....	Bankers Trust Co., New York.	$500, $1,000, and $5,000 coupon.	$1,250,000
2. Western Power Co. (of New Jersey) 2-year 6 per cent collateral trust notes. Bonds dated Mar. 1, 1915; due Mar. 1, 1917; interest payable Mar. 1 and Sept. 1.	Callable at 100½ and interest on any interest date on 90 days' notice.	....	.....do................	$100, $500, and $1,000 coupon.	1,000,000
3. Great Western Power Co. (of California) convertible 10-year debenture 6 per cent bonds dated Nov. 1, 1915; due Nov. 1, 1925; interest payable May 1 and Nov. 1.	Callable at 101 and interest. Can be exchanged after Nov. 1, 1917, and before Nov. 1, 1920, for fully paid 7 per cent accumulative preferred stock; basis of exchange, par for debentures and 95 for stock.	....	Bonds and interest payable at company's office.	.....do.......	5,000,000
4. Great Western Power Co. first-mortgage 5 per cent bonds dated July 1, 1906; due July 1, 1946; interest payable Jan. 1 and July 1.	At 106 and interest July 1, 1912, or any interest date thereafter on 90 days' notice.	On July 1 of each year beginning with 1916 company will deposit with trustee a sum equal to 1 per cent of outstanding bonds; this sum to be applied to purchase of issue at not more than 106 and interest. All bonds so purchased are to be canceled.	Mercantile Trust Co., New York; Bankers Trust Co., New York.	$1,000 coupon and multiples.[a]	25,000,000
5. California Electric Generating Co. first sinking-fund 5 per cent bonds, series A, dated Sept. 1, 1908; due Sept. 1, 1948; interest payable Mar. 1 and Sept. 1.	At 105 and interest on any interest date after Sept. 1, 1912, on 60 days' notice.	On Jan. 1 of each year beginning with 1913 company will deposit with trustee as sinking fund, $28,000 to purchase bonds of series A at rate not exceeding 105 and interest. All bonds so purchased are to be canceled.	Central Trust Co., New York; James N. Wallace.	$1,000 coupon.[a]	1,500,000
6. California Electric Generating Co. first sinking fund 5 per cent bonds, series B, dated Sept. 1, 1908; due Sept., 1948; interest payable Mar. 1 and Sept. 1.[c]	At 105 and interest on any interest date after Sept. 1, 1912, on 60 days' notice.	On Jan. 1 of each year, beginning with 1913, company will deposit with trustee as sinking fund a sum equal to 1¼ per cent of bonds in series B outstanding to purchase bonds at rate not exceeding 105 and interest; all bonds so purchased to be canceled.	Central Trust Co., New York; James N. Wallace.	$1,000 coupon[a]	3,500,000

7. City Electric Co. first-mortgage 5 per cent bonds dated July 1, 1907; due July 1, 1937; interest payable Jan. 1 and July 1.	At 105 and interest on any interest date after July 1, 1912.	Bonds to be purchased and canceled at following rate: July 1, 1913, to July 1, 1917, 1 per cent; July 1, 1918, to July 1, 1922, 1½ per cent; July 1, 1923, to July 1, 1932, 2 per cent; July 1, 1933, to July 1, 1937, 2½ per cent.	Anglo California Trust Co., San Francisco.	$1,000 coupon[a]	5,000,000
8. Consolidated Electric Co. general mortgage 5 per cent bonds dated June 1, 1915; due June 1, 1955; interest payable June 1 and Dec. 1.	At par on and after July 1, 1920........	Beginning June 1, 1920, 1 per cent annually of bonds outstanding.	.....do................	$1,000 coupon.	2,500,000
9. Central Oakland Light & Power Co. first-mortgage sinking fund 5 per cent bonds dated May 1, 1909; due May 1, 1939; interest payable May 1 and Nov. 1.	At 105 and interest....................	Beginning May 1, 1914, 1½ per cent annually of bonds outstanding.	First Federal Trust Co., San Francisco.	.....do........	800,000
10. Consumers Light & Power Co. general-mortgage sinking fund 6 per cent bonds dated Apr. 15, 1908; due Apr. 15, 1933; interest payable Apr. 15 and Oct. 15.	....	....	Mercantile Trust Co., San Francisco.	.....do........	100,000
11. Equitable Light & Power Co. 6 per cent bonds dated Apr. 30, 1910; due Apr. 30, 1935; interest payable Apr. 30 and Oct. 30.	At 105 and interest for sinking fund after Apr. 30, 1915.	Beginning Apr. 30, 1915, 2 per cent annually of bonds outstanding.	Union Trust Co., San Francisco.	$1,000 coupon; principal may be registered.	750,000
12. Southside Light & Power Co. 6 per cent bonds dated Aug. 1, 1910; due Aug. 1, 1940; interest payable Aug. 1 and Feb. 1.	At 105 and interest as a whole or for sinking fund after Aug. 1, 1915.	Beginning August, 1915, 1½ per cent annually of bonds outstanding.	Central Trust Co., San Francisco.	$100, $500, and $1,000 coupon; principal may be registered.	1,000,000
13. United Light & Power Co. (of California) 6 per cent bonds dated Oct. 1, 1910; due Oct. 1, 1945; interest payable Oct. 1 and Apr. 1.	At 110 and interest as a whole or for sinking fund after Oct. 1, 1915.	Beginning Oct. 1, 1915................	.....do................	.....do........	4,000,000
14. United Light & Power Co. (of New Jersey) collateral trust 6 per cent bonds dated Dec. 1, 1911; due Dec. 1, 1914; interest payable Dec. 1 and June 1.	At 102, in part or as a whole on any interest date.	....	Bankers Trust Co., New York.	$1,000 coupon.	3,000,000

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[a] Coupon and registered. Coupon bonds may be registered as to principal or may be exchanged for registered bonds.

TABLE 217.—*Bonds of Great Western Power Co. and subsidiaries*—Continued.

Issue.	Bonded debt.										
	Year.	Reserved for prior liens.	In sinking funds. Canceled.	In sinking funds. Alive.	Owned by Western Power Co.	Pledged as security for California Electric Generating Co.	Otherwise pledged.	In treasury.	In hands of public.	Total authenticated and outstanding.	
1	7	8	9	10	11	12	13	14	15	16	
1. Western Power Co. (of New Jersey) 2-year 6 per cent collateral trust notes. Bonds dated July 18, 1913; due July 18, 1915; interest payable Jan. 18 and July 18.	1913								$1,250,000	$1,250,000	This issue was secured by the following collateral: Great Western Power Co. first-mortgage 5 per cent bonds............ $849,000 City Electric Co. first-mortgage 5 per cent sinking fund bonds.... 533,000 California Electric Generating Co. 6 per cent cumulative preferred stock.................. 700,000 2,082,000 This issue matured on July 18, 1915, and was refunded by issue No. 2.
	1914								1,250,000	1,250,000	
2. Western Power Co. (of New Jersey) 2-year 6 per cent collateral trust notes. Bonds dated Mar. 1, 1915; due Mar. 1, 1917; interest payable Mar. 1 and Sept. 1.	1915								1,000,000	1,000,000	This issue was used to refund part of issue No. 1, which was due on July 18, 1915. The collateral securities were: Great Western Power Co. first-mortgage 5 per cent bonds........ $849,000 City Electric Co. first-mortgage 5 per cent sinking-fund bonds.... 250,000 California Electric Generating Co. 6 per cent cumulative preferred stock.................. 600,000 1,699,000

3. Great Western Power Co. (of California) convertible 10-year debenture 6 per cent bonds dated Nov. 1, 1915; due Nov. 1, 1925; interest payable May 1 and Nov. 1.	1915								5,000,000	5,000,000	On Dec. 31, 1915, $4,500,000 had been authenticated and subscribed for.
	1916								4,990,300	4,990,300	$9,700 converted into preferred stock.
	1917								4,835,000	4,835,000	$165,000 converted into preferred stock.
	1919								4,440,900	4,440,900	$559,100 converted into preferred stock.
	1920								4,177,600	4,177,600	$822,400 converted into preferred stock.
4. Great Western Power Co. first-mortgage 5 per cent bonds dated July 1, 1906; due July 1, 1946; interest payable Jan. 1 and July 1.	1906								6,967,000	6,967,000	$18,033,000 unissued.
	1907								7,077,000	7,077,000	$17,923,000 unissued.
	1908							1,229,000	8,110,000	9,339,000	$15,661,000 unissued.
	1909					$750,000		29,000	9,310,000	10,089,000	$14,911,000 unissued.
	1910					750,000		982,000	11,453,000	13,185,000	$11,815,000 unissued.
	1911					750,000		279,000	16,447,000	17,476,000	$7,524,000 unissued.
	1912					750,000			19,616,000	20,366,000	$4,634,000 unissued.
	1913				[b]$849,000	721,000	$225,000	698,000	19,645,000	22,138,000	$2,862,000 unissued.
	1914				[b]849,000	721,000	225,000	508,000	20,855,000	23,158,000	$1,842,000 unissued.
	1915				[b]849,000	707,000	330,000	584,000	20,855,000	23,325,000	$1,675,000 unissued.
	1916		$224,000		[b]849,000	693,000		704,000	20,855,000	23,101,000	$1,675,000 unissued.
	1917		448,000		[b]701,000	665,000		2,407,000	20,779,000	24,552,000	As of June 1, 1919, Great Western Power Co. of California purchased the properties of Great Western Power Co. subject to the existing mortgage. The Great Western Power Co. bonds owned by the "Of California" Co. on that date, together with the treasury bonds, have been pledged under the "Of California" Co.'s first and refunding mortgage.
	1918		670,000		[b]479,000	665,000		2,407,000	20,779,000	24,330,000	
	1919		889,000			651,000		2,700,000	20,760,000	24,111,000	
	1920		1,130,000			637,000		2,714,000	21,156,000	23,870,000	
5. California Electric Generating Co. first sinking-fund 5 per per cent bonds, series A, dated Sept. 1, 1908; due Sept. 1, 1948; interest payable Mar. 1 and Sept. 1.	1908								1,200,000	1,200,000	Guaranteed principal, interest, and sinking fund by Great Western Power Co. Secured by mortgage on Oakland steam plant and the following amounts of Great Western Power Co.'s first 5's, which do not draw interest: 1907-1912, $750,000; 1913, $721,000; 1914, $721,000; 1915, $707,000; 1916, $693,000; 1917, $665,000; 1918, $665,000; 1919, $651,000; 1920, $637,000.
	1909								1,200,000	1,200,000	
	1910								1,200,000	1,200,000	
	1911								1,200,000	1,200,000	
	1912								1,200,000	1,200,000	
	1913		59,000						1,141,000	1,141,000	
	1914		59,000						1,141,000	1,141,000	
	1915		87,000						1,113,000	1,113,000	
	1916		115,000						1,085,000	1,085,000	
	1917		171,000						1,029,000	1,029,000	
	1918		171,000						1,029,000	1,029,000	
	1919		227,000					7,000	966,000	973,000	
	1920		227,000					26,000	947,000	973,000	
6. California Electric Generating Co. first sinking fund 5 per cent bonds, series B, dated Sept. 1, 1908; due Sept., 1948; interest payable Mar. 1 and Sept. 1.[c]											No bonds of this series ever issued.

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[b] Bonds authorized but never issued.

[c] Held by Great Western Power Co. of California.

TABLE 217.—*Bonds of Great Western Power Co. and subsidiaries*—Continued.

Issue.	Bonded debt.										
	Year.	Reserved for prior liens.	In sinking funds.		Owned by Western Power Co.	Pledged as security for California Electric Generating Co.	Otherwise pledged.	In treasury.	In hands of public.	Total authenticated and outstanding.	
			Canceled.	Alive.							
1	7	8	9	10	11	12	13	14	15	16	
7. City Electric Co. first-mortgage 5 per cent bonds dated July 1, 1907; due July 1. 1937; interest payable Jan. 1 and July 1.	1907	....	....	....	....	....	....	....	$886,000	$886,000	$4,104,000 unissued.
	1908	....	....	....	....	....	....	....	1,346,000	1,346,000	$3,654.000 unissued.
	1909	....	....	....	....	....	....	....	1,700,000	1,700,000	$3,300,000 unissued.
	1910	....	....	....	....	....	....	....	1,700,000	1,700,000	$3,300,000 unissued.
	1911	....	....	....	....	....	....	....	2,400,000	2,400,000	$2,600,000 unissued.
	1912	....	....	....	....	....	....	....	2,574,000	2,574,000	$2,426,000 unissued.
	1913	....	31,000	....	....	....	....	....	2,010,000	2,543,000	Column 16 includes $533,000 pledged as partial security for issue No. 1; $2,426,000 unissued.
	1914	....	62,000	....	....	....	....	....	1,979,000	2,512,000	Do.
	1915	....	93,000	....	....	....	....	....	2,481,000	2,731,000	Column 16 includes $250,000 pledged as partial security for issue No. 2; $2,176,000 unissued.
	1916	....	123,000	....	....	....	....	....	1,663,000	2,701,000	Column 16 includes $1,038,000 owned by Western Power Co.; $2,176,000 unissued.
	1917	....	156,000	....	....	....	....	....	1,630,000	2,668,000	Column 16 includes $1,038,000 owned by Western Power Co.; $2,176,000 unissued.
	1918	....	208,000	....	....	....	....	....	1,630,000	2,616,000	Column 16 includes $986,000 owned by Great Western Power Co. of California; $2,176,000 unissued.
	1919	....	237,000	....	....	....	2,561,000	5,000	1,584,000	4,150,000	$613,000 unissued.
	1920	....	266,000	....	....	....	2,561,000	18,000	1,542,000	4,121,000	Do.

8. Consolidated Electric Co. general mortgage 5 per cent bonds dated June 1, 1915; due June 1, 1955; interest payable June 1 and Dec. 1.	1915	......	......	......	......	......	......	50,500	1,920,050	2,075,000	Amounts listed in column 16 include: 1915, $104,450 held by Great Western Power Co.; $425,000 reserved or unissued.
	1916	......	......	......	......	......	......	50,500	1,901,150	2,075,000	1916, $123,350 held by Great Western Power Co.; $425,000 reserved or unissued.
	1917	......	......	......	......	......	......	50,500	1,673,150	2,075,000	1917, $351,350 held by Great Western Power Co.; $425,000 reserved or unissued.
	1918	......	......	......	......	......	......	50,500	1,602,200	2,075,000	1918, $422,300 held by Great Western Power Co.; $425,000 reserved or unissued.
	1919	......	......	......	......	......	......	122,450	1,602,200	2,075,000	1919–20, $350,350 held by Great Western Power Co.; $425,000 reserved or unissued.
	1920	......	16,100	......	......	......	......	106,350	1,602,200	2,075,000	
9. Central Oakland Light & Power Co. first-mortgage sinking fund 5 per cent bonds dated May 1, 1909; due May 1, 1939; interest payable May 1 and Nov. 1.	1909	......	......	......	......	......	......	......	......	......	$350,000 owned by United Light & Power Co. of California and hypothecated with Bankers Trust Co. of New York. These bonds were canceled, and liability for bonds in hands of public assumed by Consolidated Electric Co. June 1, 1915.
	1910	......	......	......	......	......	......	......	......	......	
	1911	......	......	......	......	......	......	......	143,000	493,000	
	1912	......	......	......	......	......	......	......	143,000	493,000	
	1913	......	......	......	......	......	......	......	143,000	493,000	
	1914	......	......	......	......	......	......	......	143,000	493,000	
	1915	......	......	......	......	......	......	......	143,000	143,000	
	1916	......	......	......	......	......	......	......	143,000	143,000	
	1917	......	70,000	......	......	......	......	......	73,000	73,000	
	1918	......	75,000	......	......	......	......	......	68,000	68,000	
	1919	......	75,000	......	......	......	......	......	68,000	68,000	
	1920	......	77,000	......	......	......	......	2,000	64,000	66,000	
10. Consumers Light & Power Co. general mortgage sinking-fund 6 per cent bonds dated Apr. 15, 1908; due Apr. 15, 1933; interest payable Apr. 15 and Oct. 15.	1908	......	......	......	......	......	......	......	......	......	Liability for bonds in hands of public assumed by Consolidated Electric Co. June 1, 1915.
	1909	......	......	......	......	......	......	......	......	......	
	1910	......	......	......	......	......	......	......	......	......	
	1911	......	......	......	......	......	......	......	100,000	100,000	
	1912	......	......	......	......	......	......	......	100,000	100,000	
	1913	......	......	......	......	......	......	......	100,000	100,000	
	1914	......	......	......	......	......	......	......	100,000	100,000	
	1915	......	......	......	......	......	......	......	100,000	100,000	
	1916	......	7,000	......	......	......	......	......	c 85,000	c 93,000	Including $8,000 held by Consolidated Electric Co.
	1917	......	9,000	......	......	......	......	......	c 83,000	c 91,000	
	1918	......	11,000	......	......	......	......	......	c 81,000	c 89,000	
	1919	......	13,000	......	......	......	......	3,000	c 84,000	87,000	
	1920	......	15,000	......	......	......	......	8,000	c 77,000	85,000	
11. Equitable Light & Power Co. 6 per cent bonds dated Apr. 30, 1910; due Apr. 30, 1935; interest payable Apr. 30 and Oct. 30.	1910	......	......	......	......	......	......	......	......	......	$365,000 owned by United Light & Power Co. of California and hypothecated with Bankers Trust Co. of New York. These bonds were canceled on purchase of company by Consolidated Electric Co. June 1, 1915.
	1911	......	......	......	......	......	......	......	......	365,000	
	1912	......	......	......	......	......	......	......	......	365,000	
	1913	......	......	......	......	......	......	......	......	365,000	
	1914	......	......	......	......	......	......	......	......	365,000	

c Held by Great Western Power Co. of California.

TABLE 217.—*Bonds of Great Western Power Co. and subsidiaries*—Continued.

Issue.	Bonded debt.										
	Year.	Reserved for prior liens.	In sinking funds.		Owned by Western Power Co.	Pledged as security for California Electric Generating Co.	Otherwise pledged.	In treasury.	In hands of public.	Total authenticated and outstanding.	
			Canceled.	Alive.							
1	7	8	9	10	11	12	13	14	15	16	
12. Southside Light & Power Co. 6 per cent bonds dated Aug. 1, 1910; due Aug. 1, 1940; interest payable Aug. 1 and Feb. 1.	1910										$400,000 owned by United Light & Power Co. of California and hypothecated with Bankers Trust Co. of New York. Canceled on purchase of company by Consolidated Electric Co. June 1, 1915.
	1911									$400,000	
	1912									400,000	
	1913									400,000	
	1914									400,000	
13. United Light & Power Co. (of California) 6 per cent bonds dated Oct. 1, 1910; due Oct. 1, 1945; interest payable Oct. 1 and Apr. 1.	1910										$2,023,000 pledged (Dec. 31, 1914) with Bankers Trust Co. of New York to secure $1,618,000 notes of United Light & Power Co. of New Jersey; $260,000 held by trustee of affiliated companies. These bonds were canceled, and bonds in hands of public exchanged for Consolidated Electric Co. general mortgage 5's on June 1, 1915.
	1911	$243,000								2,817,000	
	1912	243,000								3,060,000	
	1913	243,000								3,060,000	
	1914	243,000							$534,000	3,060,000	
14. United Light & Power Co. (of New Jersey) collateral trust 6 per cent bonds dated Dec. 1, 1911; due Dec. 1, 1914; interest payable Dec. 1 and June 1.	1911									564,000	Bonds in hands of public exchanged for 90 per cent of their par value in Consolidated Electric Co. general mortgage 5's on June 1, 1915.
	1912									1,522,000	
	1913										
	1914								1,618,000	1,618,000	

TABLE 218.—*Comparative balance sheet of Great Western Power Co. of California and its predecessors and subsidiaries, 1910–1920.*

Form of report used by company's accountants, 1910–1912.

	1910			
	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Total.
ASSETS.				
Capital assets:				
Cost of properties, plant, real estate in stock and bonds	$26,333,000.00	$5,000,000.00	$8,700,000.00	$40,033,000.00
Cost of properties, plant, real estate in cash	11,450,483.08	2,147,469.24	24,382.78	13,622,335.10
Treasury securities	982,000.00			982,000.00
Total capital	38,765,483.08	7,147,469.24	8,724,382.78	54,637,335.10
Investments:				
Stock of City Electric Co				
Stock of California Electric Generating Co				
The Chutes Realty Co		7,500.00		7,500.00
Panama-Pacific Exposition		10.000.00		10,000.00
Total investments		17,500.00		17,500.00
Current assets:				
Cash on hand	24,592.14	[a] 21,388.93	12,973.57	16,176.78
Cash advances and guaranties	7,000.00			7,000.00
Material and supplies	167,269.36	39,437.56		206,706.92
Accounts and loans receivable	123,219.27	133,276.32		256,495.59
Total current assets	322,080.77	151,324.95	12,973.57	486,379.29
Deferred assets:				
Deferred charges to be apportioned	26,048.72	11,821.71		37,870.43
Pacific Gas & Electric Co. investigation	21,477.96			21,477.96
Unamortized debt discount and expense		241,991.10		241,991.10
Interest		596.93		596.93
Total deferred assets	47,526.68	254,409.74		301,936.42
Proprietary and affiliated companies:				
Great Western Power Co			60,000.00	60,000.00
Contingent assets:				
Loaned motors	5,634.00			5,634.00
California Safe Deposit Trust Co	38,084.58			38,084.58
E. Hawley, trustee	750,000.00			750,000.00
First mortgage 5 per cent bonds authorized		3,300,000.00		3,300,000.00
Total contingent	793,718.58	3,300,000.00		4,093,718.58
Total assets	39,928,809.11	10,870,703.93	8,797,356.35	59,596,869.39
LIABILITIES.				
Capital liabilities:				
Capital stock	25,000,000.00	5,000,000.00	7,500,000.00	37,500,000.00
Bonds outstanding	13,185,000.00	1,700,000.00	1,200,000.00	16,085,000.00
Total capital liabilities	38,185,000.00	6,700,000.00	8,700,000.00	53,585,000.00
Current liabilities:				
Account and bills payable	682,701.09	224,929.22		907,630.31
Bond interest payable				
Total current liabilities	682,701.09	224,929.22		907,630.31
Deferred liabilities—interest		734.67		734.67
Proprietary and affiliated companies:				
City Electric Co				
California Electric Generating Co	60,000.00			60,000.00
Total companies	60,000.00			60,000.00

[a] Overdraft.

TABLE 218.—*Comparative balance sheet of Great Western Power Co. of California and its predecessors and subsidiaries, 1910–1920*—Continued.

	1910			
	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Total.
LIABILITIES—continued.				
Contingent liabilities:				
Great Western Power Co.'s bonds due Great Western Power Co.	$750,000.00			$750,000.00
First mortgage 5 per cent bonds unissued		$3,300,000.00		3,300,000.00
Working capital	116,925.00		$95,725.10	212,650.10
Total contingent liabilities	866,925.00	3,300,000.00	95,725.10	4,262,650.10
Reserves:				
Liability		35,000.00		35,000.00
Insurance		25,000.00		25,000.00
Replacement and depreciation		214,820.00		214,820.00
Bad debts		3,574.22		3,574.22
Total reserves		278,394.22		278,394.22
Total liabilities	39,794,626.09	10,504,058.11	8,795,725.10	59,094,409.30
Surplus:				
At beginning of year	74,519.87	246,116.66		320,636.53
Profit and loss for the year	59,663.15	285,529.16	1,631.25	346,823.56
	134,183.02	531,645.82	1,631.25	667,460.09
Less dividends paid		165,000.00		165,000.00
Total surplus	134,183.02	366,645.82	1,631.25	502,460.09
Total liabilities and surplus	39,928,809.11	10,870,703.93	8,797,356.35	59,596,869.39

	1911			
	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Total.
ASSETS.				
Capital assets:				
Cost of properties, plant, real estate in stock and bonds	$26,333,000.00	$5,000,000.00	$8,700,000.00	$40,033,000.00
Cost of properties, plant, real estate in cash	12,246,410.86	2,414,724.20	33,559.61	14,694,694.67
Treasury securities	279,000.00	700,000.00		979,000.00
Total capital	38,858,410.86	8,114,724.20	8,733,559.61	55,706,694.67
Investments:				
Stock of City Electric Co.	5,651,912.50			5,651,912.50
Stock of California Electric Generating Co.	750,000.00			750,000.00
The Chutes Realty Co.		7,500.00		7,500.00
Panama-Pacific Exposition		10,000.00		10,000.00
Total investments	6,401,912.50	17,500.00		6,419,412.50
Current assets:				
Cash on hand	166,414.85	6,911.36	19,210.51	192,536.72
Cash advances and guaranties	5,000.00			5,000.00
Material and supplies	148,054.89	34,948.35		183,003.24
Accounts and loans receivable	181,711.55	112,829.26		294,540.81
Total current assets	501,181.29	154,688.97	19,210.51	675,080.77
Deferred assets:				
Deferred charges to be apportioned	28,512.00	26,012.34		54,524.34
Pacific Gas & Electric Co. investigation				
Unamortized debt discount and expense		232,122.23		232,122.23
Interest		596.93		596.93
Total deferred assets	28,512.00	258,731.50		287,243.50
Proprietary and affiliated companies:				
Great Western Power Co.		75,000.00	70,041.67	145,041.67

TABLE 218.—*Comparative balance sheet of Great Western Power Co. of California and its predecessors and subsidiaries, 1910–1920*—Continued.

	1911			
	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Total.
ASSETS—continued.				
Contingent assets:				
Loaned motors	$5,634.00			$5,634.00
California Safe Deposit Trust Co.				
E. Hawley, trustee	750,000.00			750,000.00
First mortgage 5 per cent bonds authorized		$2,600,000.00		2,600,000.00
Total contingent assets	755,634.00	2,600,000.00		3,355,634.00
Total assets	46,545,650.65	11,220,644.67	$8,822,811.79	66,589,107.11
LIABILITIES.				
Capital liabilities:				
Capital stock	27,500,000.00	5,000,000.00	7,500,000.00	40,000,000.00
Bonds outstanding	17,476,000.00	2,400,000.00	1,200,000.00	21,076,000.00
Total capital liabilities	44,976,000.00	7,400,000.00	8,700,000.00	61,076,000.00
Current liabilities:				
Accounts and bills payable	487,494.58	262,908.21	2,500.00	752,902.79
Bond interest payable			20,000.00	20,000.00
Total current liabilities	487,494.58	262,908.21	22,500.00	772,902.79
Deferred liabilities—interest		2,371.85		2,371.85
Proprietary and affiliated companies:				
City Electric Co	75,000.00			75,000.00
California Electric Generating Co.	70,041.67			70,041.67
Total companies	145,041.67			145,041.67
Contingent liabilities:				
Great Western Power Co.'s bonds due Great Western Power Co.	750,000.00			750,000.00
First mortgage 5 per cent bonds unissued		2,600,000.00		2,600,000.00
Working capital	110,852.24		95,725.10	206,577.34
Total contingent liabilities	860,852.24	2,600,000.00	95,725.10	3,556,577.34
Reserves:				
Liability	1,722.68	35,404.50		37,127.18
Insurance		25,000.00		25,000.00
Replacement and depreciation		334,820.00		334,820.00
Bad debts		4,198.71		4,198.71
Total reserves	1,722.68	399,423.21		401,145.89
Total liabilities	46,471,111.17	10,664,703.27	8,818,225.10	65,954,039.54
Surplus:				
At beginning of year	134,183.02	366,645.82	1,631.25	502,460.09
Profit and loss for the year	[b] 59,643.54	279,295.58	2,955.44	222,607.48
	74,539.48	645,941.40	4,586.69	725,067.57
Less dividends paid		90,000.00		90,000 00
Total surplus	74,539.48	555,941.40	4,586.69	635,067.57
Total liabilities and surplus	46,545,650.65	11,220,644.67	8,822,811.79	66,589,107.11

[b] Deficit.

TABLE 218.—*Comparative balance sheet of Great Western Power Co. of California and its predecessors and subsidiaries, 1910–1920*—Continued.

	1912			
	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Total.
ASSETS.				
Fixed capital: Cost of plant, buildings, lands	$41,898,615.62	$7,991,441.01	$8,637,885.50	$58,527,942.13
Treasury securities, pledged	....	833,000.00	....	833,000.00
Other investments	6,402,412.50	13,500.00	....	6,415,912.50
Current assets:				
Cash	566,898.16	16,594.51	37,846.57	611,339.24
Notes and bills receivable	240,530.72	85,241.74	....	325,772.46
Materials and supplies	218,435.07	8,803.86	....	227,238.93
Miscellaneous	845,488.99	603,392.01	80,000.00	1,528,881.00
	1,871,352 94	714,032.12	117,846.57	2,703,231.63
Total assets	50,172,381.06	9,551,973.13	8,755,732.07	68,480,086.26
LIABILITIES.				
Capital stock	27,500,000.00	5,000,000.00	7,500,000.00	40,000,000.00
Funded debt	20,366,000.00	2,574,000.00	1,200,000.00	24,140,000.00
Current liabilities:				
Loans and notes payable	299,346.61	627,500.00	....	926,846.61
Accounts payable	....	69,791.95	....	69,791.95
Miscellaneous	1,438,118.99	747.68	....	1,438,866.67
	1,737,465.60	698,039.63	....	2,435,505.23
Accrued liabilities not due:				
Unmatured interest	....	2,154.17	20,000.00	22,154.17
Taxes accrued	48.60	....	....	48.60
	48.60	2,154.17	20,000.00	22,202.77
Deferred credit items:				
Reserves	24,936.65	85,046.99	28,000.00	137,983.64
Depreciations	....	331,840.00	....	331,840.00
Profit and loss	543,930.21	860,892.34	7,732.07	1,412,554.62
	568,866.86	1,277,779.33	35,732.07	1,882,378.26
Total liabilities	50,172,381.06	9,551,973.13	8,755,732.07	68,480,086.26

TABLE 218.—*Comparative balance sheet of Great Western Power Co. of California and its predecessors and subsidiaries, 1910–1920*—Continued.

Standard form adopted by Railroad Commission of California, 1913-1920.

	1913			
	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Total.
ASSETS.				
Fixed capital	$42,124,395.24	$7,947,678.84	$8,642,292.94	$58,714,367.02
Cash and deposits:				
Cash	97,212.34	7,565.64	718.26	105,496.24
Special deposits	516,845.00	61,040.17	1,700.00	579,585.17
Total cash and deposits	614,057.34	68,605.81	2,418,26	685,081.41
Notes receivable	46,206.84	637.45		46,844.29
Accounts receivable:				
Accounts with system corporations	412,666.79	854,223.00	87,680.44	1,354,570.23
Due from consumers and agents	230,198.05	109,375.37		339,573.42
Miscellaneous accounts receivable	26,570.10	2,456.25		29,026.35
Total accounts receivable	669,434.94	966,054.61	87,680.44	1,723,169.99
Interest and dividends receivable	135.00		3,341.80	6.803,47
Investments:				
Securities of other corporations	6,407,312.50	8,000.00		6,415,312.50
Miscellaneous investments				
Total investments	6,407,312.50	8,000.00		6,415,312.50
Materials and supplies	197,494.16	10,626.00		208,120.16
Sinking funds		125.70	148.20	273.90
Treasury securities	923,000.00	533,000.00		1,456,000.00
Prepaid expenses:				
Prepaid rents	186.95	120.00		306.95
Prepaid taxes	33,439.53	22,858.62	186.95	56,485.10
Prepaid insurance	1,761.71	2,920.15		4,681.86
Other prepayments	52,403.27	4,940.09		57,343.36
Total prepaid expenses	87,791.46	30,838.86	186.95	118,817.27
Unamortized discount on securities and expenses:				
Stocks	385,870.88			385,870.88
Bonds	114,774.68	286,143.29		400,917.97
Total unamortized discount on securities and expenses	500,645.56	286,143.29		786,788.85
Other suspense	6,172.58	330.75		6,503.33
Construction work in progress	781,547.56	18,777.47		800,325.03
Total assets	52,358,193.18	9,870,818.78	8,736,068.59	70,965,080.55
LIABILITIES.				
Capital stock	27,500,000.00	5,000,000.00	7,500,000.00	40,000,000.00
Funded debt	22,138,000.00	2,543,000.00	1,141,000.00	25,822,000.00
Notes payable	455,703.17			455,703.17
Accounts payable:				
Accounts with system corporations	687,680.44	643,285.13		1,330,965.57
Audited vouchers and wages unpaid	190,337.25	32,320.58		222,657.83
Consumer's deposits	14.50	166.50		181.00
Miscellaneous accounts payable	14,268.03		3,197.11	17,465.14
Total accounts payable	892,300.22	675,772.21	3,197.11	1,571,269.54
Interest accrued	522,182.69	50,500.00	20,716.66	593,399.35
Taxes accrued	4,094.39			4,094.39
Dividends declared				
Service billed in advance			186.95	186.95
Reserves for accrued depreciation		329,994.62		329,994.62
Casualty and insurance reserves	17,402.55	66,065.13		83,467.68
Income invested since Dec. 31, 1912, in fixed capital	390.68	441,848.40	4,407.44	446,646.52
Reserves invested in sinking funds		25,740.00	56,000.00	81,740.00
Other reserves from income or surplus	1,525.21	13,367.80		14,893.01
Miscellaneous				
Corporate surplus unappropriated	826,594.27	724,530.62	10,560.43	1,561,685.32
Suspense				
Total liabilities	52,358,193.18	9,870,818.78	8,736,068.59	70,965,080.55

TABLE 218.—*Comparative balance sheet of Great Western Power Co. of California and its predecessors and subsidiaries, 1910–1920*—Continued.

	1914			
	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Total.
ASSETS.				
Fixed capital	$43,081,945.97	$8,360,574.04	$8,642,388.71	$60,084,908.72
Cash and deposits:				
Cash	78,549.50	16,285.65	1,138.48	95,973.63
Special deposits	554,676.00	76,805.48	550.00	632,031.48
Total cash and deposits	633,225.50	93,091.13	1,688.48	728,005.11
Notes receivable	67,197.97	59,033.35	......	126,231.32
Accounts receivable:				
Accounts with system corporations	620,708.03	854,223.00	115,478.28	1,590,409.31
Due from consumers and agents	187,903.09	82,533.41	......	270,436.50
Miscellaneous accounts receivable	31,890.50	4,291.95	......	36,182.45
Total accounts receivable	840,501.62	941,048.36	115,478.28	1,897,028.26
Interest and dividends receivable	......	......	6,591.80	6,591.80
Investments:				
Securities of other corporations	6,402,662.50	10,000.00	......	6,412,662.50
Miscellaneous investments	857,754.98	......	......	857,754.86
Total investments	7,260,417.36	10,000.00	......	7,270,417.36
Materials and supplies	169,383.54	3,539.20	......	172,922.74
Sinking funds	......	194.04	148.20	342.24
Treasury securities	225,000.00	533,000.00	......	758,000.00
Prepaid expenses:				
Prepaid rents	57.52	120.00	......	177.52
Prepaid taxes	39,406.51	23,650.00	57.52	63,114.03
Prepaid insurance	2,118.64	2,664.82	......	4,783.46
Other prepayments	......	......	......	......
Total prepaid expenses	41,582.67	26,434.82	57.52	68,075.01
Unamortized discount on securities and expenses:				
Stocks	385,870.88	237,107.18	......	622,978.06
Bonds	248,886.39	46,949.40	......	295,835.79
Total unamortized discount on securities and expenses	634,757.27	284,056.58	......	918,813.85
Other suspense	5,824.67	118.64	......	5,943.31
Construction work in progress	74,935.42	23,745.08	......	98,680.50
Total assets	53,034,771.99	10,334,835.24	8,766,352.99	72,135,960.22
LIABILITIES.				
Capital stock	27,500,000.00	5,000,000.00	7,500,000.00	40,000,000.00
Funded debt	22,650,000.00	2,512,000.00	1,141,000.00	26,303,000.00
Notes payable	266,323.24	6,000.00	......	272,323.24
Accounts payable:				
Accounts with system corporations	715,478.28	995,326.37	......	1,710,804.65
Audited vouchers and wages unpaid	126,766.23	18,003.55	......	144,769.78
Consumer's deposits	343.90	48.30	......	392.20
Miscellaneous accounts payable	12,568.21	485.25	3,461.61	16,515.07
Total accounts payable	855,156.62	1,013,863.47	3,461.61	1,872,481.70
Interest accrued	554,669.27	49,953.00	19,566.67	624,188.94
Taxes accrued	4,085.63	......	......	4,085.63
Dividends declared	......	......	......	......
Service billed in advance	......	......	57.52	57.52
Reserves for accrued depreciation	......	328,026.39	......	328,026.39
Casualty and insurance reserves	11,215.75	69,339.27	......	80,555.02
Income invested since Dec. 31, 1912, in fixed capital	20,880.00	......	......	20,880.00
Reserves invested in sinking funds	......	51,170.00	56,000.00	107,170.00
Other reserves from income or surplus	3,862.91	13,865.72	28,000.00	45,728.63
Miscellaneous	......	......	......	......
Corporate surplus unappropriated	1,168,578.57	1,290,617.39	18,267.19	2,477,463.15
Suspense	......	......	......	......
Total liabilities	53,034,771.99	10,334,835.24	8,766,352.99	72,135,960.22

NOTE.—Combined balance sheets for Great Western Power Co., City Electric Co., and California Electric Generating Co., for years prior to 1914, with intercompany items eliminated, are not available. Balance sheet for Dec. 31, 1914, with intercompany items eliminated, shows assets amounting to $59,512,444.03 as against $72,135,960.22, with intercompany items not eliminated. Similar figures for 1915 are respectively $67,630,186.79 as against $75,246,281.26.

Table 218.—*Comparative balance sheet of Great Western Power Co. of California and its predecessors and subsidiaries, 1910-1920*—Continued.

	1915				
	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Consolidated Electric Co.	Total.
ASSETS.					
Fixed capital	$43,449,485.48	$8,610,947.56	$8,642,987.23	$2,228,428.76	$62,931,849.03
Cash and deposits:					
Cash	65,529.45	20,539.43	441.69	10,036.08	96,546.65
Special deposits	534,702.50	77,088.75	2,000.00	8,161.25	621,952.50
Total cash and deposits	600,231.95	97,628.18	2,441.69	18,197.33	718,499.15
Notes receivable	55,781.42	16.05		5,612.20	61,409.67
Accounts receivable:					
Accounts with system corporations	195,590.40	473,111.84	124,805.40	79,340.66	872,848.30
Due from consumers and agents	223,645.22	113,884.68			337,529.90
Miscellaneous accounts receivable	243,939.55	1,237.69		41.13	245,218.37
Total accounts receivable	663,175.17	588,234.21	124,805.40	79,381.79	1,455,596.57
Interest and dividends receivable	6,202.71	7,626.69			13,829.40
Investments:					
Securities of other corporations	6,507,363.50	7,000.00			6,514,363.50
Miscellaneous investments	1,027,002.31				1,027,002.31
Total investments	7,534,365.81	7,000.00			7,541,365.81
Materials and supplies	150,112.95	3,807.30			153,920.25
Sinking funds		337.65	148.20		485.85
Treasury securities	914,000.00			50,500.00	964,500.00
Prepaid expenses:					
Prepaid rents	7,136.39	9,091.06			16,227.45
Prepaid taxes	42,214.91	28,450.34		16,107.45	86,772.70
Prepaid insurance	2,208.53	2,083.55			4,292.08
Other prepayments	11,173.08				
Total prepaid expenses	62,732.91	39,624.95		16,107.45	118,465.31
Unamortized discount on securities and expenses:					
Stocks	385,870.88	237,107.18			622,978.06
Bonds	259,650.19	171,259.64		1,284.00	432,193.83
Total unamortized discount on securities and expenses	645,521.07	408,366.82		1,284.00	1,055,171.89
Other suspense	3,359.83				3,359.83
Construction work in progress	201,019.84	26,808.66			227,828.50
Total assets	54,285,989.14	9,790,398.07	8,770,382.52	2,399,511.53	75,246,281.26
LIABILITIES.					
Capital stock	27,500,000.00	5,000,000.00	7,500,000.00	10,000.00	40,010,000.00
Funded debt	23,325,000.00	2,731,000.00	1,113,000.00	2,318,000.00	29,487,000.00
Notes payable	372,500.00	6,000.00			378,500.00
Accounts payable:					
Accounts with system corporations	405,061.50	17,973.40			423,034.90
Audited vouchers and wages unpaid	257,028.93	73,505.49			330,534.42
Consumers' deposits	329.00	173.30			502.30
Miscellaneous accounts payable	5,690.22	57.00	2,965.15	45.63	8,758.00
Total accounts payable	668,109.65	91,709.19	2,965.15	45.63	762,829.62
Interest accrued	553,013.18	68,853.00	20,550.00	20,838.33	663,254.51
Taxes accrued	25,703.13	449.00	290.25		26,442.38
Dividends declared					
Service billed in advance				16,107.45	16,107.45
Reserves for accrued depreciation		304,731.77			304,731.77
Casualty and insurance reserves	17,439.53	76,510.16			93,949.69
Income invested since Dec. 31, 1912—in fixed capital	41,760.00				41,760.00
Reserves invested in sinking funds	113,918.28	78,790.00	84,000.00		276,708.28
Other reserves from income or surplus		14,069.93	28,000.00	21,970.00	64,039.93
Miscellaneous					
Corporate surplus unappropriated	1,668,545.37	1,418,285.02	21,577.12	12,550.12	3,120,957.63
Suspense					
Total liabilities	54,285,989.14	9,790,398.07	8,770,382.52	2,399,511.53	75,246,281.26

TABLE 218.—*Comparative balance sheet of Great Western Power Co. of California and its predecessors and subsidiaries, 1910–1920*—Continued.

	1916					
	Great Western Power Co. of California.	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Consolidated Electric Co.	Total.
ASSETS.						
Fixed capital..........	$115,206.02	$44,607,306.74	$9,463,473.44	$4,394,610.41	$2,186,779.34	$60,767,375.95
Cash and deposits:						
Cash.............	349,747.56	519,219.19	34,749.93	160.41	3,961.24	907,838.33
Special deposits...	7,547.00	821,780.05	68,742.64	1,650.00	8,678.75	908,398.44
Total cash and deposits.......	357,294.56	1,340,999.24	103,492.57	1,810.41	12,639.99	1,816,236.77
Notes receivable......	....	99,512.71	....	....	....	99,512.71
Accounts receivable:						
Accounts with system corporations............	....	840,664.43	403.20	121,405.33	108,976.65	1,071,449.61
Due from consumers and agents.	1,914.54	236,472.88	112,096.54	....	....	350,483.96
Miscellaneous accounts receivable	1,532.12	97,309.78	2,354.89	....	108.74	101,305.53
Total accounts receivable.....	3,446.66	1,174,447.09	114,854.63	121,405.33	109,085.39	1,523,239.10
Interest and dividends receivable....	47,175.00	613.96	....	3,850.00	....	51,638.96
Investments:						
Securities of other corporations.....	32,196,900.00	1,334,167.47	4,000.00	....	....	33,535,067.47
Miscellaneous investments.......	....	1,198,036.82	1,000.00	....	....	1,199,036.82
Total investments.........	32,196,900.00	2,532,204.29	5,000.00	....	....	34,734,104.29
Materials and supplies.	1,223.53	208,700.37	6,885.10	....	....	216,809.00
Sinking funds.........	....	....	592.10	148.20	268.17	1,008.47
Treasury securities....	....	704,000.00	....	....	50,500.00	754,500.00
Prepaid expenses:						
Prepaid rents.....	60.00	8,667.38	7,156.04	....	....	15,883.42
Prepaid taxes.....	414.98	46,542.28	33,668.52	....	12,376.22	93,002.00
Prepaid insurance.	....	2,255.71	2,902.30	....	....	5,158.01
Other prepayments	....	18,413.87	1,500.00	....	....	19,913.87
Total prepaid expenses......	474.98	75,879.24	45,226.86	....	12,376.22	133,957.30
Unamortized discount on securities and expenses:						
Stocks............	....	2,500,000.00	....	4,248,700.00	....	6,748,700.00
Bonds............	450,133.24	266,399.83	163,293.98	....	....	881,078.30
Total unamortized discount on securities and expenses..	450,133.24	2,766,399.83	163,293.98	4,248,700.00	1,251.25	7,629,778.30
Other suspense........	[a] 1,392.52	17,938.83	120.00	....	....	16,666.31
Construction work in progress............	359.14	358,750.43	101,758.58	....	....	460,868.15
Corporate deficit......	41,254.83	....	....	....	....	41,254.83
Total assets.....	33,212,075.44	53,886,752.73	10,004,697.26	8,770,524.35	2,372,900.36	108,246,950[illegible]
LIABILITIES.						
Capital stock..........	27,500,000.00	27,500,000.00	5,000,000.00	7,500,000.00	10,000.00	67,510,000.00
Funded debt.........	5,000,000.00	23,101,000.00	2,701,000.00	1,085,000.00	2,311,000.00	34,198,000.00
Notes payable.........	....	....	....	....	....	....

[a] Credit item.

TABLE 218.—*Comparative balance sheet of Great Western Power Co. of California and its predecessors and subsidiaries, 1910–1920*—Continued.

	1916					
	Great Western Power Co. of California.	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Consolidated Electric Co.	Total.
LIABILITIES—contd.						
Accounts payable:						
Accounts with system corporations	$628,455.01	$184,227.73	$258,766.87	....	....	$1,071,449.61
Audited vouchers and wages unpaid	944.63	189,742.53	56,421.28	....	....	247,108.44
Consumers' deposits	37.50	1,567.10	231.60	....	....	1,836.20
Miscellaneous accounts payable	23,734.64	12,416.44	2,514.00	....	$111.74	38,776.82
Total accounts payable	653,171.78	387,953.80	317,933.75	....	111.74	1,359,171.07
Interest accrued	57,440.00	552,000.00	68,175.00	$19,733.33	19,468.33	716,816.66
Taxes accrued	1,443.01	17,131.67	412.75	322.00	....	19,309.43
Dividends declared	....	....	....	....	....	....
Service billed in advance	....	....	....	....	12,376.22	12,376.22
Reserves for accrued depreciation	....	....	285,914.36	....	....	285,914.36
Casualty and insurance reserves	....	23,021.36	80,071.39	....	....	103,092.75
Income invested since Dec. 31, 1912—in fixed capital	....	62,640.00	....	....	....	62,640.00
Revenues invested in sinking funds	....	....	....	....	....	....
Other reserves from income or surplus	20.65	6,968.36	1,210.29	....	....	8,199.30
Miscellaneous	....	....	....	....	....	....
Corporate surplus unappropriated	....	979,821.60	1,549,979.72	165,469.02	19,944.07	2,715,214.41
Suspense	....	1,256,215.94	....	....	....	1,256,215.94
Total liabilities	33,212,075.44	53,886,752.73	10,004,697.26	8,770,524.35	2,372,900.36	108,246,950.14

	1917					
	Great Western Power Co. of California.	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Consolidated Electric Co.	Total.
ASSETS.						
Fixed capital	$124,181	$45,974,241	$10,143,090	$4,394,610	$2,115,567	$62,751,689
Cash and deposits:						
Cash	1,589	38,412	4,209	350	119	44,679
Special deposits	7,803	535,139	68,128	1,075	10,998	623,143
Total cash and deposits	9,392	573,551	72,337	1,425	11,117	667,822
Notes receivable	....	150,251	73,595	....	....	223,846
Accounts receivable:						
Accounts with system corporations	47,037	814,503	....	92,796	153,710	1,108,046
Due from consumers and agents	1,374	284,080	86,654	....	....	372,108
Miscellaneous accounts receivable	1,615	58,980	11,877	....	173	72,645
Total accounts receivable	50,026	1,157,563	98,531	92,796	153,883	1,552,799
Interest and dividends receivable	43,475	2,006	....	7,700	....	53,181
Investments:						
Securities of other corporations	32,063,700	1,567,098	....	....	....	33,630,798
Miscellaneous investments	....	1,479,760	1,000	....	....	1,480,760
Total investments	32,063,700	3,046,858	1,000	....	....	35,111,559
Materials and supplies	1,712	330,907	11,444	....	....	344,063
Sinking funds	....	....	....	148	3,948	4,097
Treasury securities	....	2,407,000	....	....	50,500	2,457,500

TABLE 218.—*Comparative balance sheet of Great Western Power Co. of California and its predecessors and subsidiaries, 1910–1920*—Continued.

	1917					
	Great Western Power Co. of California.	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Consolidated Electric Co.	Total.
ASSETS—continued.						
Prepaid expenses:						
Prepaid rents	$30	$270	$120			$420
Prepaid taxes	1,094	63,019	43,315			107,428
Prepaid insurance		2,130	2,650			4,780
Other prepayments		12,338				12,338
Total prepaid expenses	1,124	77,757	46,085			124,966
Unamortized discount on securities and expenses:						
Stocks	1,205	2,500,000		$4,248,700		6,749,905
Bonds	398,401	271,388	155,328		$1,218	826,335
Total unamortized discount on securities and expenses	399,606	2,771,388	155,328	4,248,700	1,218	7,576,240
Other suspense	[a] 1,301	14,154				12,853
Construction work in progress	121	121,085	49,283			170,489
Total assets	32,692,036	56,626,761	10,650,694	8,745,379	2,336,236	111,051,106
LIABILITIES.						
Capital stock	27,510,211	27,500,000	5,000,000	7,500,000	10,000	67,520,211
Funded debt	4,990,300	24,552,000	2,668,000	1,029,000	2,239,000	35,478,300
Notes payable		713,750				713,750
Accounts payable:						
Accounts with system corporations	33,392	92,795	914,322		35,537	1,076,046
Audited vouchers and wages unpaid	447	227,421	44,888			272,756
Consumers' deposits	35	3,182	711			3,928
Miscellaneous accounts payable	135	14,742	5,458	135	173	20,643
Total accounts payable	34,009	338,140	965,379	135	35,710	1,373,373
Interest accrued	57,706	553,816	67,500	18,225	21,180	718,427
Taxes accrued	9,721	108,430	866	11,645	4,000	134,662
Dividends declared	85,250					85,250
Service billed in advance			280,395			280,395
Reserves for accrued depreciation						
Casualty and insurance reserves		37,483	86,878			124,361
Income invested since Dec. 31, 1912—in fixed capital		83,520	92,445	112,000		287,965
Reserves invested in sinking funds						
Other reserves from income or surplus	32	12,312	8,162			20,506
Miscellaneous		[b]1,455,867	59,028			1,514,895
Corporate surplus unappropriated	4,807	1,271,443	1,422,040	74,374	26,346	2,798,010
Total liabilities	32,692,036	56,626,761	10,650,694	8,745,379	2,336,236	111,051,106

	1918					
	Great Western Power Co. of California.	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Consolidated Electric Co.	Total.
ASSETS.						
Fixed capital	$128,232	$45,936,471	$10,272,916	$4,393,096	$2,113,936	$62,844,651
Cash and deposits:						
Cash	2,709	64,536	10,513	241	129	78,128
Special deposits	7,683	555,443	70,530	4,800	10,630	649,086
Total cash and deposits	10,392	619,979	81,043	5,041	10,759	727,214
Notes receivable		115,188				115,188

[a] Credit item.

[b] Includes $1,436,867 suspense (interest capitalized).

TABLE 218.—*Comparative balance sheet of Great Western Power Co. of California and its predecessors and subsidiaries, 1910–1920*—Continued.

	1918					
	Great Western Power Co. of California.	Graat Western Power Co.	City Electric Co.	California Electric Generating Co.	Consolidated Electric Co.	Total.
ASSETS—continued.						
Accounts receivable:						
Accounts with system corporations	$771,624	$438,638		$122,473	$131,807	$1,464,542
Due from consumers and agents	1,300	431,757	$133,064			566,121
Miscellaneous accounts receivable	689	69,766	7,755		16	78,226
Total accounts receivable	773,613	940,161	140,819	122,473	131,823	2,108,889
Interest and dividends receivable	36,625	3,236		11,453		51,314
Investments:						
Securities of other corporations	31,817,100	1,684,857				33,501,957
Miscellaneous investments		517,830	1,000			518,830
Total investments	31,817,100	2,202,687	1,000			34,020,787
Materials and supplies	2,104	299,727	11,324			313,155
Sinking funds			219	148	414	781
Treasury securities		2,407,000			50,500	2,457,500
Prepaid expenses:						
Prepaid rents		485	120			605
Prepaid taxes	349	68,910	42,789			112,048
Prepaid insurance	3	2,511	2,649			5,163
Other prepayments		69,138				69,138
Total prepaid expenses	352	141,044	45,558			186,954
Unamortized discount on securities and expenses:						
Stocks	19,860	2,500,000		4,248,700		6,768,560
Bonds	335,809	275,651	147,363		1,186	760,009
Total unamortized discount on securities and expenses	355,669	2,775,651	147,363	4,248,700	1,186	7,528,569
Other suspense	[a] 1,370	2,089				719
Construction work in progress	120	59,449	23,137			82,706
Total assets	33,122,837	55,502,682	10,723,379	8,780,911	2,308,618	110,438,427
LIABILITIES.						
Capital stock	27,673,684	27,500,000	5,000,000	7,500,000	10,000	67,683,684
Funded debt	4,835,000	24,330,000	2,616,000	1,029,000	2,232,000	35,042,000
Notes payable	350,000	359,477				709,477
Accounts payable:						
Accounts with system corporations		667,339	750,624		12,080	1,430,043
Audited vouchers and wages unpaid	111,276	102,993	30,205			244,474
Consumers' deposits	35	6,841	2,346			9,221
Miscellaneous accounts payable		100,231	3,259	135	16	103,641
Total accounts payable	111,311	877,404	786,434	135	12,096	1,787,380
Interest accrued	56,033	578,177	67,900	21,950	20,745	744,805
Taxes accrued	3,240	147,888	35,929	19,343	700	207,100
Dividends declared	71,500					71,500
Service bill in advance						
Reserves for accrued depreciation	880	122,996	282,198			406,074
Casualty and insurance reserves		52,598	94,926			147,524
Income invested since Dec. 31, 1912—in fixed capital		104,400	92,445	112,000		308,845
Reserves invested in sinking funds						
Other reserves from income or surplus	98	18,252	14,322			32,672
Miscellaneous		19,000				19,000
Corporate surplus unappropriated	21,091	1,392,490	1,733,225	98,483	33,077	3,278,366
Total liabilities	33,122,837	55,502,682	10,723,378	8,780,911	2,308,618	110,438,427

[a] Credit item.

TABLE 218.—*Comparative balance sheet of Great Western Power Co. of California and its predecessors and subsidiaries, 1910–1920*—Continued.

	1919					
	Great Western Power Co. of California.	Great Western Power Co.[c]	City Electric Co.[c]	California Electric Generating Co.	Consolidated Electric Co.[c]	Total.
ASSETS.						
Fixed capital	$58,650,814	$45,652,528	$10,324,763	$4,468,490	$2,113,811	$121,210,406
Cash and deposits:						
Cash	94,188	85,558	8,177	155	129	188,207
Special deposits	3,905,058	142,129	31,396	3,375	45,842	4,127,800
Total cash and deposits	3,999,246	227,687	39,573	3,530	45,971	4,316,007
Notes receivable	104,757	110,424				215,181
Accounts receivable:						
Accounts with system corporations	46,000	265,983		32,032	121,002	465,017
Due from consumers and agents	611,946	481,166	92,966			1,186,078
Miscellaneous accounts receivable	456,410	236,202	2,977			695,587
Total accounts receivable	1,114,356	983,351	95,943	32,032	121,002	2,346,684
Interest and dividends receivable	11,785	11,837		948		24,570
Investments:						
Securities of other corporations	1,035,674	1,498,064				2,533,738
Miscellaneous investments	572,717	519,205				1,091,922
Total investments	1,608,392	2,017,268				3,625,660
Materials and supplies	402,109	273,928	13,329	148		689,514
Sinking fund	1,359		219		339	1,917
Treasury securities	5,741,800	2,421,000	1,563,000		50,500	9,776,300
Prepaid expenses:						
Prepaid rents	695	599	20			1,314
Prepaid taxes	135,320	12,154	7,131			154,605
Prepaid insurance	5,423	2,042	2,105			9,570
Other prepayments	65,938	81,804	30,000			177,742
Total prepaid expenses	207,376	96,601	39,256			343,233
Unamortized discount on securities and expenses:						
Stocks	138,133	2,500,000		4,248,700		6,886,833
Bonds	1,691,033	657,346	144,825		1,154	2,494,357
Total unamortized discount on securities and expenses	1,829,166	3,157,346	144,825	4,248,700	1,154	9,381,190
Other suspense	[a] 2,471	82,337				79,866
Construction work in progress	2,257,626	115,987	7,424			2,381,037
Total assets	75,926,315	55,150,297	12,228,332	8,753,848	2,332,777	154,391,569
LIABILITIES.						
Capital stock	28,838,526	27,500,000	5,000,000	7,500,000	10,000	68,848,526
Funded debt	40,931,900	24,330,000	4,179,000	973,000	3,230,000	72,643,900
Notes payable		12,556				12,556
Accounts payable:						
Accounts with system corporations	32,032	366,533	576,698			975,263
Audited vouchers and wages unpaid	406,282	86,548	33,756			426,586
Consumers' deposits	15,268	8,629	3,977			27,874
Miscellaneous accounts payable	164,311	161,045	5,117		15	330,488
Total accounts payable	617,892	622,755	619,548		15	1,860,210

[a] Credit item.
[c] As of May 31. Company absorbed by Great Western Power Co. of California June 1, 1919.

TABLE 218.—*Comparative balance sheet of Great Western Power Co. of California and its predecessors and subsidiaries, 1910–1920*—Continued.

	1919					
	Great Western Power Co. of California.	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Consolidated Electric Co.	Total.
LIABILITIES—continued.						
Interest accrued	$788,669	$497,188	$58,525	$19,592	$57,336	$1,421,310
Taxes accrued	188,365	147,155	46,008	20,815	908	403,251
Dividends declared	104,500					104,500
Reserve for accrued depreciation	741,991	219,857	323,060			1,284,908
Casualty and insurance reserves	99,964	53,364	97,768			251,096
Otherr eserves from income or surplus	38,038	19,820	15,136			72,994
Income invested since Dec. 31, 1912—in fixed capital	125,280	104,400				229,680
Miscellaneous						
Corporate surplus unappropriated	3,451,189	1,643,203	1,889,287	240,441	34,517	7,258,637
Suspense						
Total liabilities	75,926,315	55,150,297	12,228,332	8,753,848	2,332,777	154,391,567

	1920		
	Great Western Power Co. of California.	California Electric Generating Co.	Total.
ASSETS.			
Fixed capital	$59,493,263	$4,468,490	$63,961,753
Cash and deposits:			
Cash	331,230	221	331,451
Special deposits	1,216,500	2,975	1,219,475
Total cash and deposits	1,547,730	3,196	1,550,926
Notes receivable	284,217		284,217
Accounts receivable:			
Accounts with system corporations		59,988	59,988
Due from consumers and agents	521,546		521,546
Miscellaneous accounts receivable	640,517		640,517
Total accounts receivable	1,162,063	59,988	1,222,051
Interest and dividends receivable	433	1,848	2,281
Investments:			
Securities of other corporations	957,738		957,738
Miscellaneous investments	556,647		556,647
Total investments	1,514,385		1,514,385
Materials and supplies	538,824		538,824
Sinking funds	1,051	148	1,199
Treasury securities	5,759,700		5,759,700
Prepaid expenses:			
Prepaid rents	335		335
Prepaid taxes	152,796		152,796
Prepaid insurance	5,651		5,651
Other prepayments	32,738		32,738
Total prepaid expenses	191,519		191,519
Unamortized discount on securities and expenses:			
Stocks	218,799	4,248,700	4,467,499
Bonds	1,940,691		1,940,691
Miscellaneous	4,997		4,997
Total unamortized discount on securities and expenses	2,164,487	4,248,700	6,413,187
Other suspense	[a] 7,986		[a] 7,986
E. H. Rollins & Sons, subscribers for general mortgage bonds	741,960		741,960
Construction work in progress	11,313,364		11,313,364
Total assets	84,705,012	8,782,370	93,487,382

[a] Credit item.

TABLE 218.—*Comparative balance sheet of Great Western Power Co. of California and its predecessors and subsidiaries, 1910–1920*—Continued.

	1920		
	Great Western Power Co. of California.	California Electric Generating Co.	Total.
LIABILITIES.			
Capital stock	$29,416,084	$7,500,000	$36,916,084
Funded debt	45,378,500	973,000	46,351,500
Notes payable	2,321,336		2,321,336
Accounts payable:			
Accounts with system corporations	59,988		59,988
Audited vouchers and wages unpaid	650,366		650,366
Consumers' deposits	19,133		19,133
Miscellaneous accounts payable	305,858		305,858
Total accounts payable	1,035,345		1,035,345
Interest accrued	913,551	19,192	932,743
Taxes accrued	238,211	20,571	258,782
Dividends declared	110,000		110,000
Reserve for accrued depreciation	1,045,980		1,045,980
Casualty and insurance reserve	63,728		63,728
Income invested since Dec. 31, 1912—in fixed capital			
Reserves invested in sinking funds			
Other reserve from income or surplus	58,601		58,601
Miscellaneous			
Corporate surplus unappropriated	4,123,676	269,607	4,393,283
Suspense			
Total liabilities	84,705,012	8,782,370	93,487,382

TABLE 219.—*Earnings and expenses of Great Western Power system, 1910–1920.*

Form used by company's accountants.

	1910			
	Great Western Power Co.	City Electric Co.[a]	California Electric Generating Co.	Total.
Revenue:				
Electric earnings	$930,176.99	$912,792.44	[b]$50,000.00	$1,892,969.43
Other earnings	2,179.24	9,464.34	1,631.25	13,274.83
Total gross revenue	932,356.23	922,256.78	51,631.25	1,906,244.26
Deduct.				
Generating expenses	92,621.26	316,368.18		408,989.44
Current purchased	29,137.87			29,137.87
Distributing expenses	57,529.22	21,143.37		78,672.59
General expense	87,365.67	80,371.69		167,737.36
Taxes	32,472.27	20,167.60		52,639.87
Total expenses	299,126.29	438,050.84		737,177.13
Net earnings before deducting fixed charges	633,229.94	484,205.94	51,631.25	1,169,067.13
Fixed charges:				
Bond interest	592,827.79	85,000.00	50,000.00	727,827.79
Reserve for replacement and depreciation		80,000.00		80,000.00
Reserve for liability		10,000.00		10,000.00
Reserve for insurance		10,000.00		10,000.00
Reserve for bad debts		3,407.91		3,407.91
Amortization of debt discount and expense		10,268.87		10,268.87
Total fixed charges	592,827.79	198,676.78	50,000.00	841,504.57
Less interest charged to construction on uncompleted work	19,261.00			19,261.00
Net deduction	573,566.79	198,676.78	50,000.00	822,243.57
Net profit and loss to surplus	59,663.15	285,529.16	1,631.25	346,823.56

[a] City Electric Co. was not acquired by Great Western Power system until July 1, 1911.
[b] Rent of plant.

TABLE 219.—*Earnings and expenses of Great Western Power system, 1910–1920*—Continued.

	1911			
	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Total.
Revenue:				
Electric earnings	$1,003,993.48	$932,167.78	$60,000.00	$1,996,161.26
Other earnings	3,867.08	[c] 174.88	2,955.44	6,647.64
Total gross revenue	1,007,860.56	931,992.90	62,955.44	2,002,808.90
Deduct.				
Generating expenses	69,648.23	278,380.83		348,029.76
Current purchased	26,488.85			26,488.85
Distributing expenses	64,018.88	27,509.75		91,528.63
General expense	116,256.94	100,881.14		217,138.08
Taxes	39,086.05	25,998.60		65,084.65
Total expenses	315,499.65	432,770.32		748,269.97
Net earnings before deducting fixed charges	692,360.91	499,222.58	62,955.44	1,254,538.93
Fixed charges:				
Bond interest	757,267.22	85,000.00	60,000.00	902,267.22
Reserve for replacement and depreciation		120,000.00		120,000.00
Reserve for liability				
Reserve for insurance				
Reserve for bad debts		4,658.13		4,658.13
Amortization of debt discount and expense		10,268.87		10,268.87
Total fixed charges	757,267.22	219,927.00	60,000.00	1,037,194.22
Less interest charged to construction on uncompleted work	5,262.77			5,262.77
Net deduction	752,004.45	219,927.00	60,000.00	1,031,931.45
Net profit and loss to surplus	[c] 59,643.54	279,295.58	2,955.44	222,607.48

	1912			
	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Total.
Operating revenue	$1,435,029.34	$974,571.61		$2,409,600.95
Add:				
Rent accrued from lease of electric plant			$238,000.00	238,000.00
Miscellaneous rent revenues	649.00			649.00
Interest revenue on funded debt owned				
Miscellaneous interest revenues	12,868.37	6,092.89	3,145.38	22,106.64
Miscellaneous nonoperating revenues				
Total nonoperating revenue	13,517.37	6,092.89	241,145.38	260,755.64
Gross revenue from all sources	1,448,546.71	980,664.50	241,145.38	2,670,356.59
Operating expenses	[d] 777,737.21	573,040.67		1,350,777.88
Gross corporate income	670,809.50	407,623.83	241,145.38	1,319,578.71
Deduct:				
Uncollectible bills				
Rent expenses				
Interest accrued on funded debt	710,195.70	86,583.07	60,000.00	856,778.77
Other interest deductions	4,004.15	3,219.82		7,223.97
Sinking fund chargeable to income		12,870.00	28,000.00	40,870.00
Rent for lease of other electric plant				
Rent for conduits, poles, and other supports—electric				
Rent for instruments and equipment				
Miscellaneous rent deductions				
Amortization of debt discount and expense				
Total deductions from gross income	714,199.85	102,672.89	88,000.00	904,872.74
Surplus for year		304,950.94	153,145.38	414,705.97
Deficit for year	43,390.35			
Dividends			150,000.00	150,000.00
Balance	[c] 43,390.35	304,950.94	3,145.38	264,705.97

[c] Deficit.

[d] Includes $238,000 paid in rent of California Electric Generating Co.'s Oakland steam plant.

TABLE 219.—*Earnings and expenses of Great Western Power system, 1910–1920*—Continued.

Standard form adopted by Railroad Commission of California, 1913–1920.

	1913			
	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Total.
Electric operations:				
Operating revenue	$1,845,702.58	$1,018,981.27	...	$2,864,683.85
Operating expenses	534,090.17	596,555.59	$1,793.40	1,132,439.16
Net operating revenue	1,311,612.41	422,425.68	[c] 1,793.40	1,732,244.69
Add:				
Rent accrued from lease of electric plant	...	...	238,319.78	238,319.78
Miscellaneous rent revenues	6,849.10	68.33	...	6,917.43
Interest revenue on funded debt owned	697.92	...	...	697.92
Miscellaneous interest revenues	245,341.54	48,935.22	3,494.55	297,771.31
Miscellaneous nonoperating revenues	6,067.50	...	...	6,067.50
Total nonoperating revenues	258,956.06	49,003.55	241,814.33	549,773.94
Gross corporate income	1,570,568.47	471,429.23	240,020.93	2,282,018.63
Deduct:				
Uncollectible bills	4,218.89	2,493.78	...	6,712.67
Rent expenses	10,912.50	...	...	10,912.50
Interest accrued on funded debt	999,678.34	99,218.05	58,526.38	1,157,422.77
Other interest deductions	49,575.33	36,795.83	...	86,371.16
Rent for lease of other electric plant	238,319.78	2,400.00	...	240,719.78
Rent for conduits, poles, and other supports—electric	919.18	...	...	919.18
Rent for instruments and equipment	...	120.00	...	120.00
Miscellaneous rent deductions	585.00	692.40	...	1,277.40
Amortization of debt discount and expense	...	...	...	...
Total miscellaneous deductions	1,304,209.02	141,720.06	58,526.38	1,504,455.46
Balance of year carried to corporate surplus	266,359.45	329,709.17	181,494.55	777,563.17

	1914			
	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Total.
Electric operations:				
Operating revenue	$1,989,936.30	$1,074,080.50	...	$3,064,016.80
Operating expenses	457,794.77	796,842.24	$2,044.43	1,256,681.44
Net operating revenue	1,532,141.53	277,238.26	[c]2,044.43	1,807,335.36
Add:				
Rent accrued from lease of electric plant	...	...	237,094.44	237,094.44
Miscellaneous rent revenues	9,915.00	57.30	...	9,972.30
Interest revenue on funded debt owned	173.50	...	...	173.50
Miscellaneous interest revenues	266,082.03	53,014.85	3,299.32	322,396.20
Miscellaneous nonoperating revenues	...	...	...	...
Total nonoperating revenues	276,170.53	53,072.15	240,393.76	569,636.44
Gross corporate income	1,808,312.06	330,310.41	238,349.33	2,376,971.80
Deduct:				
Uncollectible bills	6,084.05	2,649.46	...	8,733.51
Rent expenses	11,422.85	...	...	11,422.85
Interest accrued on funded debt	1,048,810.89	100,214.16	57,050.01	1,206,075.06
Other interest deductions	57,888.18	36,000.00	...	93,888.18
Sinking fund chargeable to income	...	...	...	...
Rent for lease of other electric plant	237,094.44	2,400.00	...	239,494.44
Rent for conduits, poles, and other supports—electric	1,075.60	...	...	1,075.60
Rent for instruments and equipment	...	240.00	...	240.00
Miscellaneous rent deductions	919.92	401.66	...	1,321.58
Amortization of debt discount and expense.	3,531.80	2,086.71	...	5,618.51
Total miscellaneous deductions	1,366,827.73	143,991.99	57,050.01	1,567,869.73
Balance of year carried to corporate surplus	441,484.33	186,318.42	181,299.32	809,102.07

[c] Deficit.

TABLE 219.—*Earnings and expenses of Great Western Power system, 1910–1920*—Continued.

	1915				
	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Consolidated Electric Co.	Total.
Operating revenue	$2,329,246.74	$1,258,043.96		$203,709.58	$3,791,000.28
Operating expenses	537,589.32	956,926.52	$1,880.76	160,713.94	1,657,110.54
Net operating revenue	1,791,657.42	301,117.44	[c] 1,880.76	42,995.64	2,133,889.74
Add:					
Rent accrued from lease of electric plant			235,764.09	37,758.75	273,522.84
Miscellaneous rent revenues	16,811.41	166.45			16,977.86
Interest revenue on funded debt owned	3,050.63			40.00	3,090.63
Miscellaneous interest revenues	236,852.46	26,637.35	3,309.93	257.30	267,057.04
Miscellaneous nonoperating revenues	5,438.33			3,891.66	9,329.99
Total nonoperating revenues	262,152.83	26,803.80	239,074.02	41,947.71	569,978.36
Gross corporate income	2,053,810.25	327,921.24	237,193.26	84,943.35	2,703,868.10
Deduct:					
Uncollectible bills	8,892.07	3,035.47			11,927.54
Rent expenses	20,816.93				20,816.93
Interest accrued on funded debt	1,085,200.00	128,345.14	55,883.33	66,718.75	1,336,147.22
Other interest deductions	24,910.76	8,670.00			33,580.76
Rent for lease of other electric plant	250,462.31	22,860.53			273,322.84
Rent for conduits, poles, and other supports—electric	1,250.17	142.75		690.63	2,083.55
Rent for instruments and equipment		245.00			245.00
Miscellaneous rent deductions	1,319.35	6,783.50			8,102.85
Amortization of debt discount and expense	7,901.62	2,086.64			9,988.26
Total miscellaneous deductions	1,400,753.21	172,169.03	55,883.33	[e] 70,266.98	1,699,072.55
Balance of year carried to corporate surplus	653,057.04	155,752.21	181,309.93	14,676.37	1,004,795.55

	1916					
	Great Western Power Co. of California.	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Consolidated Electric Co.	Total.
Operating revenue	$5,312.19	$2,898,818.58	$1,531,714.25			$4,435,845.02
Operating expenses	5,301.95	760,075.52	1,233,851.19	$1,855.10	$28,978.10	2,030,061.86
Net operating revenue	10.24	2,138,743.06	297,863.06	[c] 1,855.10	[c] 28,978.10	2,405,783.16
Add:						
Rent accrued from lease of electric plant				234,338.43	$147,165.62	381,504.05
Miscellaneous rent revenues		18,630.46	438.15			19,059.61
Interest revenue on funded debt owned	85,853.90	7,458.43				93,312.33
Miscellaneous interest revenues	450,155.52	223,370.48	2,823.14	3,891.90	541.01	680,782.05
Miscellaneous nonoperating revenues		3,078.61				3,078.61
Total nonoperating revenues	536,009.42	252,537.98	3,261.29	238,230.33	147,706.63	1,177,745.65
Gross corporate income	536,019.66	2,391,281.04	301,124.35	236,375.23	118,728.09	3,583,528.37
Deduct:						
Uncollectible bills	20.65	10,912.54	8,696.99			19,630.18
Rent expenses		20,421.95			1,300.00	21,721.95
Miscellaneous nonoperating expenses		4,057.85				4,057.85
Interest accrued on funded debt	274,722.60	1,085,200.00	136,060.55	54,483.33	114,209.33	1,664,675.81
Other interest deductions		7,885.33	371.02			8,256.35

[c] Deficit.

[e] Includes $2,857.60 miscellaneous nonoperating expenses.

TABLE 219.—*Earnings and expenses of Great Western Power system, 1910–1920*—Continued.

	1916					
	Great Western Power Co. of California.	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Consolidated Electric Co.	Total.
Deduct—Continued.						
Rent for lease of other electric plant	$137.50	$291,485.34	$90,018.71			$381,641.55
Rent for conduits, poles, and other supports—electric		1,554.35	692.50			2,246.85
Rent for instruments and equipment			281.00			281.00
Miscellaneous rent deductions	40.00	2,593.48	16,910.00			19,543.48
Amortization of debt discount and expense	8,493.06	8,512.56	7,965.66		$32.75	25,004.03
Total miscellaneous deductions	283,413.81	1,432,623.40	260,996.43	$54,483.33	115,542.08	2,147,059.05
Balance of year carried to corporate surplus	252,605.85	958,657.64	40,127.92	181,891.90	3,186.01	1,436,469.32

	1917					
	Great Western Power Co. of California.	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Consolidated Electric Co.	Total.
Electric operations:						
Operating revenue	$12,579.89	$3,188,838.92	$1,529,252.82			$4,730,671.63
Operating expenses	20,637.22	866,911.37	1,307,745.18	$5,895.76	$13,653.59	2,214,843.12
Net operating revenues	c 8,057.33	2,321,927.55	221,507.64	c 5,895.76	c 13,653.59	2,515,828.51
Add:						
Rents accrued from lease of electric plant				237,071.59	127,790.87	364,862.46
Miscellaneous rent revenues	25,801.06		1,438.00			27,239.06
Interest revenue on funded debt owned	17,920.36	91,061.10				108,981.46
Miscellaneous interest and dividend revenues	16,365.66	626,516.22	1,134.67	3,904.80		647,921.35
Miscellaneous nonoperating revenue	8,398.75					8,398.75
Total nonoperating revenues	717,577.32	68,485.83	2,572.67	240,976.39	127,790.87	1,157,403.08
Gross corporate income	709,519.99	2,390,413.38	224,080.31	235,080.63	114,137.28	3,673,231.59
Deduct:						
Uncollectible bills	125.98	8,161.78	12,108.05			20,391.83
Rent expenses		24,725.72	3,075.00			27,800.72
Miscellaneous nonoperating expenses		821.29				821.29
Interest accrued on funded debt	299,918.92	1,079,864.71	134,365.50	53,175.84	110,832.86	1,678,157.83
Other interest deductions		14,657.14	32.37			14,689.51
Rent for lease of other electric plant		284,313.21	80,549.25			364,862.46
Rent for conduits, poles, and other supports		1,899.76	315.00			2,214.76
Rent for instruments and equipment			240.00			240.00
Miscellaneous rent deductions	31.00	3,487.20	17,939.00			21,457.20
Amortization of debt discount and expense	51,037.84	9,030.58	7,965.56		32.75	68,066.73
Total miscellaneous deductions	351,113.74	1,426,961.39	256,589.73	53,175.84	110,865.61	2,198,706.31
Balance of year carried to corporate surplus	358,406.25	963,451.99	a 32,509.42	181,904.79	3,271.67	1,474,525.28

c Deficit.

TABLE 219.—*Earnings and expenses of Great Western Power system, 1910–1920*—Continued.

	1918					
	Great Western Power Co. of California.	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Consolidated Electric Co.	Total.
Electric operations:						
Operating revenue	$13,543.48	$3,422,608.08	$1,535,475.89			$4,971,627.45
Operating expenses	23,798.81	1,280,002.94	951,281.74	$11,643.00	$4,000.00	2,270,726.49
Net operating revenues	c10,255.33	2,142,605.14	584,194.15	c11,643.00	c 4,000.00	2,700,900.96
Add:						
Rents accrued from lease of other electric plants				241,361.04	117,026.06	358,387.10
Miscellaneous rent revenues		26,703.41	2,142.70			28,846.11
Interest revenue on funded debt owned	81,602.78	21,322.73				102,925.51
Miscellaneous interest and dividend revenues	607,757.95	27,513.44	1,313.48	3,809.47		640,394.37
Total nonoperating revenues	689,360.73	75,539.58	3,456.16	245,170.51	117,026.06	1,130,553.04
Gross corporate income	679,105.40	2,218,144.72	587,650.31	233,527.51	113,026.06	3,831,454.00
Deduct:						
Uncollectible bills	134.34	11,401.41	7,256.66			18,792.41
Rent expenses		23,140.29	3,600.00			26,740.29
Miscellaneous nonoperating expenses						
Interest accrued on funded debt	292,792.69	1,069,375.00	132,677.78	51,450.00	110,132.65	1,656,428.12
Other interest deductions	13,941.65	29,562.65	2.25			43,506.28
Rent for lease of other electric plant		282,527.91	75,859.19			358,387.10
Rent for conduits, poles, and other supports		2,487.68	540.00			3,027.68
Rent for instruments and equipment			240.00			240.00
Miscellaneous rent deductions	31.00	3,194.55	17,939.00			21,164.55
Amortization of debt discount and expense	52,110.67	9,522.53	7,965.56		32.50	69,631.26
Total miscellaneous deductions	359,010.35	1,431,211.75	246,080.44	51,450.00	110,165.15	2,197,917.69
Balance of year carried to corporate surplus	320,095.05	786,932.97	341,569.87	182,077.51	2,860.91	1,633,536.31

c Deficit.

TABLE 219.—*Earnings and expenses of Great Western Power system, 1910–1920*—Continued.

	1919					
	Great Western Power Co. of California.	Great Western Power Co.	City Electric Co.	California Electric Generating Co.	Consolidated Electric Co.	Total.
Electric operations:						
Operating revenue	$3,128,928.50	$1,509,382.93	$733,727.83			$5,372,039.26
Operating expenses	1,570,443.63	553,227.42	573,024.49	$13,315.00	$208.33	2,710,219.87
Net operating revenue	1,558,484.87	956,155.51	160,703.34	[c]13,315.00	[c] 208.33	2,661,820.39
Add:						
Rents accrued for lease of electric plant				247,303.12	47,279.91	294,583.03
Miscellaneous rent revenues	22,929.55	9,124.27	930.20			32,984.02
Interest accrued on funded debt owned	4,325.65	9,720.04	85.00			14,130.69
Miscellaneous interest revenues	159,988.50	12,784.52	163.19	3,258.09		176,194.30
Dividend revenues	750.00	250.00				1,000.00
Miscellaneous nonoperating revenues	3,770.00	5,557.50				9,327.50
Total nonoperating revenues	191,763.70	37,436.33	1,178.39	250,561.21	47,279.91	528,219.54
Gross corporate income	1,750,248.57	993,591.84	161,881.73	237,246.21	47,071.58	3,190,039.93
Deduct:						
Uncollectible bills	5,375.00	2,625.00	1,000.00			9,000.00
Rent expenses	13,539.66	9,269.40	1,500.00			24,409.06
Nonoperating taxes	3,602.36	1,310.73				4,913.09
Interest accrued on funded debt	1,115,221.27	442,875.00	54,500.00	50,050.00	45,799.09	1,708,445.36
Other interest deductions	13,588.80	7,992.36	1.05			21,582.21
Rent for lease of other electric plant	144,117.64	119,817.05	30,648.34			294,583.03
Rent for conduit, poles, and other supports	1,160.05	931.23	225.00			2,316.28
Rent for instruments and equipment	140.00		100.00			240.00
Miscellaneous rent deductions	11,469.37	1,583.93	7,057.50			20,110.80
Amortization of debt discount and expense	71,489.11	4,176.60	3,318.96		32.50	79,017.17
Total miscellaneous deductions	1,379,703.26	590,681.30	98,350.85	50,050.00	45,831.59	2,164,617.00
Balance of year carried to corporate surplus	370,545.31	402,910.54	63,530.88	187,196.21	1,239.99	1,025,422.93

[c] Deficit.

TABLE 219.—*Earnings and expenses of Great Western Power system, 1910–1920*—Contd.

	1920		
	Great Western Power Co. of California.	California Electric Generating Co.	Total.
Electric operations:			
Operating revenue	$5,865,702.98		$5,865,702.98
Operating expenses	2,966,076.82	$18,774.58	2,984,851.40
Net operating revenue	2,899,626.16	[c] 18,774.58	2,880,851.58
Add:			
Rents accrued from lease of electric plant		247,440.13	247,440.13
Miscellaneous rent revenues	38,025.00		38,025.00
Interest accrued on funded debt owned	6,310.10		6,310.10
Miscellaneous interest revenues	633,222.65	965.61	634,188.26
Dividend revenues	1,500.00		1,500.00
Total nonoperating revenues	679,057.75	248,405.74	927,463.49
Gross corporate income	3,578,683.91	229,631.16	3,808,315.07
Deduct:			
Uncollectible bills	15,000.00		15,000.00
Rent expenses	22,921.02		22,921.02
Nonoperating taxes	3,645.37		3,645.37
Interest accrued on funded debt	1,901,197.06	48,649.99	1,949,847.05
Other interest deductions	97,048.07		97,048.07
Rent for lease of other electric plant	247,440.13		247,440.13
Rent for conduit, poles, and other supports	2,063.52		2,063.52
Rent for instruments and equipment	240.00		240.00
Miscellaneous rent deductions	20,819.78		20,819.78
Amortization of debt discount and expense	109,150.29		109,150.29
Total miscellaneous deductions	2,419,525.24	48,649.99	2,468,175.23
Balance of year carried to corporate surplus	1,159,158.67	180,981.17	1,340,139.84

[c] Deficit.

TABLE 220.—*Classified electric revenues of Great Western Power system, 1913–1920.*

[Intercompany sales eliminated.]

Class of load.	1913			
	Great Western Power Co.	City Electric Co.	Total Great Western Power Co., City Electric Co.	Per cent of total electric revenue.
Operating revenue, electric:				
Municipal street lighting—				
Arc	$6,841.40	....	$6,841.40	0.3
Incandescent	11,367.45	....	11,367.45	.4
Municipal lighting, miscellaneous	5,801.82	....	5,801.82	.2
Municipal power	15,086.25	....	15,086.25	.6
Commercial lighting—				
Flat rate	85,300.31	$210.00	85,510.31	3.2
Metered	164,786.01	409,869.22	574,655.23	21.3
Commercial power—				
Flat rate	680.00	225.00	905.00	....
Metered	639,978.38	231,007.52	870,985.90	32.3
Railway power	59,774.86	343,079.77	402,854.63	14.9
Other electric corporations	690,152.41	17,524.88	707,677.29	26.3
Rent of meters	....	1,136.65	1,136.65	....
Miscellaneous electric revenues	63.00	1,773.05	1,836.05	....
Breakdown service	....	....	....	....
Total operating revenue, electric	1,679,831.89	1,004,826.09	2,684,657.98	99.5
Other operating revenue:				
Rent of electric appliances	....	574.50	574.50	....
Electric merchandise and jobbing revenue	[a] 598.81	15.00	[a] 583.81	....
Sale of by-products	....	....	....	....
Steam sales revenue	....	13,565.68	13,565.68	.5
Total other operating revenue	[a] 598.81	14,155.18	13,556.37	.5
Gross electric revenue	1,679,233.08	1,018,981.27	2,698,214.35	100.0

Class of load.	1914			
	Great Western Power Co.	City Electric Co.	Total Great Western Power Co., City Electric Co.	Per cent of total electric revenue.
Operating revenue, electric:				
Municipal street lighting—				
Arc	$6,998.25	....	$6,998.25	0.3
Incandescent	12,008.90	....	12,008.90	.5
Municipal lighting, miscellaneous	6,979.98	$2,581.67	9,561.65	.4
Municipal power	11,314.04	2,870.92	14,184.96	.5
Commercial lighting—				
Flat rate	68,441.67	225.00	68,666.67	2.6
Metered	240,806.18	420,429.80	661,235.98	24.7
Commercial power—				
Flat rate	958.20	900.00	1,858.20	....
Metered	637,555.15	256,007.66	893,562.81	33.4
Railway power	87,926.20	352,660.55	440,586.75	16.4
Other electric corporations	533,843.54	16,093.35	549,936.89	20.5
Rent of meters	10.00	1,138.50	1,148.50	....
Miscellaneous electric revenue	71.25	3,783.00	3,854.25	.1
Breakdown service	....	600.00	600.00	....
Total operating revenue, electric	1,606,913.36	1,057,290.45	2,664,203.81	99.4
Other operating revenue:				
Rent of electric appliances	78.05	808.45	886.50	....
Electric merchandise and jobbing revenue	26.89	....	26.89	....
Steam sales revenue	....	15,981.60	15,981.60	.6
Total other operating revenue	104.94	16,790.05	16,894.99	.6
Gross electric revenue	1,607,018.36	1,074,080.50	2,681,098.80	100.0

[a] Debit item.

TABLE 220.—*Classified electric revenues of Great Western Power system, 1913–1920*—Continued.

Class of load.	1915				
	Great Western Power Co.	City Electric Co.	Consolidated Electric Co.	Total City Electric, Great Western, and Consolidated Electric Co.	Per cent of total gross electric revenue.
Operating revenue, electric:					
Municipal street lighting—					
Arc	$6,412.91			$6,412.91	0.2
Incandescent	12,257.05			12,257.05	.4
Miscellaneous	2,091.54	$2,680.68		4,772.22	.1
Municipal power	10,406.34	4,585.67		14,992.01	.5
Commercial lighting—					
Flat rate	39,976.58	451.75	$355.00	40,783.33	1.3
Metered	319,117.14	521,868.96	79,897.33	920,883.43	28.4
Commercial power—					
Flat rate	3,938.36	1,013.25	1,200.00	6,151.61	.2
Metered	734,919.12	305,568.48	34,431.37	1,074,918.97	33.2
Railway power	124,002.79	353,030.15	51,783.90	528,816.84	16.3
Other electric corporations	527,448.65	16,024.83	1,708.15	545,181.63	16.8
Rent of meters		1,001.00	22.00	1,023.00	
Miscellaneous electric revenues	92.05	2,191.00	7.30	2,290.35	
Breakdown service		600.00		600.00	
Total operating revenue, electric	1,780,662.53	1,209,015.77	169,405.05	3,159,083.35	97.4
Other operating revenues:					
Rent of electric appliances	98.95	[a] 532.13	12.50	[a] 420.68	
Electric merchandise and jobbing revenue	[a] 3,138.10		67.55	[a] 3,070.55	
Steam sales revenue	2,536.73	49,560.32	34,224.48	86,321.53	2.6
Total other operating revenue	[a] 502.42	49,028.19	34,304.53	82,830.30	2.6
Gross electric revenues	1,780,160.11	1,258,043.96	203,709.58	3,241,913.65	100.0

Class of load.	1916				
	Great Western Power Co. of California.	Great Western Power Co.	City Electric Co.	Total Great Western Power Co. of California, Great Western, and City Electric Co.	Per cent of total.
Operating revenue, electric:					
Municipal street lighting—					
Arc		$6,016.05		$6,016.05	0.1
Incandescent		12,524.05		12,524.05	.3
Miscellaneous		313.65		313.65	
Municipal power		17,130.30	$2,494.35	19,624.65	.4
Commercial lighting—					
Flat rate	$617.16	29,309.54	1,128.20	31,054.90	.7
Metered	2,251.61	393,626.56	630,016.13	1,025,894.30	23.1
Commercial power—					
Flat rate		7,036.13	3,866.05	10,902.18	.3
Metered	2,407.05	982,281.89	404,391.41	1,389,080.35	31.3
Railway power		215,141.10	353,734.50	568,875.60	12.8
Other electric corporations		1,195,047.83	4,052.46	1,199,100.29	27.1
Rent of meters			847.30	847.30	
Miscellaneous electric revenues		73.30	3,749.70	3,823.00	.1
Breakdown service			273.25	273.25	
Total operating revenue, electric	5,275.82	2,858,500.40	1,404,553.35	4,268,329.57	96.2
Other operating revenue:					
Rent of electric appliances	.50	132.58	17.60	150.68	
Electric merchandise and jobbing revenues	35.87	[a] 7,119.92		[a] 7,084.05	
Sale of by-products		34,433.30		34,433.30	.6
Steam sales revenue		12,072.22	127,143.30	140,015.52	3.2
Total other operating revenue	36.37	40,318.18	127,160.90	167,515.45	3.8
Gross electric revenues	5,312.19	2,898,818.58	1,531,714.25	[b] 4,435,845.02	100.0

[a] Debit item.

[b] Operating revenues of California Electric Generating Co. and Consolidated Electric Co. for 1916 are included with Great Western Power Co. of California and City Electric Co.

TABLE 220.—*Classified electric revenues of Great Western Power system, 1913–1920*—Continued.

Class of load.	1917				
	Great Western Power Co. of California.	Great Western Power Co.	City Electric Co.	Total Great Western Power Co. of California and Great Western and City Electric Cos.	Per cent of total.
Operating revenues, electric:					
Municipal street lighting—					
Arc		$2,482.02		$2,482.02	0.05
Incandescent		16,157.63		16,157.63	.3
Miscellaneous		412.67		412.67	
Municipal power		15,639.72	$2,658,15	18,297.87	.4
Commercial lighting—					
Flat rate	$1,941.72	21,329.55	1,567.14	24,838.41	.5
Metered	5,923.62	409,873.24	611,959.22	1,027,756.08	21.8
Commercial power—					
Flat rate	50.69	9,661.89	5,681.30	15,393.88	.3
Metered	4,672.85	1,183,784.25	454,645.26	1,643,102.36	34.9
Railway power		238,265.25	309,032.21	547,297.46	11.6
Other electric corporations		1,232,914.25	4,631.66	1,237,545.91	26.2
Rent of meters			716.87	716.87	
Miscellaneous electric revenues		69.55	2,228.85	2,298.40	.04
Total operating revenue, electric	12,588.88	3,130,590.02	1,393,120.66	4,536,299.56	96.09
Other operating revenues:					
Rent of electric appliances		302.32	36.00	338.32	
Electric merchandise and jobbing revenues	[a] 8.99	[a] 880.32		[a] 889.31	
Sale of by-products		43,344.30		43,344.30	.91
Steam sales revenue		15,482.60	136,096.16	151,578.76	3
Total other operating revenue	[a] 8.99	58,248.90	136,132.16	194,372.07	3.91
Gross electric revenues	12,579.89	3,188,838.92	1,529,252.82	4,720,671.63	100.00

Class of load.	1918				
	Great Western Power Co. of California.	Great Western Power Co.	City Electric Co.	Total Great Western Power Co. of California and Great Western and City Electric Cos.	Per cent of total.
Operating revenues, electric:					
Municipal street lighting—					
Arc		$1,218.60		$1,218.60	0.03
Incandescent		17,817.59		17,817.59	.36
Miscellaneous		574.27		574.27	
Municipal power		30,108.56	$3,085.96	33,194.52	.67
Commercial lighting—					
Flat rate	$1,949.51	11,037.16	1,280.88	14,267.55	.29
Metered	6,038.89	477,361.76	698,994.96	1,182,395.61	23.78
Commercial power—					
Flat rate	60.66	10,637.58	4,489.14	15,187.38	.32
Metered	5,384.77	1,786,028.97	570,086.81	2,361,500.55	47.50
Railway power		236,170.48		236,170.48	4.75
Other electric corporations		762,583.60	79,667.16	842,250.76	16.94
Rent of meters			537.00	537.00	
Miscellaneous electric revenues		690.90	813.28	1,504.18	.03
Total operating revenue, electric	13,433.83	3,334,229.47	1,358,955.19	4,706,618.49	94.67
Other operating revenues:					
Electric merchandise and jobbing revenues	109.65	7,414.33	36.00	7,559.98	.15
Sale of by-products		64,901.28		64,901.28	1.30
Steam sales revenue		16,063.00	176,484.70	192,547.70	3.88
Total other operating revenue	109.65	88,378.61	176,520.70	265,008.96	5.33
Gross electric revenues	13,543.48	3,422,608.08	1,535,475.89	4,971,627.45	100.00

[a] Debit item.

TABLE 220.—*Classified electric revenues of Great Western Power system, 1913–1920*—Continued.

Class of load.	1919				
	Great Western Power Co. of California.	Great Western Power Co (to May 31, 1919).	City Electric Co. (to May 31, 1919).	Total Great Western Power Co. of California and Great Western and City Electric Cos.	Per cent of total.
Operating revenues, electric:					
Municipal street lighting—					
Arc	$717.50	$512.50	....	$1,230.00	0.02
Incandescent	11,125.35	7,874.65	....	19,000.00	.35
Miscellaneous	278.15	195.28	....	473.43	....
Municipal power	39,314.11	19,692.79	$1,361.54	60,368.44	1.12
Commercial lighting—					
Flat rate	4,970.54	2,227.59	177.88	7,376.01	.12
Metered	805,025.20	255,918.18	358,267.44	1,419,210.82	26.45
Commercial power—					
Flat rate	8,142.04	4,517.61	1,379.89	14,039.54	.26
Metered	1,600,193.66	819,325.51	253,185.28	2,672,704.45	49.77
Railway power	145,236.60	97,256.15	....	242,492.75	4.51
Other electric corporations	266,067.65	291,697.22	8,370.86	566,135.73	10.54
Breakdown service	2,997.90	234.56	....	3,232.46	.06
Rent of meters	281.25	....	217.50	498.75	....
Miscellaneous electric revenue	4,943.70	555.20	314.57	5,813.47	.11
Total operating revenue, electric	2,889,293.65	1,500,007.24	623,274.96	5,012,575.85	93.31
Other operating revenues:					
Electric appliances	22.00	....	15.00	37.00	....
Electric merchandise and jobbing revenues	516.88	[a] 109.65	....	407.23	....
Sale of by-products	115,724.56	1,396.73	....	117,121.29	2.19
Steam sales revenue	123,371.41	8,088.61	110,437.87	241,897.89	4.50
Total other operating revenue	239,634.85	9,375.69	110,452.87	359,463.41	6.69
Gross electric revenues	3,128,928.50	1,509,382.93	733,727.83	5,372,039.26	100.00

Class of load.	1920	
	Great Western Power Co. of California.	Per cent of total.
Operating revenues, electric:		
Municipal street lighting—		
Arc	$1,408.50	0.02
Incandescent	21,703.59	.37
Miscellaneous	463.84	....
Municipal power	58,284.19	1.00
Commercial lighting—		
Flat rate	7,942.22	.12
Metered	1,705,794.15	29.09
Commercial power—		
Flat rate	19,735.53	.34
Metered	3,128,520.18	53.38
Railway power	280,245.57	4.78
Other electric corporations	158,758.08	2.71
Breakdown service	7,773.42	.11
Rent of meters	398.43	....
Miscellaneous electric revenue	20,340.77	.34
Total operating revenue, electric	5,411,368.47	92.26
Other operating revenues:		
Electric appliances	56.15	....
Electric merchandise and jobbing revenues	1,871.79	.03
Sale of by-products	160,181.34	2.73
Steam sales revenue	292,225.23	4.98
Total other operating revenue	454,334.51	7.74
Gross electric revenues	5,865,702.98	100.00

[a] Debit item.

FINANCIAL TABLES FOR WESTERN STATES GAS & ELECTRIC CO. AND SUBSIDIARIES.

TABLE 221.—*Capitalization, outstanding stock, and dividends of Western States Gas & Electric Co. and subsidiaries.*

[Term of incorporation, uniformly 50 years.]

Western States Gas & Electric Co.

Company.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.			Dividends.[a]	
			Per share.	Preferred.	Common.	On preferred stock.	On common stock.
Western States Gas & Electric Co., Stockton; incorporated Nov. 30, 1910.	$15,000,000	1910	$100	$1,500,000	$1,501,500	$8,750	....
		1911	......	1,800,000	3,231,500	118,558	$48,276
		1912	......	2,125,000	3,231,500	143,631	....
		1913	......	2,125,000	3,231,500	148,750	....
		1914	......	2,125,000	3,231,500	148,750	....
		1915	......	2,125,000	3,231,500	148,750	[b] 30,925
		1916	......	2,125,000	3,231,500	148,750	74,728
		1917	......	2,125,000	3,231,500	148,750	77,556
		1918	......	2,303,000	3,231,500	150,424	78,767
		1919	......	2,303,000	3,231,500	152,665	72,708
		1920	......	2,906,000	3,231,500	168,554	72,708

Subsidiary companies.[c]

Company.	Date of incorporation.	Capitalization.	Years (Dec. 31).	Par value of stock outstanding.		Dividends.	
				Per share.	Total.	Rate.	Amount.
American River Electric Co., San Francisco (properties purchased by Western States Gas & Electric Co.).	Apr. 17, 1903	$2,500,000	1907–1910	$50	$2,500,000	......	....
Stockton Gas & Electric Corporation, San Francisco (successor of Stockton Gas & Electric Co. Properties purchased by Western States Gas & Electric Co.).	July 30, 1907	1,500,000	1908	100	600,000	......	....
			1909–10	....	1,500,000	......	....
Stockton Gas & Electric Co., San Francisco (consolidation of Stock, Gas, Light & Heat Co., and Stockton Natural Gas Co.).	Nov. 24, 1894	1,000,000	1902–3	50	500,000	......	....
			1904	....	....	......	....
			1905–6	....	600,000	......	....
Stockton Gas, Light & Heat Co., Stockton, Calif. (see Stockton Gas & Electric Co.).	July 8, 1884	1,000,000	....	100	....	......	....
Stockton Natural Gas Co., Stockton, Calif. (see Stockton Gas & Electric Co.).	Apr. 20, 1888	200,000	....	100	....	......	....
Citizens Natural Gas Co., Stockton, Calif. (stock control purchased by Western States Gas & Electric Co.).	Oct. 18, 1889	20,000	....	....	....	......	....
Humboldt Gas & Electric Co., Eureka, Calif. (consolidation of Eureka Lighting Co. and North Mountain Power Co., properties purchased by Western States Gas & Electric Co.).	Feb. 26, 1907	1,500,000	1909–10	....	777,024	......	....
North Mountain Power Co., San Francisco (see Humboldt Gas & Electric Co.)	Sept. 24, 1902	500,000	1905–1910	1	284,000	......	....

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[a] The rate of dividends on preferred stock was 7 per cent, that on common stock was 0.1 per cent in 1911, 2 25 per cent in 1915–1918. Blank spaces indicate that no dividends were paid.

[b] Dividends were declared for 5 months, August to December, only.

[c] The subsidiary companies listed are no longer active. Little information on stock outstanding and dividends is available.

TABLE 221.—*Capitalization, outstanding stock, and dividends of Western States Gas & Electric Co. and subsidiaries*—Continued.

Subsidiary Companies—Continued.

Company.	Date of incorporation.	Capitalization.	Years (Dec. 31).	Par value of stock outstanding.		Dividends.	
				Per share.	Total.	Rate.	Amount.
Eureka Lighting Co., San Francisco; changed to Eureka, Dec. 30, 1908 (see Humboldt Gas & Electric Co.).	Mar. 15, 1894	$250,000	....	$100	....	......	....
Ferndale Electric Light Co., Ferndale, Calif.	Aug 11, 1896	10,000	....	1	....	......	....
Fortuna Lighting Co., Fortuna, Calif.	Oct. 22, 1904	60,000	....	1	....	......	....
Arcata Light & Power Co., Arcata, Calif.	Jan. 18, 1905	50,000	....	1	....	......	....
Richmond Light & Power Corporation, San Francisco.	June 6, 1910	2,500,000	....	100	....	......	....
Richmond Light & Power Co., San Francisco (successor to Richmond Light & Water Co., properties purchased by Western States Gas & Electric Co.).	Nov. 10, 1902	150,000	....	100	....	......	....
Richmond Light & Water Co., San Francisco.	Nov. 23, 1901	25,000	....	10	....	......	....

TABLE 222.—*Bonds of Western States Gas & Electric Co.*

Issue.	Callable.	Sinking-fund deposits.	Bond denomination.	Trustee.	Authorized.
1	2	3	4	5	6
1. Western States Gas & Electric Co. first and refunding sinking fund 5 per cent bonds dated June 1, 1911; due June 1, 1941. Interest payable June and Dec. 1.	At 105 and interest	One-half of 1 per cent of bonds issued Dec. 1, 1912, June 1, and Dec. 1, 1913, June 1, 1914, and Dec. 1, 1914. On the first day of June and December of each year up to and including June 1, 1919, 1 per cent; Dec. 1, 1919, and on first day of June and December in each year thereafter until maturity of bonds, 1¾ per cent of bonds issued.	$500 and $1,000 coupon.[a]	Girard Trust Co., Philadelphia, Pa.	$10,000,000
2. Western States Gas & Electric Co. first and refunding 5 per cent bonds dated Dec. 1, 1910; due Dec. 1, 1940. Interest payable June and December.	do	Two per cent of outstanding bonds from Dec. 1, 1913, to 1920, and 3 per cent from 1921 to 1939, inclusive.	do	do	10,000,000
3. Western States Gas & Electric Co. gold notes. Bonds dated Oct. 1, 1914; due Oct. 1, 1917. Interest payable Apr. and Oct. 1.	Oct. 1, 1916, at 101 per cent and at any interest date thereafter at 101½ per cent.	None	$100, $500, and $1,000 coupon.[a]	Guaranty Trust Co., New York, N. Y.	1,500,000
4. Western States Gas & Electric Co. 10-year 6 per cent notes. Bonds dated Feb. 1, 1917; due Feb. 1, 1927. Interest payable Feb. and Aug. 1.	Prior to Feb. 1, 1921, at 102 thereafter and prior to Feb. 1, 1925 at 101; thereafter at par on 30 days' notice.		$100, $500, and $1,000 coupon[a]; $1,000 registered.	do	5,000,000
5. Western States Gas & Electric Co. 5-year 6½ per cent collateral trust notes. Bonds dated Aug. 1, 1918; due Aug. 1, 1923. Interest payable Feb. and Aug. 1.	Prior to Feb. 1, 1921 at 102; thereafter until Feb. 1, 1923 at 101; on Feb. 1, 1923 at 100½ and interest.		$1,000 coupon[a]	Union Trust Co., San Francisco.	1,500,000
6. American River Electric Co. first sinking fund 5 per cent bonds dated July 1, 1903; due July 1, 1933. Interest payable Jan. and July 1.	After 5 years and before 11 years from date at 110. After 11 years and before 21 years at 107½. Thereafter at 100 and interest, plus a bonus of three-fourths for each year between date of call and maturity.	Cash payments July 1 of each year as follows: 1908 to 1912 not less than 1 per cent, 1913 to 1917 not less than 1½ per cent, 1918 to 1922 not less than 2 per cent, 1923 to 1927 not less than 2½ per cent, 1928 to 1932 not less than 3 per cent, of amount of bonds outstanding. Money so deposited is to be expended (*a*) in redeeming and canceling bonds of this issue; (*b*) in purchase of bonds of this issue, said bonds to be kept alive; (*c*) in purchase of other securities said securities to be kept alive.	do[a]	do	1,000,000

7. Stockton Gas & Electric Co. first 6 per cent bonds dated Jan. 1, 1909; due Jan. 1, 1934. Interest payable Jan. 1 and July 1.	On or after Jan. 1, 1914, at 106 and interest.	Three per cent per annum of bonds outstanding, commences in 1913 and runs to 1933.	$100, $500, and $1,000 coupon.[a]	U. S. Mortgage & Trust Co., New York.	1,500,000
8. Humboldt Gas & Electric Co. first 5 per cent bonds dated Oct. 1, 1908; due Oct. 1, 1938. Interest payable Apr. 1 and Oct. 1.	On any interest date at 105..........	$12,000 per annum, beginning Oct. 1, 1910, to be used in redemption of bonds.	$1,000 coupon.	Mercantile Trust Co., San Francisco.	630,000
9. Eureka Lighting Co. first 5 per cent bonds dated July 1, 1907; due July 1, 1937. Interest payable Jan. 1 and July 1.	....	$6,000 per annum from July 1, 1909..........	....do..........	Union Trust Co., San Francisco.	225,000

Issue.	Bonded debt.							Notes.
	Year.	Reserved for prior liens.	In sinking fund.		In treasury.	Held by public.	Total authenticated.	
			Canceled.	Alive.				
1	7	8	9	10	11	12	13	14
1. Western States Gas & Electric Co. first and refunding sinking fund 5 per cent bonds dated June 1, 1911; due June 1, 1941. Interest payable June and Dec. 1.	1911	$1,007,000	....	....	....	$2,393,000	$3,428,000	No further issue of refunding bonds can be made except (1) to retire underlying bonds; (2) for betterments and improvements at 75 per cent of cost, when net earnings for twelve months preceding have been at least twice the fixed charges on all bonds outstanding and contemplated to be issued. Secured by fiscal lien on property formerly belonging to the Richmond Light & Power Co. and by direct lien on all other property of the Western States Gas & Electric Co., subject at the date of the mortgage to $2,575,000 underlying bonds as follows: Humboldt Gas & Electric Co. $639,000 American River Electric Co. 972,000 Stockton Gas & Electric Corporation.............. 750,000 Eureka Lighting Co......... 214,000 2,575,000
	1912	452,000	....	....	....	3,548,000	4,028,000	
	1913	452,000	[b] $42,000	....	....	4,257,000	4,299,000	
	1914	452,000	[b] 94,000	....	$10,000	4,355,000	4,459,000	
	1915	452,000	[b] 198,000	....	22,000	4,665,000	4,885,000	
	1916	452,000	[b] 304,500	....	22,000	4,558,500	4,885,000	
	1917	452,000	[b] 412,500	....	7,000	4,465,500	4,885,000	
	1918	452,000	[b] 530,500	....	7,000	[c] 4,347,500	[d] 5,844,000	
	1919	452,000	[b] 665,500	....	52,500	4,464,500	[d] 6,141,500	
	1920	452,000	[b] 932,500	....	....	4,197,500	[e] 6,528,000	

[a] Principal may be registered.

[b] Bonds canceled have been cremated, not held intact

[c] Total par value actually outstanding at end of year; $966,000 nominally but not actually issued.

[d] Includes $959,000 pledged as collateral for notes dated Aug. 1, 1918.

[e] Includes $1,398,000 pledged as collateral for notes dated Aug. 1, 1918.

TABLE 222.—*Bonds of Western States Gas & Electric Co.*—Continued.

Issue.	Bonded debt.							Notes.
	Year.	Reserved for prior liens.	In sinking fund.		In treasury.	Held by public.	Total authenticated.	
			Canceled.	Alive.				
	7	8	9	10	11	12	13	14
2. Western States Gas & Electric Co. first and refunding 5 per cent bonds dated Dec. 1, 1910; due Dec. 1, 1940. Interest payable June and December.	1911	$2,500,000					$2,500,000	$2,500,000 of these bonds were deposited as a collateral for a $2,000,000 collateral-note issue. The collateral notes were retired in connection with the issue of the mortgage (No. 1) dated June 1, 1911.
3. Western States Gas & Electric Co. gold notes. Bonds dated Oct. 1, 1914; due Oct. 1, 1917. Interest payable Apr. and Oct. 1.	1914				$451,000	$280,000	731,000	By terms of mortgage, notes to the extent of $900,000 par value to be available for issue at date of indenture. $600,000 to be issued thereafter, providing earnings of company for payment of bond interest were three times the interest of the notes outstanding and new notes to be issued. Retired in 1917.
	1915					621,500	621,500	
	1916					621,500	621,500	
4. Western States Gas & Electric Co. 10-year 6 per cent notes. Bonds dated Feb. 1, 1917; due Feb. 1, 1927. Interest payable Feb. and Aug. 1.	1917					1,564,000	1,564,000	Unissued, $3,436,000.
	1918					1,564,000	1,564,000	Do.
	1919					1,564,000	1,564,000	Do.
	1920					1,564,000	1,564,000	Do.
5. Western States Gas & Electric Co. 5-year 6½ per cent collateral-trust notes. Bonds dated Aug. 1, 1918; due Aug. 1, 1923. Interest payable Feb. and Aug. 1.	1918					690,000	690,000	Reserved, $810,000.
	1919					690,000	690,000	Do.
	1920					990,000	990,000	Reserved, $510,000.
6. American River Electric Co. first sinking fund 5 per cent bonds dated July 1, 1903; due July 1, 1933. Interest payable Jan. and July 1.	1903							Closed under No. 2. By the terms of this mortgage, bonds to cover betterments and extensions could be issued only when net earnings were double the interest charges on bonds outstanding and those to be issued.
	1905							
	1906							
	1907							
	1908							
	1909							Secured by first lien on real and personal property of the American River Electric Co., in Eldorado, Calaveras, Amador, and San Joaquin counties, Calif.
	1910						1,000,000	
	1911			$28,000		584,000	612,000	
	1912			45,000		435,000	480,000	

	1913			61,000		419,000	480,000	$520,000 bonds of this issue had been acquired on or before Dec. 31, 1912, by the Western States Gas & Electric Co., and pledged as collateral under its first and refunding mortgage.
	1914			88,000		392,000	480,000	
	1915			98,000		382,000	480,000	
	1916			127,000		353,000	480,000	
	1917			149,000		331,000	480,000	
	1918			176,000		304,000	480,000	
	1919			205,000		275,000	480,000	
	1920			235,000		245,000	480,000	
7. Stockton Gas & Electric Co. first 6 per cent bonds dated Jan. 1, 1909; due Jan. 1, 1934. Interest payable Jan. and July 1.	1909							This issue refunded the 6 per cent mortgage issue of Stockton Gas & Electric Co. which was due March 1, 1905, but was extended to Jan. 1, 1909. This issue (No. 4) refunded by issue No. 1. Bonds were issuable for 75 per cent of cost of extensions and additions, but only when net earnings were double the interest charges on all bonds outstanding and those to be issued. A first lien on property of the Stockton Gas & Electic Corporation which was assumed by the Western States Gas & Electric Co. Refunded in 1911-12 by issuing Western States Gas & Electric Co. first and refunding sinking-fund bonds.
	1910						750,000	
	1911						395,000	
8. Humboldt Gas & Electric Co. first 5 per cent bonds dated Oct. 1, 1908; due Oct. 1, 1938. Interest payable Apr. and Oct. 1.	1908							All bonds outstanding were retired in June 1911. Although the North Mountain Co. (which was absorbed by the Humboldt Gas & Electric Co.) had authorized an issue of $200,000 first mortgage 5 per cent bonds—none of these had ever been authenticated.
	1909							
	1910						639,000	
9. Eureka Lighting Co. first 5 per cent bonds dated July 1, 1907; due July 1, 1937. Interest payable Jan. and July 1.	1907							All bonds outstanding were retired in June, 1911.
	1908							
	1910		$11,000			214,000	214,000	

Table 223.—*Comparative balance sheet of Western States Gas & Electric Co., 1910–1920.*

	1910	1911	1912	1913	1914
ASSETS.					
Total fixed capital	[a]$7,553,302	[a]$8,610,592	[a]$9,925,607	$10,066,284	$10,218,429
Cash and deposits:					
Cash				59,320	45,603
Special deposits				318	300
	26,073	46,077	70,068	59,638	45,903
Notes receivable				11,599	17,418
Accounts receivable:					
Accounts with system corporations				218	
Due from consumers and agents				132,366	120,550
	[b] 129,043	[b] 139,787	[b] 129,629	132,584	120,550
Investments:					
Securities of other corporations				48,827	48,828
Miscellaneous				35,032	[c] 35,057
				83,859	83,885
Materials and supplies	15,573	31,119	43,722	49,936	49,293
Sinking fund	16,414	12,160	19,187	23,145	47,111
Bonds redeemed	17,000	28,000	45,000	61,000	88,000
Treasury securities					461,000
Prepaid expenses:					
Prepaid insurance	4,020	3,873	3,469	3,015	1,665
Prepaid interest	22,500	107,300	43,255		
	26,520	111,173	46,724	3,015	1,665
Unamortized discount on securities and expenses:					
Bonds				523,558	559,958
Other suspense	1,650	10,610	20,461	63,793	58,775
Miscellaneous		42,083	55,352	17,054	13,047
Total assets	7,785,575	9,031,601	10,355,750	11,095,465	11,765,034
LIABILITIES.					
Capital stock	3,001,500	5,031,500	5,356,500	5,356,500	5,356,500
Funded debt	4,603,000	3,428,000	4,028,000	4,737,000	5,576,000
Notes payable		255,000	611,294	596,855	314,100
Accounts payable:					
Accounts with system corporations				21,300	55,166
Audited vouchers and wages unpaid				42,956	41,067
Consumers' deposits	4,833	8,530	15,902	16,730	17,682
Miscellaneous	89,562	3,638	58,732	813	990
	94,395	12,168	74,634	81,799	114,905
Interest accrued	[d]38,246	[d] 129,346	[d] 128,145	21,488	23,169
Taxes accrued	3,243	24,031	34,504	34,730	33,420
Dividends declared				98,067	98,068
Reserve for accrued depreciation				60,000	120,000
Miscellaneous	17,450	11,314	7,756	2,552	1,563
Corporate surplus unappropriated	27,741	140,242	114,917	106,474	127,309
Total liabilities	7,785,575	9,031,601	10,355,750	11,095,465	11,765,034

[a] Includes items which are listed under "Unamortized discount on securities and expenses" in sheets for 1913–1915.

[b] Includes notes receivable.

[c] Glass works.

[d] Includes dividends accrued.

TABLE 223.—*Comparative balance sheet of Western States Gas & Electric Co., 1910–1920*—Continued.

	1915	1916	1917	1918	1919	1920
ASSETS.						
Total fixed capital	$10,442,080	$10,879,856	$11,534,502	$11,936,681	$4,513,988	$5,262,292
Cash and deposits:						
Cash	244,580	56,108	24,487	112,609	172,357	105,365
Special deposits	300	300	300	300	300	300
	244,880	56,408	24,787	112,909	172,657	105,665
Notes receivable	11,310	4,171	682	996	585	1,984
Accounts receivable:						
Due from consumers and agents	131,506	143,878				
Miscellaneous accounts receivable			188,336	172,113	203,073	260,537
	131,506	143,878	189,018	172,113	203,073	260,537
Other current assets			30,282	250	153	23
Investments:						
Securities of other corporations	48,828	6,040	6,065	6,065	31,065	31,065
Miscellaneous	[c] 35,057	[c] 35,057				
	83,885	41,097	6,065	6,065	31,065	31,065
Materials and supplies	47,257	79,480	126,267	123,631	166,006	266,648
Sinking fund	61,319	52,786	52,753	63,802	112,946	120,035
Bonds redeemed	98,000	127,000	149,000	176,000	205,000	235,000
Treasury securities	22,000	22,000	7,000	148,900	133,300	290,600
Prepaid expenses:						
Prepaid insurance	1,396	1,485	1,283	1,754	3,050	1,807
Prepaid interest		3,789				
	1,396	5,274	1,283	1,754	3,050	1,807
Unamortized discount on securities and expenses:						
Stock			[e] 427,810	[e] 433,135	7,810	32,164
Bonds	[f] 627,501	606,860	231,499	235,670	[e] 427,810 [g] 217,058	[e] 427,810 [g] 146,245
	627,501	[g] 606,860	[h] 659,309	[h] 668,805	652,678	606,219
Other suspense	50,626	37,835	25,792	25,136	[i] 2,538	37,541
Leased signs and motors	8,328	7,289	9,737	12,655	12,005	13,888
Plant and franchise account			25,500		7,842,630	7,834,264
Depreciation and renewal fund			25,500		25,000	
Bonds deposited as collateral on 6½ per cent notes				959,000	959,000	1,398,000
Total assets	58,954	45,124	61,029	996,791	15,030,598	16,466,468
LIABILITIES.						
Capital stock	5,356,500	5,356,500	5,356,500	5,534,500	5,534,500	6,137,500
Funded debt	5,788,500	5,682,000	6,516,500	8,047,500	8,210,000	8,629,500
Notes payable	140,880	450,000	236,500	95,000	302,500	838,750
Accounts payable:						
Accounts with system corporations	22,141	10,261	79,493	27,195	103,690	181,466
Audited vouchers and wages unpaid	74,947	68,060	113,524	90,918	199,627	191,528
Consumers' deposits	15,589	12,402	16,113	18,391	21,421	81,067
Miscellaneous	1,033	1,013	941	931		
	113,710	91,736	210,071	137,435	324,737	454,061

[c] Glass works.
[e] Prior to Jan. 1, 1913.
[f] Includes $45,366 on notes Western States Gas & Electric Co., 3-year coupon.
[g] Subsequent to Jan. 1, 1913.
[h] Includes $41,561 on notes Western States Gas & Electric Co., 3-year coupon.
[i] Credit item.

TABLE 223.—*Comparative balance sheet of Western States Gas & Electric Co., 1910–1920*—Continued.

	1915	1916	1917	1918	1919	1920
LIABILITIES—continued.						
Interest accrued	$28,348	$28,316	$57,723	$75,770	$76,132	$83,887
Taxes accrued	7,654	40,335	48,575	73,083	35,327	89,224
Dividends declared	37,187	37,188	42,035	37,828	38,889	45,708
Reserve for accrued depreciation	210,000	237,782	269,640	331,419	374,935	431,627
Miscellaneous	2,569	471	5,255	14,200	....	....
Preferred stock in treasury subscribed but unissued	....	....	....	....	9,300	79,000
Corporate surplus unappropriated	144,740	139,606	98,497	61,961	124,278	177,210
Total liabilities	11,830,088	12,063,934	12,841,296	14,408,696	15,030,598	16,466,468

TABLE 224.—*Earnings and expenses of Western States Gas & Electric Co., 1910–1920.*

	1910	1911	1912	1913	1914
Electric operations:					
Operating revenues	$750,696	$866,399	$978,862	$880,653	$896,473
Operating expenses	332,881	368,332	463,076	493,142	486,844
Net operating electric revenue	[a] 417,815	[a] 498,067	[a] 515,786	387,511	409,629
Gas operations:					
Operating revenues	....	....	....	204,994	220,544
Operating expenses	....	....	....	103,741	102,731
Net operating gas revenue	....	....	....	101,253	117,813
Water operations:					
Operating revenues	....	....	....	....	....
Operating expenses	....	....	....	....	....
Net operating water revenue	....	....	....	....	....
Total net operating revenue	417,815	498,067	515,786	488,764	527,442
Add:					
Nonoperating revenue—					
Miscellaneous interest revenues	....	....	....	....	....
Miscellaneous nonoperating	....	....	....	....	....
Total nonoperating revenues	....	....	....	....	....
Gross corporate income	417,815	498,067	515,786	488,764	530,571
Deduct:					
Uncollectible bills	....	....	....	....	4,316
Interest accrued on funded debt	143,429	209,982	196,479	211,628	238,304
Other interest deductions	....	....	....	47,522	37,296
Amortization of debt discount and expense	....	....	....	....	3,926
Total deductions	143,429	209,982	196,479	259,150	283,842
Surplus for year	274,386	288,085	319,307	229,614	246,729

[a] For years 1910–1912 operating expenses of gas and electric are not segregated, and operating revenues as given include gas revenues as follows: 1910, $152,231; 1911, $166,780; 1912, $196,041.

TABLE 224.—*Earnings and expenses of Western States Gas & Electric Co., 1910–1920*—Continued.

	1915	1916	1917	1918	1919	1920
Electric operations:						
Operating revenues	$944, 193	$984, 300	$1,089,906	$1, 240, 428	$1,480,968	$1, 739, 075
Operating expenses	496, 433	509, 703	589, 131	722, 387	904, 168	1, 141, 089
Net operating electric revenue	447, 760	474, 597	500, 775	518, 041	576, 801	597, 986
Gas operations:						
Operating revenues	238, 734	255, 038	292, 121	368, 807	403, 920	471, 885
Operating expenses	110, 263	122, 359	153, 747	229, 412	263, 640	327. 378
Net operating gas revenue	128, 471	132, 679	138, 374	139, 395	140, 280	144, 508
Water operations:						
Operating revenues	....	....	20, 842	19, 760	14, 569	13, 950
Operating expenses	....	....	18, 189	18, 694	17, 485	16, 346
Net operating water revenue	....	....	2, 652	1, 066	b 2, 916	b 2, 396
Total net operating revenue	576, 231	607, 276	641, 802	658, 502	714, 165	740, 097
Add:						
Nonoperating revenue	....	....	....	....	1, 846	....
Gross corporate income	576, 231	607, 276	641, 802	658, 502	716, 010	740, 097
Deduct:						
Uncollectible bills	4, 773	5, 538	7, 871	8, 887	10, 262	11, 703
Nonoperating revenue deductions	....	....	....	....	....	....
Interest accrued on funded debt	276, 878	285, 239	306, 699	344, 225	373, 126	372, 953
Other interest deductions	3, 862	7, 014	18, 650	13, 263	5, 734	18, 425
Amortization of debt discount and expense	6, 690	12, 466	17, 424	28, 010	40, 486	42, 821
Miscellaneous deductions	....	....	....	....	....	....
Total deductions	292, 203	310, 257	350, 644	394, 385	429, 607	445, 901
Surplus for year	284, 028	297, 019	291, 158	264, 117	286, 402	294, 196

b Debit item.

TABLE 225.—*Classified electric revenues, Western States Gas & Electric Co., 1913–1920.*

Class of load.	1913		1914		1915	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$60, 004	6. 8	$62, 921	7. 0	$60, 687	6. 4
Incandescent	4, 307	. 5	4, 770	. 5	10, 205	1. 1
Commercial lighting—						
Flat rate	20, 009	2. 3	14, 389	1. 6	9, 137	1. 0
Metered	382, 199	43. 4	398, 744	44. 6	429, 652	45. 5
Commercial power—						
Flat rate	1, 846	. 2	1, 950	. 2	1, 106	. 1
Metered	346, 654	39. 3	345, 367	38. 5	367, 559	38. 9
Railway power	59, 364	6. 8	62, 018	6. 9	59, 472	6. 3
Joint electric rent revenue	1, 678	. 2	1, 485	. 1	1, 410	. 1
Miscellaneous electric	3, 441	. 4	3, 731	. 5	4, 129	. 5
Total operating revenues, electric	879, 502	99. 9	895, 405	99. 9	943, 357	99. 9
Other operating revenues:						
Rent of electric appliances	117	....	149	....	....	....
Electric merchandise and jobbing revenues	784	....	718	....	836	. 1
Sale of by-products	250	....	201	....	....	....
Total other operating revenues	1, 151	. 1	1, 068	. 1	836	. 1
Gross electric revenues	880, 653	100. 0	896, 473	100. 0	944, 193	100. 0

TABLE 225.—*Classified electric revenues, Western States Gas & Electric Co., 1913–1920*—Continued.

Class of load.	1916 Revenue.	1916 Per cent of gross electric revenues.	1917 Revenue.	1917 Per cent of gross electric revenues.	1918 Revenue.	1918 Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$63,203	6.4	$62,413	6	$65,406	5
Incandescent	11,633	1.2	12,270	1	12,576	1
Commercial lighting—						
Flat rate	8,230	.9	9,074	1	8,102	1
Metered	459,173	46.7	486,455	45	527,528	43
Commercial power—						
Flat rate	509	.0	293			
Metered	372,603	37.9	451,302	41	560,285	45
Railway power	62,066	6.3	59,316	5	59,952	5
Joint electric rent revenue	1,410	.1	1,440		1,350	
Miscellaneous electric	4,913	.5	5,004	1	4,098	
Total operating revenues, electric	983,739	100.0	1,087,567	100	1,239,297	100
Other operating revenues:						
Rent of electric appliances	65		67		45	
Electric merchandise and jobbing revenues	496		2,273		1,086	
Sale of by-products						
Total other operating revenues	561		2,339		1,131	
Gross electric revenues	984,300	100.0	1,089,906	100	1,240,428	100

Class of load.	1919 Revenue.	1919 Per cent of gross electric revenue.	1920 Revenue.	1920 Per cent of gross electric revenue.
Operating revenue, electric:				
Municipal street lighting—				
Arc	$64,610	4.4	$56,244	3.2
Incandescent	17,394	1.2	28,549	1.6
Commercial lighting—				
Flat rate	9,315	.7	10,199	.6
Metered	620,734	41.9	734,325	42.3
Commercial power—				
Metered	685,973	46.3	819,567	47.2
Railway power	75,663	5.2	83,259	4.7
Joint electric rent revenue	1,388		1,375	.1
Miscellaneous electric revenue	5,112	.3	4,689	.3
Total operating revenues, electric	1,480,190	100.0	1,739,075	100.0
Other operating revenues:				
Electric merchandise and jobbing revenues	779		683	
Sale of by-products			184	
Total other operating revenues	779		867	
Gross electric revenues	1,480,968	100.0	1,739,075	100.0

TABLE 226.—*Classified gross revenues of Western States Gas & Electric Co., Stockton system, 1900–1912.*

Year.	Gross revenue, electric.	Gross revenue, gas and miscellaneous.	Total.
1900	$57,241	$71,161	$128,402
1901	62,521	67,958	130,479
1902	65,685	70,723	136,408
1903	67,523	68,001	135,524
1904	109,644	73,916	183,560
1905	184,292	80,522	264,814
1906	247,459	95,384	342,843
1907	287,274	116,947	404,221
1908	337,813	144,486	482,299
1909	369,364	127,200	496,564
1910	400,285	134,035	534,320
1911	458,237	141,821	600,058
1912	508,273	166,674	674,947

TABLE 227.—*Capitalization, outstanding stock, and dividends of Snow Mountain Water & Power Co.*

[Term of incorporation, 50 years.]

Date of incorporation.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.		Dividends.	
			Preferred.	Common.	Preferred.	Common.
Feb. 13, 1906	$5,000,000	1906–1919	None.	$5,000,000	None.	None.
Feb. 26, 1920 (amended)	[a]10,000,000	1920	$1,222,000	4,300,000	None.	None.

[a] Common, $8,500,000; preferred, $1,500,000.

TABLE 228.—*Bonds of Snow Mountain Water & Power Co.*

Issue.	Year.	In sinking funds—canceled.	In hands of public.	Total authenticated.
Snow Mountain Water & Power Co., first mortgage 5 per cent gold bonds, dated Jan. 1, 1907, due Jan. 1, 1937.	1912–1916	....	$1,250,000	$1,250,000
	1917	$25,000	1,225,000	1,225,000
	1918	50,000	1,200,000	1,200,000
	1919	74,000	1,176,000	1,176,000
	1920	98,000	1,152,000	1,152,000

NOTE.—All the bonds issued by the Snow Mountain Water & Power Co. are in the hands of the controlling interests of the company. Bonds of this company are not listed in the San Francisco stock and bond exchange and are not dealt in by the general public.

TABLE 229.—*Comparative balance sheet of Snow Mountain Water & Power Co., 1912–1920.*

	1912	1913	1914	1915
ASSETS.				
Total fixed capital	$5,334,228.44	$5,336,315.12	$5,335,631.14	$5,334,884.48
Cash and deposits:				
Cash		1,249.13	434.30	6,026.10
Special deposits			20.30	
Total cash and deposits	678.92	1,249.13	454.60	6,026.10
Notes receivable	1,000.00	1,000.00	2,809.93	2,290.18
Accounts receivable:				
Accounts with system corporation		1,105.41	1,375.13	1,304.64
Due from consumers and agents		50.00	50.00	150.00
Miscellaneous accounts receivable			25.00	27.28
Total accounts receivable		1,155.41	1,450.13	1,481.92
Materials and supplies	8,612.55	8,612.55	8,612.55	
Treasury securities	700,000.00	700,000.00	700,000.00	700,000.00
Unamortized discount on securities and expenses:				
Stocks	300,000.00	300,000.00	300,000.00	300,000.00
Funded debt	39,622.72			
Bonds		39,622.72	39,622.72	39,622.72
	339,622.72	339,622.72	339,622.72	339,622.72
Miscellaneous	700.31			
Corporate deficit	70,528.71	104,291.49	115,470.07	120,291.82
Total assets	6,455,371.65	6,492,246.42	6,504,051.14	6,504,597.22
LIABILITIES.				
Capital stock (investment)	5,000,000.00	5,000,000.00	5,000,000.00	5,000,000.00
Funded debt	1,250,000.00	1,250,000.00	1,250,000.00	1,250,000.00
Notes payable	187,624.35	187,624.35	192,624.35	166,624.35
Accounts payable:				
Audited vouchers and wages unpaid			1,112.00	1,200.00
Miscellaneous accounts payable	17,747.30	9,603.33		
Total accounts payable	17,747.30	9,603.33	1,112.00	1,200.00
Interest accrued		13,934.46	3,440.60	3,440.60
Reserve for accrued depreciation		31,084.28	56,874.19	83,332.27
Total liabilities	6,455,371.65	6,492,246.42	6,504,051.14	6,504,597.22

TABLE 229.—*Comparative balance sheet of Snow Mountain Water & Power Co., 1912–1920*—Continued.

	1916	1917	1918	1919	1920
ASSETS.					
Total fixed capital	$5,332,716.00	$5,373,347.47	$5,374,299.71	$5,432,504.98	$5,462,702.02
Cash and deposits:					
Cash	5,452.57	5,505.86	21,194.74	26,390.27	
Special deposits					11,359.63
Total cash and deposits	5,452.57	5,505.86	21,194.74	26,390.27	11,359.63
Notes receivable	1,500.00	1,500.00			
Accounts receivable:					
Accounts with system corporation	453.49	230.56			
Due from consumers and agents	50.00	50.00	12,261.02	8,981.55	21,399.20
Miscellaneous accounts receivable	47.00	96.30		75.55	75.55
Total accounts receivable	550.49	376.86	12,261.02	9,057.10	21,474.75
Miscellaneous investments			30,594.75		
Treasury securities	700,000.00	700,000.00	700,000.00	700,000.00	978,000.00
Total prepaid expenses			3,460.00	1,780.00	100.00
Unamortized discount on securities and expenses:					
Stocks	300,000.00	300,000.00	300,000.00	85,000.00	146,100.00
Bonds	39,622.72	39,622.72	39,622.72	39,622.72	39,622.72
Total	339,622.72	339,622.72	339,622.72	124,622.72	185,722.72
Construction work in progress					1,101,050.10
Miscellaneous—bond security deposit					141,635.75
Corporate deficit	122,896.64	127,768.12	129,521.74	129,994.94	
Total assets	6,502,738.46	6,548,121.03	6,610,954.68	6,424,350.01	7,902,044.97
LIABILITIES.					
Capital stock (investment)	5,000,000.00	5,000,000.00	5,000,000.00	5,000,000.00	6,500,000.00
Funded debt	1,250,000.00	1,225,000.00	1,200,000.00	1,176,000.00	1,152,000.00
Notes payable	145,624.35	187,124.35		55,000.00	
Accounts payable:					
Audited vouchers and wages unpaid	600.00				
Miscellaneous accounts payable			35,000.00		239.52
Total accounts payable	600.00		35,000.00		239.52
Interest accrued	2,940.61	3,565.61			23,865.33
Reserve for accrued depreciation	103,573.50	132,431.07	160,954.68	193,350.01	225,940.12
Miscellaneous—assessment			215,000.00		
Total liabilities	6,502,738.46	6,548,121.03	6,610,954.68	6,424,350.01	7,902,044.97

TABLE 230.—*Earnings and expenses of Snow Mountain Water & Power Co., 1912–1920.*

	1912	1913	1914	1915	1916	1917	1918	1919	1920
Deficit Jan. 1	$92,677	$70,529	$104,292	$115,471	$120,293	$122,898	$127,769	$129,522	$131,060
Operating revenue	128,117	124,576	127,963	135,708	127,957	126,257	127,479	127,188	119,938
Operating expenses	40,597	72,530	66,489	68,461	62,667	65,240	68,960	69,353	72,035
Net operating revenue	87,520	52,046	61,474	67,247	65,290	61,017	58,519	57,835	47,903
Nonoperating revenue:									
Rents from buildings, lands, operations of others, etc	200	271	431	....	1,106	3,641	1,483	....	....
Interest and dividend revenue	....	....	....	....	43	3	....	....	....
Total nonoperating revenue	200	271	431	....	1,149	3,644	1,483	....	....
Gross corporate income	87,720	52,318	61,905	67,247	66,439	64,661	60,002	57,835	47,903
Deductions from gross income:									
Nonoperating revenue deductions	....	....	3,132	156	156	206	201	199	738
Interest accrued on funded debt	62,500	62,500	62,500	62,500	62,500	62,500	60,000	58,800	57,600
Other interest deductions	3,072	23,503	7,452	9,413	6,388	6,826	1,554	374	....
Amortization of debt discount and expenses	....	78	....	....	....	....	....	....	....
Amortization of capital, Russian River pumping plant	....	....	....	....	....	....	....	....	1,206
Total deductions from gross income	65,572	86,081	73,084	72,069	69,044	69,632	61,755	59,373	59,544
Surplus for year	22,148	....	....	....	....	....	....	....	....
Deficit for year	....	33,763	11,179	4,822	2,605	4,871	1,753	1,538	11,641
Deficit Dec. 31	70,529	104,292	115,471	120,293	122,898	127,769	129,522	131,060	143,701

TABLE 231.—*Classified revenues of Snow Mountain Water & Power Co., 1914–1920.*

	1914	1915	1916	1917	1918	1919	1920
Commercial lighting, metered	$127,533	$134,924	$126,808	$122,613	$125,996	$126,764	$119,638
Sale of water	246	355	328	326	374	424	278
Sundry earnings	184	429	821	3,318	1,109	....	322
Total	127,963	135,708	127,957	126,257	127,479	127,188	119,938

FINANCIAL TABLES FOR COAST COUNTIES GAS & ELECTRIC CO. AND PRINCIPAL SUBSIDIARIES.

TABLE 232.—*Capitalization, outstanding stock, and dividends of Coast Counties Gas & Electric Co. and principal subsidiaries.*

[Term of incorporation, uniformly 50 years. Unless otherwise stated in footnotes, par value of all stock is $100.]

Coast Counties Gas & Electric Co.

Company.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.			Dividends.[a]		
			Original preferred.	Prior preferred.	Common.	Original preferred.	Prior preferred.	Common.
Coast Counties Gas & Electric Co., San Francisco, Calif., incorporated Mar. 20, 1912.	$4,000,000	1912	$1,000,000	....	$1,000,000	[b]$45,000	....	......
		1913	1,000,000	....	1,000,000	60,000	....	......
		1914	1,000,000	....	1,000,000	60,000	....	......
		1915	1,000,000	$61,200	1,000,000	60,000	$1,173	......
		1916	1,000,000	100,000	1,000,000	60,000	4,833	......
		1917	1,000,000	100,000	1,000,000	[c]55,000	6,000	......
		1918	1,000,000	145,000	1,000,000	[d]20,000	7,614	......
		1919	1,000,000	158,600	1,000,000	....	9,006	......
		1920	1,000,000	167,000	1,000,000	....	9,832	......

Subsidiary companies.

Company.	Date of incorporation.	Capitalization.	Year (Dec. 31).	Par value of common stock outstanding.	Dividends.
Union Traction Co., Santa Cruz, Calif. (controlled by Coast Counties Gas & Electric Co. through ownership of entire capital stock).	Oct. 8, 1904	$750,000	[e]1905–1918	$750,000	([f])
Coast Counties Light & Power Co., San Francisco (property now owned by Coast Counties Gas & Electric Co.).	Mar. 5, 1906	1,500,000	[g]1907–1911	1,500,000	([h])
Big Creek Light & Power Co., San Francisco (property now owned by Coast Counties Gas & Electric Co.).	Feb. 13, 1907	500,000	([i])	([i])	([i])
San Benito Light & Power Co., San Francisco (property now owned by Coast Counties Gas & Electric Co.).	Apr. 5, 1909	250,000	1911	250,000	([i])
Watsonville Light & Power Co., San Francisco (purchased in fee by Coast Counties Light & Power Co.).	Feb. 27, 1904	250,000	1905–1908	250,000	([i])
Watsonville Water & Light Co., San Francisco (absorbed by Watsonville Light & Power Co.).	Dec. 5, 1896	500,000	([i])	([i])	([i])
Watsonville Gas Co., San Francisco (absorbed by Watsonville Light & Power Co.).	Sept. 30, 1901	[j]50,000	([i])	([i])	([i])
Santa Cruz Gas Co., Santa Cruz, Calif., (absorbed by Santa Cruz Electric Light & Power Co., which later became the property of the Coast Counties Light & Power Co.).	Nov. 16, 1867	36,000	([i])	([i])	([i])
Santa Cruz Electric Railway Co., Santa Cruz (consolidated with Santa Cruz, Capitola & Watsonville Ry. to form Union Traction Co.).	Aug. 25, 1892	([k])	([i])	([i])	([i])
Santa Cruz, Capitola & Watsonville Ry., Los Angeles, Calif. (consolidated with Santa Cruz Electric Ry. to form Union Traction Co.).	Sept. 16, 1902	350,000	([i])	([i])	([i])
Santa Cruz Electric Light & Power Co. (absorbed 1908 by Coast Counties Light & Power Co.).	....	300,000	1906–1908	154,540	([i])

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[a] Rate of dividends on all stock was 6 per cent except as noted.
[b] Dividends paid for 9 months only.
[c] Dividends paid for 9 months at 6 per cent and for 3 months at 4 per cent.
[d] Dividends discontinued June 25.
[e] Years ending June 30 instead of Dec. 31.
[f] No dividends paid.
[g] No data secured for years prior to 1911.
[h] Fifteen cents per share monthly, beginning September, 1907.
[i] No data obtainable.
[j] Par value of shares $10.
[k] No par value given.

NOTE.—Data not available for Santa Cruz Electric Light & Power Co., Cooperative Gas Co. of Santa Cruz, and the Pajaro Gas & Electric Co.

TABLE 233.—*Bonds of Coast Counties Gas & Electric Co.*

Issue.	Callable.	Sinking-fund deposits.	Trustee.	Denomination.	Authorized.
1	2	3	4	5	6
1. Coast Counties Light & Power Co. first-mortgage 5 per cent bonds dated Aug. 1, 1906; due Aug. 1, 1946; interest payable Feb. 1 and Aug. 1.	At 107½..............	One per cent of bonds annually, beginning June 30, 1911; bonds to be kept alive.	Mercantile Trust Co., San Francisco.	[a] $1,000	$1,000,000
2. Big Creek Light & Power Co. first-mortgage 4 per cent bonds dated May 1, 1907; due May 1, 1947; interest payable May 1 and Nov. 1.	At par on any interest date.	Beginning Mar. 30, 1908, $3,600 per annum to be applied to purchase of bonds of this issue; bonds to be kept alive.	.....do................	[a] 1,000	339,000
3. San Benito Light & Power Co. first-mortgage 6 per cent bonds dated Sept. 1, 1910; due Sept. 1, 1950; interest payable Mar. 1 and Sept. 1.	At 110 and interest....	One per cent annually of bonds outstanding, beginning June 30, 1915; bonds to be kept alive.	Anglo-California Trust Co., San Francisco.	[a] 1,000	209,000
4. Union Traction Co. first-mortgage 5 per cent bonds dated Feb. 1, 1905; due Feb. 1, 1935; interest payable Feb. 1 and Aug. 1.	After Feb. 1, 1910, at 110 and interest.	1910–1915 (beginning Feb. 1, 1910), one-half of 1 per cent of bonds outstanding annually; 1916–1920, 1 per cent; 1921–1933, 2 per cent; bonds in fund to be canceled.	Union Trust Co., San Francisco.	[a] 1,000	750,000
5. Coast Counties Gas & Electric Co. debenture 6 per cent bonds dated Jan. 1, 1914; due Jan. 1, 1924; interest payable Jan. 1 and July 1.	At 101 and interest....	No sinking fund..............................	Mercantile Trust Co., San Francisco.	[a] 1,000	300,000

Issue.	Year.	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total authenticated.	Notes.
			Canceled.	Alive.				
1	7	8	9	10	11	12	13	14
1. Coast Counties Light & Power Co. first-mortgage 5 per cent bonds dated Aug. 1, 1906; due Aug. 1, 1946; interest payable Feb. 1 and Aug. 1.	1912	....	....	$20,000	....	$980,000	$1,000,000	Closed mortgage.
	1913	....	....	32,000	....	968,000	1,000,000	
	1914	....	....	44,000	....	956,000	1,000,000	
	1915	....	....	57,000	....	943,000	1,000,000	
	1916	....	....	70,000	....	930,000	1,000,000	
	1917	....	....	84,000	....	916,000	1,000,000	
	1918	....	....	99,000	....	901,000	1,000,000	
	1919	....	....	115,000	....	885,000	1,000,000	
	1920	....	....	132,000	....	868,000	1,000,000	

2. Big Creek Light & Power Co. first-mortgage 4 per cent bonds dated May 1, 1907; due May 1, 1947; interest payable May 1 and Nov. 1.	1912	....	....	18,000	....	321,000	339,000	Do.
	1913	....	....	23,000	....	316,000	339,000	
	1914	....	....	27,000	....	312,000	339,000	
	1915	....	....	32,000	....	307,000	339,000	
	1916	....	....	37,000	....	302,000	339,000	
	1917	....	....	43,000	....	296,000	339,000	
	1918	....	....	48,000	....	291,000	339,000	
	1919	....	....	53,000	....	386,000	339,000	
	1920	....	....	59,000	....	380,000	339,000	
3. San Benito Light & Power Co. first-mortgage 6 per cent bonds dated Sept. 1, 1910; due Sept. 1, 1950; interest payable Mar. 1 and Sept. 1.	1912	....	....	....	[b] $50,000	150,000	150,000	Do.
	1913	....	....	....	[b] 50,000	150,000	150,000	
	1914	....	....	....	[b] 50,000	150,000	150,000	
	1915	....	....	....	[b] 50,000	150,000	150,000	
	1916	....	....	2,000	[b] 50,000	148,000	150,000	
	1917	....	....	4,000	[b] 50,000	146,000	150,000	
	1918	....	....	5,000	[b] 50,000	145,000	150,000	
	1919	....	....	7,000	[b] 50,000	143,000	200,000	
	1920	....	....	7,000	[b] 50,000	143,000	200,000	
4. Union Traction Co. first-mortgage 5 per cent bonds dated Feb. 1, 1905; due Feb. 1, 1935; interest payable Feb. 1 and Aug. 1.	[c] 1912	....	$11,000	....	[b] 100,000	639,000	639,000	
	[c] 1913	....	15,000	....	[b] 100,000	635,000	635,000	
	[c] 1914	....	19,000	....	[b] 100,000	631,000	631,000	
	[c] 1915	....	19,000	....	[b] 100,000	631,000	631,000	
	[c] 1916	....	19,000	....	[b] 100,000	631,000	631,000	
	1917	....	19,000	....	[b] 100,000	631,000	631,000	
	1918	....	19,000	....	[b] 100,000	631,000	631,000	
	1919	....	19,000	....	[b] 100,000	631,000	631,000	
	1920	....	19,000	....	[b] 100,000	631,000	631,000	
5. Coast Counties Gas & Electric Co. debenture 6 per cent bonds dated Jan. 1, 1914; due Jan. 1, 1924; interest payable Jan. 1 and July 1.	1915	....	....	....	[b] 150,000	150,000	150,000	
	1916	....	....	....	[b] 150,000	150,000	150,000	
	1917	....	....	....	[b] 150,000	150,000	150,000	
	1918	....	....	....	[b] 150,000	150,000	150,000	
	1919	....	....	....	[b] 150,000	150,000	150,000	
	1920	....	....	....	[b] 150,000	150,000	150,000	

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[a] Coupon bonds; principal may be registered.

[b] Unissued.

[c] Year ending June 30.

NOTE.—No provisions for conversion made for any of the bonds illustrated in this table.

TABLE 234.—*Comparative balance sheet of Coast Counties Gas & Electric Co., 1912 1920.*

	1912	1913	1914	1915	1916
ASSETS.					
Total fixed capital	$2,583,651	$2,713,551	$2,764,526	$2,788,841	$2,813,254
Cash and deposits:					
Cash	6,679	3,281	3,585	1,632	10,186
Special deposits	....	1,025	1,025	1,288	1,151
Total cash and deposits	6,679	4,306	4,610	2,920	11,337
Notes receivable	....	31,993	14,649	11,802	12,080
Accounts receivable:					
Accounts with system corporations	....	....	....	15,162	15,431
Due from consumers and agents	....	59,919	61,957	58,214	52,338
Miscellaneous accounts receivable	....	....	9,704	10,000	8,472
Total accounts receivable	[a] 48,691	59,919	71,661	83,376	76,241
Interest and dividends receivable	....	1,429	....	....	....
Investments:					
Securities of other corporations	....	2,000	855,180	855,180	855,955
Advance to system corporations	....	855,180	....	....	....
Miscellaneous investments	....	775	775	....	....
Total investments	893,180	857,955	855,955	855,180	855,955
Materials and supplies	27,866	26,444	24,489	25,140	28,524
Sinking funds	....	57,441	74,350	93,636	113,629
Treasury securities	31,000	2,050,000	2,200,000	....	....
Prepaid expenses:					
Prepaid taxes	....	563	....	475	....
Prepaid insurance	....	974	860	523	1,114
Other prepayments	....	2,912	2,861	1,043	....
Total prepaid expenses	....	4,449	3,721	2,041	1,114
Unamortized discount on securities and expenses:					
Stocks	....	....	....	6,693	11,273
Bonds	....	....	10,427	....	....
Miscellaneous	....	....	989	9,269	8,257
Total unamortized discount on securities and expenses	....	....	11,416	15,962	19,530
Other suspense	....	358	7,119	1,209	....
Construction work in progress	....	9,069	....	154	12,004
Miscellaneous	20,815	....	....	....	....
Total assets	3,611,883	5,816,914	6,032,496	3,880,261	3,943,598
LIABILITIES.					
Capital stock	2,000,000	4,000,000	4,000,000	2,061,200	2,100,000
Installments on stock subscriptions	....	....	....	....	....
Funded debt	1,489,000	1,539,000	1,839,000	1,639,000	1,639,000
Notes payable	20,000	108,937	66,604	42,847	54,723
Accounts payable:					
Accounts with system corporations	....	7,549	....	....	....
Audited vouchers and wages unpaid	53,221	87,273	6,242	25,163	20,265
Consumers' deposits	5,951	7,415	5,631	5,144	4,811
Miscellaneous accounts payable	....	....	26,186	....	469
Total accounts payable	59,172	102,237	38,059	30,307	25,545
Interest accrued	26,093	27,962	30,825	30,984	31,042
Taxes accrued	....	....	527	....	....
Reserve for accrued depreciation	2,160	2,160	20,580	40,580	58,180
Casualty and insurance reserves	....	1,361	3,636	6,482	7,259
Reserves invested in sinking fund	....	....	....	....	....
Other reserves from income or surplus	....	....	....	155	1,374
Corporate surplus unappropriated	15,458	35,257	33,265	28,706	26,475
Total liabilities	3,611,883	5,816,914	6,032,496	3,880,261	3,943,598

[a] Includes notes receivable.

TABLE 234.—*Comparative balance sheet of Coast Counties Gas & Electric Co., 1912–1920*—Continued.

	1917	1918	1919	1920
ASSETS.				
Total fixed capital	$2,859,679	$2,904,410	$2,987,477	$3,124,044
Cash and deposits:				
Cash	15,510	19,208	23,377	19,026
Special deposits	1,793	1,572	1,434	1,425
Total cash and deposits	17,303	20,780	24,811	20,451
Notes receivable	2,653	2,311	1,698	925
Accounts receivable:				
Accounts with system corporations	12,859	12,859	12,859	10,287
Due from consumers and agents	50,169	51,579	46,109	53,789
Miscellaneous accounts receivable	12,916	6,120	12,237	9,036
Total accounts receivable	75,944	70,558	71,205	73,112
Interest and dividends receivable	159	....	....	....
Investments:				
Securities of other corporations	865,139	867,484	869,265	874,419
Advance to system corporations	....	....	....	....
Miscellaneous investments	....	....	....	....
Total investments	865,139	867,484	859,265	874,419
Materials and supplies	46,390	43,733	40,654	50,317
Sinking fund	134,772	154,878	177,792	202,563
Treasury securities	....	....	....	....
Prepaid expenses:				
Prepaid taxes	....	7,875	1,998	....
Prepaid insurance	789	393	1,016	767
Other prepayments	....	106	32	5,882
Total prepaid expenses	789	8,374	3,046	6,650
Unamortized discount on securities and expenses:				
Stocks	11,483	18,425	20,470	21,585
Bonds	7,077	5,898	4,718	3,539
Miscellaneous	....	....	....	....
Total unamortized discount on securities and expenses	18,560	24,323	25,188	25,124
Other suspense	....	....	....	....
Construction work in progress	25,642	17,323	7,018	....
Miscellaneous	....	....	....	....
Total assets	4,047,031	4,114,174	4,208,154	4,377,605
LIABILITIES.				
Capital stock	2,100,100	2,145,000	2,158,600	2,167,000
Installments on stock subscription	557	963	89	270
Funded debt	1,639,000	1,639,000	1,639,000	1,639,000
Notes payable	115,333	87,231	14,000	13,800
Accounts payable:				
Accounts with system corporations	....	....	....	....
Audited vouchers and wages unpaid	30,324	41,984	67,744	68,026
Consumers' deposits	5,318	9,517	15,670	20,757
Miscellaneous accounts payable	....	....	....	....
Total accounts payable	35,642	51,501	80,415	88,783
Interest accrued	31,86	31,139	31,145	30,593
Taxes accrued	....	253	....	8,631
Reserve for accrued depreciation	82,180	118,429	164,620	217,287
Casualty and insurance reserve	10,184	12,533	17,110	22,119
Reserve invested in sinking fund	....	4,440	11,845	20,620
Other reserves from income or surplus	1,247	1,861	[b] 3,162	256
Miscellaneous accrued expenses	....	....	1,650	4,760
Corporate surplus unappropriated	31,602	21,824	92,842	164,486
Total liabilities	4,047,031	4,114,174	4,208,154	4,377,605

[b] Debit item.

TABLE 235.—*Earnings and expenses of Coast Counties Gas & Electric Co., 1909–1920.*

Account.	1909	1910	1911	1912	1913	1914
Electric operations (see note):						
Operating revenue	$193,677	$237,047	[a]$274,323	$238,417	$269,662	$252,501
Operating expenses	122,859	139,067	145,981	125,618	159,035	136,667
Net operating electric revenue	70,818	97,980	128,342	112,799	110,627	115,834
Gas operations:						
Operating revenue					90,798	96,960
Operating expenses					54,299	69,031
Net operating gas revenue					36,499	27,929
Total net operating revenue	70,818	97,980	128,342	112,799	147,126	143,763
Add:						
Nonoperating revenues—						
Union Traction Co	16,313	15,057	[b] 14,793			
Rents accrued from lease of electric plant						
Interest and dividend revenues—						
Interest revenue on funded debt owned				619		
Dividend revenue					1,889	
Miscellaneous interest revenues					207	333
Total interest and dividend revenues				619	2,097	333
Sinking and reserved fund accretions						
Profits from operations of others				1,413		
Miscellaneous nonoperating revenue				454	3,369	
Total nonoperating revenues				2,486	5,466	333
Gross corporate income	87,131	113,037	143,135	115,285	152,592	144,096
Deduct:						
Uncollectible bills						
Rent expenses						
Interest expenses					5,983	
Nonoperating taxes						661
Total nonoperating revenue deductions					5,983	661
Interest accrued on funded debt	57,576	63,560	[c] 69,560	54,420	70,173	75,925
Other interest deductions				407		6,055
Amortization of debt discount and expense						800
Miscellaneous deductions from income						
Rent deductions						
Total deductions	57,576	63,560	69,560	54,827	76,156	83,441
Surplus for year	29,555	49,477	73,575	60,458	76,436	60,655

[a] Earnings from Hollister division for 8 months only.
[b] Increased taxes of $824.07 over 1910 charged against operating.
[c] Bond interest of San Benito Light & Power Co. on $150,000, 6 per cent, for 8 months only.

TABLE 235.—*Earnings and expenses of Coast Counties Gas & Electric Co., 1909–1920*—Continued.

Account.	1915	1916	1917	1918	1919	1920
Electric operations (see note):						
Operating revenue	$247,475	$262,828	$286,148.91	$299,748.85	$376,071	$459,735
Operating expenses	126,170	136,863	156,118.42	198,295.01	222,867	300,595
Net operating electric revenue	121,305	125,965	130,030.49	101,453.84	153,204	159,140
Gas operations:						
Operating revenue	89,977	100,837	104,279.52	121,065.29	143,721	173,688
Operating expenses	67,240	75,329	85,648.92	112,352.33	127,872	165,450
Net operating gas revenue	22,737	25,508	18,630.60	8,712.96	15,850	8,238
Total net operating revenue	144,042	151,473	148,661.09	110,166.80	169,054	167,378
Add:						
Nonoperating revenues—						
Union Traction Co.	....	....	....	....	....	....
Rents accrued from lease of electric plant	....	....	....	....	....	....
Miscellaneous rent revenues (electric)	....	....	....	....	....	187
Miscellaneous rent revenues (gas)	....	....	....	....	203	340
Interest and dividend revenues—						
Interest revenue on funded debt owned	....	....	....	....	....	500
Miscellaneous interest revenues	271	....	444.52	450.16	240	117
Total interest and dividend revenues	271	....	444.52	450.16	240	617
Sinking and reserve fund accretions	....	5,023	6,049.16	....	....	....
Profits from operations of others	....	....	....	....	....	....
Miscellaneous nonoperating revenue	487	315	285.00	433.60	2,847	2,434
Total nonoperating revenues	758	5,338	6,778.68	883.76	3,391	3,578
Gross corporate income	144,800	156,811	155,439.77	111,050.56	172,444	170,956
Deduct:						
Uncollectible bills	....	1,939	2,105.53	2,197.24	4,032	4,840
Rent expenses	1,590	1,749	1,880.04	....	....	....
Nonoperating taxes	....	359	191.22	304.66	427	312
Total nonoperating revenue deductions	1,590	4,047	4,176.78	2,501.90	4,459	5,152
Interest accrued on funded debt	77,374	81,561	81,560.00	81,560.00	81,560	81,560
Other interest deductions	6,635	2,522	3,904.14	6,334.26	2,897	615
Amortization of debt discount and expense	....	1,162	1,179.48	1,179.48	1,179	1,179
Miscellaneous deductions from income	....	....	....	....	....	....
Rent deductions	....	....	....	2,986.50	3,708	3,451
Total deductions	85,599	89,292	90,820.41	94,562.14	93,803	91,958
Surplus for year	59,201	67,519	64,619.36	16,488.42	78,641	78,998

NOTE.—In operating revenues, operating expenses, and net operating revenues for 1909 to 1912 electricity and gas are not segregated. Net operating revenue of Union Traction Co. listed only up to the end of 1911.

TABLE 236.—*Classified revenues, Coast Counties Gas & Electric Co., 1913–1920.*

Class of load.	1913		1914		1915	
	Revenues.	Per cent of gross electric revenues.	Revenues.	Per cent of gross electric revenues.	Revenues.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$10,464	3.9	$10,658	4.2	$10,664	4.3
Incandescent	7,321	2.7	7,834	3.1	8,159	3.3
Municipal lighting, miscellaneous	422	.1	973	.4	593	.2
Municipal power	7,313	2.7	3,203	1.3	2,166	.9
Commercial lighting—						
Flat rate	7,853	2.9	6,672	2.6	5,737	2.3
Metered	127,948	47.4	128,374	50.9	128,527	51.9
Commercial power—						
Flat rate	966	.4	1,126	.4	388	....
Metered	107,376	39.9	89,232	35.3	88,351	35.7
Other electric corporations	....	....	....	....	....	....
Miscellaneous electric	....	....	634	.3	1,150	.5
Rent of meters	....	....	....	....	....	....
Total operating revenues, electric	269,663	100.0	248,706	98.5	245,736	99.3
Other operating revenues:						
Rent of electric appliances	....	....	....	....	....	....
Electrical merchandise and jobbing revenue	....	....	66	....	153	....
Steam sales revenues	....	....	3,729	1.5	1,586	.7
Total other operating revenues	....	....	3,795	1.5	1,739	.7
Gross electric revenues	269,663	100.0	252,501	100.0	247,475	100.0

Class of load.	1916		1917		1918	
	Revenues.	Per cent of gross electric revenues.	Revenues.	Per cent of gross electric revenues.	Revenues.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$10,937	4.2	$11,429	4.0	$11,674	3.8
Incandescent	8,266	3.1	8,248	2.8	8,265	2.4
Municipal lighting, miscellaneous	1,077	.4	2,051	.7	2,306	.7
Municipal power	2,686	1.0	6,218	2.0	6,353	1.2
Commercial lighting—						
Flat rate	5,090	1.9	....	....	....	....
Metered	144,688	55.0	147,410	51.4	152,300	52.6
Commercial power—						
Flat rate	165	....	....	....	....	....
Metered	85,669	32.6	103,215	36.6	113,086	37.6
Other electric corporations	....	....	2,440	.8	2,735	.8
Miscellaneous electric	1,907	.7	2,282	.8	1,217	.4
Rent of meters	26	....	47	....	36	....
Total operating revenues, electric	260,511	99.1	283,340	99.1	297,972	99.5
Other operating revenues:						
Rent of electric appliances	48	....	88	....	73	....
Electrical merchandise and jobbing revenue	2,268	.9	2,721	.9	1,703	.5
Total other operating revenues	2,316	.9	2,809	.9	1,776	.5
Gross electric revenues	262,827	100.0	286,149	100.0	299,748	100.0

TABLE 236.—*Classified revenues, Coast Counties Gas & Electric Co., 1913–1920*—Continued.

Class of load.	1919		1920	
	Revenues.	Per cent of gross electric revenues.	Revenues.	Per cent of gross electric revenues.
Operating revenue, electric:				
Municipal street lighting—				
Arc	$12,437	3.3	$12,558	2.7
Incandescent	8,767	2.4	8,572	1.8
Municipal lighting, miscellaneous	2,659	.5	3,229	.7
Municipal power	8,308	2.3	7,715	1.7
Commercial lighting—				
Flat rate	....	....	....	....
Metered	189,834	50.5	221,783	48.3
Commercial power—				
Flat rate	....	....	....	....
Metered	148,256	39.4	198,766	43.2
Other electric corporations	4,367	1.2	6,405	1.4
Miscellaneous electric	....	....	....	....
Rent of meters	25	....	23	....
Total operating revenues, electric	374,653	99.6	459,051	99.8
Other operating revenues:				
Rent of electric appliances	12	....	11	....
Electric merchandise and jobbing revenue	1,406	.4	673	.1
Steam sales revenue	....	....	....	....
Total other operating revenues	1,418	.4	684	.1
Gross electric revenues	376,071	100.0	459,735	100.0

FINANCIAL TABLES FOR SAN JOAQUIN LIGHT & POWER CORPORATION AND PRINCIPAL SUBSIDIARIES.

TABLE 237.—*Capitalization, outstanding stock, and dividends of San Joaquin Light & Power Corporation and principal subsidiaries.*

[Term of incorporation, uniformly 50 years. Par value of all stock is $100 unless stated otherwise in footnotes.]

San Joaquin Light & Power Corporation, Fresno, Calif.

Company.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.			Dividends.[a]		
			Prior preferred.	Preferred.	Common.	Prior preferred.	Preferred.	Common.
San Joaquin Light & Power Corporation, incorporated July 19, 1910.	$25,000,000	1910		$5,500,000	$10,000,000			
		1911		6,500,000	11,000,000			
		1912		6,500,000	11,000,000		$385,991.86	
		1913		6,500,000	11,000,000		390,000.00	
		1914		6,500,000	11,000,000		97,500.00	
		1915		6,500,000	11,000,000			
		1916		6,500,000	11,000,000			
		1917		6,500,000	11,000,000		292,500.00	
		1918		6,500,000	11,000,000		390,000.00	
		1919		6,500,000	11,000,000		390,000.00	
		1920	$1,240,200	6,500,000	11,000,000	$43,996.00	390,000.00	

Predecessors and subsidiary companies.[b]

Company.	Date of incorporation.	Capitalization.	Par value of common stock outstanding.	Dividends.
San Joaquin Light & Power Co., Los Angeles	May 13, 1905	$3,000,000		
San Joaquin Power Co., Los Angeles	Aug. 11, 1902	800,000		
San Joaquin Electric Co., Fresno, Calif.	Apr. 2, 1895	800,000		
Merced Falls Gas & Electric Co., San Francisco	Sept. 7, 1899	[c] 250,000		
Power Transit & Light Co., San Francisco	Dec. 24, 1902	2,500,000		
Bakersfield Gas & Electric Light Co., Bakersfield, Calif.	June 7, 1890	100,000		
Bakersfield & Kern Electric Railway Co., Bakersfield, Calif.	Mar. 26, 1910	250,000		
Power Development Co., San Francisco	Oct. 26, 1894	500,000		
Selma Water Works, Fresno, Calif.	Mar. 11, 1908	75,000		
Madera Water Works, Fresno, Calif.	Mar. 6, 1908	50,000		
Madera Electric Water Co., Madera, Calif.	Mar. 16, 1907	50,000	$50,000	
Lemoore Light & Power Co., Fresno, Calif.	Apr. 21, 1909	50,000		
Madera Light & Power Co., Fresno, Calif.	Sept. 24, 1908	50,000		
Midway Light & Power Co., Maricopa, Calif.	Sept. 8, 1910	250,000		

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[a] The rate of dividends on preferred stock was 6 per cent in 1912 and 1913, 1½ per cent in 1914, 4½ per cent in 1917, and 6 per cent in 1918, no dividends being paid in 1915-16. Blanks in columns indicate that no dividends were paid.

[b] All the companies in this system except San Joaquin Light & Power Corporation and Bakersfield & Kern Electric Railway Co. are inactive. No dividends have been paid.

[c] Par value of share, $10.

TABLE 237.—*Capitalization, outstanding stock, and dividends of San Joaquin Light & Power Corporation and principal subsidiaries*—Continued.

Midland Counties Public Service Corporation, Fresno, Calif.

Company.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.		Dividends.[d]	
			Preferred.	Common.	Preferred.	Common.
Midland Counties Public Service Corporation, Fresno, Calif. (incorporated Nov. 26, 1900, as Coalinga Water & Electric Co.; name changed in 1912).	$2,000,000	1913	$500	$1,000,000	....	......
		1914	500	1,000,000	$2.50	......
		1915-1918	500	1,000,000	....	......

Subsidiary companies of Midland Counties Public Service Corporation.

Company.	Date of incorporation.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.		Dividends.	
				Preferred.	Common.	Preferred.	Common.
Coalinga Water & Electric Co., Fresno, Calif.	Nov. 20, 1909	$2,000,000	1909	....	....	....	......
			1910	....	....	....	......
			1911	....	....	....	......
			1912	....	....	....	......
Midland Counties Gas & Electric Co., San Francisco.	Feb. 2, 1912	1,000,000	1911	....	....	....	......
			1912	....	....	....	......
San Luis Gas & Electric Co., San Francisco.	Apr. 13, 1903	200,000	....	....	....	....	......
Santa Maria Electric & Gas Co., Los Angeles, Calif.	Aug. 14, 1907	250,000	(e)	....	....	....	......
Paso Robles Light & Water Co., El Paso de Robles, Calif.	Mar. 13, 1906	100,000	1906-1913	....	....	....	......
Russell Robinson Light & Water Co., Arroyo Grande, San Luis Obispo, Calif.	Apr. 30, 1906	50,000	....	....	....	....	......

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[d] The rate of interest on preferred stock was 0.5 per cent in 1914. No other dividends declared.

[e] Dissolved by decree of the superior court of Los Angeles County in November, 1912.

TABLE 238.—*Bonds of San Joaquin Light & Power Corporation and principal subsidiaries (including Midland Counties Public Service Corporation).*

Issue.	Callable.	Sinking-fund deposits.	Denomination of bond.	Trustee.	Total issue authorized.
1	2	3	4	5	6
1. San Joaquin Light & Power Corporation first and refunding mortgage 6 per cent bonds, series A, dated Aug. 1, 1910; due Aug. 1, 1950, interest payable Feb. 1 and Aug. 1.	On any interest date at 102½	$100,000 per annum Aug. 1, 1915, to Aug. 1, 1924; from 1925 to 1930, 2½ per cent of bonds outstanding; thereafter increasing to maximum of 4½ per cent from 1945 to 1949. Bonds are to be kept alive.	a $1,000	Equitable Trust Co., New York.	$25,000,000
2. San Joaquin Light & Power Corporation first and refunding mortgage 5 per cent bonds, series B, dated Aug. 1, 1910; due Aug. 1, 1950; interest payable Feb. 1 and Aug. 1.	On any interest date at 105	do	a 1,000	do	
3. San Joaquin Light & Power Corporation 6 per cent bonds, series B, dated Aug. 1, 1910; due Aug. 1, 1950; interest payable Feb. 1 and Aug. 1.	Same as issue 1	do	a 1,000	do	
4. San Joaquin Light & Power Corporation 6 per cent bonds, series C, dated Aug. 1, 1910; due Aug. 1, 1950; interest payable Feb. 1 and Aug. 1.	do	do	a 1,000	do	
5. San Joaquin Light & Power Corporation collateral trust 6 per cent notes, dated Aug. 1, 1913; due Aug. 1, 1915; interest payable Feb. 1, May 1, Aug. 1, and Nov. 1.	On any interest date at 101		a 1,000	Savings Union Bank & Trust Co., San Francisco.	1,875,000
6. San Joaquin Light & Power Corporation 6 per cent notes, convertible debentures, series A, dated May 1, 1917; due May 1, 1927; interest payable May 1 and Nov. 1.	On any interest date prior to May 1, 1922, at 102 and thereafter at 101 and interest.	None	a 1,000	Security Trust & Savings Bank, Los Angeles.	4,500,000
7. San Joaquin Light & Power Corporation 6 per cent notes, convertible debentures, series B, dated May 1, 1917; due May 1, 1927; interest payable May 1 and Nov. 1.	On any interest date prior to May 1, 1924, at 102, and thereafter at 101 and interest.		a 1,000	do	
8. San Joaquin Light & Power Corporation convertible collateral trust 8 per cent bonds, dated Nov. 1, 1920; due Nov. 1, 1935; interest payable May 1 and Nov. 1.	On any interest date at 104		1,000, 500	Union Bank & Trust Co.	5,000,000

9. San Joaquin Light & Power Corporation collateral trust 7 per cent notes, dated Mar. 1, 1908; due Mar. 1, 1911.	....	....	100 500	Columbia Trust Co. Los Angeles.	50,000
10. San Joaquin Light & Power Co. first sinking fund 5 per cent bonds, dated July 24, 1905; due July 24, 1945; interest payable June 1 and Dec. 1.	On and after Aug. 24, 1910, at 110 and interest.	1½ per cent of outstanding bonds per annum from June 1, 1910, to June 1, 1919; 2 per cent from June 1, 1920, to June 1, 1940.	*a* 1,000	Union Trust Co., San Francisco.	3,000,000
11. San Joaquin Power Co. first-mortgage 5 per cent bonds, dated Dec. 1, 1902; due Dec. 1, 1942; interest payable June 1 and Dec. 1.	....	1½ per cent of bonds outstanding, beginning Jan. 1, 1907.	*a* 1,000	.....do...............	800,000
12 Selma Light & Water Co. first-mortgage 5 per cent bonds, dated Jan. 1, 1902; due serially to 1920; interest payable Jan. 1 and July 1.	....	Sufficient funds to retire entire issue serially.	....	Individuals..........	20,000
13 Power Transit & Light Co. bonds, dated June 1, 1903; due June 1, 1933; interest payable June 1 and Dec. 1.	On any interest date at 4½ per cent, reinvestment basis.	10 per cent of net earnings, beginning June 1, 1908. Bonds in fund to be kept alive.	1,000	Mercantile Trust Co., San Francisco.	2,500,000
14 Bakersfield & Kern Electric Ry. first-mortgage 5 per cent bonds, dated 1901; due July 1, 1931; interest payable Jan. 1 and July 1.	....	10 per cent of net earnings from May 1, 1908, the annual minimum to be $2,500.	*a* 1,000	Union Trust Co., San Francisco.	250,000
15. Bakersfield Gas & Electric Light Co. first-mortgage 6 per cent bonds, dated Aug. 15, 1901; due Aug. 15, 1911 to Aug. 15, 1921, serially, $20,000; interest payable monthly.	....	Sufficient funds to be deposited monthly to discharge all bonds at maturity.	....	Title Insurance & Trust Co., Los Angeles.	50,000
Midland Counties system.					
16. Midland Counties Public Service Corporation first and refunding 6 per cent bonds, dated Oct. 1, 1915; due Oct. 1, 1953; interest payable Apr. 1 and Oct. 1.	On any interest date after Oct. 1, 1918, at 107½ and interest.	Annual deposits are as follows: 2 per cent of bonds outstanding Oct. 1, 1916, to 1925; 2½ per cent, 1926 to 1935; 3 per cent, 1936 to 1953.	1,000	Securities Trust & Savings Bank, Los Angeles.	3,000,000
17. Midland Counties Gas & Electric Co. first-mortgage 6 per cent bonds, dated Jan. 1, 1912; due Jan. 1, 1932; interest payable Jan. 1 and July 1.	On any interest date after Jan. 1, 1915, at 105 and accrued interest.	2 per cent per annum, of which 1 per cent is to be expended for permanent improvements and 1 per cent in purchasing bonds of this issue.	1,000	Los Angeles Trust & Savings Bank, Los Angeles.	1,000,000
18. Coalinga Water & Electric Co. first-mortgage 6 per cent bonds, dated Jan. 1, 1910; due Jan. 1, 1940; interest payable Jan. 1 and July 1.	At 101 and interest....................	Annual deposits on outstanding bonds as follows: Dec. 31, 1913, to Dec. 31, 1917, 1½ per cent; 1918 to 1923, 2½ per cent; 1923 to 1927, 2½ per cent; 1928 to 1939, 3 per cent.	....	Southern Trust Co., Los Angeles.	2,000,000

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a Principal may be registered.

TABLE 238.—*Bonds of San Joaquin Light & Power Corporation and principal subsidiaries (including Midland Counties Public Service Corporation)*—Continued.

Issue.	Date.	Reserved for prior liens.	In sinking fund.		Bonded debt.			Remarks.
			Canceled.	Alive.	Authenticated in treasury.	In hands of public.	Total authenticated.	
1	7	8	9	10	11	12	13	14
1. **San Joaquin Light & Power Corporation first and refunding mortgage 6 per cent bonds, series A, dated Aug. 1, 1910; due Aug. 1, 1950; interest payable Feb. 1 and Aug. 1.**	1910–1914	None.	None.	None.	None.	$1,500,000	$1,500,000	**One-half of the sinking fund may be invested in new property and in investing the balance. Series A bonds must be given preference providing they may be purchased at not exceeding 102½.**
	1915	None.	None.	$17,000	None.	1,483,000	1,500,000	
	1916	None.	None.	37,000	$1,000	1,462,000	1,500,000	
	1917			58,000	20,000	1,422,000	[b] 1,500,000	
	1918			80,000	1,000	1,419,000	[c] 1,500,000	
	1919			117,000	18,000	1,365,000	1,500,000	
	1920			141,000	18,000	1,341,000	1,500,000	
2. **San Joaquin Light & Power Corporation first and refunding mortgage 5 per cent bonds, series B, dated Aug. 1, 1910; due Aug. 1, 1950; interest payable Feb. 1 and Aug. 1.**	1910	$3,994,000	None.	None.				
	1911	3,289,000	None.	None.		1,831,000	1,831,000	
	1912	3,161,000	None.	None.		2,756,000	2,756,000	
	1913	3,108,000	None.	None.	1,214,000	2,770,000	3,984,000	
	1914	3,066,000	None.	None.	1,437,000	2,900,000	4,337,000	
	1915	3,052,000	None.	None.		1,796,000	1,796,000	
	1916	3,010,000	None.	None.		979,000	979,000	
	1917	2,985,000				799,000	799,000	
	1918	2,920,000				799,000	799,000	
	1919	2,881,000				799,000	799,000	
	1920	2,829,000				799,000	799,000	
3. **San Joaquin Light & Power Corporation 6 per cent bonds, series B, dated Aug. 1, 1910; due Aug. 1, 1950; interest payable Feb. 1 and Aug. 1.**	1915	None.	None.	None.	None.	1,128,000	1,128,000	No bonds of this series issued until 1915.
	1916	None.	None.	None.	None.	1,945,000	1,945,000	
	1917	None.	None.	None.	None.	2,125,000	2,125,000	
	1918	None.	None.	None.	None.	2,125,000	2,125,000	
	1919					2,125,000	2,125,000	
	1920					2,125,000	2,125,000	
4. **San Joaquin Light & Power Corporation 6 per cent bonds, series C, dated Aug. 1, 1910; due Aug. 1, 1950; interest payable Feb. 1 and Aug. 1.**	1915	None.	None.	None.	97,000	1,529,000	1,626,000	Do.
	1916	None.	None.	None.	12,000	2,067,000	2,079,000	
	1917	None.	None.	None.	17,000	3,072,000	3,089,000	
	1918	None.	None.	None.		4,202,000	4,202,000	
	1919	None.	None.	None.		7,165,000	7,165,000	
	1920	None.	None.	None.		8,700,000	11,325,000	

5. San Joaquin Light & Power Corporation collateral trust 6 per cent notes, dated Aug. 1, 1913; due Aug. 1, 1915; interest payable Feb. 1, May 1, Aug. 1, and Nov. 1.	1913	....	....	....	....	954,000	954,000	Secured by deposit of $4,000 collateral series B refunding bonds for each $3,000 par value of notes
	1914	....	....	....	....	954,000	954,000	
6. San Joaquin Light & Power Corporation 6 per cent notes, convertible debentures, series A, dated May 1, 1917; due May 1, 1927; interest payable May 1 and Nov. 1.	1917	....	....	....	250,000	750,000	750,000	Unissued $3,500,000.
	1918	....	....	....	....	1,000,000	1,000,000	Do.
	1919	....	....	....	....	1,000,000	1,000,000	
	1920	....	....	....	....	1,000,000	1,000,000	
7. San Joaquin Light & Power Corporation 6 per cent notes, convertible debentures, series B, dated May 1, 1917; due May 1, 1927; interest payable May 1 and Nov. 1.	1919	....	....	....	....	1,000,000	1,000,000	
	1920	....	....	....	....	1,000,000	1,000,000	
8. San Joaquin Light & Power Corporation convertible collateral trust 8 per cent bonds, dated Nov. 1, 1920; due Nov. 1, 1935; interest payable May 1 and Nov. 1.	1920	....	....	....	....	2,625,000	2,625,000	Secured by deposit of equal amount of series C 6 per cent bonds.
9. San Joaquin Light & Power Corporation collateral trust 7 per cent notes, dated Mar. 1, 1908; due Mar. 1, 1911.	1908	None.	None.	None.	....	50,000	50,000	Secured by deposit of first sinking fund 5 per cent bonds.
	1909	None.	None.	None.	....	50,000	50,000	
	1910	None.	None.	None.	....	50,000	50,000	
10. San Joaquin Light & Power Co. first sinking-fund 5 per cent bonds, dated July 24, 1915; due July 24, 1945; interest payable June 1 and Dec. 1.	1905	....	....	....	None.	961,000	961,000	
	1906	177,000	None.	None.	None.	1,387,000	1,564,000	
	1907	172,000	None.	None.	None.	1,728,000	1,900,000	
	1908	172,000	None.	None.	None.	2,016,000	2,188,000	
	1909	170,000	None.	None.	None.	2,525,000	2,695,000	
	1910	136,000	45,000	None.	None.	2,819,000	2,955,000	
	1911	134,000	90,000	None.	None.	2,776,000	2,910,000	
	1912	132,000	135,000	None.	None.	2,733,000	2,865,000	
	1913	104,000	218,000	None.	None.	2,678,000	2,782,000	
	1914	99,000	218,000	None.	None.	2,683,000	2,782,000	
	1915	97,000	228,000	None.	89,000	2,586,000	2,772,000	
	1916	94,000	268,000	None.	50,000	2,588,000	2,732,000	
	1917	27,000	335,000	32,000	13,000	2,595,000	2,608,000	
	1918	25,000	348,000	35,000	47,000	2,545,000	2,592,000	
	1919	25,000	387,000	38,000	16,000	2,534,000	2,550,000	
	1920	25,000	439,000	39,000	13,000	2,484,000	2,497,000	

[b] Includes $20,000 owned by corporation.

[c] Includes $1,000 owned by corporation.

TABLE 238.—*Bonds of San Joaquin Light & Power Corporation and principal subsidiaries (including Midland Counties Public Service Corporation)*—Continued.

Issue.	Date.	Reserved for prior liens.	In sinking fund.		Bonded debt.			Remarks.
			Canceled.	Alive.	Authenticated in treasury.	In hands of public.	Total authenticated.	
1	7	8	9	10	11	12	13	14
11. San Joaquin Power Co. first-mortgage 5 per cent bonds, dated Dec. 1, 1902; due Dec. 1, 1942; interest payable June 1 and Dec. 1.	1902	None.	None.	None.	None.	....	....	
	1903	None.	None.	None.	None.	$557,000	$557,000	
	1904	None.	None.	None.	None.	708,000	708,000	
	1905	None.	$573,000	None.	None.	227,000	227,000	
	1906	None.	623,000	None.	None.	177,000	177,000	
	1907	None.	628,000	None.	None.	172,000	172,000	
	1908	None.	628,000	None.	None.	172,000	172,000	
	1909	None.	630,000	None.	None.	170,000	170,000	
	1910	None.	664,000	None.	None.	136,000	136,000	
	1911	None.	666,000	None.	None.	134,000	134,000	
	1912	None.	668,000	None.	None.	132,000	132,000	
	1913	None.	696,000	None.	None.	104,000	104,000	
	1914	None.	701,000	None.	None.	99,000	99,000	
	1915	None.	703,000	None.	$3,000	94,000	97,000	
	1916	None.	706,000	None.	2,000	92,000	94,000	
	1917–1920	None.	775,000	None.	None.	25,000	25,000	$20,000 retired by sinking fund; $755,000 retired by exchange.
12. Selma Light & Water Co. first-mortgage 5 per cent bonds, dated Jan. 1, 1902; due serially to 1920; interest payable Jan. 1 and July 1.	1907	None.	None.	None.	None.	16,000	16,000	Bonds of this issue assumed by San Joaquin Light & Power Co. on purchase of property in 1907.
	1908	None.	1,000	None.	None.	15,000	15,000	
	1909	None.	2,000	None.	None.	14,000	14,000	
	1910	None.	4,000	None.	None.	12,000	12,000	
	1911	None.	5,000	None.	None.	11,000	11,000	
	1912	None.	6,000	None.	None.	10,000	10,000	
	1913	None.	None.	None.	None.	10,000	10,000	On Jan. 20, 1914, the 10 bonds remaining in the hands of the public were exchanged for San Joaquin Light & Power Corporation 5 per cent bonds, series B.
13. Power Transit & Light Co. bonds, dated June 1, 1903; due June 1, 1933; interest payable June 1 and Dec. 1	1903	None.	None.	None.	222,000	778,000	1,000,000	From the most reliable reports available it appears that before its acquisition by San Joaquin Light & Power Corporation, Power Transit & Light Co. had authenticated $1,000,000 out of a total authorized issue of $2,500,000 first-mortgage bonds. Of
	1904	None.	None.	None.	222,000	778,000	1,000,000	
	1905	None.	None.	None.	222,000	778,000	1,000,000	
	1906	None.	None.	$8,000	222,000	770,000	1,000,000	
	1907	None.	None.	13,000	222,000	765,000	1,000,000	

	1908	None.	None.	19,000	222,000	759,000	1,000,000	this $1,000,000 authenticated $778,000 had been sold and $222,000 remained in treasury. A part of the $1,500,000 which remained unauthenticated was reserved to retire bonds of underlying issues. When San Joaquin Light & Power Corporation acquired Power Transit & Light Co. and assumed its bonded debt, the first mortgage of latter company was closed and $222,000 face-value bonds in treasury canceled by resolution of its board of directors, passed Oct. 5, 1910, leaving $778,000 outstanding, of which part was in sinking fund. Before Dec. 31, 1911, $633,000 of bonds in hands of public had been exchanged for San Joaquin Light & Power Corporation's first and refunding 5 per cent bonds and had been deposited with trustee.
	1909	None.	None.	26,000	222,000	752,000	1,000,000	
	1910	None.	None.	26,000	98,000	654,000	778,000	
	1911	None.	None.	32,000	633,000	113,000	778,000	
	1912	None.	None.	32,000	633,000	113,000	778,000	
	1913	None.	None.	40,000	633,000	105,000	778,000	
	1914	None.	None.	49,000	633,000	96,000	778,000	
	1915	None.	None.	49,000	633,000	96,000	778,000	
	1916	None.	None.	49,000	633,000	96,000	778,000	
	1917	None.	None.	59,000	633,000	86,000	778,000	
	1918	None.	None.	71,000	633,000	74,000	778,000	
	1919	None.	None.	72,000	633,000	73,000	778,000	
	1920	None.	None.	76,000	633,000	69,000	778,000	
14. **Bakersfield & Kern Electric Ry.** first-mortgage 5 per cent bonds, dated 1901; due July 1, 1931; interest payable Jan. 1 and July 1.	1901	None.	None.	None.	None.	100,000	150,000	
	1902 1909	None.	None.	None.	None.	125,000	125,000	
	1910	None.	None.	3,000	None.	122,000	125,000	
	1911	None.	None.	10,000	None.	115,000	125,000	
	1912	None.	None.	15,000	None.	110,000	125,000	
	1913	None.	None.	21,000	None.	104,000	125,000	
	1914	None.	None.	26,000	None.	99,000	125,000	
	1915	None.	2,000	56,000	2,000	65,000	123,000	
	1916	None.	2,000	69,000	7,000	47,000	123,000	
	1917	None.	2,000	77,000	3,000	43,000	123,000	
	1918	None.	2,000	80,000	3,000	43,000	123,000	
	1919	None.	2,000	82,000		38,000	123,000	
	1920	None.	2,000	92,000		31,000	123,000	
15. **Bakersfield Gas & Electric Light Co.** first-mortgage 6 per cent bonds, dated Aug. 15, 1901; due Aug. 15, 1911, to Aug. 15, 1921, serially, $20,000; interest payable monthly.	1901	None.	None.	None.	None.	50,000	50,000	
	1902	None.	None.	None.	None.	50,000	50,000	
	1903	None.	None.	None.	None.	50,000	50,000	
	1904	None.	None.	None.	None.	50,000	50,000	
	1905	None.	None.	None.	None.	50,000	50,000	
	1906	None.	10,000	None.	None.	40,000	40,000	
	1907	None.	10,000	None.	None.	40,000	40,000	
	1908	None.	10,000	None.	None.	40,000	40,000	
	1909	None.	10,000	None.	None.	40,000	40,000	
	1910	None.	10,000	None.	None.	40,000	40,000	
	1911	None.	30,000	None.	None.	20,000	20,000	
	1912	None.	32,000	None.	None.	18,000	18,000	
	1913	None.	34,000	None.	None.	16,000	16,000	
	1914	None.	36,000	None.	None.	14,000	14,000	
	1915	None.	38,000	None.	None.	12,000	12,000	
	1916	None.	40,000	None.	None.	10,000	10,000	Retired in 1917.

TABLE 238.—*Bonds of San Joaquin Light & Power Corporation and principal subsidiaries (including Midland Counties Public Service Corporation*—Continued.

Issue.	Date.	Reserved for prior liens.	In sinking fund.		Bonded debt.			Remarks.
			Canceled.	Alive.	Authenticated in treasury.	In hands of public.	Total authenticated.	
1	7	8	9	10	11	12	13	14
Midland Counties system.								
16. Midland Counties Public Service Corporation first and refunding 6 per cent bonds dated Oct. 1, 1915; due Oct. 1, 1953; interest payable Apr. 1 and Oct. 1.	1913	None.	None.	None.	None.	$455,000	$455,000	
	1914	None.	None.	None.	None.	445,000	455,000	
	1915	None.	None.	None.	None.	455,000	455,000	
	1916	None.	None.	None.	None.	455,000	455,000	
	1917	None.	None.	None.	$77,000	497,000	574,000	
	1918	None.	None.	None.	218,000	497,000	715,000	
	1919	None.	None.	None.	388,000	497,000	885,000	
	1920	None.	None.	None.	388,000	497,000	885,000	
17. Midland Counties Gas & Electric Co. first-mortgage 6 per cent bonds, dated Jan. 1, 1912; due Jan. 1, 1932; interest payable Jan. 1 and July 1.	1912	None.	None.	None.	None.	275,000	275,000	
	1913	None.	None.	None.	15,000	275,000	290,000	
	1914	None.	None.	None.	15,000	275,000	290,000	
	1915	None.	$2,000	None.	15,000	273,000	288,000	
	1916	None.	5,000	None.	15,000	270,000	285,000	
	1917	None.	8,000	None.	15,000	267,000	282,000	
	1918	None.	....	None.	None.	264,000	264,000	
	1919	None.	13,000	None.	None.	262,000		
	1920	None.	15,000	None.	None.	260,000		
18. Coalinga Water & Electric Co. first-mortgage 6 per cent bonds, dated Jan. 1, 1910; due Jan. 1, 1940; interest payable Jan. 1 and July 1.	1910	None.	None.	None.	None.	100,000	100,000	
	1911	None.	None.	None.	None.	150,000	150,000	
	1912	None.	9,000	None.	None.	584,000	584,000	
	1913	None.	9,000	None.	38,000	[d] 546,000	584,000	
	1914	None.	17,000	None.	38,000	83,000	121,000	
	1915	None.	[e] None.	$28,000	38,000	72,000	100,000	
	1916	None.	None.	36,000	38,000	[d] 64,000	100,000	
	1917	None.	None.	48,000	[f] 7,000	100,000	100,000	
	1918	None.	None.	62,000	[f] 13,000	25,000	100,000	
	1919	None.	None.	77,000	3,000	20,000	100,000	Retired in 1920.

[d] $455,000 par value of these bonds were refunded by Midland Counties Public Service Corporation for first and refunding 6's and are deposited with trustee of that issue.
[e] During 1915, $25,000 par value of bonds which had been canceled were reinstated and will be carried alive in sinking fund.
[f] Owned by company.

TABLE 239.—*Comparative balance sheet, San Joaquin Light & Power Corporation, 1912–1920.*

	1912	1913	1914	1915
ASSETS.				
Total fixed capital	$23,654,629	$23,519,786	$23,856,413	$25,088,991
Cash and deposits:				
Cash	....	20,238	105,239	215,529
Special deposits	....	....	....	....
Total cash and deposits	72,168	20,238	105,239	215,529
Notes receivable	34,990	259,736	297,547	315,020
Accounts receivable:				
Accounts with system corporations	....	338,674	329,822	354,228
Due from consumers and agents	....	237,704	230,164	270,070
Miscellaneous	....	171,254	114,614	77,821
Total accounts receivable	....	747,632	674,600	702,119
Other current assets	1,081,456	....	....	....
Investments:				
Securities of other corporations	....	313,697	314,447	305,187
Miscellaneous	....	26,941	28,466	29,991
Total investments	....	340,638	342,913	335,178
Materials and supplies	386,171	376,659	346,097	305,909
Sinking funds	....	56,703	69,857	127,650
Treasury securities	1,615,095	633,000	633,000	695,513
Prepaid expenses:				
Prepaid taxes	....	1,638	1,005	672
Prepaid insurance	....	1,761	1,890	1,663
Other prepayments	....	664	2,040	1,368
Total prepaid expenses	....	4,063	4,935	3,703
Unamortized discount on securities and expenses:				
Stocks	1,250,000	1,250,000	1,250,000	1,250,000
Bonds	398,170	469,758	478,247	441,945
Miscellaneous	....	31,039	16,886	....
Total unamortized discount on securities and expenses	1,648,170	1,750,797	1,745,133	1,691,945
Other suspense	....	234,024	47,869	98,612
Construction work in progress	....	1,671,049	1,367,104	370,777
Total assets	28,492,679	29,614,325	29,490,707	29,950,946
LIABILITIES.				
Capital stock	17,500,000	17,500,000	17,500,000	17,500,000
Funded debt	7,619,000	8,588,000	8,930,000	9,515,000
Notes payable	969,990	1,051,749	971,748	331,376
Accounts payable:				
Audited vouchers and wages unpaid	....	346,171	161,522	79,333
Consumers' deposits	....	28,246	30,980	28,324
Miscellaneous	[a] 658,478	164,784	39,380	35,687
Total accounts payable	658,478	539,201	231,882	143,344
Interest accrued	101,750	123,576	131,750	163,099
Taxes accrued	163	1,741	3,642	5,710
Dividends declared	....	97,500	16,406	16,406
Service billed in advance	....	18,344	25,591	23,807
Reserve for accrued depreciation	456,775	405,782	552,402	629,123
Casualty and insurance reserves	....	6,012	4,076	9,560
Reserves invested in sinking funds	....	285,757	342,857	489,149
Other reserves from income or surplus	[b] 280,148	36,464	72,839	75,533
Capital surplus	906,375	936,842	321,260	321,260
Miscellaneous	....	....	....	....
Corporate surplus unappropriated	....	23,357	386,254	727,579
Total liabilities	28,492,679	29,614,325	29,490,707	29,950,946

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[a] Accounts payable, $195,816; miscellaneous, $462,662; total, $658,478.
[b] Includes all reserves except that for accrued depreciation.

TABLE 239.—*Comparative balance sheet, San Joaquin Light & Power Corporation, 1912–1920*—Continued.

	1916	1917	1918	1919	1920
ASSETS.					
Total fixed capital	$25,559,963	$25,989,904	$27,236,981	$29,692,032	$30,991,663
Cash and deposits:					
Cash	350,018	229,100	211,016	368,283	399,730
Special deposits	....	....	....	....	....
Total cash and deposits	350,018	229,100	211,016	368,283	399,730
Notes receivable	313,962	229,901	415,485	371,555	561,850
Accounts receivable:					
Accounts with system corporations	346,821	326,547	326,906	291,084	256,231
Due from consumers and agents	273,185	357,140	269,919	264,865	565,586
Miscellaneous	153,745	334,767	441,141	599,351	695,969
Total accounts receivable	773,751	1,018,454	1,037,966	1,155,300	1,517,787
Other current assets	....	....	....	....	....
Investments:					
Securities of other corporations	309,908	306,122	303,197	255,775	292,764
Miscellaneous	32,024	33,041	100,888	110,550	110,900
Total investments	341,932	339,163	404,085	366,325	403,663
Materials and supplies	355,844	490,832	734,462	781,064	1,466,315
Sinking funds	161,242	196,716	234,534	277,511	315,702
Treasury securities	652,836	710,277	678,415	665,448	660,525
Prepaid expenses:					
Prepaid rents	....	....	....	1,931	1,404
Prepaid taxes	566	1,737	710	3,299	3,183
Prepaid insurance	2,038	1,842	3,275	6,746	12,255
Other prepayments	1,411	1,311	958	345	3,245
Total prepaid expenses	4,015	4,890	4,943	12,320	20,088
Unamortized discount on securities and expenses:					
Stocks	1,250,000	1,250,000	1,250,000	1,250,000	1,332,698
Bonds	366,251	405,639	501,980	760,545	994,955
Miscellaneous	....	....	....	....	....
Total unamortized discount on securities and expenses	1,616,251	1,655,639	1,751,980	2,010,545	2,327,653
Other suspense	251,737	279,949	260,911	550,477	727,249
Construction work in progress	631,837	1,897,586	2,087,439	4,392,349	10,113,737
Total assets	31,013,388	33,042,411	35,058,217	40,643,209	49,505,461
LIABILITIES.					
Capital stock	17,500,000	17,500,000	17,500,000	17,500,000	18,740,200
Funded debt	10,010,000	11,699,000	12,996,000	16,980,000	21,088,000
Notes payable	122,408	62,653	411,476	1,080,715	2,258,997
Accounts payable:					
Audited vouchers and wages unpaid	274,197	295,172	364,122	1,209,438	1,722,977
Consumers' deposits	26,211	28,728	32,850	40,175	51,893
Miscellaneous	37,431	28,420	153,466	175,388	232,163
Total accounts payable	337,839	352,320	550,438	1,425,001	2,007,034
Interest accrued	175,764	209,435	240,717	330,367	411,179
Taxes accrued	7,479	9,285	12,503	15,374	18,626
Dividends declared	16,406	....	....	....	....
Service billed in advance	12,086	10,611	13,892	13,132	366,223
Reserve for accrued depreciation	633,984	673,937	808,942	875,861	2,171,688
Casualty and insurance reserves	21,001	27,881	26,068	10,444	21,789
Reserves invested in sinking funds	638,242	788,216	938,109	1,092,886	191,503
Other reserves from income or surplus	79,683	80,411	69,013	....	....
Capital surplus	321,260	....	....	321,260	321,260
Miscellaneous	....	321,260	321,260	....	....
Accrued sinking fund	....	....	....	70,164	....
Casualty reserve—construction	....	....	....	46,314	150,098
Bad debts reserve	....	....	....	3,990	11,637
Auto insurance reserve	....	....	....	5,600	....
Auto depreciation reserve—construction	....	....	....	3,171	32,893
Corporate surplus unappropriated	1,137,236	1,307,402	1,169,799	868,930	1,714,336
Total liabilities	31,013,388	33,042,411	35,058,217	40,643,209	49,505,461

TABLE 239.—*Comparative balance sheet, San Joaquin Light & Power Corporation, 1912–1920*—Continued.

Investment in electric property, San Joaquin Light & Power Corporation and its predecessors. Dec. 31, 1895–1914.

1895	$72,200	1905	$1,480,986
1896	407,196	1906	2,013,685
1897	460,941	1907	2,163,221
1898	485,664	1908	2,264,435
1899	568,510	1909	2,466,839
1900	715,027	1910	2,865,534
1901	876,060	1911	5,911,721
1902	937,832	1912	7,031,120
1903	1,023,702	1913	8,233,891
1904	1,177,580	1914	9,093,271

NOTE.—Figures in this table were compiled by auditing department, Railroad Commission of California.

TABLE 240.—*Earnings and expenses of San Joaquin Light & Power Corporation, 1896–1920.*

Year.	Earnings.	Expenses.	Profit.
1896	$11,932.26	$11,879.68	$52.58
1897	43,854.11	27,194.88	16,659.23
1898	47,407.53	41,436.50	5,971.03
1899	93,530.40	41,642.59	51,887.81
1900	135,741.64	52,494.23	83,247.41
1901	171,949.01	60,370.21	111,578.80
1902	227,335.70	71,521.77	155,813.93
1903	250,660.10	87,139.12	163,520.98
1904	287,768.38	91,742.66	194,025.72
1905	324,322.76	118,281.33	206,041.43
1906	375,620.86	130,780.10	244,840.76
1907	427,525.57	152,179.46	275,346.11
1908	494,630.31	160,006.83	334,623.48
1909	567,914.78	199,098.67	368,816.11
1910	760,464.70	316,249.95	444,214.75
1911	943,868.71	478,538.82	465,329.89
1912	1,201,581.73	536,367.68	665,214.05

NOTE.—The above table was prepared by the Auditing Department of Railroad Commission of California and includes the operations of the following companies: Power Development Co., San Joaquin Electric Co., Bakersfield Gas & Electric Light Co., San Joaquin Power Co., Power Transit & Light Co., San Joaquin Light & Power Co., Merced Falls Gas & Electric Co., Madera Light & Power Co., Lemoore Light & Power Co., and San Joaquin Light & Power Corporation.

	1913	1914	1915	1916
Electric operations:				
Operating revenues	$1,461,398	$1,569,283	$1,577,712	$1,560,951
Operating expenses	769,809	636,054	618,948	581,603
Net operating electric revenue	691,589	933,229	958,764	979,348
Gas operations:				
Operating revenues	176,145	161,430	139,834	150,822
Operating expenses	133,272	125,648	104,293	99,928
Net operating gas revenue	42,873	35,782	35,541	50,894
Water operations:				
Operating revenues	15,064	15,739	15,709	15,636
Operating expenses	12,721	10,331	7,593	5,788
Net operating water revenue	2,343	5,408	8,116	9,848
Total net operating revenue	736,805	974,419	1,002,421	1,040,090
Add:				
Nonoperating revenues—				
Rents from buildings, land, and apparatus, water			a 14	
Miscellaneous rent revenues, electric	4,064	4,042		
Interest and dividend revenues—				
Miscellaneous interest revenues	2,617	5,562	6,561	10,784
Dividend revenues	377	9,534	1,058	977
Total interest and dividend revenues	2,994	15,096	7,619	11,761
Sinking and reserve fund accretions	5,684	2,651	2,623	6,075
Miscellaneous nonoperating revenues	669	2,406	a 1,490	3,574
Total nonoperating revenues	13,411	24,195	8,738	21,410
Gross corporate income	750,216	998,614	1,011,159	1,061,500

a Deficit.

TABLE 240.—*Earnings and expenses of San Joaquin Light & Power Corporation, 1896–1920*—Continued.

	1913	1914	1915	1916
Deduct:				
Uncollectible bills	$4,596	$4,869	$4,800	$4,800
Nonoperating revenue deductions—				
Miscellaneous nonoperating expenses	1,386	272	200	10
Nonoperating taxes	181	414	357	526
Total nonoperating revenue deductions	1,567	686	557	536
Interest accrued on funded debt	343,152	403,511	402,629	461,888
Other interest deductions	76,349	73,530	81,007	12,263
Rent for instruments and equipment, electric	179	456	80	....
Amortization of debt discount and expenses	16,904	37,902	28,973	11,465
Miscellaneous deductions from income	....	....	....	....
Total deductions	442,747	520,955	518,046	490,952
Surplus for year	307,469	477,659	493,113	570,548

	1917	1918	1919	1920
Electric operations:				
Operating revenues	$1,776,262	$2,326,928	$2,955,932	$3,926,513
Operating expenses	732,107	1,333,017	2,040,831	2,090,336
Net operating electric revenue	1,044,155	993,911	915,102	1,836,177
Gas operations:				
Operating revenues	181,354	197,944	235,146	284,470
Operating expenses	121,961	134,634	165,336	211,094
Net operating gas revenue	59,393	63,310	69,810	73,375
Water operations:				
Operating revenues	17,151	18,197	20,492	22,877
Operating expenses	6,157	6,617	9,816	13,284
Net operating water revenue	10,994	11,580	10,676	9,593
Total net operating revenue	1,114,541	1,068,802	995,588	1,919,145
Add:				
Nonoperating revenues—				
Rents from buildings, land, and apparatus, water	....	....	....	....
Miscellaneous rent revenues, electric	....	....	....	....
Interest and dividend revenues—				
Miscellaneous interest revenues	35,141	13,453	18,688	66,870
Dividend revenues	732	....	....	....
Total interest and dividend revenues	35,873	13,453	18,688	66,870
Sinking and reserve fund accretions	8,263	10,130	12,315	14,584
Miscellaneous nonoperating revenues	12,302	5,878	21,266	42,068
Total nonoperating revenues	56,438	29,461	52,269	123,521
Gross corporate income	1,170,979	1,098,263	1,047,857	2,042,666
Deduct:				
Uncollectible bills	4,729	4,800	5,973	11,000
Nonoperating revenue deductions—				
Miscellaneous nonoperating expenses	....	....	....	....
Nonoperating taxes	627	709	253	333
Total nonoperating revenue deductions	627	709	253	333
Interest accrued on funded debt	512,664	635,273	675,302	763,614
Other interest deductions	17,748	26,677	64,288	151,132
Rent for instruments and equipment, electric	....	....	....	....
Amortization of debt discount and expenses	12,826	17,879	28,148	60,103
Miscellaneous deductions from income	....	....	....	....
Total deductions	548,594	685,338	773,964	986,183
Surplus for year	622,386	412,925	273,893	1,056,483

NOTE.—Detailed statement of earnings and expenses for 1913–1916 is from official annual report of corporation to Railroad Commission of California.

TABLE 241.—*Classified revenues, San Joaquin Light & Power Corporation, 1913–1920*

Class of load.	1913		1914		1915	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$40,033	2.7	$41,390	2.7	$49,265	3.1
Incandescent	10,282	.7	11,349	.7	12,675	.8
Municipal lighting, miscellaneous	7,689	.5	8,042	.5	7,752	.5
Municipal power	12,623	.9	13,821	.9	18,338	1.2
Commercial lighting—						
Flat rate	6,071	.4	7,548	.5	5,844	.4
Metered	568,099	38.9	590,531	37.6	588,789	37.3
Commercial power—						
Flat rate	170,928	11.8	219,091	14.0	256,883	16.3
Metered	589,055	40.3	516,825	33.0	486,797	30.8
Railway power	44,020	3.0	42,540	2.7	33,209	2.1
Other electrical corporations	....	....	111,229	7.0	113,205	7.2
Rent meter	....	....	150	....	2	....
Miscellaneous electric	432	....	16	....	286	....
Total operating revenues, electric	1,449,232	99.2	1,562,532	99.6	1,573,045	99.7
Other operating revenues:						
Rent of electric appliances	126	....	181	....	106	....
Electric merchandise and jobbing revenues	12,040	.8	6,569	.4	4,561	.3
Total other operating revenues	12,166	.8	6,750	.4	4,667	.3
Gross electric revenues	1,461,398	100.0	1,569,282	100.0	1,577,712	100.0

Class of load.	1916		1917		1918	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$53,914	3.5	$44,285	2.5	$39,495	1.7
Incandescent	13,069	1.3	13,729	.8	21,726	.9
Municipal lighting, miscellaneous	11,409	1.1	18,307	1.0	18,512	.8
Municipal power	23,606	2.4	25,098	1.4	35,821	1.5
Commercial lighting—						
Flat rate	3,876	.4	1,852	.1	799	....
Metered	551,500	33.4	588,982	33.2	691,849	29.8
Commercial power—						
Flat rate	255,571	16.4	308,034	17.4	425,914	18.3
Metered	505,256	32.4	618,081	34.8	857,979	36.9
Railway power	40,618	2.6	37,397	2.1	36,879	1.6
Other electrical corporations	93,950	6.0	102,901	5.8	179,657	7.7
Rent meter	193	....	....	....	....	....
Miscellaneous electric	....	....	....	....	....	....
Total operating revenues, electric	1,552,962	99.5	1,758,666	99.1	2,308,631	99.2
Other operating revenues:						
Rent of electric appliances	154	....	15	....	510	....
Electric merchandise and jobbing revenues	7,835	.5	17,581	.9	17,787	.8
Total other operating revenues	7,989	.5	17,596	.9	18,298	.8
Gross electric revenues	1,560,951	100.0	1,776,262	100.0	2,326,928	100.0

TABLE 241.—*Classified revenues, San Joaquin Light & Power Corporation, 1913–1920*—Continued.

Class of load.	1919		1920	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:				
Municipal street lighting—				
Arc	$42,531	1.4	$43,641	1.1
Incandescent	24,292	.8	29,147	.7
Municipal lighting, miscellaneous	27,047	.9	32,678	.8
Municipal power	33,708	1.1	37,346	1.0
Commercial lighting—				
Flat rate	869	....	549	....
Metered	836,827	28.3	1,132,215	28.8
Commercial power—				
Flat rate	546,898	18.6	61,486	1.6
Metered	1,159,713	39.3	2,014,701	51.3
Railway power	37,092	1.2	38,051	1.0
Other electrical corporations	213,633	7.3	517,708	13.2
Rent of meters	....	....	....	....
Miscellaneous electric	....	....	....	....
Total operating revenues, electric	2,922,610	98.9	3,907,523	99.5
Other operating revenues:				
Rent of electric appliances	[a] 400	....	....	....
Electric merchandise and jobbing revenues	33,722	1.1	18,990	.5
Total other operating revenues	33,322	1.1	18,990	.5
Gross electric revenues	2,955,932	100.0	3,926,513	100.0

[a] Debit item.

TABLE 242.—*Comparative balance sheet of Midland Counties Public Service Corporation, 1913–1920.*

	1913	1914	1915	1916
ASSETS.				
Fixed capital	$1,949,011	$1,953,618	$1,959,877	$1,962,276
Cash	3,604	18,396	3,483	3,170
Notes receivable	22,445	111	....	3,397
Accounts receivable:				
Due from consumers and agents	26,864	35,501	41,990	33,752
Miscellaneous	15,100	10,064	10,365	54,912
Total accounts receivable	41,964	45,565	52,355	88,664
Interest and dividends receivable	1,601	....	....	....
Materials and supplies	83,983	67,406	46,082	53,167
Sinking funds	....	85	28,741	37,244
Treasury securities	....	....	....	1,026
Prepaid expenses:				
Prepaid taxes	425	500	310	160
Prepaid insurance	726	731	490	339
Other prepayments	....	34	513	173
Total prepaid expenses	1,151	1,265	1,313	672
Unamortized discount on securities and expenses: Bonds.	47,713	49,959	48,460	46,787
Other suspense	14,668	6,981	13,645	8,670
Construction work in progress	160,334	193,938	191,727	271,115
Corporate deficit	....	12,096	45,889	51,538
Total assets	2,326,474	2,349,420	2,391,572	2,527,727
LIABILITIES.				
Capital stock	1,000,500	1,000,500	1,000,500	1,000,500
Installment on stock subscriptions	....	....	....	....
Funded debt	821,000	813,000	828,000	825,000
Notes payable	289,822	392,320	355,544	399,499

TABLE 242.—*Comparative balance sheet of Midland Counties Public Service Corporation, 1913–1920*—Continued.

	1913	1914	1915	1916
LIABILITIES—continued.				
Accounts payable:				
Audited vouchers and wages unpaid	$100,135	$5,485	$12,779	$23,736
Consumers' deposits	3,716	3,601	3,738	2,553
Miscellaneous	11,832	26,787	50,451	95,572
Total accounts payable	115,683	35,873	66,968	121,861
Interest accrued	15,630	10,946	17,952	27,389
Taxes accrued	489	693	1,026	1,109
Dividends declared	21,295	....	....	....
Service billed in advance	235	9,792	2,637	1,631
Reserve for accrued depreciation	39,283	56,277	69,683	82,456
Casualty and insurance reserves	2,366	3,903	4,840	6,266
Reserves invested in sinking funds	8,895	17,085	30,741	42,244
Other reserves from income or surplus	8,190	9,030	13,680	19,769
Corporate surplus unappropriated	3,086	....	....	....
Total liabilities	2,326,474	2,349,420	2,391,572	2,527,727

	1917	1918	1919	1920
ASSETS.				
Fixed capital	$2,149,317	$2,190,839	$2,317,002	$2,428,421
Cash	16,988	25,312	21,463	9,632
Notes receivable	15,772	109,305	106,124	100,316
Accounts receivable:				
Due from consumers and agents	64,940	59,124	50,592	63,467
Miscellaneous	10,342	14,335	14,931	13,341
Total accounts receivable	75,282	73,459	65,523	76,808
Interest and dividends receivable	....	....	....	....
Investments—securities	....	....	....	158,384
Materials and supplies	48,638	58,557	80,791	81,920
Sinking funds	48,349	62,827	78,339	2,972
Treasury securities	7,010	13,000	3,030	....
Prepaid expenses:				
Prepaid taxes	....	107	182	491
Prepaid insurance	340	643	881	1,177
Other prepayments	114	91	....	....
Total prepaid expenses	454	841	1,063	1,669
Unamortized discount on securities and expenses: Bonds	47,673	46,391	45,226	43,889
Other suspense	19,437	26,189	73,667	81,267
Construction work in progress	361,173	443,343	515,844	256,729
Corporate deficit	64,166	70,951	51,336	25,007
Total assets	2,854,259	3,121,014	3,359,407	3,267,015
LIABILITIES.				
Capital stock	1,000,500	1,000,500	1,000,500	1,000,500
Installment on stock subscriptions	100,050	200,100	200,100	200,100
Funded debt	864,000	861,000	859,000	757,000
Notes payable	377,398	518,111	493,611	835,420
Accounts payable:				
Audited vouchers and wages unpaid	21,207	56,862	16,151	13,954
Consumers' deposits	3,121	3,792	5,072	6,031
Miscellaneous	272,705	207,453	457,397	211,632
Total accounts payable	297,033	268,107	478,621	231,617
Interest accrued	33,530	53,990	76,180	9,717
Taxes accrued	1,553	1,331	1,132	1,761
Dividends declared	....	....	....	....
Service billed in advance	481	319	422	218
Reserve for accrued depreciation	91,055	105,711	112,043	194,613
Casualty and insurance reserves	6,170	6,349	1,000	3,354
Reserves invested in sinking funds	67,229	91,898	120,819	24,568
Other reserves from income or surplus	15,260	13,598	....	....
Accrued sinking fund	....	....	6,043	....
Casualty reserve—construction	....	....	2,756	3,834
Bad debts reserve	....	....	889	1,518
Auto depreciation reserve—construction	....	....	6,291	2,794
Corporate surplus unappropriated	....	....	....	....
Total liabilities	2,854,259	3,121,014	3,359,407	3,267,015

TABLE 243.—*Earnings and expenses of Midland Counties Public Service Corporation, 1913–1920.*

	1913	1914	1915	1916
Electric operations:				
Operating revenues	$170,104	$168,693	$169,851	$207,748
Operating expenses	123,521	121,217	121,085	114,923
Net operating electric revenue	46,583	47,476	48,766	92,825
Gas operations:				
Operating revenues	23,849	26,233	27,374	16,440
Operating expenses	13,778	17,874	20,405	21,066
Net operating gas revenue	10,071	8,359	6,969	[a] 4,626
Water operations:				
Operating revenues	10,837	10,338	10,889	11,464
Operating expenses	7,272	9,007	8,743	9,693
Net operating water revenue	3,565	1,331	2,146	1,771
Total net operating revenue	60,219	57,167	57,881	89,970
Add:				
Nonoperating revenues—				
Miscellaneous rent revenues [b]	....	330	335	3 25
Miscellaneous interest revenues	3,826	526	118	23
Rents for buildings, land, and apparatus, water	....	....	....	....
Interest and dividend revenues	....	....	....	....
Total interest and dividend revenues	3,826	856	453	348
Sinking and reserve fund accretions	....	....	2,355	840
Miscellaneous nonoperating revenues	188	[c] 383	162	349
Total nonoperating revenues	4,014	473	2,970	1,537
Gross corporate income	64,233	57,640	60,852	91,507
Deduct:				
Uncollectible bills	447	1,078	1,080	1,080
Nonoperating taxes	17	44	43	14
Miscellaneous nonoperating expenses	....	....	....	....
Nonoperating revenue deductions	....	....	....	....
Total nonoperating revenue deductions	17	44	43	14
Interest accrued on funded debt	47,738	48,837	49,727	49,500
Other interest deductions	17,483	25,122	26,998	27,260
Miscellaneous rent deductions	....	....	....	....
Miscellaneous deductions	....	....	....	....
Amortization of debt discount and expense	1,713	1,356	1,284	1,673
Total deductions	67,398	76,437	79,132	79,527
Surplus for year	....	....	....	11,980
Deficit for year	3,166	18,797	18,280	....

	1917	1918	1919	1920
Electric operations:				
Operating revenues	$268,076.33	$360,769.99	$464,865	$613,614
Operating expenses	153,520.07	245,501.05	337,020	470,336
Net operating electric revenue	114,556.26	115,268.94	127,845	143,278
Gas operations:				
Operating revenues	10,370.41	24,389.03	36,356	10,429
Operating expenses	22,882.90	33,497.10	32,761	13,046
Net operating gas revenue	[a] 12,512.49	[a] 9,108.07	3 594	[a] 2,617
Water operations:				
Operating revenues	8,887.53	2,599.61	2,720	3,456
Operating expenses	11,174.29	3,917.34	4,772	5,056
Net operating water revenue	[a] 2,286.76	[a] 1,317.73	[a] 2.002	[a] 1,600
Total net operating revenue	99,757.01	104,843.14	129,437	139,061

[a] Operating loss. [b] Electric. [c] Loss.

TABLE 243.—*Earnings and expenses of Midland Counties Public Service Corporation, 1913–1920*—Continued.

	1917	1918	1919	1920
Add:				
Nonoperating revenues—				
Miscellaneous rent revenues [b]	$310.00	$300.00	$403	$373
Miscellaneous interest revenues	17.61		914	17,095
Rents for buildings, land, apparatus, water		37.50		
Interest and dividend revenues		42.23		
Total interest and dividend revenues	327.61	379.73	1,316	17,468
Sinking and reserve fund accretions	3,329.01	3,132.51	4,104	2,280
Miscellaneous nonoperating revenues	49.00	100.64	34	3,193
Total nonoperating revenues	3,705.62	3,612.88	5,454	22,941
Gross corporate income	103,462.63	108,456.02	134,892	162,001
Deduct:				
Uncollectible bills	1,080.00	1,680.00	1,080	1,020
Nonoperating taxes			3	
Miscellaneous nonoperating expenses	328.53	843.58	251	
Nonoperating revenue deductions				
Total nonoperating revenue deductions	328.53	843.58	1,335	1,020
Interest accrued on funded debt	49,779.33	50,835.84	51,460	45,596
Other interest deductions	38,447.10	34,752.78	31,659	56,305
Miscellaneous rent deductions		16.00		
Miscellaneous deductions				
Amortization of debt discount and expense	1,263.65	1,292.64	1,335	1,337
Total deductions	90,898.61	89,420.84	85,788	104,258
Surplus for year	12,564.02	19,035.18	49,103	57,743

[b] Electric.

TABLE 244.—*Classified revenues of Midland Counties Public Service Corporation (according to classification of Railroad Commission of California), 1913–1920.*

Class of load.	1913		1914		1915	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$4,328	2.5	$3,617	2.5	$3,632	2.1
Incandescent	7,974	4.7	7,734	4.6	6,654	3.9
Municipal lighting, miscellaneous	102		269		175	
Municipal power	1,062	.6	67		551	.3
Commercial lighting—						
Flat rate	323		168		170	
Metered	96,264	56.6	92,601	54.9	94,922	56.0
Commercial power—						
Flat rate	3,000	2.0	11,109	6.6	19,785	11.6
Metered	47,856	28.1	45,804	27.1	38,492	23.1
Railway power	3,440	2.4	3,709	2.2	3,357	2.0
Rent of meters			720	.4	390	
Miscellaneous electric	239		60			
Total operating revenues, electric	164,588	96.9	165,858	98.3	168,128	99.0
Other operating revenues:						
Rent of electric appliances	664	.3	29		6	
Electric merchandise and jobbing revenue	4,852	2.8	2,806	1.7	1,717	1.0
Total other operating revenues	5,516	3.1	2,835	1.7	1,723	1.0
Gross electric revenues	170,104	100.0	168,693	100.0	169,851	100.0

TABLE 244.—*Classified revenues of Midland Counties Public Service Corporation (according to classification of Railroad Commission of California), 1913–1920*—Con.

Class of load.	1916		1917		1918	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$3,503	1.8	$3,456.54	1.3	$856.12	0.2
Incandescent	7,938	3.8	7,671.69	2.9	6,623.94	1.9
Municipal lighting, miscellaneous	29		218.72		510.11	.1
Municipal power	3,094	1.6	4,818.88	1.8	9,354.09	2.6
Commercial lighting—						
Flat rate	169		140.27		147.70	
Metered	102,366	49.3	121,212.18	45.3	131,891.30	36.6
Commercial power—						
Flat rate	17,049	8.2	34,982.76	13.1	48,435.05	13.4
Metered	59,525	28.6	86,893.64	32.4	156,385.17	43.4
Railway power	3,504	1.8	4,129.27	1.6	4,025.41	1.1
Rent of meters	338		360.00			
Miscellaneous electric	2,402	1.2				
Total operating revenues, electric	199,917	96.3	263,863.95	98.4	358,228.89	99.3
Other operating revenues:						
Rent of electric appliances	48		153.96		9.50	
Electric, merchandise, and jobbing revenue	7,783	3.7	4,058.42	1.6	2,531.60	.7
Total other operating revenues	7,831	3.7	4,212.38	1.6	2,541.10	.7
Gross electric revenues	207,748	100.0	268,076.33	100.0	360,769.99	100.0

Class of load.	1919		1920	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:				
Municipal street lighting—				
Arc				
Incandescent	$6,661	1.5	$8,038	1.3
Municipal lighting, miscellaneous	575		1,055	.1
Municipal power	10,020	2.1	8,925	1.4
Commercial lighting—				
Flat rate	139		139	
Metered	154,749	33.3	198,836	32.5
Commercial power—				
Flat rate	53,225	11.5	57,082	9.4
Metered	232,699	50.1	333,290	54.3
Railway power	4,108	.9	4,275	.7
Rent of meters				
Miscellaneous electric				
Total operating revenue, electric	462,175	99.4	611,641	99.7
Other operating revenues:				
Rent of electric appliances	19		[a] 25	
Electric merchandise and jobbing revenue	2,672	.6	1,998	.3
Total other operating revenues	2,690	.6	1,973	.3
Gross electric revenues	464,865	100.0	613,614	100.0

[a] Debit item.

FINANCIAL TABLES FOR SOUTHERN CALIFORNIA EDISON CO. AND PRINCIPAL SUBSIDIARIES AND PREDECESSORS.

[See Tables 258 to 262 for financial data concerning Mount Whitney Power & Electric Co. and its predecessors and subsidiaries.]

TABLE 245.—*Capitalization, outstanding stock, and dividends of Southern California Edison Co. and principal subsidiaries.*

[Term of incorporation uniformly 50 years. Unless otherwise stated in footnotes par value of all stock is $100.]

Company.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.			Dividends.					
			First preferred.	Second preferred.	Common.	First preferred.		Second preferred.		Common.	
						Rate.	Amount.	Rate.	Amount.	Rate.	Amount.
						P. ct.		*P. ct.*		*P. ct.*	
Southern California Edison Co., Chino, San Bernardino County, Calif.; incorporated July 6, 1909	a $30,000,000	1909	$4,000,000		$7,200,000	1¼	$50,000				
		1910	4,000,000		7,200,000	5	200,000			3¾	$270,000.00
		1911	4,000,000		7,900,000	5	200,000			5	371,250.00
		1912	4,000,000		8,400,000	5	200,000			5	420,000.00
		1913	4,000,000		10,400,000	5	200,000			5	b 420,000.00
		1914	4,000,000		10,400,000	5,6	230,000			6	624,000.00
		1915	4,000,000		10,400,000	6	240,000			6	624,000.00
		1916	4,000,000		10,411,000	6,7	250,000			6,7	b 650,272.25
		1917	4,000,000	$12,029,900	14,064,572	7	280,000	c 5	$296,407	7	781,834.39
		1918	4,000,000	12,029,900	14,206,972	7	280,000	5	601,495	7	991,420.51
		1919	4,000,000	12,029,900	18,526,972	7	280,000	5	601,495	7	1,069,338.39
		1920	4,000,000	12,029,900	19,671,372	7	280,000	5	601,495	7	1,321,392.66

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[a] Increased in 1917 to $100,000,000, of which $4,000,000 is 4 per cent cumulative and participating first preferred; $12,500,000 is 5 per cent cumulative second preferred: and $83,500,000 is common stock.

[b] In addition to this amount a scrip dividend of $150,000 was paid.

[c] Paid for six months only.

TABLE 245.—*Capitalization, outstanding stock, and dividends of Southern California Edison Co. and principal subsidiaries*—Continued.

Subsidiary and earlier companies.

Company.	Date of incorporation.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.		Dividends.			
						Preferred stock.		Common stock.	
				Preferred.	Common.	Rate.	Amount.	Rate.	Amount.
						Per cent.		*Per cent.*	
Long Beach Consolidated Gas Co. (formerly controlled by Southern California Edison Co. through stock ownership), Los Angeles, Calif. Changed to Long Beach on May 2, 1911.	July 29, 1910	$1,500,000	1910	$85,000	$675,500				
			1911	85,000	675,700				
			1912	85,000	675,700				
			1913	85,000	675,700				
			1914	191,000	675,700				
			1915	191,000	675,700	6	$11,460		
Santa Barbara Electric Co. (controlled by Southern California Edison Co. through stock ownership), Santa Barbara, Calif. Name changed from Santa Barbara Gas & Electric Co.	Aug. 21, 1909	1,000,000	1909	400,000	400,900				
			1910	400,000	400,900	6	24,000		
			1911	400,000	400,900	6	24,000	0.5	$2,000.00
			1912	400,000	400,900	6	24,000		
			1913	400,000	400,900				
			1914	400,000	400,900	5	20,000	3	12,000.00
			1915	400,000	400,900	5	20,000	4	16,000.00
			1916	400,000	400,900	5	24,000 36,000	4	16,103.50
			1917	400,000	409,000	6	24,000	4	16,036.00
			1918	400,000	409,000	6	24,000	4	16,036.00
			1919	400,000	409,000	6	24,000	4	16,036.00
			1920	400,000	409,000	6	24,000	4	16,036.00
The Edison Electric Co.	July 27, 1902 (Wyoming)	10,000,000 (later increased to $13,000,000)	1902	2,000,900	948,840				
			1903	3,066,900	1,249,400	5	104,468		
			1904	3,666,300	2,701,100	5	144,733		
			1905	3,769,600	3,687,600	7½	268,997		
			1906	3,980,800	4,966,100	5	196,144		
			1907	3,996,000	7,200,000	3¾	148,486	2½	180,000.00
			1908	3,996,000	7,200,000	5	199,800	5	360,000.00
			1909			3¾	149,850	1¼	90,000.00
Edison Electric Co. (name changed from Los Angeles Edison Electric Co. on May 10, 1900), Los Angeles, Calif.	July 7, 1894	500,000							
		[d] 1,000,000	1898		771,050				2,500.00
		[e] 1,250,000	1899		857,050				
			1900		1,021,300				18,822.00
		[f] 2,000,000	1901		1,458,000				37,164.00
			1902		2,000,000				63,160.00
West Side Lighting Co., Los Angeles	June 5, 1896	500,000							
Peoples Gas Co. of Monrovia, Monrovia, Calif.	Mar. 30, 1906	50,000							

Colton Gas Co. (sold to Seth Hartley et al Nov. 1, 1907), Redlands, Calif.	Oct. 12, 1903	$100,000								
Redlands Gas Co. (sold to Home Gas Co. of Redlands in 1910), Redlands, Calif.	Feb. 19, 1900	100,000								
Riverside Light & Fuel Co. (sold to Southern California Gas Co. in 1911), Riverside, Calif.	Oct. 26, 1901	150,000								
Whittier Light & Fuel Co., county of Los Angeles, Calif.	Oct. 16, 1902	100,000								
Pomona & Ontario Light & Fuel Co., Los Angeles, Calif.	Feb. 10, 1902	150,000								
United Electric, Gas & Power Co., Los Angeles, Calif.	Feb. 10, 1900	650,000								
California Power Co., San Francisco, Calif.	June 24, 1899	5,000,000								
Santa Ana Gas & Electric Co., Santa Ana, Calif.	June 17, 1891	100,000								
Pasadena Electric Light & Power Co., Pasadena, Calif.	Feb. 9, 1888	[g] 50,000								
Mountain Power Co., Los Angeles, Calif.	Feb. 29, 1912	1,500,000	1912							
Southern California Power Co., Redlands, Calif.	Apr. 19, 1897	1,000,000								
Redlands Electric Light & Power Co., Redlands, Calif.	Oct. 8, 1892	[h] 200,000								
Union Power Co., Los Angeles, Calif.	Jan. 30, 1904	2,000,000	1904	2.000,000						

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[d] Increased May 9, 1898.
[e] Increased July 31, 1899.
[f] Increased May 23, 1901.
[g] Increased to $100,000 on Apr. 17, 1895
[h] Increased to $500,000 on Aug. 2, 1898

TABLE 245.—*Capitalization, outstanding stock, and dividends of Southern California Edison Co. and principal subsidiaries*—Continued.

Pacific Light & Power Corporation.

Company.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.			Dividends on first preferred stock.[i]
			First preferred.	Second preferred.	Common.	
Pacific Light & Power Corporation, Los Angeles, Calif., incorporated Jan. 12, 1910; absorbed May 26, 1917, by Southern California Edison Co.	$40,000,000	1910	$1,073,500	$9,882,700	$11,073,500	$10,102
		1911	1,207,000	9,922,700	12,207,000	63,058
		1912	1,182,000	9,975,000	10,559,500	72,232
		1913	3,057,000	9,975,000	10,559,500	78,585
		1914	5,000,000	9,975,000	10,559,500	186,010
		1915	5,000,000	9,975,000	10,559,500	300,000
		1916	5,000,000	9,975,000	10,559,500	150,000

Predecessors and subsidiaries of Pacific Light & Power Corporation.

Company.	Date of incorporation.	Capitalization.	Year (Dec. 31).	Common stock outstanding (par value).	Dividends.
Pacific Light & Power Co., Los Angeles, Calif.	Mar. 6, 1902	[j]$10,000,000	1903–1911	$10,000,000	....
San Gabriel Electric Co., Los Angeles, Calif.	May 24, 1897	[k] 500,000	1901	700,000	[l]$24,500
			1902	770,000	14,700
			1903–1913	770,000	....
San Antonio Light & Power Co., Pomona, Calif.	July 8, 1891	240,000	....	....	....
Sierra Power Co., Pomona, Calif.	Mar. 20, 1900	75,000	....	....	....
Mentone Power Co., Los Angeles, Calif.	Aug. 16, 1901	500,000	1901–1913	300,000	....
Kern River Co., Portland, Me.	June 28, 1897	2,500,000	1902–1907	2,500,000	....
			1908–1913	10,000	....
Electric Power Co., Los Angeles, Calif.	Sept. 19, 1894	1,000,000	1900	500,000	....
			1901	500,000	....
			1902–1913	510,000	....
San Joaquin & Eastern Railroad Co. (controlled through stock ownership), Los Angeles, Calif.	Mar. 16, 1912	1,000,000	1912–1916	1,000,000	....
Riverside Power Co., Riverside, Calif.	Apr. 10, 1901	250,000	....	....	....

Ventura County Power Co.

Company.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.		Dividends.	
			Preferred.	Common.	Preferred.	Common.
Ventura County Power Co., San Buenaventura, Calif., incorporated Aug. 2, 1906; absorbed Nov. 30, 1917, by Southern California Edison Co.	$2,500,000	1906	$181,700	$545,500	....	....
		1907	331,700	845,500	....	....
		1908–1913	381,700	845,500	....	....
		1914	381,700	810,000	[m]$34,353	[m] $72,900
		1915	350,780	706,060	....	....
		1916	350,780	706,060	....	....

Subsidiaries of Ventura County Power Co.

Company.	Date of incorporation.	Capitalization.
Ventura Water, Light & Power Co., Los Angeles, Calif.	Apr. 15, 1901	$500,000
Oxnard Light & Water Co., Oxnard, Calif.	Mar. 12, 1904	150,000
Santa Paula Electric Co., Santa Paula, Calif.	May 12, 1902	[n]200,000

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[i] The rate of dividends on first preferred stock was 6 per cent. No dividends were paid on second preferred and common stock.

[j] Exchanged for shares second preferred stock of Pacific Light & Power Corporation between January, 1910, and May, 1912.

[k] The capital was increased to $1,000,000 May 2, 1901.

[l] Dividends for 1901 were paid at rate of 50 cents per share.

[m] The rate of dividends for preferred and common stock for 1914 was 9 per cent.

[n] Par value of shares $10.

NOTE.—No information available in regard to stock outstanding and dividends for subsidiary companies,

TABLE 246.—*Bonds of Southern California Edison Co. and principal subsidiaries.*

Issue.	Callable or convertible.	Sinking-fund deposits.	Trustee.	Denomination.	Authorized.
1	2	3	4	5	6
A. Southern California Edison Co. general and refunding mortgage 6 per cent bonds dated July 1, 1917:					
"Series of 1917," dated July 1, 1917; due July 1, 1919; interest payable Jan. 1 and July 1.	At 100½ on any interest date	None	Harris Trust & Savings Bank, Chicago; Los Angeles Trust & Savings Bank, Los Angeles.	Coupon bonds $100, $500, and $1,000; principal may be registered.	$136,000,000
"Series of 1919," bearing interest from Feb. 1, 1919; due Feb. 1, 1944; interest payable Feb. 1 and Aug. 1.	At 105 and interest on any interest date up to and including Feb. 1, 1942; and at 102 and interest on any interest date thereafter.	On Mar. 1 and Sept. 1 of each year, 1 per cent of the aggregate par value of outstanding bonds of the company including this issue and all underlying bonds after providing for sinking-fund payments made to trustees of underlying mortgages.	do	do	
1. Southern California Edison Co. general mortgage 5 per cent bonds, dated Nov. 1, 1909; due Nov. 1, 1939; interest payable July 1 and Jan. 1.	On any interest date at 105 and interest; not convertible.	1 per cent of bonds outstanding Mar. 1 and Sept. 1 each year.	Harris Trust & Savings Bank, Chicago; Los Angeles Trust & Savings Bank, Los Angeles.	$1,000	30,000,000
2. Southern California Edison Co. debenture 6 per cent bonds, dated Apr. 1, 1911; due Apr. 1, 1916; interest payable Apr. 1 and Oct. 1.	On any interest date at 101 and interest; convertible to 10 shares of common stock.	None	Los Angeles Trust & Savings Bank, Los Angeles.	$1,000	1,000,000
2A. Southern California Edison Co. 6 per cent convertible debentures, dated Mar. 15, 1915; due Mar. 15, 1920; interest payable Mar. 1 and Sept. 15.	Convertible at option of holder into common stock, 11 shares for each $1,000 bond; callable at 101 and interest on any interest date.	do	do	$1,000	5,000,000

TABLE 246.—*Bonds of Southern California Edison Co. and principal subsidiaries*—Continued.

Issue. 1	Callable or convertible. 2	Sinking-fund deposits. 3	Trustee. 4	Denomination. 5	Authorized. 6
2B. Southern California Edison Co. debenture 7 per cent gold bonds, dated Jan. 15, 1919; due $1,000,000 annually on Jan. 15 of each year 1921 to 1928, both inclusive; interest payable Jan. 15 and July 15.	On the 15th day of any month on 60 days' notice, at 105 and interest, for all debentures having 4 years or more to run; at 104 and interest for all debentures having less than 4 years and more than 3 years to run; at 103 and interest for all debentures having less than 3 and more than 2 years to run; at 102 for all debentures having less than 2 years and more than 6 months to run; at 101 for all debentures having less than 6 months to run.	None	Bankers Trust Co., New York.	Coupon bonds $100, $500, and $1,000; principal may be registered.	$8,000,000
3. The Edison Electric Co. debenture 6 per cent bonds, dated Mar. 1, 1907; due Mar, 1, 1910; interest payable Mar. 1 and Sept. 1.	On any interest date at 101 and interest: convertible to 10 shares of common stock.	do	Los Angeles Trust Co., Los Angeles.	$1,000	800,000
4. The Edison Electric Co. (of Wyoming) first and refunding 5 per cent bonds, dated Sept. 1, 1902; due Sept. 1, 1922; interest payable Mar. 1 and Sept. 1.	On any interest date on and after Sept. 1, 1907, at 110 and interest; not convertible.	10 per cent of net earnings, beginning Sept. 1, 1907; or, if property is sold, 1½ per cent of bonds outstanding Sept. 1 each year.	Los Angeles Trust Co., Los Angeles; U. S. Mortgage & Trust Co., New York.	$1,000 coupon; principal may be registered.	10,000,000
5. Edison Electric Co., of Los Angeles, first mortgage 5 per cent bonds, dated Sept. 1, 1899; due Sept. 1, 1929; interest payable Mar. 1 and Sept. 1.	Neither callable nor convertible	1 per cent of outstanding bonds annually, beginning Jan. 1, 1905.	Title Insurance & Trust Co., Los Angeles.	$1,000	1,250,000
6. Edison Electric Co., of Los Angeles, 6 per cent bonds, dated Dec. 2, 1897; due Nov. 1, 1927; interest payable May 1 and Nov. 1.	do	10 per cent of net earnings, beginning Sept. 1, 1898.	do	440 at $1,000, 100 at $500, 100 at $100.	500,000
7. Mountain Power Co. first-mortgage 5 per cent bonds dated Dec. 1, 1900; due Dec. 1, 1920; interest payable June 1 and Dec. 1.	do	1 per cent of bonds outstanding annually, beginning Jan. 1, 1906.	do	$1,000	400,000

8. Santa Ana Gas & Electric Co. first-mortgage 5 per cent bonds dated July 1, 1893; due July 1, 1908; interest payable Jan. 1 and July 1.	Neither callable nor convertible..	1 per cent of bonds outstanding, beginning Jan. 1, 1905.	Title Insurance & Trust Co., Los Angeles.	$1,000..........	100,000
9. Santa Ana Gas Co. 7 per cent bonds dated July 1, 1893; due July 1, 1908; interest payable Jan. 1 and July 1.	.....do..........................	None...........................	W. D. Woolwine........	$500............	16,000
10. Redlands Electric Light & Power Co. first-mortgage 6 per cent bonds dated Sept. 1, 1898, due Sept. 1, 1928; interest payable Mar. 1 and Sept. 1.	On any interest date after Sept. 1, 1903, at 103. Not convertable.	Cancel or provide sinking fund to cancel bonds as follows: 1908–1912, 5 bonds each year. 1913–1917, 10 bonds each year. 1918–1922, 10 bonds each year. 1923–1927, 15 bonds each year.	Union Trust Co., San Francisco.	790 of $500, 100 of $50.	400,000
11. Southern California Power Co. first-mortgage 6 per cent bonds dated July 31, 1897; due Aug. 1, 1927; interest payable Feb. 1 and Aug. 1.	On any interest date after Aug. 1, 1906, at premium of one-half of 1 per cent for each year from date of redemption to date of maturity. Not convertible.	None...........................	Title Insurance & Trust Co., Los Angeles.	$1,000..........	500,000
12. The Pasadena Electric Light & Power Co first-nortgage 6 per cent bonds dated Nov. 6, 1895; due Dec. 20, 1915; interest payable Jan. 1, and July 1.	Neither callable nor convertible....	.....do..........................	State Loan & Trust Co., Los Angeles.	$1,000..........	30,000
13. United Electric Gas & Power Co. first mortgage 5 per cent bonds dated Dec. 1, 1900; due Dec. 1, 1920; interest payable June 1 and Dec. 1.	.....do..........................	$15,000 annually, beginning Jan. 2, 1905.	Broadway Bank & Trust Co., Los Angeles.	$1,000 coupon...	500,000
14. Long Beach & Alamitos Gas, Electric & Power Co. first mortgage 5 per cent bonds dated Jan. 1, 1901; due Dec. 1, 1920; interest payable June 1 and Dec. 1.	.....do..........................	None...........................	.....do................	$500 coupon.....	100,000
15. Riverside Light & Fuel Co. first mortgage 5 per cent bonds dated Sept. 1, 1903; due Sept. 1, 1923; interest payable Mar. 1 and Sept. 1.	.....do..........................	.....do..........................	Title Insurance & Trust Co., Los Angeles.	$500 coupon.....	75,000
16. Whittier Light & Fuel Co. first mortgage 5 per cent bonds dated Dec. 31, 1902; due Jan. 1, 1923; interest payable Jan. 1 and July 1.	.....do..........................	.....do..........................	Los Angeles Trust Co., Los Angeles.	$500 coupon.....	40,000
17. Pomona & Ontario Light & Fuel Co. first mortgage 5 per cent bonds dated June 1, 1902; due June 1, 1922; interest payable June 1 and Dec. 1.	.....do..........................	.....do..........................	Union Trust Co., San Francisco.	$500 coupon.....	75,000

TABLE 246.—*Bonds of Southern California Edison Co. and principal subsidiaries*—Continued.

Issue.	Callable or convertible.	Sinking-fund deposits.	Trustee.	Denomination.	Authorized.
1	2	3	4	5	6
18. **Redlands Gas Co.** 5 per cent bonds dated May 1, 1903; due May 1, 1933; interest payable May 1 and Nov. 1.	After May 1, 1908, at 105 and interest. Not convertible.	Cancel 5 bonds each year, May 1, 1912, to May 1, 1932, at 105 and interest.	Union Trust Co., San Francisco.	$500	$100,000
19. **Redlands Gas Co.** 6 per cent bonds dated Oct. 1, 1900; due Oct. 10, 192; interest payable Apr. 1 and Oct. 1.	After Oct. 1, 1905, at 103 and interest. Not convertible.	None	do	$500	50,000
20. **Colton Gas Co.** 6 per cent bonds dated Jan. 1, 1905; due Jan. 1, 1935; interest payable Jan. 1 and July 1.	After Jan. 1, 1910, at 105 and interest. Not convertible.	do	Los Angeles Trust Co., Los Angeles.	$1,000	50,000
Pacific Light & Power Co. bonds.					
21. **Pacific Light & Power Corporation** first and refunding 5 per cent sinking-fund gold bonds dated Nov. 20, 1911; due Sept. 1, 1951; interest payable Mar. 1 and Sept. 1.	As a whole (or in part by lot for sinking fund) at 105 and interest on any interest date upon 60 days' notice.	Sinking fund of 1 per cent of bonds issued, including bonds reserved for refunding, beginning in 1914.	United States Mortgage & Trust Co., New York.	$1,000 coupon or multiples and registered.	$35,000,000
22. **Pacific Light & Power Corporation** collateral-trust 6 per cent bonds dated July 1, 1910; due July 1, 1915; interest payable Jan. 1 and July 1.	On any interest date at 102½ and interest. Convertible on any interest date into first-mortgage bonds of Southern California Gas Co.—either a 6 per cent 40-year bond at par or a 5 per cent 40-year bond at 90.		Trust Co. of America, New York.	$1,000 coupon; principal may be registered.	3,000,000
23. **Pacific Light & Power Corporation** collateral-trust 6 per cent bonds dated May 1, 1913; due May 1, 1914; interest payable May 1 and Nov. 1.	At 101½ and interest		United States Mortgage & Trust Co., New York.	do	5,000,000
24. **Pacific Light & Power Corporation** collateral-trust 6 per cent bonds dated July 1, 1915; due July 1, 1917; interest payable Jan. 1 and July 1.	At 102½. Convertible on any date before Apr. 1, 1917, into first-mortgage 6 per cent 40-year bonds of Southern California Gas Co. at par.		Mortimer N. Buckner, New York.	do	2,338,000

25. **Pacific Light & Power Co.** first mortgage gold 5 per cent bonds dated Sept. 1, 1902; due July 1, 1942; interest payable Jan. 1 and July 1.		2 per cent of outstanding bonds, 1905 to 1909, inclusive, and 2½ per cent from 1910 to 1942. Sinking fund to be invested in bonds at price not exceeding 110. If the bonds can not be procured at 110 investment may be made in other securities.	National Bank of Commerce, New York; Union Trust Co., San Francisco.	$1,000 coupon; principal may be registered.	$10,000,000
26. **San Gabriel Electric Co.** first-mortgage 6 per cent bonds dated Feb. 26, 1898; due Apr. 1, 1928; interest payable Apr. 1 and Oct. 1.	At 104 and interest after Apr. 1, 1903.		Union Trust Co., San Francisco.	$1,000 coupon; principal may be registered.	500,000
27. **Mentone Power Co.**, first-mortgage 5 per cent bonds, dated Dec. 1, 1901; due Dec. 1, 1931; interest payable June 1 and Dec. 1.			do		300,000
28. **Electric Power Co.** first 5 per cent bonds dated Dec. 1, 1911; due Dec. 1, 1951; interest payable June 1 and Dec. 1.	At 102½ on any interest date.	1 per cent of outstanding bonds.	Security Trust & Savings Bank, Los Angeles.		1,000,000
29. **Ventura County Power Co.** sinking fund 6 per cent bonds, dated Nov. 1, 1906; due Nov. 1, 1936; interest payable May 1 and Nov. 1.	At 101 and interest on any interest date.	2 per cent of outstanding bonds, beginning Nov. 1, 1911.	Title Insurance & Trust Co., Los Angeles.	$1,000; principal may be registered.	1,000,000
30. **Ventura Water, Light & Power Co.** first 6 per cent bonds, dated July 9, 1901; due May 1, 1921; interest payable May 1 and Nov. 1.	At 101 and interest on any interest date after May 1, 1906.		do	$500; principal may be registered.	250,000
Subsidiaries controlled through stock ownership.					
31. **Santa Barbara Gas & Electric Co.** first-mortgage 6 per cent bonds, dated July 1, 1911; due July 1, 1941; interest payable Jan. 1 and July 1.	At 105 and interest on any interest date. Not convertible.	Annual cash sinking fund, beginning July 1, 1913; 1 per cent of bonds outstanding for redemption of bonds and an extra 1 per cent beginning on the same date for permanent extensions and additions or for redeeming bonds.	Los Angeles Trust & Savings Bank, Los Angeles.	$100, $500, and $1,000, all coupon.	$1,000,000
32. **Long Beach Consolidated Gas Co.** first-mortgage 6 per cent bonds dated Nov. 1, 1910; due Nov. 1, 1940; interest payable Mar. and Nov. 1.	At 103 and interest on or after Nov. 1, 1913, or any interest date. Not convertible.	1 per cent of bonds outstanding, beginning Nov. 1, 1911, to be used exclusively in redeeming these bonds. Additional fund of 1 per cent from Nov. 1, 1915, to be used for permanent extensions or for purchase of bonds.	do	$1,000 coupon; principal may be registered.	1,000,000

TABLE 246.—*Bonds of Southern California Edison Co. and principal subsidiaries*—Continued.

Issue.	Callable or convertible.	Sinking-fund deposits.	Trustee.	Denomination.	Authorized.
1	2	3	4	5	6
33. Santa Barbara & Suburban Railway Co. first-mortgage 6 per cent bonds dated Mar. 15, 1912; due Mar. 15, 1937; interest payable Mar. 15 and Sept. 15.	At 105 and interest on any interest date.	2 per cent of outstanding bonds, beginning Mar. 15, 1915.	Los Angeles Trust & Savings Bank, Los Angeles.	$1,000; principal may be registered.	$500,000
34. Santa Barbara & Suburban Railway Co. second-mortgage 5 per cent bonds dated Mar. 15, 1912; due Mar. 15, 1942; interest payable Mar. 15 and Sept. 15.	.....do........................	....	.....do.................	$500; principal may be registered.	163,000
35. Santa Barbara Gas & Electric Co. first-mortgage 5 per cent bonds dated July 1, 1916; due, 10,000 annually, July 1, 1920 to 1940, and balance July 1, 1941; interest payable Jan. 1 and July 1.	At 103 and interest on any interest date.	1 per cent of par value of bonds outstanding under this mortgage issued in excess of the first million bonds to be used in purchasing or calling by lot at 105 and interest. Bonds mature in 1941.	Los Angeles Trust & Savings Bank, Los Angeles; or E. H. Rollins & Sons, San Francisco or New York.	$100, $500, $1,000; principal may be registered.	3,500,000
36. San Joaquin & Eastern Railroad Co. first 5 per cent bonds, dated Mar. 1, 1912; due Mar. 1, 1952; interest payable Mar. 1 and Sept. 1.	At 100 and interest on any interest date.	1 per cent of outstanding bonds, beginning Mar. 1, 1917.	Security Trust & Savings Bank, Los Angeles.	$1,000 coupon; principal may be registered.	1,000,000
37. Fontana Power Co. first-mortgage 6 per cent serial gold bonds, dated Feb. 1, 1917; due Feb. 1, 1922–1947; interest payable Feb. 1 and Aug. 1.	Callable as a whole or in part on any interest date at 104 and interest.	Provides for serial redemption.....	Los Angeles Trust & Savings Bank, Los Angeles.	.....do..........	350,000

NOTE.—The Southern California Edison Co. maintains four sinking funds: (1) Sinking fund to redeem bonds of the Edison Electric Co., (2) sinking fund to redeem bonds of United Electric Gas & Power Co., (3) sales of property account to redeem bonds of the Edison Electric Co., (4) special trust fund to redeem bonds of Southern California Edison Co. or reimbursement for construction, expenditures, and also for payment of other sinking funds. At the end of 1915 these funds contained a total of $250,371. Total additions to the fund during the year amounted to $492,231 and total withdrawals to $549,341, leaving at the end of the year $193,261 cash uninvested in the fund. No bonds were listed as in the sinking fund.

TABLE 246.—*Bonds of Southern California Edison Co. and principal subsidiaries*—Continued.

Issue.	Bonded debt.							Notes.
	Year (Dec. 31).	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total authenticated.	
			Canceled.	Alive.				
1	7	8	9	10	11	12	13	14
A. Southern California Edison Co. general and refunding mortgage 6 per cent bonds dated July 1, 1917:								
"Series of 1917," dated July 1, 1917; due July 1, 1919; interest payable Jan. 1 and July 1.	1917	$39,284,500				$10,000,000	$10,000,000	
	1918	39,284,500				10,000,000	10,000,000	Retired July 1, 1919.
"Series of 1919," bearing interest from Feb. 1, 1919; due Feb. 1, 1944; interest payable Feb. 1 and Aug. 1.	1919	34,361,000				8,000,000	8,000,000	
	1920	34,172,000				20,878,000	20,878,000	
1. Southern California Edison Co. general mortgage 5 per cent bonds, dated Nov. 1, 1909; due Nov. 1, 1939; interest payable July 1 and Jan. 1.	1909	10,296,000					7,290,000	
	1910	5,520,000				7,290,000	9,348,000	
	1911	5,478,000				9,348,000	10,043,000	
	1912	5,329,000				10,043,000	11,847,000	
	1913	5,296,000			$1,122,000	10,725,000	13,360,000	
	1914	5,296,000			518,000	12,842,000	13,360,000	
	1915	5,296,000				13,360,000	13,360,000	
	1916	5,296,000				13,360,000	13,360,000	
	1917	5,296,000				13,360,000	13,360,000	
	1918	5,296,000				13,360,000	13,360,000	Unissued, $11,344,000.
	1919	5,296,000				13,360,000	13,360,000	Do.
	1920	5,296,000				13,360,000	13,360,000	Do.
2. Southern California Edison Co. debenture 6 per cent bonds, dated Apr. 1, 1911; due Apr. 1, 1916; interest payable Apr. 1 and Oct. 1.	1911	None.	None.			1,000,000	1,000,000	
	1912	None.	None.			332,000	332,000	$668,000 retired.
	1913	None.	None.			332,000	332,000	
	1914	None.	None.			332,000	332,000	
	1915	None.	None.			332,000	332,000	$332,000 retired at maturity, Apr. 1, 1916.
2A. Southern California Edison Co. 6 per cent convertible debentures, dated Mar. 15, 1915; due Mar. 15, 1920; interest payable Mar. 15 and Sept. 15.	1915	332,000			2,668,000	2,000,000	2,000,000	Entries in column 9 show amounts exchanged for common stock; entries in column 11, bonds unissued.
	1916	332,000	10,000		2,668,000	1,990,000	1,990,000	
	1917	332,000	22,000		2,668,000	1,978,000	1,978,000	
	1918	332,000	22,000		2,668,000	1,978,000	1,978,000	
	1919	332,000	23,000		2,668,000	1,977,000	1,977,000	

TABLE 246.—*Bonds of Southern California Edison Co. and principal subsidiaries*—Continued.

Issue.	Bonded debt.							Notes.
	Year (Dec. 31).	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total authenticated.	
			Canceled.	Alive.				
1	7	8	9	10	11	12	13	14
2B. Southern California Edison Co. debenture 7 per cent gold bonds, dated Jan. 15, 1919; due $1,000,000 annually on Jan. 15 of each year 1921 to 1928, both inclusive; interest payable Jan. 15 and July 15.	1919	....	....	....	....	$8,000,000	$8,000,000	
	1920	....	....	....	....	8,000,000	8,000,000	
3. The Edison Electric Co. debenture 6 per cent bonds, dated Mar. 1, 1907; due Mar. 1, 1910; interest payable Mar. 1 and Sept. 1.	1907	None.	None.	....	....	800,000	800,000	
	1908	None.	None.	....	....	800,000	800,000	
	1909	None.	None.	....	....	800,000	800,000	
	1910	None.	None.	....	....	....	....	$800,000 retired; redeemed by general mortgage of Nov. 1, 1909.
4. The Edison Electric Co. first and refunding 5 per cent bonds, dated Sept. 1, 1902; due Sept. 1, 1922; interest payable Mar. 1 and Sept. 1.	1902	$477,000	None.	....	....	1,721,000	1,721,000	Closed under general mortgage of Nov. 1, 1909.
	1903	477,000	None.	....	....	2,726,000	2,726,000	
	1904	477,000	None.	....	....	4,133,000	4,133,000	
	1905	477,000	None.	....	....	5,358,000	5,358,000	
	1906	477,000	None.	....	....	7,935,000	7,935,000	
	1907	477,000	None.	....	....	9,523,000	9,523,000	
	1908	467,000	$104,000	....	....	9,429,000	9,429,000	
	1909	467,000	282,000	....	....	9,222,000	9,222,000	
	1910	467,000	459,000	....	....	4,501,000	9,071,000	$4,570,000 exchanged for Southern California Edison Co. 5's.
	1911	467,000	1,301,000	....	....	3,592,000	8,203,000	$4,611,000
	1912	467,000	1,430,000	....	....	3,329,000	8,078,000	$4,749,000
	1913	467,000	1,430,000	....	....	3,186,000	7,968,000	$4,782,000
	1914	467,000	1,664,000	....	....	3,090,000	7,869,000	$4,779,000
	1915	467,000	1,756,000	....	....	2,998,000	7,777,000	$4,779,000
	1916	467,000	1,887,000	....	....	2,895,000	7,646,000	$4,751,000
	1917	467,000	1,992,000	....	....	2,806,000	7,541,000	$4,735,000
	1918	467,000	2,095,000	....	....	2,743,000	7,438,000	$4,695,000
	1919	467,000	2,196,000	....	....	2,708,000	7,337,000	$4,629,000
	1920	467,000	2,403,000	....	....	2,668,000	7,330,000	$4,662,000
5. Edison Electric Co., of Los Angeles first mortgage 5 per cent bonds, dated Sept. 1, 1899; due Sept. 1, 1929; interest payable Mar. 1 and Sept. 1.	1899	138,000	....	....	....	659,000	659,000	
	1900	69,000	....	....	....	743,000	743,000	
	1901	69,000	....	....	....	1,181,000	1,181,000	Closed under first and refunding mortgage of Sept. 1, 1902.

	1902	69,000	240,000	....	....	941,000	941,000	$550,000 of this issue exchanged during 1903 for the Edison Electric Co. first and refunding 5's and $1,000 exchanged during 1912 for Southern California Edison Co. 5's.
	1903	69,000	240,000	....	....	391,000	391,000	
	1904	69,000	240,000	....	....	391,000	391,000	
	1905	69,000	240,000	....	....	391,000	391,000	
	1906	69,000	240,000	....	....	391,000	391,000	
	1907	69,000	240,000	....	....	391,000	391,000	
	1908	69,000	240,000	....	....	391,000	391,000	
	1909	69,000	240,000	....	....	391,000	391,000	
	1910	69,000	240,000	....	....	391,000	391,000	
	1911	69,000	240,000	....	....	391,000	391,000	
	1912	69,000	240,000	....	....	390,000	390,000	
	1913	69,000	240,000	....	....	390,000	390,000	
	1914	69,000	240,000	....	....	390,000	390,000	
	1915	69,000	240,000	....	....	390,000	390,000	
	1916	69,000	240,000	....	....	390,000	390,000	
	1917	69,000	240,000	....	....	390,000	390,000	
	1918	69,000	240,000	....	....	390,000	390,000	
	1919	69,000	240,000	....	....	390,000	390,000	$286,000 exchanged for Edison Electric Co. of Los Angeles 5's.
	1920	69,000	593,000	....	....	38,000	38,000	$267,000 exchanged for Edison Electric Co. of Los Angeles 5's.
6. Edison Electric Co., of Los Angeles, 6 per cent bonds, dated Dec. 2, 1897; due Nov. 1, 1927; interest payable May 1 and Nov. 1.	1898	None.	....	....	....	307,800	307,800	
	1899	44,400	....	....	....	65,600	65,600	
	1900	50,500	....	....	....	48,500	48,500	
	1901	....	51,000	....	....	48,000	48,000	Closed under first and refunding mortgage of Sept. 1, 1902; $104,000 unissued, and $297,000 exchanged for other issues and canceled.
	1902	....	51,000	....	....	48,000	48,000	
	1903	....	51,000	....	....	48,000	48,000	
	1904	....	51,000	....	....	48,000	48,000	
	1905	....	51,000	....	....	48,000	48,000	
	1906	....	51,000	....	....	48,000	48,000	
	1907	....	51,000	....	....	48,000	48,000	
	1908	....	51,000	....	....	48,000	48,000	
	1909	....	51,000	....	....	48,000	48,000	
	1910	....	51,000	....	....	48,000	48,000	
	1911	....	51,000	....	....	48,000	48,000	
	1912	....	51,000	....	....	48,000	48,000	
	1913	....	51,000	....	....	48,000	48,000	
	1914	....	51,000	....	....	48,000	48,000	
	1915	....	51,000	....	....	48,000	48,000	
	1916	....	51,000	....	....	48,000	48,000	
	1917	....	51,000	....	....	48,000	48,000	
	1918	....	51,000	....	....	48,000	48,000	
	1919	....	51,000	....	....	48,000	48,000	
	1920	....	80,000	....	....	19,000	19,000	
7. Mountain Power Co. first-mortgage 5 per cent bonds dated Dec. 1, 1900; due Dec. 1, 1920; interest payable June 1 and Dec. 1.	1902	....	....	....	....	40,000	40,000	Closed under first and refunding mortgage of Sept. 1, 1902.
	1903	....	....	....	....	....	....	$40,000 exchanged for Southern California Edison Co.'s 5's. Mortgage canceled, property reconveyed.

TABLE 246.—*Bonds of Southern California Edison Co. and principal subsidiaries*—Continued.

Issue.	Bonded debt.							Notes.
	Year (Dec. 31).	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total authenticated.	
			Canceled.	Alive.				
1	7	8	9	10	11	12	13	14
8. Santa Ana Gas & Electric Co. first-mortgage 5 per cent bonds dated July 1, 1893; due July 1, 1908; interest payable Jan. 1 and July 1.	1902	$10,000				$33,000	$33,000	Closed under first and refunding mortgage of Sept. 1, 1902.
	1903	10,000				7,000	7,000	$26,000 exchanged for The Edison Electric Co.'s first and refunding 5's.
	1904	10,000				7,000	7,000	$26,000 exchanged for The Edison Electric Co.'s first and refunding 5's. Mortgage canceled, property reconveyed.
	1905	10,000				7,000	7,000	$26,000 Exchanged for The Edison Electric Co.'s first and refunding 5's.
	1906	10,000				7,000	7,000	$26,000
	1907	10,000				7,000	7,000	$26,000
	1908	10,000				7,000	7,000	$26,000
	1909	10,000				7,000	7,000	$26,000
	1910	10,000				7,000	7,000	$26,000
	1911	10,000						$26,000 exchanged for The Edison Electric Co.'s first and refunding 5's; $7,000 exchanged for Southern California Edison Co.'s 5's.
9. Santa Ana Gas Co. 7 per cent bonds dated July 1, 1893; due July 1, 1908; interest payable Jan. 1 and July 1.	1902					10,000	10,000	Closed under first and refunding mortgage of Sept. 1, 1902.
	1903					10,000	10,000	
	1904					10,000	10,000	
	1905					10,000	10,000	
	1906					10,000	10,000	Mortgage canceled.
	1907					10,000	10,000	
	1908							$10,000 retired.
10. Redlands Electric Light & Power Co. first-mortgage 6 per cent bonds dated Sept. 1, 1898; due Sept. 1, 1928; interest payable Mar. 1 and Sept. 1.	1902					252,000	252,000	Closed under first and refunding mortgage of Sept. 1, 1902.
	1903							$252,000. Mortgage canceled; property reconveyed.
11. Southern California Power Co. first-mortgage 6 per cent bonds dated July 31, 1897; due Aug. 1, 1827; interest payable Feb. 1 and Aug. 1.	1899					96,000	96,000	
	1900					15,000	15,000	
	1901					15,000	15,000	Closed under first and refunding mortgage of Sept. 1, 1902.
	1902					15,000	15,000	
	1903					15,000	15,000	
	1904					15,000	15,000	

	1905					15,000			
	1906					15,000			
	1907					15,000			
	1908					15,000			
	1909					15,000			
	1910					15,000			
	1911					15,000			
	1912					15,000			
	1913					15,000			
	1914					15,000			
	1915					15,000			
	1916					15,000			
	1917					15,000		$15,000 retired Aug. 1, 1917.	
12. The Pasadena Electric Light & Power Co. first-mortgage 6 per cent bonds dated Nov. 6, 1895; due Dec. 20, 1915; interest payable Jan. 1 and July 1.	1899					11,000			
	1900					6,000			
	1901					6,000		Closed under first and refunding mortgage of Sept. 1, 1902.	
	1902					6,000			
	1903					6,000			
	1904					6,000			
	1905					6,000			
	1906					6,000			
	1907					6,000			
	1908					6,000			
	1909					6,000			
	1910					6,000		$6,000 exchanged for Southern California Edison Co.'s 5's. Mortgage canceled, property reconveyed.	
13. United Electric Gas & Power Co. first mortgage 5 per cent bonds dated Dec. 1, 1900; due Dec. 1, 1920; interest payable June 1 and Dec. 1.	1903					500,000		Closed under general mortgage of Nov. 1, 1909.	
	1904					500,000			
	1905		15,000			485,000			
	1906		30,000			470,000			
	1907		45,000			455,000			
	1908		60,000			440,000			
	1909		75,000			425,000			
	1910		103,000			354,000	397,000	$43,000	Exchanged for Southern California Edison Co.'s 5's.
	1911		319,000			154,000	181,000	$27,000	
	1912		334,000			139,000	166,000	$27,000	
	1913		383,000			95,000	117,000	$22,000	
	1914		398,000			80,000	102,000	$22,000	
	1915		412,000			66,000	88,000	$22,000	
	1916		427,000			53,000	73,000	$20,000	
	1917		441,000			45,000	59,000	$14,000	
	1918		456,000			30,000	44,000	$14,000	
	1919		470,000		16,000	None.	14,000	$14,000	
	1920		500,000		None.	None.	None.		

TABLE 246.—*Bonds of Southern California Edison Co. and principal subsidiaries*—Continued.

Issue.	Bonded debt.							Notes.
	Year (Dec. 31).	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total authenticated.	
			Canceled.	Alive.				
1	7	8	9	10	11	12	13	14
14. Long Beach & Alamitos Gas, Electric & Power Co. first-mortgage 5 per cent bonds dated Jan. 1, 1901; due Dec. 1, 1920; interest payable June 1 and Dec. 1.	1903					$12,000	$12,000	Closed under general mortgage of Nov. 1, 1909.
	1904					12,000	12,000	
	1905					12,000	12,000	
	1906					12,000	12,000	
	1907					12,000	12,000	
	1908					12,000	12,000	
	1909					12,000	12,000	
	1910							$12,000 exchanged for Southern California Edison Co. 5's. Mortgage canceled, property reconveyed.
15. Riverside Light & Fuel Co. first-mortgage 5 per cent bonds dated Sept. 1, 1903; due Sept. 1, 1923; interest payable Mar. 1 and Sept. 1.	1906					75,000	75,000	Closed under general mortgage of Nov. 1, 1909.
	1907					75,000	75,000	
	1908					75,000	75,000	
	1909					75,000	75,000	
	1910					31,000	31,000	$44,000 exchanged for Southern California Edison Co. 5's.
	1911							$46,000 exchanged for Southern California Edison Co. 5's. Property sold to and outstanding bonds assumed by Southern California Gas Co.
16. Whittier Light & Fuel Co. first-mortgage 5 per cent bonds dated Dec. 31, 1902; due Jan. 1, 1923; interest payable Jan. 1 and July 1.	1906					35,000	35,000	Closed under general mortgage of Nov. 1, 1909.
	1907					35,000	35,000	
	1908					35,000	35,000	
	1909					35,000	35,000	
	1910							$35,000 exchanged for Southern California Edison Co. 5's. Mortgage canceled, property reconveyed.
17. Pomona & Ontario Light & Fuel Co. first-mortgage 5 per cent bonds dated June 1, 1902; due June 1, 1922; interest payable June 1 and Dec. 1.	1906					60,000	60,000	Closed under general mortgage of Nov. 1, 1909.
	1907					60,000	60,000	
	1908					60,000	60,000	
	1909					60,000	60,000	

	1910					17,000	17,000	$43,000 Exchanged for Southern California Edison Co. 5's. $7,000 retired May, 1916.
	1911					17,000	17,000	$43,000
	1912					7,000	7,000	$53,000
	1913					7,000	7,000	$53,000
	1914					7,000	7,000	$53,000
	1915					7,000	7,000	$53,000
18. Redlands Gas Co. 5 per cent bonds dated May 1, 1903; due May 1, 1933; interest payable May 1 and Nov. 1.	1906	$51,500				48,500	48,500	Property sold to and bonds assumed by Home Gas & Electric Co.
	1907	51,500				48,500	48,500	
	1908	51,500				48,500	48,500	
19. Redlands Gas Co. 6 per cent bonds dated Oct. 1, 1900; due Oct. 1, 1920; interest payable Apr. 1 and Oct. 1.	1906					50,000	50,000	Do.
	1907					50,000	50,000	
	1908					50,000	50,000	
20. Colton Gas Co. 6 per cent bonds dated Jan. 1, 1905; due Jan. 1, 1935; interest payable Jan. 1 and July 1.	1906					15,000	15,000	Property sold to and bonds assumed by Seth Hartley et al.

Pacific Light & Power Co. bonds.

21. Pacific Light & Power Corporation first and refunding 5 per cent bonds dated Nov. 20, 1911; due Sept. 1, 1951; interest payable Mar. 1 and Sept. 1.	1911	$8,846,000			$324,000	$10,000,000	$10,324,000	
	1912	8,349,000			645,000	10,000,000	10,645,000	
	1913	8,349,000			2,209,000	10,000,000	12,209,000	
	1914	8,179,000		$264,000	1,783,000	12,211,000	14,258,000	
	1915	8,179,000		543,000	None.	13,715,000	14,258,000	
	1916	8,179,000		814,900	None.	13,444,000	14,258,000	
	1917	8,179,000		1,123,000	None.	8,135,000	9,258,000	Unissued $12,563,000; deposited under Southern California Edison Co. general-mortgage issue of 1909, $5,000,000.
	1918	8,179,000		1,451,000	None.	7,807,000	9,258,000	Do.
	1919			1,779,000	None.	7,479,000	9,258,000	Do.
	1920			2,148,000	None.	7,110,000	9,258,000	Do.
22. Pacific Light & Power Corporation collateral-trust 6 per cent bonds dated July 1, 1910; due July 1, 1915; interest payable Jan. 1 and July 1.	1910					2,000,000	2,000,000	Interest on this issue is paid by the Southern California Gas Co. and does not appear in "Interest accrued on funded debt" in Pacific Light & Power Corporation earnings and expenses account. Retired in 1915.
	1911					2,388,000	2,388,000	
	1912		$612,000			2,388,000	2,388,000	
	1913		662,000			2,338,000	2,338,000	
	1914		662,000			2,338,000	2,338,000	
23. Pacific Light & Power Corporation collateral-trust 6 per cent bonds dated May 1, 1913; due May 1, 1914; interest payable May 1 and Nov. 1.	1913	2,500,000				2,500,000	2,500,000	
24. Pacific Light & Power Corporation collateral-trust 6 per cent bonds dated July 1, 1915; due July 1, 1917; interest payable Jan. 1 and July 1.	1915					2,388,000	2,388,000	
	1916					2,388,000	2,388,000	

TABLE 246.—*Bonds of Southern California Edison Co. and principal subsidiaries*—Continued.

Issue.	Bonded debt.							Notes.
	Year (Dec. 21).	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total authenticated.	
			Canceled.	Alive.				
1	7	8	9	10	11	12	13	14
25. Pacific Light & Power Co. first gold 5 per cent bonds dated Sept. 1, 1902; due July 1, 1942; interest payable Jan. 1 and July 1.	1902	$500,000				$1,511,000	$2,011,000	$2,350,000 of outstanding bonds of this issue ar guaranteed by the Los Angeles Ry. Co.
	1903	395,000				3,305,000	3,700,000	
	1904	395,000				4,466,000	4,861,000	
	1905	380,000		$96,000		5,814,000	6,194,000	
	1906	377,000		241,000		6,253,000	6,630,000	
	1907	366,000		336,000		6,350,000	6,716,000	
	1908	366,000		506,000	$300,000	8,828,000	9,494,000	
	1909	359,000		634,000	180,000	8,827,000	9,366,000	
	1910	347,000		1,030,000	60,000	8,563,000	8,970,000	
	1911	347,000		1,308,000		8,345,000	8,692,000	
	1912	313,000		1,417,000	271,000	7,999,000	8,583,000	
	1913	304,000		1,688,000	31,000	7,977,000	8,312,000	
	1914	291,000		1,858,000	14,000	7,837,000	8,142,000	
	1915	285,000		2,081,000		7,634,000	7,919,000	
	1916	274,000		2,280,000		7,446,000	9,726,000	
	1917	264,000		2,458,000		7,278,000	9,736,000	
	1918	253,000		2,887,000		6,860,000	9,747,000	
	1919			2,887,000		6,860,000	9,747,000	
	1920			3,080,000		6,679,000	9,759,000	
26. San Gabriel Electric Co. first-mortgage 6 per cent bonds dated Feb. 26, 1898; dne Apr. 1, 1928; interest payable Apr. 1 and Oct. 1.	1898					424,000	424,000	
	1899					500,000	500,000	
	1900					500,000	500,000	
	1901					500,000	500,000	
	1902					500,000	500,000	
	1903		$105,000			395,000	395,000	
	1904		105,000			395,000	395,000	
	1905		120,000			380,000	380,000	
	1906		123,000			377,000	377,000	
	1907		134,000			366,000	366,000	
	1908		134,000			366,000	366,000	
	1909		141,000			359,000	359,000	
	1910		153,000			347,000	347,000	
	1911		153,000			347,000	347,000	
	1912		187,000			313,000	313,000	

	1913		196,000			304,000	304,000
	1914		209,000			291,000	291,000
	1915		215,000			285,000	291,000
	1916		226,000			274,000	274,000
	1917		236,000			264,000	264,000
	1918		247,000			253,000	253,000
	1919		259,000			241,000	241,000
	1920		271,000			229,000	229,000
27. Mentone Power Co. first-mortgage 5 per cent bonds, dated Dec. 1, 1901; due Dec. 1, 1931; interest payable June 1 and Dec. 1.	1901		263,000			37,000	37,000
	1902		263,000			37,000	37,000
	1903		263,000			37,000	37,000
	1904		263,000			37,000	37,000
	1095		263,000			37,000	37,000
	1906		263,000			37,000	37,000
	1907		263,000			37,000	37,000
	1908		263,000			37,000	37,000
	1909		263,000			37,000	37,000
	1910		263,000			37,000	37,000
	1911		263,000			37,000	37,000
	1912		263,000			37,000	37,000
	1913		263,000			37,000	37,000
	1914		263,000			37,000	37,000
	1915		263,000			37,000	37,000
	1916		263,000			37,000	37,000
	1917		263,000			37,000	37,000
	1918		263,000			37,000	37,000
	1919		263,000			37,000	37,000
	1920		263,000			37,000	37,000
28. Electric Power Co. first 5 per cent bonds, dated Dec. 1, 1911; due Dec. 1, 1951; interest payable June 1 and Dec. 1.	1911					1,000,000	1,000,000
	1912					1,000,000	1,000,000
	1913					1,000,000	1,000,000
	1914					1,000,000	1,000,000
	1915					1,000,000	1,000,000
	1916					1,000,000	1,000,000
29. Ventura County Power Co. sinking fund 6 per cent bonds, dated Nov. 1, 1906; due Nov. 1, 1936; interest payable May 1 and Nov. 1.	1918	172,000	145,000			683,000	683,000
	1919		182,000			646,000	646,000
	1920		198,000			630,000	630,000
30. Ventura Water, Light & Power Co. first 6 per cent bonds, dated July 9, 1901; due May 1, 1921; interest payable May 1 and Nov. 1,	1918		78,000			172,000	172,000
	1919		78,000			172,000	172,000
	1920		250,000				

TABLE 246.—*Bonds of Southern California Edison Co. and principal subsidiaries*—Continued.

Bonds of subsidiaries controlled through stock ownership.

Issue.	Bonded debt.							Notes.
	Year (Dec. 31).	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total authenticated.	
			Canceled.	Alive.				
1	7	8	9	10	11	12	13	14
31. Santa Barbara Gas & Electric Co. first-mortgage 6 per cent bonds, dated July 1, 1911; due July 1, 1941; interest payable Jan. 1 and July 1.	1911					$623,000	$623,000	This issue was refunded July 1, 1916, by Santa Barbara Gas & Electric Co.'s first-mortgage 5's.
	1912					664,000	664,000	
	1913		$6,500			666,500	666,500	
	1914		13,500			750,500	750,500	
	1915		21,000			842,500	842,500	
32. **Long Beach Consolidated Gas Co. first-mortgage 6 per cent bonds dated Nov. 1, 1910; due Nov. 1, 1940; interest payable Mar. and Nov. 1.**	1910					300,000	300,000	Sold to Southern Counties Gas Co. of California under authorization of Railroad Commission dated May 22, 1916.
	1911					433,000	433,000	
	1912		8,000			425,000	425,000	
	1913		12,000			421,000	421,000	
	1914		12,000			481,000	481,000	
	1915		12,000			513,000	513,000	
33. **Santa Barbara & Suburban Railway Co. first-mortgage 6 per cent bonds dated Mar. 15, 1912; due Mar. 15, 1937; interest payable Mar. 15 and Sept. 15.**	1912					250,000	250,000	
	1913					250,000	250,000	
	1914					250,000	250,000	
	1915					250,000	250,000	
	1916					250,000	250,000	
	1917		14,000			236,000	236,000	
	1918		14,000			236,000	236,000	Unissued $250,000.
	1919		14,000			236,000	236,000	
	1920		14,000			236,000	236,000	
34. **Santa Barbara & Suburban Railway Co. second-mortgage 5 per cent bonds dated Mar. 15, 1912; due Mar. 15, 1942; interest payable Mar. 15 and Sept. 15.**	1912					163,000	163,000	Interest guaranteed by Southern California Edison Co. for five years.
	1913					163,000	163,000	
	1914					163,000	163,000	
	1915					163,000	163,000	
	1916					163,000	163,000	
	1917					163,000	163,000	
	1918					163,000	163,000	
	1919					163,000	163,000	
	1920					163,000	163,000	

35. Santa Barbara Gas & Electric Co. first-mortgage 5 per cent bonds dated July 1, 1916; due, 10,000 annually, July 1, 1920 to 1940, and balance July 1, 1941; interest payable Jan. 1 and July 1.	1916					1,000,000	1,000,000	This issue refunded the Santa Barbara Gas & Electric Co. first-mortgage 6's. Unissued $2,500,000.
	1917					1,000,000	1,000,000	
	1918					1,000,000	1,000,000	
	1919		229,300			770,700	770,000	
	1920		239,300			760,700	760,000	
36. San Joaquin & Eastern Railroad Co. first 5 per cent bonds, dated Mar. 1, 1912; due Mar. 1, 1952; interest payable Mar. 1 and Sept. 1.	1912					1,000,000	1,000,000	
	1913					1,000,000	1,000,000	
	1914					1,000,000	1,000,000	
	1915					1,000,000	1,000,000	
	1916					1,000,000	1,000,000	
	1917					1,000,000	1,000,000	
	1918					1,000,000	1,000,000	
	1919					1,000,000	1,000,000	
	1920					1,000,000	1,000,000	
37. Fontana Power Co. first-serial 6 per cent bonds dated Feb. 1, 1917.	1917–1920					350,000	350,000	System leased by Southern California Edison Co.

TABLE 247.—*Comparative balance sheet of Southern California Edison Co., 1910–1920.*

Form used by company's accountants, Dec. 31, 1910–1912.

	1910	1911	1912
ASSETS.			
Capital assets:			
Plants and property	$25,145,332.51	$25,510,462.48	$27,729,027.08
Construction deposits (Harris Trust & Savings Bank, trustee)		1,001,890.41	157.04
	25,145,332.51	26,512,352.89	27,729,184.12
Current assets:			
Cash		230,606.85	113,757.89
Bills receivable	[a] 644,063.26	65,355.26	353,708.18
Accounts receivable		542,613.68	552,627.44
Due from system corporations	113,995.50	135,053.24	67,874.86
Materials and supplies	287,353.17	233,326.38	581,201.00
Sinking fund	84,045.71	83,410.84	138,134.80
Treasury bonds			
Common stock sale, 1913–14			
Miscellaneous		7,261.57	1,764.89
	1,129,457.64	1,297,607.82	1,809,069.06
Deferred charges:			
Unamortized discount on funded debt	587,693.00	62,720.00	191,227.50
Prepaid insurance and taxes	194,874.04	457.63	6,275.21
Prepaid interest			3,923.60
Miscellaneous prepaid accounts			74,406.31
	782,567.04	63,177.63	275,832.62
Trustee of treasury stock		329,000.00	
Total assets	27,057,357.19	28,202,138.34	29,814,085.80
LIABILITIES.			
Capital liabilities:			
Common stock	7,200,000.00	7,900,000.00	8,400,000.00
Preferred stock	4,000,000.00	4,000,000.00	4,000.000.00
Bonds	12,657,000.00	13,565,000.00	13,971,000.00
Bonds called		29,000.00	25,000.00
	23,857,000.00	25,494,000.00	26,396,000.00
Current liabilities:			
Debentures		1,000,000.00	332,000.00
Notes payable	802,000.00	300,000.00	1,170,000.00
Accounts payable	377,129.46	152,014.71	355,906.03
Sundry deposits	63,788.79	80,901.04	69,655.94
Accrued interest	93,360.59	79,218.85	69,959.59
Accrued taxes			12,684.89
Scrip dividend			
	1,336,278.84	1,612,134.60	2,010,206.45
Reserve and surplus:			
Reserve for accrued depreciation	1,250,332.56	614,838.28	1,150,918.13
Reserve for liability insurance		5,802.98	14,660.98
Reserve for uncollectible bills			15,000.00
Surplus	613,745.79	475,362.48	227,300.24
	1,864,078.35	1,096,003.74	1,407,879.35
Total liabilities	27,057,357.19	28,202,138.34	29,814,085.80

[a] Also includes miscellaneous.

TABLE 247.—*Comparative balance sheet of Southern California Edison Co., 1910-1920*—Continued.

Standard form adopted by Railroad Commission of California.

	1913	1914	1915	1916
ASSETS.				
Fixed capital	$29,492,250	$30,792,759	$31,430,124	$31,235,724
Cash and deposits:				
Cash	413,449	402,361	456,707	377,591
Special deposits	5,167	5,998	8,783	3,560
Total cash and deposits	418,616	408,359	465,490	381,151
Notes receivable	460,968	424,802	395,961	552,931
Accounts receivable:				
Accounts with system corporations	215,250	99,744	174,866	213,252
Due from consumers and agents	414,121	346,612	327,622	307,095
Miscellaneous accounts receivable	191,752	197,832	189,852	203,685
Total accounts receivable	821,123	644,188	692,340	724,032
Interest and dividends receivable	839	5,317	5,217	17
Investments:				
Securities of other corporations	823,904	927,083	926,183	913,627
Miscellaneous investments	22,986	48,424	92,957	92,307
Total investments	846,890	975,507	1,019,140	1,005,934
Materials and supplies	631,865	519,482	498,253	549,586
Sinking funds	70,379	250,371	193,261	531,553
Other special funds				
Treasury securities	1,122,000	518,000		
Prepaid expenses:				
Prepaid taxes	2,133	17,926	19,351	14,310
Prepaid insurance	4,775	8,139	10,130	8,328
Other prepayments	161,236	267,053	216,687	245,190
Total prepaid expenses	168,144	293,118	246,168	267,828
Unamortized discount on securities and expenses:				
Stocks	400,000	798,049	796,599	797,862
Bonds	249,542	489,541	539,440	523,317
Miscellaneous			60,213	45,827
Total unamortized discount on securities and expenses	649,542	1,287,590	1,396,252	1,367,006
Other suspense	1,060	1,442	1,752	24,849
Construction work in progress	260,309	428,664	689,680	991,491
Common stock sale 1913-14	307,580			
Miscellaneous				
Total assets	35,251,565	36,549,599	37,033,638	37,632,102
LIABILITIES.				
Capital stock	14,400,000	14,400,000	14,400,000	14,411,000
Installments in stock subscriptions				
Funded debt	15,935,000	17,322,000	19,216,000	18,754,000
Notes payable	2,273,200	2,050,500		500,000
Accounts payable:				
Audited vouchers and wages unpaid	355,773	198,635	248,675	235,096
Consumers' deposits	90,554	92,052	88,944	62,177
Miscellaneous accounts payable	2,711	11,397	120	5,439
Total accounts payable	449,038	302,084	337,739	302,712
Interest accrued	70,392	66,445	97,423	90,651
Taxes accrued	15,013	5,115	2,295	3,859
Dividends declared				
Service billed in advance				
Accrued dividends on stock exchanged for debentures				44
Reserve for accrued depreciation	1,712,255	2,142,749	2,625,988	2,832,827
Casualty and insurance reserves	11,084	14,764	25,558	34,357
Other reserves from income or surplus	13,711	15,000	15,000	
Scrip dividends	150,000			
Corporate surplus unappropriated	221,872	230,942	313,635	687,652
Miscellaneous				15,000
Total liabilities	35,251,565	36,549,599	37,033,638	37,632,102

TABLE 247.—*Comparative balance sheet of Southern California Edison Co., 1910–1920*—Continued.

	1917	1918	1919	1920
ASSETS.				
Fixed capital	$68,619,895.32	$72,850,803.13	$74,749,309.13	$83,141,751.51
Cash and deposits:				
Cash	1,450,180.54	1,080,999.22	1,026,098.29	964,390.31
Special deposits	2,211.83	1,741.50	1,454.90	2,369.00
Total cash and deposits	1,452,392.37	1,082,740.72	1,027,553.19	966,759.31
Notes receivable	122,058.75	63,650.47	69,328.16	37,290.29
Accounts receivable:				
Accounts with system corporations	692,721.88	1,168,826.33	1,504,463.37	316,143.55
Due from consumers and agents	947,19 .41	750,213.61	823,110.76	1,308,298.57
Miscellaneous accounts receivable	1,895,845.37	1,409,155.13	2,448,010.40	2,274,523.43
Total accounts receivable	3,535,766.66	3,328,195.07	4,775,584.53	3,898,965.55
Interest and dividends receivable	16.66	16.68	16.68	16.68
Investments:				
Securities of other corporations	3,433,708.56	3,434,039.28	4,069,842.68	2,354,190.56
Miscellaneous investments	1,257,711.87	1,449,454.27	1,333,400.92	1,119,347.13
Total investments	4,691,420.43	4,883,493.55	5,403,243.60	3,473,537.69
Materials and supplies	1,727,490.54	1,416,926.13	1,530,888.54	2,542,689.50
Sinking funds	186,400.76	221,675.95	215,336.66	298,240.92
Other special funds	1,880,189.97	150,000.00	....	....
Treasury securities	....	....	....	....
Prepaid expenses:				
Prepaid interest	13,780.30	67,703.89	8,086.61	23,710.89
Prepaid taxes	6,640.92	6,699.56	2,863.62	16,750.62
Prepaid insurance	10,023.60	9,915.71	11,604.72	12,504.82
Other prepayments	352,164.50	637,714.42	367,635.13	817,296.67
Total prepaid expenses	382,609.32	722,033.58	390,190.08	870,263.00
Unamortized discount on securities and expenses:				
Stocks	1,157,077.17	1,169,010.17	1,639,342.53	1,744,989.53
Bonds	860,568.05	598,426.66	1,027,173.54	2,715,341.21
Miscellaneous	31,529.66	17,516.54	332,474.39	....
Total unamortized discount on securities and expenses	2,049,174.88	1,784,953.37	2,998,990.46	4,460,330.74
Other suspense	35,562.25	*a* 108.98	21,676.08	211,675.51
Construction work in progress	3,689,257.20	1,794,743.60	9,044,175.94	21,961,867.63
Common stock sale 1913–14	....	....	....	....
Miscellaneous	151,931.44	200,293.08	225,296.34	275,816.35
Total assets	88,524,166.58	88,499,416.35	100,451,589.39	122,139,204.68
LIABILITIES.				
Capital stock	30,094,472.00	30,236,872.00	34,556,872.00	35,701,272.00
Installment in stock subscriptions	174,179.85	72,245.83	248,092.92	79,700.14
Funded debt	45,217,500.00	44,575,000.00	49,771,000.00	63,054,000.00
Notes payable	5,457,046.27	6,078,592.98	5,449,262.15	7,391,582.74
Accounts payable:				
Audited vouchers and wages unpaid	724,887.49	499,454.09	1,225,741.31	1,201,251.09
Consumers' deposits	125,442.77	199,696.48	279,371.58	750,763.53
Miscellaneous accounts payable	84,301.54	131,080.21	149,641.39	1,870,447.20
Total accounts payable	934,631.80	830,230.78	1,654,754.28	3,822,461.82
Interest accrued	243,580.70	237,689.86	687,178.10	1,023,224.28
Taxes accrued	15,400.95	19,139.53	33,662.35	860,945.26
Accrued dividends on subscribed stock	37.34	10.69	38.83	3.01
Service billed in advance	5,265.44	4,212.08	3,158.72	2,105.36
Accrued dividends on stock exchanged for debentures	....	....	....	....
Reserve for accrued depreciation	5,672,791.14	5,798,961.78	6,228,075.53	7,634,054.92
Casualty and insurance reserves	69,286.67	61,548.66	52,962.43	71,953.17
Other reserves from income or surplus	....	....	....	....
Reserved for uncollectible bills	26,944.03	....	35,971.70	87,603.81
Corporate surplus unappropriated	613,030.39	568,482.69	580,560.38	1,260,298.17
Miscellaneous	26,944.03	16,429.47	....	....
Shaver Lake Lumber Co. bond guaranty	....	....	1,150,000.00	1,150,000.00
Total liabilities	88,524,166.58	88,499,416.35	100,451,589.39	122,139,204.86

TABLE 248.—*Comparative balance sheet of Pacific Light & Power Corporation and subsidiaries, 1906–1916.*

	1906	1907	1908
ASSETS.			
Cash on hand	$13,404	$13,432	$2,047
Balance in banks	18,470	[a] 25,420	[a] 26,817
Accounts receivable	834,314	430,941	890,239
Fixed property accounts	1,567,634	2,386,913	1,567,250
Undistributed property accounts	79,007	214,491	9,563,649
Land	230,518	224,261	304,852
Oil wells	289,537	121,474	176,863
Edna		6,624	36,664
No. 2			2,256
No. 3			69,907
Steam power plants:			
Los Angeles	506,477	553,029	558,753
Redondo	184,268	1,240,023	2,098,259
Pacific electric plant			1,095
Hydraulic power plants		2,101,213	2,108,070
Azusa	2,526,374	430,171	445,921
Transmission and distribution systems	2,197,079	2,370,475	2,444,396
Azusa		72,731	79,441
Redondo		71,979	77,840
Pacific electric plant			152
Gas plants	63,905	86,074	375,312
Distribution system, gas	150,741	169,412	735,980
Sinking fund:			
Pacific Light & Power Co	257,218	357,089	530,514
San Gabriel Electric Co	23,400	30,940	38,260
Bills receivable	2,509,562	3,953	13,684
Franchises	10,867	13,954	2,314,411
Water rights and rights of way	13,361,810	10,901,238	10,888,816
Discount on bonds			389,300
Profit and loss	13,906		2,456
Total assets	24,838,491	21,774,997	35,689,570
LIABILITIES.			
Bills payable	2,990,945	1,567,821	959,265
Interest reserve—San Gabriel Electric Co	6,349	6,334	26,544
Audited vouchers	251,214	584,931	265,588
Accounts payable	772,116	457,188	1,010,497
Profit and loss	334,711	424,860	420,304
Undivided profits	760,550	1,168,768	1,352,987
Surplus	174,261	99,750	99,750
Casualty reserve account	7,000	7,000	7,000
Reserve account	7,345	345	224,635
Bonds:			
San Gabriel Electric Co	395,000	395,000	395,000
Pacific Light & Power Co	6,299,000	6,788,000	10,403,000
Capital stock	12,775,000	10,275,000	20,525,000
Total liabilities	24,838,491	21,774,997	35,689,570

[a] Deficit.

NOTE.—Assets of San Gabriel Electric Co. and Pacific Light & Power Co. for 1899 to 1905, inclusive were as follows:

San Gabriel Electric Co.:		Pacific Light & Power Co.:	
Mar. 31, 1899	$1,148,438	Mar. 31, 1903	$12,702,994
Mar. 31, 1900	1,288,736	Mar. 31, 1904	15,130,273
Mar. 31, 1901	1,341,907	Mar. 31, 1905	16,688,497
Mar. 31, 1902	1,773,597	Dec. 31, 1905	17,701,248

	1909	1910	1911	1912
ASSETS.				
Capital:				
Water rights and rights of way	$11,401,594	$2,469,856	$13,474,060	$20,290,859
Development	994,781	11,036,629	915,605	
Plants	5,360,565	5,981,799	6,122,025	
Transmission and distribution system	2,933,079	3,160,636	3,423,393	
Oil properties	750,437	586,762	638,832	
Land	226,688	232,325	262,333	17,549,971
Sundries	41,961	56,470	39,839	
Funds with trustee for sinking fund	584	584	106,543	
Big Creek construction			498,077	
Interest during construction			21,496	
Uncompleted work orders			35,957	
Big Creek construction deposits			7,837,500	3,964,217
Total capital assets	21,709,689	23,525,061	33,375,660	41,805,047

TABLE 248.—*Comparative balance sheet of Pacific Light & Power Corporation and subsidiaries, 1906–1916*—Continued.

	1909	1910	1911	1912
ASSETS.				
Treasury assets: Stocks and bonds	$253,504	$12,032,467	$12,918,050	$5,041,389
Current assets:				
Material and supplies	180,476	256,130	207,326	229,597
Bills receivable	17,096	20,321	130,977	639,695
Accounts receivable	240,117	273,682	404,600	483,681
Municipal deposits	2,123	1,600	1,700	1,625
Bonds loaned	350,000			
Petty and commissary cash	1,024	1,090	1,269	1,284
Cash in banks		210,795	345,579	19,921
Deposit for bond interest				271,827
Deferred payments on property				446,446
Unaudited undistributed invoices payable				85,363
Total current assets	790,836	763,618	1,091,451	2,179,439
Deferred charges:				
Bond discount and expense	531,055	543,622	1,751,006	1,716,683
Suspense	16,784	17,630	19,521	30
Prepaid insurance				1,018
Prepaid rent				59
Prepaid taxes		20,275	2,378	4,509
Total deferred charges	547,839	581,527	1,772,905	1,772,299
Total assets	23,301,868	36,902,673	49,158,066	50,748,174
LIABILITIES.				
Capital liabilities:				
Capital stock	10,000,000	22,029,700	23,336,700	21,716,500
Bonds—				
Pacific Light & Power Co., outstanding	9,007,000	8,623,000	8,345,000	
Underlying bonds—San Gabriel Electric Co.	359,000	347,000	347,000	
Funds for bond purchase—				
Mentone Power Co.	37,000	37,000	37,000	
Sierra Power Co.	11,000	8,000	5,000	21,653,000
Funds for stock	75,000	75,000	75,000	99,400
Oil lands	30,000	15,000	10,000	
Electric power plants	110,500	104,000		
Bonds—				
Pacific Light & Power Co., collateral 6's		2,000,000	2,388,000	
Pacific Light & Power Co., first and refunding			10,324,000	
Total capital liabilities	19,629,500	33,238,700	44,867,700	43,468,900
Current liabilities:				
Accruals—				
Sinking fund	339,963	176,740	29,966	219,851
License and taxes				1,714
Interest funded debt	9,568	9,578	177,041	444,389
Interest floating debt	14,987	17,581	31,754	14,195
San Joaquin Light & Power Corporation (Big Creek construction)			10,684	
Line and meter deposits	6,983	11,366	10,349	12,870
Bills payable	1,061,666	918,105	1,808,106	1,715,774
Bonds borrowed	133,000			1,172,177
Pay rolls	36,846	37,774	44,491	54,373
Sundry creditors	257,645	554,762	274,494	175,885
Advance payments	15,116	22,684	25,035	26,018
Bank overdrafts	21,077			
Prepaid rents collected			11,585	10,948
Total current liabilities	1,896,851	1,748,590	2,423,505	3,848,194
Profit and loss:				
Reserve	936,482	1,117,167	1,428,785	1,726,585
Capital surplus	139,427		356,386	1,612,848
Surplus	139,427		81,690	91,647
Bond surplus—				
Pacific Light & Power Co.	636,714	1,022,084		
San Gabriel Electric Co.	38,894	50,886		
Sierra Power Co.	24,000	27,000		
Deficit		301,754		
Total profit and loss	1,775,517	1,915,383	1,866,861	3,431,080
Total liabilities	23,301,868	36,902,673	49,158,066	50,748,174

TABLE 248.—*Comparative balance sheet of Pacific Light & Power Corporation and subsidiaries, 1906–1916*—Continued.

	1913	1914	1915	1916
ASSETS.				
Fixed capital	$37,562,962	$48,279,124	$48,777,921	$49,142,146
Cash and deposits:				
Cash	110,633	11,758	[a] 8,381	44,235
Special deposits	200,950	1,525	1,035	1,020
	311,583	13,283	[a] 7,346	45,255
Notes receivable	472,413	505,741	303,262	22,414
Accounts receivable:				
Accounts with system corporations	450,277	180,908	281,037	294,828
Due from consumers and agents	329,558	330,072	378,280	424,625
Miscellaneous	379,631	186,458	207,086	116,276
	1,159,466	697,438	866,403	835,729
Interest and dividends receivable	138,468	43,586	51,672	20,200
Other current assets				
Investments:				
Securities of other corporations	3,668,231	2,888,155	2,886,265	2,985,278
Advances to system corporations for construction, equipment and betterments		268,977	268,976	268,977
Miscellaneous		35,558	28,880	23,022
	3,668,231	3,192,690	3,184,121	3,277,277
Materials and supplies	445,719	575,316	537,605	566,753
Sinking funds	131	205,548	439,290	687,248
Treasury securities	2,238,995	1,796,000		
Prepaid expenses:				
Prepaid rent	59			
Prepaid taxes	617	5,582	1,739	1,708
Prepaid insurance	2,437	2,436	3,180	5,292
Other prepayments	611		74,966	118,981
	3,724	8,018	79,885	125,981
Unamortized discount on securities and expenses:				
Stocks	1,527,500	1,818,950	1,818,950	1,818,950
Bonds	1,674,008	2,028,094	2,235,307	2,171,507
Miscellaneous	1,875	3,333		
	3,203,383	3,850,377	4,054,257	3,990,457
Other suspense	535	198,169	205,721	206,666
Construction work in progress	9,059,400	353,633	135,977	682,503
Total assets	58,265,010	59,718,923	58,628,768	59,602,629
LIABILITIES.				
Capital stock	23,591,500	25,534,500	25,534,500	25,534,500
Funded debt	22,896,000	24,775,000	24,552,000	24,353,000
Notes payable	5,700,079	4,185,661	2,780,152	2,513,627
Accounts payable:				
Audited vouchers and wages unpaid	187,144	192,812	165,197	135,369
Consumers' deposits	51,681	48,831	50,283	48,800
Miscellaneous	964,071	218,516	640,101	1,460,992
	1,202,896	460,159	855,581	1,645,161
Interest accrued	488,987	240,906	253,831	355,271
Taxes accrued		6,094	9,900	20,707
Service billed in advance	9,979	8,861	7,374	6,320
Reserve for accrued depreciation	756,249	1,938,377	1,924,516	3,460,505
Casualty and insurance reserve	6,950		5,006	
Reserve invested in sinking fund	1,758,583	882,496	1,116,238	
Other reserves from income or surplus	1,587	1,432	9,080	21,951
Corporate surplus unappropriated	1,852,201	1,685,437	1,580,590	1,691,587
Total liabilities	58,265,010	59,718,923	58,628,768	59,602,629

[a] Deficit.

TABLE 249.—*Comparative balance sheet, Ventura County Power Co., 1912–1916.*

[Company absorbed Nov. 30, 1917, by Southern California Edison Co.]

	1912	1913	1914	1915	1916
ASSETS.					
Fixed capital	$2,037,862	$1,948,820	$1,966,269	$1,979,162	$2,009,441
Cash and deposits:					
Cash	12,898	2,329	[a] 610	4,571	3,003
Special deposits					
	12,898	2,329	[a] 610	4,571	3,003
Notes receivable	37,695	7,000			
Accounts receivable:					
Due from consumers and agents		25,078	23,315	23,833	33,832
Miscellaneous		815	13,258	4,583	12,349
		25,893	36,573	28,416	46,181
Investments: Securities of other corporations		6,067	4,625	625	625
Materials and supplies	23,565	17,890	14,664	15,842	26,247
Sinking funds		274			
Other special funds		660			
Treasury securities	1,272,800	1,272,800			1,000
Prepaid expenses:					
Prepaid taxes		5,832	1,497	1,629	1,602
Prepaid insurance		224	445	390	311
		6,056	1,942	2,019	1,913
Unamortized discount on securities and expenses:					
Stocks		350,000	315,942	193,253	36,911
Bonds		32,100	31,150	20,679	19,595
	350,000	382,100	347,092	213,932	56,506
Other suspense			9,677	9,230	7,300
Construction work in progress			500	5,032	7,727
Miscellaneous assets	3,546				
Corporate deficit		[a] 33,736	13,164	19,223	
Total assets	3,744,432	3,703,624	2,393,896	2,278,053	2,159,943
LIABILITIES.					
Capital stock	2,500,000	2,500,000	1,191,700	1,056,840	1,056,840
Funded debt	962,000	943,000	924,000	905,000	887,000
Notes payable	130,850	120,850	27,320	17,320	37,320
Accounts payable:					
Audited vouchers and wages unpaid		14,459	30,536	8,675	11,955
Consumers' deposits		3,119	3,415	3,654	2,438
Miscellaneous accounts payable		7,498	5,860	43,358	94,130
	26,410	25,076	39,811	55,688	108,524
Interest accrued		12,299	9,475	9,488	9,885
Service billed in advance				1,102	921
Taxes accrued				983	862
Reserve for accrued depreciation		12,707	41,982	50,106	49,772
Casualty and insurance reserved		[b] 715		563	590
Income invested since Dec. 31, 1912, in fixed capital		41,319			
Accrued sinking funds			3,080	21,497	
Other reserves from income or surplus	22,710		185	3,125	6,217
Corporate surplus unappropriated	102,462				2,012
Assessment		49,088	156,341	156,341	
Total liabilities	3,744,432	3,703,624	2,393,896	2,278,053	2,159,943

[a] Credit item.

[b] Debit item.

TABLE 250.—*Earnings and expenses, Southern California Edison Co., 1902–1920.*

Year.	Gross revenue.	Maintenance, operation, and taxes.	Net revenue.	Fixed charges (bond, interest, and amortization).	Balance.	Miscellaneous payments.			Net surplus.
						Dividends.	Depreciation.	Total.	
1902	$486,343	$228,545	$257,798	$113,352	$144,446	$63,160	....	$63,160	$81,286
1903	690,074	330,450	359,624	138,351	221,273	116,968	....	116,968	104,305
1904	983,144	502,810	480,334	228,427	251,907	144,733	....	144,733	107,174
1905	1,272,564	528,904	743,659	299,246	444,413	268,887	$236,450	505,447	[a] 61,034
1906	1,731,521	719,997	1,011,523	424,224	587,299	196,144	481,565	677,709	[a] 90,410
1907	2,206,380	868,374	1,338,006	574,517	763,489	328,486	243,337	571,823	191,666
1908	2,477,062	1,032,452	1,444,610	601,442	843,168	559,800	280,000	839,800	3,368
1909	2,895,407	1,486,153	1,409,254	598,712	810,542	289,850	500,000	789,850	20,692
1910	3,384,933	1,717,857	1,667,076	651,492	1,015,584	470,000	545,000	1,015,000	584
1911	3,738,165	1,835,885	1,902,280	624,829	1,277,451	571,250	650,000	1,221,250	56,201
1912	4,337,441	2,329,086	2,008,355	708,796	1,299,559	620,000	650,000	1,270,000	29,559

	1913	1914	1915	1916
Electric operations:				
Operating revenues	$4,473,033	$4,461,807	$4,507,387	$4,746,190
Operating expenses	2,865,339	2,740,795	2,616,094	2,749,110
Net operating electric revenue	1,607,694	1,721,012	1,891,293	1,997,080
Gas operations:				
Operating revenues	256,230	294,824	301,220	155,185
Operating expenses	232,826	260,578	268,277	101,998
Net operating gas revenue	23,404	34,246	32,943	53,187
Total net operating revenue	1,631,098	1,755,258	1,924,236	2,050,267
Add:				
Nonoperating revenues—				
Rent accrued from lease of electric plant	14,452	....	....	....
Miscellaneous rent revenues (electric)	5,115	4,457	5,398	2,674
Interest and dividend revenues—				
Interest revenues on funded debt owned	2,600	4,037	3,658	7,799
Miscellaneous interest revenues	9,137	46,859	45,710	42,746
Dividend revenues	....	38,375	61,070	81,999
Total interest and dividend revenues	11,737	89,271	110,438	132,545
Sinking and reserve fund accretions	1,458	4,543	3,767	6,644
Miscellaneous nonoperating revenues	29,692	5,762	19,939	19,955
Total nonoperating revenues	62,453	104,033	139,542	161,818
Gross corporate income	1,693,551	1,859,291	2,063,778	2,212,084
Deduct:				
Uncollectible bills	26,650	30,791	34,247	33,125
Nonoperating revenue deductions—				
Rent expenses	62	147	223	270
Miscellaneous nonoperating expenses	11,632	4,690	14,177	17,581
Nonoperating taxes	742	686	633	682
Total nonoperating revenue deductions	12,436	5,523	15,033	18,533
Interest accrued on funded debt	745,234	814,827	940,027	966,647
Other interest deductions	59,085	59,461	29,631	[b] 6,732
Rent deductions for electric plant, conduits, poles and other supports, etc	5,476	684	574	473
Amortization of debt discount and expense	....	17,039	32,949	40,583
Miscellaneous deductions from income	36,300	....	....	....
Total deductions	858,531	928,325	1,052,461	1,066,083
Surplus for year	835,020	930,966	1,011,317	1,146,001

[a] Deficit.
[b] Credit item.

TABLE 250.—*Earnings and expenses, Southern California Edison Co., 1902–1920*—Continued.

	1917	1918	1919	1920
Electric operations:				
Operating revenues	$6,061,320.44	$7,361,939.13	$9,191,074	$13,211,555
Operating expenses	3,246,277.20	3,725,054.87	5,388,403	8,349,917
Net operating electric revenue	2,815,043.24	3,636,884.26	3,802,671	4,861,638
Gas operations:				
Operating revenues	4,779.90	64,172.29	19,323	....
Operating expenses	2,814.87	81,265.96	22,197	....
Net operating gas revenue	1,965.03	[a] 17,092.77	[a] 2,874	....
Water operations:				
Operating revenues	1,940.00	26,825.86	30,849	35,440
Operating expenses	1,647.00	24,741.94	34,742	36,718
Net operating water revenue	293.00	2,083.92	[a] 3,893	[a] 1,278
Total net operating revenues	2,817,301.27	3,621,875.41	3,795,905	4,860,360
Add:				
Nonoperating revenues:				
Rent accrued from lease of electric plant	433,184.20	701,921.38	760,052	824,583
Miscellaneous rent revenues (electric)	8,369.47	4,417.52	7,399	13,542
Interest and dividend revenues:				
Interest revenues on funded debt owned	29,216.67	50.00	50	50
Miscellaneous interest revenues	34,803.47	150,367.95	188,500	192,648
Dividend revenues	47,521.50	37,496.00	37,496	37,496
Total interest and dividend revenues	111,541.64	187,913.95	226,046	230,194
Sinking and reserve fund accretions	10,712.67	2,921.57	3,874	1,591
Miscellaneous nonoperating revenues	126,576.74	469,965.66	464,391	484,969
Total nonoperating revenues	690,384.72	1,367,143.08	1,461,762	1,554,879
Gross corporate income	3,507,685.99	4,989,018.49	5,257,666	6,415,239
Deduct:				
Uncollectible bills	20,039.97	17,361.64	34,980	27,050
Nonoperating revenue deductions:				
Rent expenses	538.08	73.41	1,166	143
Miscellaneous nonoperating expenses	55,856.45	81,700.19	131,055	151,589
Nonoperating taxes	6,056.64	2,848.78	1,222	2,246
Total nonoperating revenue deductions	62,451.17	84,622.38	133,443	153,978
Interest accrued on funded debt	1,723,201.94	2,375,852.72	2,727,131	3,352,762
Other interest deductions	42,314.47	323,736.43	13,789	[b] 458,569
Rent deductions:				
Rent for conduits, poles, and other supports (electric)	1,394.09	973.35	942	1,960
Rent for lease of electric plant	....	60,687.11	28,491	55,211
Total rent deductions	1,394.09	61,660.46	29,433	57,171
Amortization of debt discount and expense	146,343.05	282,319.14	363,286	211,053
Total deductions	1,995,744.69	3,045,552.77	3,274,483	3,343,444
Surplus for year	1,511,941.30	1,943,465.72	1,983,183	3,071,795

[a] Deficit.
[b] Credit item.

TABLE 251.—*Classified revenues, Southern California Edison Co., 1904–1920.*

Classified gross revenues, 1904–1912.

Year.	Total light.	Total power.	Miscellaneous electric operating revenue.	Total electric operating revenue.	Non-operating revenue.	Gas.	Gross revenues.
1904	$679,420.58	$199,441.73	$7,714.89	$886,577.20	[a]$28,023.71	$112,031.99	$970,585.48
1905	816,057.42	247,335.63	18,201.53	1,081,594.58	10,030.84	171,956,38	1,263,581,80
1906	1,007,960.05	400,251.15	40,916.66	1,449,127.86	14,646.67	260,560.97	1,724,335.50
1907	1,254,908.29	580,747.85	40,110.92	1,875,767.06	731.17	329,882.86	2,206,381.09
1908	1,372,046.79	717,584.25	26,744.63	2,116,375.67	[a]6,317.22	367,003.87	2,477,062.22
1909	1,478,040.41	1,011,524.74	28,808.52	2,518,373.67	6,203.50	370,829.68	2,895,406.85
1910	1,555,251.96	1,387,781.16	35,139.98	2,978,173.10	51,150.98	355,609.17	3,384,933.25
1911	1,717,361.25	1,665,427.47	53,201.77	3,435,990.49	70,774.91	231,400.07	3,738,165.47
1912	1,932,793.70	2,076,914.01	54,924.94	4,064,632.65	36,432.39	239,435.72	4,340,500.76

[a] Nonoperating loss.

Classified electric operating revenues according to classification of Railroad Commission of California, 1913–1920.

Class of load.	1913		1914		1915	
	Revenue.	Per cent of gross electric revenue.	Revenue.	Per cent of gross electric revenue.	Revenue.	Per cent of gross electric revenue.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$60,072	1.3	$60,597	1.4	$63,542	1.5
Incandescent	83,672	1.9	130,587	2.9	159,930	3.5
Municipal lighting, miscellaneous	14,176	.3	20,494	.5	33,776	.7
Municipal power	93,397	2.1	80,100	1.8	65,991	1.6
Commercial lighting—						
Flat rate	11,358	.3	8,914	.2	7,742	.1
Metered	1,996,122	44.7	2,180,580	48.8	2,251,622	50.0
Commercial power—						
Flat rate	177	....	8,714	.2	7,060	.1
Metered	1,644,950	36.8	1,485,906	33.3	1,443,568	32.1
Railway power, metered	377,150	8.4	341,937	7.7	345,333	7.7
Other electrical corporations	135,759	3.0	82,709	1.9	76,380	1.7
Rent of meters	....	....	118	....	90	....
Breakdown service	....	....	2,403	....	2,918	....
Miscellaneous electric	281	....	8,483	.1	2,328	....
Joint electric rent revenue	....	....	....	....	....	....
Total operating revenues, electric	4,417,114	98.8	4,414,542	98.8	4,460,280	99.0
Other operating revenues:						
Rent of electric appliances and jobbing	5,891	.1	9,252	.3	10,977	.2
Electric merchandise	50,029	1.1	38,013	.9	36,131	.8
Steam sales revenues	....	....	....	....	....	....
Total other operating revenues	55,920	1.2	47,265	1.2	47,108	1.0
Gross electric revenues	4,473,034	100.0	4,461,807	100.0	4,507,388	100.0

TABLE 251.—*Classified revenues, Southern California Edison Co., 1904–1920*—Continued.

Class of load.	1916		1917		1918	
	Revenue.	Per cent of gross electric revenue.	Revenue.	Per cent of gross electric revenue.	Revenue.	Per cent of gross electric revenue.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$65,445	1.4	$65,959.88	1.1	$72,488.87	0.9
Incandescent	191,212	4.0	187,230.00	3.1	202,462.79	2.7
Municipal lighting, miscellaneous	20,824	.4	18,241.24	.3	19,323.72	.2
Municipal power	67,593	1.4	91,376.86	1.5	105,091.59	2.0
Commercial lighting—						
Flat rate	6,800	.1	8,393.80	.1	7,917.55	.1
Metered	2,396,192	50.5	1,826,997.62	30.1	1,564,936.19	21.2
Commercial power—						
Flat rate	7,002	.2	2,950.00	....	1,080.00	....
Metered	1,503,061	31.7	1,951,094.91	32.2	2,209,210.93	30.0
Railway power, metered	354,143	7.5	1,121,847.47	18.5	1,692,430.96	22.0
Other electrical corporations	80,307	1.7	725,206.55	12.0	1,424,220.11	20.0
Rent of meters	86	....	100.83	....	131.31	....
Breakdown service	3,451	.1	1,302.56	....	....	....
Miscellaneous electric	2,000	....	3,669.26	.1	8,520.64	.1
Joint electric rent revenue	5,131	.1	3,300.00	.1	3,900.00	.1
Total operating revenues, electric.	4,703,247	99.1	6,007,670.98	99.1	7,311,714.66	99.3
Other operating revenues:						
Rent of electric appliances and jobbing	2,667	....	18,841.60	.3	11,972.28	.2
Electric merchandise	40,276	.9	34,807.83	.6	38,252.19	.5
Steam sales revenues	....	....	....	....	....	....
Total other operating revenues.	42,943	.9	53,649.46	.9	50,224.47	.7
Gross electric revenues	4,746,190	100.0	6,061,320.44	100.0	7,361,939.13	100.0

Class of load.	1919		1920	
	Revenue.	Per cent of gross electric revenue.	Revenue.	Per cent of gross electric revenue.
Operating revenue, electric:				
Municipal street lighting—				
Arc	$80,997	0.9	$96,813	0.7
Incandescent	219,396	2.3	278,478	2.1
Municipal lighting, miscellaneous	32,825	.3	39,957	....
Municipal power	156,947	1.7	245,958	2.0
Commercial lighting—				
Flat rate	6,008	.1	5,922	....
Metered	2,028,248	22.1	3,197,056	24.3
Commercial power—				
Flat rate	*a* 57	....	1,762	....
Metered	3,120,191	33.9	5,402,647	41.0
Railway power, metered	1,842,077	20.3	2,417,504	18.4
Other electrical corporations	1,642,270	17.8	1,464,689	11.2
Rent of meters	176	....	152	....
Breakdown service	....	....	....	....
Miscellaneous electric	10,175	.1	4,721	....
Joint electric rent revenue	3,900	....	3,900	....
Total operating revenues, electric	9,143,152	99.5	13,159,561	99.7
Other operating revenues:				
Rent of electrical appliances and jobbing	6,144	.1	7,836	....
Electric merchandise	41,779	.4	44,158	.3
Steam sales revenue	....	....	....	....
Total other operating revenues	47,922	.5	51,994	.3
Gross electric revenues	9,191,074	100.0	13,211,555	100.0

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a Debit item.

TABLE 252.—*Earnings and expenses of Pacific Light & Power Corporation, 1903–1917.*

Year.	Gross earnings.	Operating expenses.	Net earnings.	Fixed charge.	Balance for dividends and depreciation.	Dividends.	Surplus.
1903[a]	$399,051	$175,218	$223,833	$134,805	$89,028	None.	$89,028
1904[a]	652,994	344,396	308,598	177,931	130,667	None.	130,667
1905[a]	807,652	416,413	391,239	209,106	182,133	None.	182,133
1905[b c]	824,470	436,653	387,817	230,749	157,068	None.	157,068
1906[b]	1,332,534	633,441	699,093	339,431	359,662	None.	359,662
1907[b]	1,281,055	531,816	749,239	336,096	413,143	None.	413,143
1908[b]	1,821,853	970,014	851,839	474,487	377,352	None.	377,352
1909[b]	1,923,510	1,074,573	84,937	508,409	340,528	None.	340,528
1910[b d]	2,065,753	1,314,404	751,349	479,058	272,291	$10,102	262,189
1911[b]	2,294,676	1,228,699	1,065,977	471,342	594,635	63,058	531,577
1912[b]	2,546,892	1,447,244	1,099,648	480,512	619,136	72,232	546,904

	1913	1914	1915	1916	1917 [e]
Electric operations:					
Operating revenues	$2,634,991	$2,659,012	$2,925,653	$3,261,126	$1,314,297.50
Operating expenses	1,875,860	1,216,842	1,178,573	1,615,698	673,372.71
Net operating revenue	759,131	1,442,170	1,747,080	1,645,428	640,924.79
Add:					
Nonoperating revenues:					
Miscellaneous rent revenues, electric	....	5,457	7,769	17,646	105,381.41
Interest and dividend revenues:					
Interest revenues on funded debt owned	92,300	51,900	50,000	50,900	....
Miscellaneous interest revenue	18,122	60,947	47,206	6,128	....
Total interest and dividends revenues	110,422	112,847	97,206	57,028	....
Miscellaneous nonoperating revenues	116,323	60,000	59,088	57,415	....
Total nonoperating revenues	226,745	178,303	164,063	132,089	....
Gross corporate income	985,876	1,620,473	1,911,143	1,777,517	746,306.20
Deduct:					
Uncollectible bills	....	3,600	8,800	24,000	9,063.20
Nonoperating revenue deductions	....	....	....	....	23,807.83
Miscellaneous nonoperating expenses	....	1,042	61,896	65,700	....
Nonoperating taxes	....	12,039	15,076	13,531	....
Total nonoperating revenue deductions	82,713	13,081	76,972	79,231	23,807.83
Interest accrued on funded debt	447,327	1,015,992	1,095,075	1,085,516	442,595.20
Other interest deductions	63,496	212,272	229,260	132,225	55,709.33
Miscellaneous rent deductions	....	423	170	100	....
Amortization of debt discount and expense	....	49,524	61,525	62,640	26,099.85
Miscellaneous deductions from income	6,405	....	....	....	....
Total deductions	599,941	1,324,892	1,471,802	1,383,712	557,275.41
Surplus for year	385,935	295,582	439,342	393,805	189,030.79

[a] Year ended Mar. 31.
[b] Year ended Dec. 31.
[c] Nine months Apr. 1 to Dec. 31, 1905.
[d] Pacific Light & Power Corporation succeeded Pacific Light & Power Co. in 1910.
[e] Sold to Southern California Edison Co., May 31, 1917.

TABLE 253.—*Classified revenues, Pacific Light & Power Corporation, 1901–1917.*

Classified gross revenues, 1901–1912.

Year.	Electric revenues.				
	Lighting.		Power.		Total.
	Municipal.	Commercial.	Railway.	Other.	
1902[a]	$40,259	$145,423	$5,356	$68,998	$260,036
1903[a]	44,503	202,544	37,048	89,557	373,652
1904[a]	42,597	322,993	30,200	153,307	549,097
1905[a]	68,512	383,043	66,793	251,170	769,518
1905[b]	77,679	445,698	197,692	296,838	1,017,907
1906[c]	86,847	508,353	328,592	342,508	1,266,300
1907[c]	97,997	470,536	388,795	204,288	1,161,616
1908[c]	109,306	411,966	755,051	269,415	1,545,738
1909[c]	128,732	437,814	821,373	261,257	1,649,176
1910[c]	141,064	477,928	923,190	336,662	1,878,844
1911[c]	153,254	539,139	1,026,334	339,001	2,117,728
1912[c]	173,374	578,751	1,092,267	513,308	2,357,700
	1,164,124	4,924,188	5,672,691	3,186,309	14,947,312

Year.	Nonelectric revenues.					
	Gas.	Water.	Oil.	Railway.	Miscellaneous.	Total.
1909[c]	$51,765.47	$4,612.99	$107,345.88	$20,222.61	$90,387.00	$274,333.95
1910[c]	55,587.00	5,845.07	85,920.59		104,662.32	252,014.98
1911[c]	37,065.06	2,087.51	98,396.48		39,398.54	176,947.59
1912[c]			88,877.92		100,313.00	189,190.92
	144,417.53	12,545.57	380,540.87	20,222.61	334,760.86	892,487.44

[a] Year ended Mar. 31.
[b] Nine months ended Dec. 31.
[c] Year ended Dec. 31.

Classified electric operating revenues according to classification of Railroad Commission of California, 1913–1917.

Class of load.	1913		1914		1915	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$15,580	0.6	$16,423	0.6	$17,762	0.6
Incandescent	52,161	2.0	61,730	2.3	74,520	2.6
Municipal lighting, miscellaneous					2,031	
Municipal power			1,006		1,063	
Commercial lighting—						
Flat rate	402		266		1,206	
Metered	593,007	22.5	677,533	25.5	764,093	26.2
Commercial power—						
Flat rate			354			
Metered	506,523	19.2	473,928	17.8	580,589	19.9
Railway power	1,212,103	46.0	1,194,687	45.1	1,227,942	42.0
Other electrical corporations	252,264	9.6	213,390	8.0	239,204	8.2
Total operating revenues, electric	2,632,040	99.9	2,639,317	99.3	2,908,410	99.5
Other operating revenues:						
Electric merchandise and jobbing revenues	2,951	.1	19,695	.7	17,243	.5
Gross electric revenue	2,634,991	100.0	2,659,012	100.0	2,925,653	100.0

TABLE 253.—*Classified revenues, Pacific Light & Power Corporation, 1901–1917*—Continued.

Class of load.	1916 Revenue.	1916 Per cent of gross electric revenues.	1917 (to May 31). Revenue.	1917 (to May 31). Per cent of gross electric revenues.
Operating revenues, electric:				
Municipal street lighting—				
Arc	$18,153	0.5	$69,255.30	5.3
Incandescent	79,659	2.4	38,057.59	2.9
Municipal lighting, miscellaneous	2,461	.1	427.08	....
Municipal power	2,246	....	2,852.23	.2
Commercial lighting—				
Flat rate	1,084	....	526.71	....
Metered	878,456	26.9	363,133.85	27.0
Commercial power, metered	687,362	21.2	253,133.09	19.3
Railway power	1,214,794	37.3	528,799.91	40.2
Other electrical corporations	353,413	10.9	53,201.42	4.0
Total operating revenues, electric	3,237,628	99.3	1,307,387.18	99.5
Other operating revenues:				
Electric merchandise and jobbing revenues	23,498	.7	6,910.32	.5
Gross electric revenue	3,261,126	100.0	1,314,297.50	100.0

TABLE 254.—*Earnings and expenses of Ventura County Power Co., 1912–1917.*

[Company absorbed Nov. 30, 1917, by Southern California Edison Co.]

	1912	1913	1914	1915	1916	1917 (to Nov. 30).
Electric operations:						
Operating revenues	$216,104	$139,755	$138,160	$142,580	$143,794	$169,109.59
Operating expenses	117,911	85,333	98,156	73,759	87,954	114,475.96
Net operating electric revenue	98,193	54,422	40,004	68,821	55,840	54,633.63
Gas operations:						
Operating revenues	....	52,117	51,494	54,980	58,196	59,580.76
Operating expenses	....	38,536	42,283	48,397	49,465	58,024.50
Net operating gas revenue	....	13,581	9,211	6,583	8,731	1,556,26.00
Water operations:						
Operating revenues	....	37,216	21,923	22,253	23,143	23,994.56
Operating expenses	....	21,244	21,170	15,831	15,451	21,703.66
Net operating water revenue	....	15,971	753	6,422	7,692	2,290.90
Total net operating revenue	98,193	83,974	49,968	81,826	72,263	58,480.79
Add:						
Nonoperating revenues:						
Rents from buildings, land, and apparatus	1,622	....	....	....	....	....
Miscellaneous rent revenues, electric	....	....	977	732	3,547	....
Interest and dividend revenues:						
Interest revenues on funded debt owned	....	....	....	150	....	....
Miscellaneous interest revenue	....	....	781	197	[a] 77	....
Total interest and dividend revenues	690	....	781	347	[a] 77	....
Miscellaneous nonoperating revenues	572	....	....	....	31	....
Total nonoperating revenues	2,884	2,480	1,758	1,079	3,501	5,789.61
Gross corporate income	101,077	86,454	51,726	82,905	75,764	64,270.40

[a] Debit item.

TABLE 254.—*Earnings and expenses of Ventura County Power Co., 1912–1917*—Con.

	1912	1913	1914	1915	1916	1917 (to Nov. 30.)
Deduct:						
Uncollectible bills		$815	$199	$546	$839	$1,100.00
Miscellaneous nonoperating expenses				162	267	
Nonoperating taxes				128	153	
Total nonoperating revenue deductions				290	420	189.11
Interest accrued on funded debt	$58,980	57,530	56,166	55,392	54,058	48,580.00
Other interest deductions	7,054	7,644	7,267	3,902	649	1,313.05
Amortization of debt discount and expense				1,031	992	905.63
Total deductions	66,034	65,174	63,632	61,161	56,958	52,087.79
Surplus for year	35,043	20,465		21,744	18,806	12,182.61
Deficit for year			11,906			

Classified electric operating revenues according to classification of Railroad Commission of California, 1913–1917.

Class of load.	1913		1914		1915	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting, incandescent	$5,434	3.8	$5,321	3.9	$5,966	4.2
Municipal lighting, miscellaneous	1,498	1.0	1,568	1.1	1,619	1.1
Municipal power	2,877	2.0	1,702	1.1	1,844	1.3
Commercial lighting, metered	84,878	61.0	89,136	64.5	94,793	66.5
Commercial power, metered	41,924	30.0	38,910	28.3	37,400	26.3
Total operating revenues, electric	136,611	97.8	136,637	98.9	141,623	99.4
Other operating revenues:						
Rent of electric appliances	5					
Electric merchandise and jobbing revenues	3,139	2.2	1,523	1.1	957	.6
Total other operating revenues	3,144	2.2	1,523	1.1	957	.6
Gross electric revenues	139,755	100.0	138,160	100.0	142,580	100.0

Class of load.	1916		1917 (to Nov. 30).	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:				
Municipal street lighting, incandescent	$5,280	3.7	$4,520.45	2.7
Municipal lighting, miscellaneous	1,409	1.0	1,290.75	.8
Municipal power	1,711	1.2	1,073.05	.7
Commercial lighting, metered	86,017	59.8	86,535.12	51.1
Commercial power, metered	46,835	32.5	72,435.89	42.8
Total operating revenues, electric	141,252	98.2	165,855.26	98.1
Other operating revenues:				
Rent of electric appliances				
Electric merchandise and jobbing revenues	2,543	1.8	3,254.33	1.9
Total other operating revenues	2,543	1.8	3,254.33	1.9
Gross electric revenues	143,795	100.0	169,109.59	100.0

TABLE 255.—*Comparative balance sheet of Santa Barbara Gas & Electric Co., 1913–1920.*

	1913	1914	1915	1916
ASSETS.				
Total fixed capital	$1,530,518.24	$1,681,242.96	$1,828,135.73	$1,845,635.26
Total cash and deposits	4,849.23	6,428.12	10,679.84	13,847.91
Notes receivable	26.60	200.00		
Accounts receivable	26,932.74	22,390.29	27,153.39	41,177.01
Investments				
Materials and supplies	20,294.65	18,723.44	24,554.03	46,734.02
Sinking funds	3,288.50	185.50	76.50	76.50
Treasury securities	9,000.00			
Prepaid expenses	3,805.42	6,879.78	3,900.35	17,384.68
Unamortized discount on securities and expenses	30,195.19	33,583.75	35,660.14	133,836.22
Other suspense			31.30	
Automobiles			1,797.70	2,813.03
Total assets	1,628,910.57	1,769,633.84	1,931,988.98	2,101,504.63
LIABILITIES.				
Capital stock	800,900.00	800,900.00	800,900.00	800,900.00
Funded debt	666,500.00	750,500.00	842,500.00	1,000,000.00
Notes payable	45,200.00	74,000.00	90,000.00	165,000.00
Accounts payable	41,596.73	35,018.98	29,710.35	47,267.62
Interest accrued	60.98	348.74	300.01	1,173.60
Taxes accrued				
Reserve for accrued depreciation	46,303.52	78,159.65	107,246.78	71,203.02
Casualty and insurance reserves	3,481.95	3,819.15	3,999.95	3,139.77
Other reserves from income or surplus				
Reserve for uncollectible bills			200.00	200.00
Corporate surplus unappropriated	24,867.39	26,887.32	57,131.89	12,620.62
Total liabilities	1,628,910.57	1,769,633.84	1,931,988.98	2,101,504.63

	1917	1918	1919	1920
ASSETS.				
Total fixed capital	$2,015,402.23	$2,203,053.67	$1,597,775.78	$1,640,357.24
Total cash and deposits	19,609.36	16,126.58	23,266.45	17,620.28
Notes receivable	169.00	36.00	70.50	
Accounts receivable	46,148.73	58,672.27	28,631.33	172,405.10
Investments		17,500.00	5,000.00	5,000.00
Materials and supplies	83,669.01	40,818.13	24,338.59	28,589.72
Sinking funds				
Treasury securities				
Prepaid expenses	41,045.22	30,613.64	7,794.43	5,969.26
Unamortized discount on securities and expenses	128,373.46	122,910.70	90,452.22	86,245.14
Other suspense	235.10	[a] 995.99	228.86	97.42
Construction work in progress			1,806.90	36,548.26
Automobiles	5,510.39	7,695.00	9,864.64	8,766.03
Total assets	2,340,162.50	2,496,430.00	1,789,229.70	1,001,598.45
LIABILITIES.				
Capital stock	800,900.00	800,900.00	800,900.00	800,900.00
Funded debt	1,000,000.00	1,000,000.00	770,700.00	760,700.00
Notes payable	185,000.00	218,463.17	50,000.00	265,000.00
Accounts payable	184,534.94	316,295.39	71,368.08	20,357.26
Interest accrued	1,392.49	1,780.83	87.49	2,833.34
Taxes accrued		27.20	314.68	5,800.00
Reserve for accrued depreciation	113,325.03	131,842.34	65,460.26	110,795.64
Casualty and insurance reserves	1,770.29	747.66	2,871.46	5,292.14
Other reserves from income or surplus		509.43	556.59	867.01
Reserve for uncollectible bills	200.00			
Corporate surplus unappropriated	53,039.75	25,863.98	26,971.14	29,053.06
Total liabilities	2,340,162.50	2,496,430.00	1,789,229.70	2,001,598.45

[a] Credit item.

TABLE 256.—*Earnings and expenses of Santa Barbara Gas & Electric Co., 1913–1920.*

	1913	1914	1915	1916	1917	1918	1919	1920
Electric operations:								
Operating revenues	$165,397	$183,964	$205,826	$232,978	$266,922	$281,211	$317,085	$398,003
Operating expenses	115,672	119,914	128,237	144,717	170,370	203,127	226,491	305,165
Net operating revenue, electric	49,725	64,050	77,589	88,261	96,552	78,084	90,594	92,830
Gas operations:								
Operating revenues	89,116	97,667	121,353	142,295	162,107	173,375	55,841	(a)
Operating expenses	64,742	78,563	79,621	103,949	112,370	158,214	38,938	....
Net operating revenue, gas	24,374	19,104	41,732	38,346	49,737	15,161	16,904	....
Total net operating revenue	74,099	83,154	119,321	126,607	146,289	93,245	107,498	92,838
Add:								
Nonoperating revenue	676	293	695	1,223	327	1,089	929	3,477
Interest and dividend revenues	127	235	93	175	192	209	12,550	7,762
Total nonoperating revenues	803	528	788	1,398	519	1,298	13,479	11,239
Gross corporate income	74,902	83,682	120,109	128,005	146,808	94,543	120,977	104,077
Deduct:								
Uncollectible bills	1,148	1,458	1,973	906	2,576	1,500	2,150	900
Nonoperating revenue deductions	9	61	62	34	73	63	100	123
Interest accrued on funded debt	39,686	41,981	47,799	50,275	50,000	50,000	45,943	38,285
Rent deductions	....	76	78	71	....	158	159	188
Other interest deductions	2,268	3,797	3,808	6,025	8,141	22,005	17,156	13,284
Amortization of debt discount and expense	1,092	1,136	1,785	3,000	5,463	5,463	5,316	4,207
Total miscellaneous deductions	44,203	48,509	55,505	60,311	66,253	79,189	70,824	56,987
Balance of year carried to corporate surplus	30,699	35,172	64,604	67,695	80,555	15,354	50,153	47,090

[a] Gas properties sold in 1919 to Southern California Gas Co.

TABLE 257.—*Classified electric revenues, Santa Barbara Gas & Electric Co., 1913–1920.*

Class of load.	1913		1914		1915	
	Revenue.	Per cent of gross electric revenue.	Revenue.	Per cent of gross electric revenue.	Revenue.	Per cent of gross electric revenue.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$12,450	7.5	$12,524	6.8	$12,863	6.3
Incandescent	602	.4	928	.5	1,067	.5
Municipal power	378	....	397	....	427	.2
Commercial lighting—						
Flat rate	1,164	.7	964	.5	890	.4
Metered	111,039	67.2	121,342	66.1	137,418	66.8
Commercial power, metered	26,407	16.0	30,953	16.9	33,125	16.2
Railway power	10,911	6.6	14,878	8.2	16,544	8.0
Miscellaneous electric	280	....	....	....	....	....
Total operating revenues, electric	163,231	98.4	181,985	99.0	202,334	98.4
Other operating revenues:						
Rent of electric appliances and jobbing revenues	54	....	134	....	197	....
Electric merchandise	1,913	1.6	1,845	1.0	2,665	1.3
Steam sales revenues	199	....	....	....	630	.3
Total other operating revenues	2,166	1.6	1,979	1.0	3,492	1.6
Gross electric revenues	165,397	100.0	183,964	100.0	205,826	100.0

TABLE 257.—*Classified electric revenues, Santa Barbara Gas & Electric Co., 1913–1920*—Continued.

Class of load.	1916		1917		1918	
	Revenue.	Per cent of gross electric revenue.	Revenue.	Per cent of gross electric revenue.	Revenue.	Per cent of gross electric revenue.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$13,749	5.9	$13,974.55	5.2	$14,342.37	5.2
Incandescent	1,298	.6	1,890.35	.7	2,421.23	1.0
Municipal lighting, miscellaneous	1,960	.8	2,334.90	.8	3,457.62	1.2
Municipal power	522	.2	1,097.85	.4	5,204.01	1.9
Commercial lighting—						
Flat rate	828	.4	901.95	.3	860.22	.3
Metered	153,099	65.7	166,283.59	62.0	157,857.51	56.1
Commercial power—						
Flat rate	....	....	511.35	.1	168.00	....
Metered	41,777	17.9	57,082.19	23.0	73,541.88	26.1
Railway power	16,041	7.0	17,824.55	6.5	19,636.78	7.0
Miscellaneous electric	180	....	2,769.00	.1	517.60	.1
Total operating revenues, electric	229,454	98.5	264,670.28	99.1	278,007.22	98.9
Other operating revenues:						
Rent of electric appliances and jobbing revenues	121	....	96.00	....	112.00	....
Electric merchandise	2,504	1.1	1,225.17	.5	1,916.64	.7
Steam sales revenues	900	.4	930.00	.4	1,175.00	.4
Total other operating revenues	3,525	1.5	2,251.17	.9	3,203.64	1.1
Gross electric revenues	232,979	100.0	266,921.45	100.0	281,210.86	100.0

Class of load.	1919		1920	
	Revenue.	Per cent of gross electric revenue.	Revenue.	Per cent of gross electric revenue.
Operating revenue, electric:				
Municipal lighting—				
Arc	$14,792.33	4.7	$15,588.95	3.9
Incandescent	2,640.54	.8	2,748.78	.7
Municipal lighting, miscellaneous	4,461.50	1.4	5,449.02	1.4
Municipal power	12,182.04	3.8	11,100.90	2.8
Commercial lighting—				
Flat rate	861.30	.3	966.81	.2
Metered	177,153.75	55.9	227,506.70	57.2
Commercial power—				
Flat rate	....	....	....	....
Metered	81,912.68	25.8	105,232.28	26.4
Railway power	16,098.00	5.1	18,636.88	4.7
Miscellaneous electric	2,109.35	.7	3,136.90	.8
Total operating revenue, electric	312,211.49	98.5	390,367.22	98.1
Other operating revenues:				
Rent of electrical appliances and jobbing revenues	111.50	....	442.18	.1
Electric merchandise	4,262.20	1.4	7,193.93	1.8
Steam sales revenues	500.00	.1	....	....
Total other operating revenues	4,873.70	1.5	7,636.11	1.9
Gross electric revenues	317,085.19	100.0	398,003.33	100.0

FINANCIAL TABLES FOR MOUNT WHITNEY POWER & ELECTRIC CO. AND PRINCIPAL SUBSIDIARIES.

TABLE 258.—*Capitalization, outstanding stock, and dividends of Mount Whitney Power & Electric Co. and principal subsidiaries.*

[Term of incorporation uniformly 50 years.]

Company.	Date of incorporation.	Capitalization.	Par value.	Year (Dec. 31).	Par value of stock outstanding.		Dividends.			
							Preferred stock.		Common stock.	
					Preferred.	Common.	Rate.	Amount.	Rate.	Amount.
							P. ct.		*Per cent.*	
Mount Whitney Power & Electric Corporation, Visalia, Calif.	Oct. 3, 1914	(a)	$100	1914	$1,025,000	b $21,750				
				1915	1,050,000	b 21,750	7 1/12	$36,020		
				1916	1,050,000	b 21,750	7	35,000		
				1917	1,050,000	b 21,750	5¼	26,250		
				1918	1,050,000	b 21,750				
Mount Whitney Power & Electric Co., Visalia, Calif.	Nov. 8, 1909	$5,000,000	100	1909	750,000	1,875,000				
				1910	750,000	1,875,000				
				1911	750,000	1,875,000				
				1912	750,000	1,875,000	7	c 112,728.75		
				1913	750,000	1,875,000				
				1914	d 750,000	d 1,875,000	17½	131,250.00		
				1915		2,625,000	4½	e 30,625.00	⅔ of 1	$17,500.00
				1916		2,625,000				49,437.50
				1917		2,625,000			73⅓ per share	19,250.00
				1918		2,625,000				
				1919		2,625,000				
Mount Whitney Power Co., Visalia, Calif. f (succeeded by Mount Whitney Power & Electric Co., Nov. 8, 1909).	Dec. 26, 1899	g 300,000	10	1899–1903		250,000				
				1904–1908		750,000				
Tulare County Power Co., Porterville, Calif.	June 8, 1910	1,000,000	100	1900–1915						
Globe Light & Power Co., San Jose, Calif. (changed to Visalia, Nov. 21, 1904). h	June 20, 1902	200,000	10	1905–1912						
Visalia Gas Light & Heat Co., Visalia, Calif.	June 6, 1890	40,000	20	1905–1913						
Porterville Light & Power Co., Porterville, Calif.	June 18, 1899	10,000	10	1905–1913						

[a] Capitalized for $1,000,000 first preferred stock, $550,000 second preferred, and 32,500 shares of common stock (no par value).
[b] Number of shares.
[c] Cumulative 7 per cent from November, 1909, to Dec. 31, 1911.
[d] 7,500 shares of preferred stock retired by issuance of like number of shares of common stock Feb. 1, 1915.
[e] Accumulated to Feb. 1, 1915.
[f] No other data available for this or succeeding companies.
[g] Capitalization increased to $1,000,000 May 9, 1904.
[h] Charter forfeited for nonpayment of corporation tax.

TABLE 259.—*Bonds of Mount Whitney Power & Electric Co.*

Issue.	Callable or convertible.	Sinking-fund deposits.	Trustee.	Denomination.
1	2	3	4	5
1. Mount Whitney Power & Electric Co. first-mortgage 6 per cent bonds dated Oct. 1, 1909; due Oct. 1, 1939; interest payable Apr. 1 and Oct. 1.	As a whole at 110 and interest on any interest date until 1929, after which rate of call is reduced 1 per cent per annum.	Beginning Oct. 1, 1914, 1 per cent per annum of bonds outstanding to be used to retire bonds at not more than 110 and interest. Also improvement funds of 1 per cent beginning Oct. 1, 1919.	Bankers Trust Co., New York City, N. Y.	$1,000 coupon or registered.
2. Mount Whitney Power Co. first-mortgage 6 per cent bonds dated May 2, 1904: due $20,000 per annum, beginning May 2, 1906.	At par; $20,000 per annum beginning 1906.	None; bonds due serially.	First Trust & Savings Bank, Chicago, Ill.	$500 coupon.

	Bonded debt.								Remarks.
	Authorized.	Year (Dec. 31).	Reserved for prior liens.	In sinking fund.		In treasury.	In hands of public.	Total authenticated.	
				Canceled.	Alive.				
1	6	7	8	9	10	11	12	13	14
1	$5,000,000	1909	$200, 000	None.	None.	....	$800, 000	$800, 000	$4,000,000 unissued.
		1910	None.	None.	None.	....	1, 128, 000	1, 128, 000	$3,872,000 unissued.
		1911	None.	None.	None.	....	1, 225, 000	1, 225, 000	$3,775,000 unissued.
		1912	None.	None.	None.	....	1, 825, 000	1, 825, 000	$3,175,000 unissued.
		1913	None.	None.	None.	....	2, 165, 000	2, 165, 000	$2,835,000 unissued.
		1914	None.	24.000	None.	....	2, 553, 000	[a]2, 553, 000	$2,423,000 unissued.
		1915	None.	52, 000	None.	....	3, 110, 000	[a]3, 110, 000	$1,838,000 unissued.
		1916	None.	83, 000	None.	....	3, 529, 000	[a]3, 529, 000	$1,388,000 unissued.
		1917	None.	117, 000	None.	....	3, 495, 000	[a]3, 495, 000	$1,388,000 unissued.
		1918	None.	148, 000	None.	....	3, 464, 000	[a]3, 464, 000	$1,388,000 unissued.
		1919	None.	179, 000	None.	....	3, 433, 000	[a]3, 433, 000	$1,388,000 unissued.
		1920	None.	210, 000	None.	....	3, 402, 000	[a]3, 402, 000	$1,388,000 unissued.
2	340, 000	1904	....	....	....	....	....	....	No detailed figures as to annual amounts outstanding are available. According to financial manuals maximum of $280,000 was reached Dec. 31, 1908.
		1905	....	....	....	....	....	200, 000	
		1906	....	....	....	....	....	180, 000	
		1907	....	....	....	....	....	180, 000	
		1908	....	....	....	....	....	280, 000	
		1909	....	....	....	....	....	200, 000	

[a] Not including bonds canceled by sinking fund or otherwise.

TABLE 260.—*Comparative balance sheet of Mount Whitney Power & Electric Co., 1913–1919.*

	1913	1914	1915	1916	1917	1918	1919
ASSETS.							
Fixed capital	$5,150,818	$5,615,182	$6,276,834	$6,781,886	$7,076,902	$7,315,223	$8,245,809
Cash and deposits:							
Cash	13,294	5,435	60,818	35,843	117,026	146,523	118,454
Special deposits	500	10,503	7,139	177,458	6,119	....	25
	13,794	15,938	67,957	213,301	123,145	146,523	118,479
Notes receivable	35,942	42,868	85,269	58,029	24,087	16,832	9,239
Accounts receivable:							
Accounts with system corporations	....	....	2,258	....	....	....	....
Due from consumers and agents	173,062	183,158	185,415	135,397	126,882	106,284	26,199
Miscellaneous	151,097	14,187	3,651	....	....	44,914	11,321
	324,159	197,345	191,324	135,397	126,882	151,198	37,520
Other current assets	110,537	67,775	....	....	....	....	....
Investments:							
Miscellaneous nonoperating	....	....	8,250	10,246	....	....	....
Other miscellaneous	....	....	1,146	....	18,317	77,041	44,914
	....	....	9,396	10,246	18,317	77,041	44,914
Materials and supplies	101,840	60,653	57,307	67,995	129,106	326,721	277,313
Sinking funds	....	....	....	....	18	19	559
Treasury securities	54,000	....	....	....	....	....	....
Prepaid expenses:							
Prepaid rents	....	....	153	130	....	....	....
Prepaid taxes	64	273	193	1,526	1,477	332	306
Prepaid insurance	2,284	2,179	3,616	3,202	1,464	1,102	1,077
Other prepayments	4,928	247	....	....	....	8,724	10,706
	7,276	2,699	3,962	4,857	2,941	10,158	12,089
Unamortized discount on securities and expenses:							
Stocks	....	....	....	....	....	....	49,040
Bonds	188,413	201,558	251,861	262,702	252,017	239,857	211,520
Miscellaneous	....	....	14,370	6,522	....	....	....
	188,413	201,558	266,231	269,224	252,017	239,857	260,560
Other suspense	11,200	9,225	44,817	....	....	[a] 260	4,580
Construction work in progress	82,187	640	15,466	30,759	90,288	75,077	58,699
Miscellaneous	11,158	....	....	....	....	....	....
Total assets	6,047,324	6,213,883	7,018,563	7,571,875	7,843,703	8,358,389	9,069,762
LIABILITIES.							
Capital stock	2,625,000	2,625,000	2,625,000	2,625,000	2,625,000	2,625,000	2,825,000
Funded debt	2,165,000	2,553,000	3,110,000	3,529,000	3,495,000	3,464,000	3,433,000
Notes payable	319,020	290,752	108,875	....	125,000	257,000	200,000
Accounts payable:							
Accounts with system corporations	....	....	....	....	211,552	614,427	1,144,420
Sundry creditors	....	....	13,344	....	....	....	....
Audited vouchers and wages unpaid	134,021	554	216	8,860	8,780	22,744	57,671
Consumers' deposits	3,050	1,455	1,467	1,686	10,522	11,118	5,490
Miscellaneous	13,870	6,138	6,140	98,369	13,226	13,311	5,079
	150,940	8,147	21,167	108,915	244,080	661,600	1,212,660
Interest accrued	35,799	42,370	47,550	53,156	55,848	57,789	55,209
Taxes accrued	....	....	....	....	....	1,931	692
Dividend declared	....	....	....	8,750	....	....	....
Service billed in advance	....	....	....	....	1,389	....	....
Reserve for accrued depreciation	405,177	436,661	489,920	576,435	659,307	662,110	715,085
Casualty insurance reserves	....	....	....	....	3,832	2,535	616
Other reserves from income or surplus	2,632	39,420	60,806	69,089	45,177	37,403	37,302
Miscellaneous	116,537	....	....	....	....	....	....
Corporate surplus unappropriated	227,219	218,533	555,245	601,530	589,070	589,021	590,198
Total liabilities	6,047,324	6,213,883	7,018,563	7,571,875	7,843,703	8,358,389	1,069,762

[a] Credit item.

TABLE 260.—*Comparative balance sheet of Mount Whitney Power & Electric Co., 1913–1919*—Continued.

Condensed balance sheet of Tulare County Power Co.,[b] May 31, 1915.

ASSETS.

Property	$775,284
Material and supplies	5,998
Assessment paid on company stock	14,818
Unamortized discount on securities	19,725
Uncompleted work orders	113
Cash and deposits	896
Accounts receivable	34,502
Notes receivable	13,734
Accrued suspense accounts	5,009
Deficit	64,458
	934,537

LIABILITIES.

Preferred stock issued	202,519
Consumers stock issued	141,200
Common stock issued	5,275
Preferred stock issued but owned by company	7,300
Consumers stock issued but owned by company	22,400
Common stock issued but owned by company	194,725
Payments on stock not issued	11,949
Prepaid power	945
Escrow account stock	26,762
Depreciation reserve	11,060
Assessments	40,987
Notes payable	249,339
Accounts payable	8,605
Pay rolls payable	1,740
Taxes payable	6,728
Interest accrued	3,003
	934,537

[b] Tulare County Power Co. was absorbed by Mount Whitney Power & Electric Co. in August, 1915.

TABLE 261.—*Earnings and expenses of Mount Whitney Power & Electric Co., 1900–1920.*

Form of report used by company's accountants, 1900–1909.

	1900 [a]	1901 [a]	1902 [a]	1903 [a]	1904 [a]	1905 [a]	1906 [a]	1907 [a]	1908 [a]	1909 [b]
Gross earnings, electric	$34,775	$52,779	$65,361	$89,392	$101,137	$117,882	$140,585	$175,048	$229,339	$271,954
Total gross earnings	37,954	56,951	68,553	92,630	104,186	120,917	146,568	182,473	233,705	278,872
Operating expenses	26,266	25,530	31,747	38,439	42,248	59,092	63,868	76,433	94,387	102,482
Net income	11,688	31,421	36,806	54,191	61,938	61,825	82,700	106,040	139,318	176,030

[a] Year ending Oct. 31.

[b] Year ending Dec. 31.

TABLE 261.—*Earnings and expenses of Mount Whitney Power & Electric Co., 1910–1920*—Continued.

Standard form adopted by Railroad Commission of California.

[Earnings and expenses as here given for period Nov. 8, 1909, to Dec. 31, 1913, are taken from Table 1, Decision 2067, California Railroad Commission. Earnings and expenses for succeeding years are taken from company's official reports to Railroad Commission.]

	Nov. 8, 1909, to Dec. 31, 1909.	1910	1911	1912	1913
Operating revenue	$31,063.16	$328,617.21	$384,076.22	$440,211.20	$557,014.88
Operating expenses		141,258.20	154,889.87	217,801.91	256,456.51
Depreciation	6,112.18	49,249.60	58,626.30	67,451.28	58,556.34
Total operating expenses	6,112.18	190,507.80	213,516.17	285,253.19	315,012.85
Net operating revenue	24,950.98	138,109.41	170,560.05	154,958.01	242,002.03
Miscellaneous rent revenue			20.00	50.00	320.00
Interest revenue		9,089.93	6,014.69	5,520.31	29,996.20
Jobbing and merchandise revenue		6,707.24	7,528.23	8,862.81	10,570.08
Total income	24,950.98	153,906.58	184,122.97	169,391.13	282,888.31
Deductions:					
Uncollectible bills	355.03	2,977.18	3,547.57	4,022.52	5,052.67
Waterworks loss or gain		[a]711.26	557.10	261.02	
Interest on funded debt	3,162.50	54,689.17	69,504.01	85,423.34	114,918.35
Other interest	6,767.38	17,117.14	1,763.36	3,441.74	23,282.75
Amortization of debt discount	137.31	4,564.89	5,593.63	6,266.97	6,927.68
Total deductions	10,422.22	78,637.12	80,965.66	99,415.59	150,181.45
Net income	14,528.76	75,269.46	103,157.31	69,975.54	132,706.86
Miscellaneous undistributed adjustments	[c]210.64	[c]5,444.64	[c]16,136.27	6,846.44	[c]40,745.34
Dividends				[c]112,728.75	
Surplus for year	14,318.12	69,824.82	87,021.04		91,961.52
Deficit for year				35,906.77	

	1914	1915	1916	1917
Electric operations:				
Operating revenue	$670,266.89	$745,517.28	$773,929.76	$811,574.71
Operating expenses	322,719.43	383,075.95	424,058.24	569,284.57
Net operating revenue	347,547.46	362,441.33	349,871.52	242,290.14
Add:				
Miscellaneous rent revenue	320.00	300.00	320.00	275.00
Miscellaneous interest revenue		14,182.94		
Interest revenue on funded debt owned	16,319.21	5,575.00	8,041.14	7,239.90
Miscellaneous nonoperating revenues	55.62	288.68		
Total nonoperating revenues	16,694.83	20,346.62	8,361.14	7,514.90
Gross corporate income	364,242.29	382,787.95	358,232.66	249,805.04
Deduct:				
Uncollectible bills	7,575.54	5,602.75	8,986.94	11,168.38
Nonoperating taxes				
Miscellaneous nonoperating expenses	12,134.68	55.07	83.50	
Interest accrued on funded debt	141,966.47	165,528.19	199,573.96	211,134.96
Other interest deductions	26,968.60	11,921.91	5,445.20	5,206.24
Miscellaneous nonoperating deductions	19,282.83	295.61		
Rent of conduits, poles, and other supports		66.77	533.34	
Other contractual deductions from income		10,226.22		
Amortization of debt discount and expense		11,602.25	11,007.72	11,547.36
Total miscellaneous deductions	207,928.12	205,298.77	225,630.66	239,056.64
Balance of year carried to corporate surplus account	156,314.17	177,489.18	132,602.00	10,748.40

[c] Deduction.

TABLE 261.—*Earnings and expenses of Mount Whitney Power & Electric Co., 1900–1920*—Continued.

	1918	1919	1920 (to June 30).
Electric operations:			
Operating revenue	$1,046,453.30	$1,360,582.64	$690,410.93
Operating expenses	769,619.69	1,049,978.17	428,109.01
Net operating revenue	276,833.61	310,604.47	262,301.92
Add:			
Miscellaneous rent revenue	177.00	530.00	677.95
Miscellaneous interest revenue		3,703.67	641.42
Interest revenue on funded debt owned	2,847.89		
Miscellaneous nonoperating revenues			
Total nonoperating revenues	3,024.89	4,233.67	1,319.37
Gross corporate income	279,858.50	314,838.14	263,621.29
Deduct:			
Uncollectible bills	9,258.34	6,000.00	3,000.00
Nonoperating taxes	112.03	610.81	302.74
Miscellaneous nonoperating expenses		50.80	
Interest accrued on funded debt	209,174.50	207,521.83	102,990.00
Other interest deductions	32,714.71	61,879.12	47,191.67
Miscellaneous nonoperating deductions			
Rent of conduits, poles and other supports			1.00
Other contractual deductions from income			
Amortization of debt discount and expense	11,579.98	11,494.92	5,354.94
Total miscellaneous deductions	262,839.56	287,557.48	158,840.35
Balance of year carried to corporate surplus account	17,018.94	27,280.66	104,780.94

TABLE 262.—*Classified electric revenues of Mount Whitney Power Co. (according to classification of Railroad Commission of California), 1913–1920.*

Class of load.	1913		1914		1915	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$7,951	1.4	$12,605	1.9	$11,736	1.6
Incandescent	2,493	.4	2,518	.4	4,042	.5
Municipal lighting, miscellaneous	1,302	.2	1,954	.3	3,103	.4
Municipal power	10,064	1.8	12,874	1.9	13,925	1.9
Commercial lighting—						
Flat rate	4,690	.8	4,897	.7	5,764	.8
Metered	101,445	17.8	119,197	17.8	121,902	16.4
Commercial power—						
Flat rate	296,963	52.4	358,504	53.6	376,858	50.6
Metered	109,508	19.4	135,449	20.2	189,234	25.3
Railway power	16,269	2.9	16,692	2.5	18,577	2.5
Other electrical corporations	5,816	1.0	90			
Rent of meters						
Miscellaneous electric			294			
Total operating revenues, electric	556,501	98.1	665,074	99.3	745,141	100.0
Other operating revenues:						
Rent of electric appliances			334			
Electrical merchandise and jobbing	10,570	1.9	4,859	.7	376	
Total other operating revenues	10,570	1.9	5,193	.7	376	
Gross electric revenues	567,071	100.0	670,267	100.0	745,517	100.0

TABLE 262.—*Classified electric revenues of Mount Whitney Power Co. (according to classification of Railroad Commission of California), 1913–1920*—Continued.

Class of load.	1916		1917		1918	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$10,460	1.3	$9,866	1.2	$9,752	0.9
Incandescent	5,646	.7	10,753	1.3	10,328	.9
Municipal lighting, miscellaneous	2,141	.3	2,812	.4	3,405	.3
Municipal power	12,994	1.7	14,831	1.8	15,969	1.5
Commercial lighting—						
Flat rate	3,078	.4			66	
Metered	105,945	13.7	116,222	14.3	132,019	12.6
Commercial power—						
Flat rate	455,994	58.9	442,328	54.5	574,071	54.9
Metered	147,491	19.1	190,364	23.5	279,762	26.8
Railway power	14,786	1.9	16,306	2.0	13,081	1.3
Other electrical corporations						
Rent of meters	2,320	.3	2,054	.3	3,201	.3
Miscellaneous electric			6,038	.7	1,027	.1
Total operating revenues, electric	760,855	98.3	811,574	100.0	1,042,681	99.6
Other operating revenues:						
Rent of electric appliances						
Electrical merchandise and jobbing	13,075	1.7			3,772	.4
Total other operating revenues						
Gross electric revenues	773,930	100.0	811,574	100.0	1,046,453	100.0

Class of load.	1919		1920 (to June 30).	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:				
Municipal street lighting—				
Arc	$15,807	1.1	$8,405	1.2
Incandescent	18,197	1.3	10,105	1.4
Municipal lighting, miscellaneous	5,580	.4	3,406	.5
Municipal power	19,344	1.6	10,943	1.6
Commercial lighting—				
Flat rate	140		163	
Metered	212,332	15.6	142,752	20.7
Commercial power—				
Flat rate	703,702	51.8	110,867	16.1
Metered	365,839	26.9	394,053	57.1
Railway power	16,881	1.2	8,708	1.2
Other electrical corporations				
Rent of meters	1,279	.1	[a] 154	
Miscellaneous electric	536		[a] 56	
Total operating revenue, electric	1,359,639	100.0	689,191	99.8
Other operating revenues:				
Rent of electric appliances	94		50	
Electric merchandise and jobbing revenue	850		1,170	.2
Total other operating revenue	944		1,220	.2
Gross electric revenues	1,360,583	100.0	690,411	100.0

[a] Debit item.

TABLE 262.—*Classified electric revenues of Mount Whitney Power Co. (according to classification of Railroad Commission of California), 1913–1920*—Continued.

Tulare County Power Co.

Class of load.	1913		1914		1915	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal lighting, miscellaneous	$31	....	$30	....	$17.50	....
Municipal power	448	0.4	306	....	185.80	0.1
Commercial lighting—						
Flat rate	179	....	10	....	....	....
Metered	6,083	6.0	7,393	5.1	5,453.26	5.9
Commercial power—						
Flat rate	96,238	86.6	123,051	85.9	79,365.46	84.9
Metered	7,882	7.0	12,239	9.0	8,514.90	9.1
Miscellaneous electric	60	....	162	....	....	....
Total operating revenues, electric	110,921	100.0	143,191	100.0	93,536.92	100.0
Other operating revenues: Sale of by-products	216	....	204	....	120.50	....
Gross electric revenues	111,137	100.0	143,395	100.0	93,657.42	100.0

NOTE.—Tulare County Power Co. was sold to Mount Whitney Power Electric Co. in August, 1915.

FINANCIAL TABLES FOR ONTARIO POWER CO.

TABLE 263.—*Capitalization, outstanding stock, and dividends of Ontario Power Co.*

[Term of incorporation, 50 years; par value of stock is $50.]

Company.	Capitalization.	Year (Dec. 31).	Par value of common stock outstanding.	Dividends on common stock.	
				Rate.	Amount.
Ontario Power Co., Los Angeles, Calif.; incorporated Oct. 23, 1901	$500,000	1903–1913	[a]$380,000	*Per cent.*	....
		1914	380,000	6	$22,800
		1915	380,000	6	22,800
		1916	380,000	6	22,800
		1917	380,000	46	174,800
		1918	380,000	4½	17,100
		1919	380,000	....	....
		1920	[b]380,000	6½	14,700

[a] All stock is owned by San Antonio Water Co.

[b] On December 31, 1920, the company also had issued and outstanding, in addition to its common stock, $112,000 par value preferred stock on which it paid dividends during the year at the rate of 5¼ per cent, amounting to $3,675.

TABLE 264.—*Bonds of Ontario Power Co.*

Issue.	Callable.	Sinking-fund deposits.	Trustee.	Denomination.	Authorized.	Year (Dec. 31).	Reserved for prior liens.	In sinking fund.	In treasury.	In hands of public.	Total authenticated.
Ontario Power Co. first-mortgage 5 per cent bonds dated Jan. 2, 1902; due Jan. 2, 1932; interest payable Jan. 1 and July 1.			Union Trust Co., San Francisco.		$400,000	1903-1907				$380,000	$380,000
						1908				364,000	364,000
						1909				362,000	362,000
						1910				348,000	348,000
						1911				340,000	340,000
						1912				333,000	333,000
						1913				326,000	326,000
						1914				326,000	326,000
						1915		$95,000		305,000	305,000
						1916		102,000		298,000	298,000
						1917		109,000		291,000	291,000
						1918		115,000		285,000	285,000
						1919		120,000		280,000	280,000
						1920		120,000		280,000	280,000
Ontario Power Co. 7 per cent serial notes. Bonds dated July 1, 1918; due serially $6,000 par value per annum.	In part or whole July 1, 1921, or any interest date thereafter at par.	Deposit of $500, to be made on first of each month to be used in serial retirement of notes.	Oscar Arnold		90,000	1918			$23,000	67,000	67,000
						1919		6,000		84,000	84,000
						1920		12,000		78,000	78,000

TABLE 265.—*Comparative balance sheet, Ontario Power Co., 1912–1920.*

Total assets from 1907–1911, inclusive: 1907, $1,101,123; 1908, $1,124,978; 1909, $121,843; 1910, $1,125,533; 1911, $1,141,056.]

	1912	1913	1914	1915	1916
ASSETS.					
Fixed capital	$1,017,230	$1,035,942	$1,057,878	$1,089,278	$1,097,905
Cash	2,733	753	2,333	2,538	2,260
Accounts receivable:					
Due from consumers and agents		9,963	10,887	11,150	13,310
Miscellaneous		152		110	74
	14,926	10,115	10,887	11,260	13,384
Other current assets	579	182	1,105	942	619
Miscellaneous investments	4,000	5,000			
Materials and supplies	1,208	1,237	5,255	2,842	6,416
Sinking funds		495	525	325	385
Other special funds				1,000	1,000
Prepaid expenses: Prepaid insurance			225	286	89
Total assets	1,040,676	1,053,724	1,078,208	1,108,471	1,122,058
LIABILITIES.					
Capital stock	380,000	380,000	380,000	380,000	380,000
Funded debt	326,000	326,000	312,000	305,000	298,000
Notes payable	208,500				
Accounts payable:					
Audited vouchers and wages unpaid	4,995	1,453	4,845	729	3,434
Consumers' deposits					2
Miscellaneous	1,012	182,355	181,351	[a] 192,388	201,001
	6,007	183,808	186,196	[a] 194,117	204,437
Interest accrued	146				
Taxes accrued		3,442	3,442	3,745	3,909
Reserve for accrued depreciation		10,966	29,422	42,983	45,904
Unamortized premiums on debt			678	1,160	1,430
Casualty and insurance reserves				1,000	1,000
Income invested since Dec. 31, 1912, in fixed capital		18,713	40,648	72,048	67,661
Other reserves from income or surplus	305	4,034			
Corporate surplus unappropriated	119,718	126,761	125,822	108,418	119,717
Total liabilities	1,040,676	1,053,724	1,078,208	1,108,471	1,122,058

	1917	1918	1919	1920
ASSETS.				
Fixed capital	$771,617.91	$786,242.98	$905,676.98	$1,028,124.94
Cash and deposits:				
Cash	4,261.95	5,098.00	2,219.66	2,085.59
Special deposits		7,775.10		
	4,261.95	12,873.10	2,219.66	2,085.59
Accounts receivable:				
Accounts with system corporations	12,654.14	13,805.56		
Due from consumers and agents			15,014.31	20,040.09
Miscellaneous accounts receivable	169.47		2,114.18	10,696.28
	12,823.61	13,805.56	17,128.49	30,736.37
Other current assets	1,054.24	6,167.98	10,750.00	4,950.00
Miscellaneous investments		10,074.25	10,074.25	10,074.25
Materials and supplies	7,722.68	9,255.56	7,708.86	12,581.46
Sinking funds		3,000.00	3,000.00	8,650.00
Other special funds	1,500.00	2,496.45	2,591.55	3,534.55
Prepaid expenses:				
Prepaid insurance	103.94	114.40	122.05	200.56
Other prepayments				
Other suspense			494.83	267.37
Construction work in progress		52,224.90		
Total assets	799,084.33	896,255.18	959,766.67	1,101,205.09

[a] Of this amount $180.500 was due San Antonio Water Co. for advances of 6 per cent interest paid annually.

TABLE 265.—*Comparative balance sheet, Ontario Power Co., 1912–1920*—Continued.

	1917	1918	1919	1920
LIABILITIES.				
Capital stock	$380,000.00	$380,000.00	$380,000.00	$492,000.00
Funded debt	291,000.00	352,000.00	364,000.00	358,000.00
Notes payable	....	....	24,000.00	10,000.00
Accounts payable:				
Accounts with system corporations	....	....	....	....
Audited vouchers and wages unpaid	4,795.29	3,944.47	9,495.42	18,314.99
Consumers' deposits	....	14.00	61.92	142.85
Miscellaneous accounts payable	1,484.83	1,243.15	2,350.78	1,576.36
	6,280.12	5,201.62	11,908.12	20,034.20
Taxes accrued	3,005.43	3,597.72	3,628.20	4,391.87
Reserved for accrued depreciation	59,275.05	73,542.73	62,618.10	70,397.50
Unamortized premiums on debt	1,661.70	1,654.44	1,647.18	1,509.92
Casualty and insurance reserves	1,500.00	2,496.45	3,091.55	3,534.55
Corporate surplus unappropriated	56,362.03	77,762.22	108,875.52	141,337.05
Total liabilities	799,084.33	896,255.18	959,766.67	1,101,205.09

TABLE 266.—*Earnings and expenses, Ontario Power Co., 1907–1920.*

Year.	Gross revenue.	Operating expenses.	Net earnings.
1907	$67,258	$59,549	$7,709
1908	84,560	67,706	16,854
1909	84,415	80,650	3,765
1910	90,592	65,183	25,409
1911	96,593	66,830	29,763

	1912	1913	1914	1915	1916
Electric operations:					
Operating revenues	$100,773	$110,170	$100,746	$100,217	$107,337
Operating expenses	51,108	67,105	50,638	57,804	65,809
Net operating revenue, electric	49,665	43,065	50,108	42,413	41,528
Add:					
Nonoperating revenues—					
Rents from buildings, land, and apparatus	1,181	....	....	....	....
Miscellaneous nonoperating revenue	17,734	14,288	20,212	21,216	22,240
Total nonoperating revenue	18,915	14,288	20,212	21,216	22,240
Gross corporate income	68,580	57,353	70,320	63,629	63,768
Deduct:					
Uncollectible bills	729	429	310	414	505
Nonoperating revenue deductions	....	....	....	....	....
Interest accrued on funded debt	16,300	16,300	16,050	15,600	15,250
Other interest deductions	15,070	11,415	10,055	10,818	11,029
Amortization of premium on debt—credit	....	....	42	....	....
Total deductions	32,099	28,144	26,374	26,832	26,784
Surplus for year	36,481	29,209	43,946	36,797	36,984

	1917	1918	1919	1920
Electric operations:				
Operating revenues	$128,490	$132,186	$159,361	$204,277
Operating expenses	74,970	79,049	112,942	124,600
Net operating revenue, electric	53,519	53,137	46,419	79,677

TABLE 266.—*Earnings and expenses, Ontario Power Co., 1907–1920*—Continued.

	1917	1918	1919	1920
Add:				
Nonoperating revenues—				
Rents from buildings, land, and apparatus	....	....	....	....
Miscellaneous interest revenues	....	....	$134	$727
Miscellaneous nonoperating revenue	$10,673	$1,127	1,137	1,000
Total nonoperating revenue	10,673	1,127	1,271	1,727
Gross corporate income	64,192	54,264	47,690	81,404
Deduct:				
Uncollectible bills	427	478	18	281
Nonoperating revenue deductions	....	....	....	....
Interest accrued on funded debt	14,900	14,596	15,978	19,670
Other interest deductions	5,081	215	233	771
Amortization of discount on debt—credit	....	....	....	137
Total deductions	20,408	15,289	16,230	20,304
Surplus for year	43,784	38,975	31,460	60,819

TABLE 267.—*Classified electric revenues, Ontario Power Co., 1913–1920.*

Class of load.	1913		1914		1915	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenues, electric:						
Municipal street lighting—						
Arc	$6,375	5.8	$6,576	6.5	$6,468	6.5
Incandescent	....	....	....	....	....	....
Commercial cooking and heating	7,153	6.5	7,303	7.2	7,523	7.5
Commercial lighting, metered	40,089	36.4	42,199	41.9	43,127	43.1
Commercial power—						
Flat rate	40,138	36.4	19,123	19.0	17,393	17.3
Metered	15,006	13.6	17,493	17.4	17,588	17.6
Other electrical corporations	1,182	1.1	7,336	7.3	7,356	7.3
Miscellaneous electric	....	....	567	.6	762	.7
Total operating revenues, electric	109,943	99.8	100,597	99.9	100,217	100.0
Other operating revenues:						
Sale of by-products	....	....	....	....	....	....
Electric merchandise and jobbing revenues	228	.2	148	.1	None.	None.
Total other operating revenues	228	.2	148	.1	None.	None.
Gross electric revenues	110,171	100.0	100,745	100.0	100,217	100.0

Class of load.	1916		1917		1918	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$6,782	6.3	....	....	....	....
Incandescent	....	....	$6,290	5.0	$4,285	3.2
Commercial cooking and heating	8,984	8.4	14,079	11.0	15,448	11.7
Commercial lighting, metered	47,257	44.0	48,945	38.1	46,661	35.3
Commercial power, pumping	16,401	15.3	32,323	25.3	39,702	30.0
Commercial power, industrial	20,591	19.2	22,589	18	19,661	14.9
Other electrical corporations	6,559	6.1	3,765	2.2	3,050	2.3
Miscellaneous electric	762	.7	499	.4	700	.5
Total operating revenues, electric	107,337	100.0	128,490	100.0	129,507	97.9
Other operating revenues:						
Sale of by-products	....	....	....	....	2,630	2.1
Electric merchandise and jobbing revenues	....	....	....	....	49	....
Total other operating revenues	....	....	....	....	2,679	2.1
Gross electric revenues	107,337	100.0	128,490	100.0	132,186	100.0

TABLE 267.—*Classified electric revenues, Ontario Power Co., 1913-1920*—Continued.

Class of load.	1919		1920	
	Revenue.	Per cent of gross electric revenue.	Revenue.	Per cent of gross electric revenue.
Operating revenue, electric:				
Municipal street lighting, incandescent	$4,134	2.6	$4,989	2.4
Commercial cooking and heating	18,390	11.6	23,917	11.7
Commercial lighting, metered	54,122	33.9	71,172	34.8
Commercial power, metered	23,974	15.1	29,232	14.3
Power for pumping	55,264	34.7	66,162	32.4
Other electrical corporations	729	.5	4,271	2.1
Miscellaneous electric	275	.1	1,375	.7
Total operating revenue, electric	156,888	98.5	201,117	98.4
Other operating revenues:				
Sales of by-products	2,365	1.5	2,248	1.1
Electric merchandise and jobbing revenue	107		912	.5
Total other operating revenues	2,472	1.5	3,160	1.6
Gross electric revenues	159,361	100.0	204,277	100.0

FINANCIAL TABLES FOR THE NEVADA-CALIFORNIA POWER SYSTEM.

TABLE 268.—*Capitalization, outstanding stock, and dividends of The Nevada-California Power system.*

The Nevada-California Electric Corporation.

Company.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.		Dividends.			
			Preferred.	Common.	Preferred.		Common.	
					Rate.	Amount.	Rate.	Amount.
The Nevada-California Electric Corporation, Denver, Colo.; incorporated December, 1914 (Delaware); began business July 1, 1915.	$30,000,000	1915	$5,167,000	$5,167,000	2	$96,130.00		
		1916	5,343,600	8,558,200	5	266,976.25		
		1917	[a] 6,082,100	[b] 8,587,600	6	349,894.50		
		1918	[c] 6,124,400	[d] 8,587,600	5¼	320,460.00		
		1919	[e] 7,236,800	[f] 8,588,200				
		1920	[g] 7,714,600	[h] 8,588,300				

[a] Includes $35,800 owned by corporation and subsidiaries.
[b] Includes $57,500 owned by corporation and subsidiaries.
[c] Includes $77,600 owned by corporation and subsidiaries.
[d] Includes $69,500 owned by corporation and subsidiaries.
[e] Includes $167,800 owned by corporation and subsidiaries.
[f] Includes $159,700 owned by corporation and subsidiaries.
[g] Includes $268,500 owned by corporation and subsidiaries.
[h] Includes $218,800 owned by corporation and subsidiaries.

TABLE 268.—*Capitalization, outstanding stock, and dividends of The Nevada-California Power system*—Continued.

Predecessors and subsidiary companies.

Company.	Capitalization.	Years (Dec. 31).	Par value of stock outstanding.		Dividends on—			
			Preferred.	Common.	Preferred.		Common.	
					Rate.	Amount.	Rate.	Amount.
The Nevada-California Power Co., Denver, Colo.; incorporated Jan. 5, 1907 (Wyoming).	$5,000,000	[i]1908		$4,488,500			1½	$66,067.50
		[j]1909		4,566,500			4½	204,307.50
		[k]1910		4,566,500			2	91,330.00
		[l]1911		4,566,500			2	91,330.00
		[m]1912		4,566,500			4	182,660.00
		1913		5,000,000			4	190,910.00
		1914		5,000,000			4	200,000.00
		1915		5,000,000			4	200,000.00
		1916		5,000,000			4	200,000.00
		1917		5,000,000			5	250,000.00
		1918		5,000,000			4¼	212,500.00
		1919		5,000,000			6	300,000.00
		1920		[n]6,500,000			6	300,000.00
The Nevada Power, Mining, & Milling Co., Denver, Colo.; incorporated Dec. 31, 1904 (Colorado).	1,000,000	1910					(o)	
		1911						
		1912						
		1913	Dissolved.					
The Southern Sierras Power Co., Cheyenne, Wyo.; incorporated June 15, 1911 (Wyoming).	5,000,000	1911 1915		5,000,000				
		1916		5,000,000			1	50,000.00
		1917		5,000,000			1¾	87,500.00
		1918		5,000,000			½	25,000.00
		1919		5,000,000			2½	125,000.00
		1920		5,000,000			2½	125,000.00
Pacific Power Co., San Francisco; incorporated May 12, 1910 (California).	1,000,000	1910– 1914		800,033				
Pacific Power Corporation, Cheyenne, Wyo.; incorporated Nov. 30, 1914.	6,000,000	1914		500				
		1915		1,000,000				
		1916		1,000,000				
		1917						
The Central California Electric Corporation, Delaware; incorporated Jan. 22, 1915.[p]	10,000,000	1915	$1,500,000	1,820,000				
		1916	1,500,000	1,820,000				
Coachella Valley Ice & Electric Co., Redlands, Calif.; incorporated Mar. 16, 1911.	300,000	1911 1912– [q]1918		300,000			(r)	

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[i] Dividends declared in July, 1908.

[j] Dividends declared Jan. 26, Apr. 16, June 30, and Sept. 25, 1909.

[k] Dividends declared January and March, 1910.

[l] Dividends declared August, 1911.

[m] Dividends declared February and August, 1912.

[n] In December, 1920, the authorized capital stock was increased from $5,000,000 to $10,000,000 and $1,500,000 was issued in payment of a stock dividend.

[o] The first dividend of The Nevada Power, Mining & Milling Co., paid in 1906, totaled $60,000.

[p] Term of incorporation, perpetual.

[q] Purchased by The Southern Sierras Power Co. Jan. 1, 1918.

[r] No dividends have been paid on this stock.

NOTE.—In addition to the stock shown above, minor subsidiaries of The Nevada-California Electric Corporation, The Nevada-California Power Co., and The Southern Sierras Power Co. had the following amounts of stock outstanding:

Bishop Light & Power Co., 1911 to date of absorption	$15,600
Corona Gas & Electric Co., 1911 to date of absorption	50,000
Interstate Telegraph Co., 1912–1920	500,000
Elsinore Electric Light & Power Co., 1912 to date of absorption	8,500
Barstow Utility Co., 1912 to date of absorption	50,000
Hillside Water Co., 1911–1920	500,000
Cain Irrigation Co.:	
1915–1917	2,000,000
1918–1920	2,986,900
California-Nevada Canal, Water & Power Co., 1906–1917	2,000,000
Deseret Water, Oil & Irrigation Co., 1911–1920	1,500
Silver Lake Power & Irrigation Co.:	
1907–1918	100,300
1919–1920	99,800
The Sierras Construction Co.:	
1911–1919	10,900
1920	18,200
Rialto Light, Power & Water Co., 1913 to date of absorption	10,000
The Imperial Ice & Development Co., 1916–1918	1,000,000
Hydro-Electric Co., 1915–1917	1,000,000

Practically all of the outstanding stock of these small companies was owned by the corporation and its subsidiaries.

TABLE 269.—*Bonds of The Nevada-California Electric Corporation and its principal predecessors and subsidiaries.*

Issue.	Callable or convertible.	Sinking-fund deposits.	Trustee.	Denomination.
1	2	3	4	5
1. The Nevada-California Electric Corporation first-lien 6 per cent bonds, series A, dated Jan. 1, 1916; due Jan. 1, 1946; interest payable Jan. 1 and July 1.	Until Jan. 1, 1921, at 105, and thereafter at 103 and interest.	Sinking-fund deposits; three-fourths of 1 per cent of all bonds of this issue outstanding on and after Feb. 1, 1921, semiannually, to be used in cancellation issue.	International Trust Co., Denver, Colo.	$100, $500, and $1,000 coupon; principal may be registered. Also $1,000, $5,000, and $10,000 registered.
2. The Nevada-California Electric Corporation 10-year convertible debenture 6 per cent bonds, dated Apr. 1, 1916; due Apr. 1, 1926; interest payable Apr. 1 and Oct. 1.	Before Apr. 1, 1919, at 105, and on or after that date at 102 and interest. Convertible on or before Apr. 1, 1919, into deferred stock at 150 par.		do.	$200 and $1,000 coupon.
3. The Nevada-California Electric Corporation 2-year 6 per cent notes, dated Jan. 1, 1918; due Jan. 1, 1920; interest payable Jan. 1 and July 1.	At 100 and interest on any interest date on 30 days' notice.		do	$500 and $1,000 coupon.
4. The Nevada-California Electric Corporation 2-year convertible 6 per cent notes dated Jan. 1, 1918; due Jan. 1, 1920; interest payable Jan. 1 and July 1.			do	
5. The Nevada-California Electric Corporation 1-year convertible 6 per cent notes, dated Jan. 1, 1920; due Jan. 1, 1921; interest payable Jan. 1 and July 1.			do	$1,000 coupon.
6. The Nevada-California Electric Corporation 10-year 8 per cent secured gold notes, dated Nov. 1, 1920; due Nov. 1, 1930; interest payable May 1 and Nov. 1.	At 103 on any interest date on 90 days' notice.	Secured by deposit of $1,125,000 par value series A and $1,125,000 par value series B first-lien bonds of The Nevada-California Electric Corporation; securities to be maintained at 115 per cent market value.	do	$500 and $1,000 coupon; principal may be registered.
7. The Nevada-California Power Co. first sinking-fund mortgage 6 per cent bonds, dated Apr. 1, 1907; due Apr. 1, 1927; interest payable Apr. 1 and Oct. 1.	After Apr. 1, 1912, at 105 and interest on 60 days' notice. Not convertible.	20 per cent of net earnings, for each preceding six months, within 30 days after Apr. 1 and Oct. 1, beginning with Apr. 1, 1910.	do	$1,000 coupon, principal may be registered.

8. The Nevada-California Power Co. first and refunding mortgage 6 per cent bonds, series A, dated Mar. 1, 1916; due Mar. 1, 1966; interest payable Jan. 1 and July 1.	At 103 and interest on any interest date.	Semiannually on and after Feb. 1, 1920, on Feb. 1 and Aug. 1, ¾ of 1 per cent of par value of bonds outstanding.	International Trust Co., Denver.	Optional with directors.
9. The Nevada-California Power Co. first and refunding mortgage 6 per cent bonds, series B, dated Oct. 1, 1920; due Mar. 1, 1966: interest payable Oct. 1 and Apr. 1.	....do....................................	....	....do...............	$500 and $1,000 coupon; principal may be registered.
10. The Nevada Power, Mining & Milling Co. first-mortgage 6 per cent bonds, dated Apr. 1, 1906; due Apr. 1, 1926; interest payable Apr. 1 and Oct. 1.	On or after Apr. 1, 1918, at 110 and interest. Not convertible.	25 per cent of net proceeds, beginning Apr. 1, 1911.	....do...............	$1,000.
11. The Southern Sierras Power Co. first sinking-fund mortgage 6 per cent bonds, dated Sept. 1, 1911; due Sept. 1, 1936; interest payable Jan. 1 and July 1.[a]	After July 1, 1916, at 105 and interest. Not convertible.	20 per cent of net earnings semiannually from Jan. 1, 1917.	....do...............	$100, $500, and $1,000 coupons; principal may be registered.
12. The Southern Sierras Power Co. first and refunding mortgage 6 per cent bonds, series A, dated Jan. 1, 1915, due Jan. 1, 1965; interest payable Jan. 1 and July 1.	At 103 and interest on any interest date.	Semiannually on and after Feb. 1, 1920, on Feb. 1 and Aug. 1, ¾ of 1 per cent of par value of bonds outstanding.	....do...............	Optional with directors.
13. The Southern Sierras Power Co. first and refunding mortgage 6 per cent bonds, series B, dated Dec. 1, 1920; due Jan. 1, 1965; interest payable Dec. 1 and June 1.	....do....................................	....	....do...............	Do.
14. Pacific Power Co. first-mortgage 6 per cent bonds, dated July 1, 1910; payable July 1, 1925.	On any interest date after July 1, 1912, at 103. Not convertible.	To pay trustee out of net earnings quarterly for year ending July 1, 1911, a percentage sufficient to retire $10,000 par value bonds and interest, but not to be less than 10 per cent thereof quarterly for year ending July 1, 1912, a percentage sufficient to retire annually $25,000 par value bonds, and interest, which percentage shall be not less than 15 per cent thereof; and also quarterly thereafter, computed from July 1, 1912, a percentage sufficient to retire annually at least $35,000 par value bonds, and interest, which percentage shall be not less than 20 per cent of said net earnings.	German American Trust Co., Denver, Colo.	$1,000 coupon.

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[a] The Southern Sierras Power Co. had also assumed $70,000 par value of bonds of Lytle Creek Power Co. outstanding against properties purchased in San Bernardino, and $2,000 in bonds of Coachella Valley Ice & Electric Co. during 1916, all of which were paid or refunded in 1917.

TABLE 269.—*Bonds of The Nevada-California Electric Corporation and its principal predecessors and subsidiaries*—Continued.

Issue.	Callable or convertible.	Sinking-fund deposits.	Trustee.	Denomination.
1	2	3	4	5
15. Pacific Power Corporation, 6 per cent bonds dated Apr. 1, 1915; due Apr. 1, 1945.	On any interest date at 103 on 60 days' notice. Coupon and registered bonds are exchangeable for each other; bonds not otherwise convertible.	Three-fourths of 1 per cent of outstanding bonds to be set aside out of net earnings semiannually in April and October, beginning 1918.	Anglo-California Trust Co., San Francisco, and German American Trust Co., Denver, Colo.	Series A, $1,000. Later series in such denomination as may be determined by corporation.
16. The Central California Electric Corporation, first-lien 6 per cent bonds, dated Apr. 1, 1915; due Apr. 1, 1945.	On any interest date at 103 on 60 days' notice; coupon and registered bonds are exchangeable for each other but not otherwise convertible.	1½ per cent of all bonds outstanding on or after Apr. 1, 1918 annually.	International Trust Co., Denver, Colo.	$500 and $1,000 coupon; principal may be registered.
17. Coachella Valley Ice & Electric Co. first-mortgage 6 per cent bonds dated Jan. 1, 1912; due serially; interest payable Jan. 1 and July 1.	Serially, $15,000 Jan. 1 each year on and after Jan. 1, 1937, at 105 and interest.	None.	Southern Trust Co., Los Angeles.	Coupon, $1,000 and $500.
18. Corona Gas & Electric Light Co. first-mortgage 6 per cent bonds dated Dec. 15, 1916; due July 1, 1965; interest payable Jan. 1 and July 1.	At 103 and interest on any interest date.	Semiannually on and after Aug. 1, 1920, on Feb. 1 and Aug. 1, ¾ of 1 per cent of par value of bonds outstanding.	Los Angeles Trust & Savings Bank, Los Angeles, or International Trust Co., Denver.	Coupon or registered; $1,000, $500, $100.
19. Bishop Light & Power Co. first-mortgage 6 per cent bonds dated Dec. 15, 1916; due July 1, 1965; interest payable Jan. 1. and July 1.	do.	do.	do.	Do.
20. Interstate Telegraph Co. first-mortgage 6 per cent bonds dated Mar. 1, 1912; due Mar. 1, 1937; interest payable payable Jan. 1 and July 1.	At 105 and interest on any interest date after Sept. 1, 1917.	20 per cent of net earnings semiannually on and after Sept. 1, 1917.	International Trust Co., Denver.	Coupon or registered; $1,000.
21. Hillside Water Co. first-mortgage 6 per cent bonds dated Jan. 1, 1915; due Jan. 1, 1965; interest payable Jan. 1 and July 1.				
22. Cain Irrigation Co. first-mortgage 6 per cent bonds dated Apr. 1, 1915; due Apr. 1, 1945; interest payable Apr. 1 and Oct. 1.				
23. The Imperial Ice & Development Co. first-mortgage 6 per cent bonds dated Oct. 1, 1916; due Oct. 1, 1966; interest payable Jan. 1 and July 1.				

Issue.	Authorized.	Year (Dec. 31).	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total issued.	Notes.
				Canceled.	Alive.				
1	6	7	8	9	10	11	12	13	14
1. The Nevada-California Electric Corporation, first-lien 6 per cent bonds, series A, dated Jan. 1, 1916; due Jan. 1, 1946; interest payable Jan. 1 and July 1.	$15,000,000	1916					$4,760,000	$4,760,000	
		1917				$742,000	5,155,400	6,899,400	$1,002,000 owned by corporation and subsidiaries.
		1918		$18,000		1,020,000	6,179,000	7,849,200	$632,200 owned by corporation and subsidiaries.
		1919	$3,728,000	151,300		2,706,000	8,123,800	11,272,000	$290,900 owned by corporation and subsidiaries.
		1920	4,058,000	204,200		1,923,200	8,593,000	10,942,000	$221,600 owned by corporation and subsidiaries.
2. The Nevada-California Electric Corporation, 10-year convertible debenture 6 per cent bonds, dated Apr. 1, 1916; due Apr. 1, 1926; interest payable Apr. 1 and Oct. 1.	1,500,000	1916		200			1,456,800	1,484,200	$31,400 owned by corporation and subsidiaries.
		1917		489,200			990,800	1,500,000	$20,000 owned by corporation and subsidiaries.
		1918		513,600			986,400	1,500,000	
		1919		1,000			336,800	1,500,000	$1,162,200 converted into preferred.
		1920		1,000			336,800	1,500,000	Do.
3. The Nevada-California Electric Corporation, 2-year 6 per cent notes, dated Jan. 1, 1918; due Jan. 1, 1920; interest payable Jan. 1 and July 1.	2,000,000	1918					1,097,000	1,097,000	$903,000 unissued.
		1919		410,000			687,000	1,097,000	Do.
4. The Nevada-California Electric Corporation 2-year convertible 6 per cent notes dated Jan. 1, 1918; due Jan. 1, 1920; interest payable Jan. 1 and July 1.	300,000	1918		3,800			290,200	294,000	
		1919		96,800			197,200	294,000	
5. The Nevada-California Electric Corporation 1-year convertible 6 per cent notes, dated Jan 1, 1920; due Jan. 1, 1921; interest payable Jan. 1 and July 1.	120,200	1920		37,000			83,200	120,200	
6. The Nevada-California Electric Corporation 10-year 8 per cent secured gold notes, dated Nov. 1, 1920; due Nov. 1, 1930; interest payable May 1 and Nov. 1.	1,500,000	1920					1,500,000	1,500,000	
7. The Nevada-California Power Co., first sinking-fund mortgage 6 per cent bonds, dated Apr. 1, 1907; due Apr. 1, 1927; interest payable Apr. 1 and Oct. 1.	3,000,000	1907					2,319,000	2,319,000	Bonds of this issue were not reserved to retire, but were actually exchanged for The Nevada Power Mining & Milling Co.'s first 6's of 1906.
		1908					2,912,000	2,912,000	
		1909					2,900,000	2,900,000	
		1910		64,000			2,836,000	2,900,000	
		1911		138,000			2,815,000	2,953,000	

TABLE 269.—*Bonds of The Nevada-California Electric Corporation and its principal predecessors and subsidiaries*—Continued.

Issue.	Authorized.	Year (Dec. 31).	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total issued.	Notes.
				Canceled.	Alive.				
1	6	7	8	9	10	11	12	13	14
7. The Nevada-California Power Co., first-sinking-fund mortgage 6 per cent bonds, dated Apr. 1, 1907; due Apr. 1, 1927; interest payable Apr. 1 and Oct. 1—Continued.	$3,000,000	1912		$225,000			$2,775,000	$3,000,000	
		1913		304,000			2,696,000	3,000,000	
		1914		367,000			2,633,000	3,000,000	
		1915		418,000			2,582,000	3,000,000	
		1916		515,000			2,121,000	3,000,000	$364,000 owned by corporation and subsidiaries.
		1917		575,000			2,023,000	3,000,000	$402,000 owned by corporation and subsidiaries.
		1918		625,000			1,889,000	3,000,000	$486,000 owned by corporation and subsidiaries.
		1919		690,000			1,783,000	3,000,000	$527,000 owned by corporation and subsidiaries.
		1920		793,000			1,621,000	3,000,000	$586,000 owned by corporation and subsidiaries.
8. The Nevada-California Power Co. first and refunding mortgage 6 per cent bonds, series A, dated Mar. 1, 1916; due Mar. 1, 1966; interest payable Jan. 1 and July 1.	6,000,000	1916						b2,244,000	
		1917						b2,577,000	
		1918						b2,577,000	
		1919						b3,310,000	
		1920						b3,727,000	
9. The Nevada-California Power Co. first and refunding mortgage 6 per cent bonds, series B, dated Oct. 1, 1920; due Mar. 1, 1966; interest payable Oct. 1 and Apr. 1.	5,000,000	1920						b 20,000	
10. The Nevada Power, Mining & Milling Co., first-mortgage 6 per cent bonds, dated Apr. 1, 1906; due Apr. 1, 1926; interest payable Apr. 1 and Oct. 1.	700,000	1906		None.			700,000	700,000	Exchanged for the preceding issue between Apr. 1, 1907, and Dec. 31, 1910.
11. The Southern Sierras Power Co., first sinking-fund mortgage 6 per cent bonds, dated Sept. 1, 1911; due Sept. 1, 1936; interest payable Jan. 1 and July 1. a	5,000,000	c1911					2,000,000	2,000,000	Guaranteed by The Nevada-California Power Co.
		1912					2,500,000	2,500,000	
		1913					2,500,000	2,500,000	
		1914					2,500,000	2,500,000	
		1915					2,650,000	2,650,000	
		1916					2,185,000	2,650,000	$465,000 owned by corporation and subsidiaries.
		1917		17,000			2,012,500	2,650,000	$620,500 owned by corporation and subsidiaries.
		1918		45,000			1,919,000	2,650,000	$686,000 owned by corporation and subsidiaries.
		1919		60,000			1,904,000	2,650,000	$686,000 owned by corporation and subsidiaries.
		1920		84,500			1,833,000	2,650,000	$732,500 owned by corporation and subsidiaries.

12. The Southern Sierras Power Co. first and refunding mortgage 6 per cent bonds, series A, dated Jan. 1, 1915; due Jan. 1, 1965; interest payable Jan. 1 and July 1.	5,000,000	1915							
		1916						[b] 48,000	
		1917						[b]1,035,000	
		1918						[b]1,035,000	
		1919						[b]1,747,000	
		1920		24,000				2,434,000	$2,410,000 owned by corporation and subsidiaries.
13. The Southern Sierras Power Co. first and refunding mortgage 6 per cent bonds, series B, dated Dec. 1, 1920; due Jan. 1, 1965; interest payable Dec. 1 and June 1.	5,000,000	1920						[b] 803,000	
14. Pacific Power Co. first-mortgage 6 per cent bonds, dated July 1, 1910; payable July 1, 1925.	1,000,000	1910					800,000	800,000	
		1911					800,000	800,000	
		1912					800,000	800,000	
		1913					800,000	800,000	
		1914					800,000	800,000	Foreclosed, 1915.
15. Pacific Power Corporation 6 per cent bonds, dated Apr. 1, 1915; due Apr. 1, 1945.	7,500,000	1915					800,000	800,000	
		1916						[b]935,000	
		1917						[b] 935,000	
		1918		14,000				935,000	$921,000 owned by corporation and subsidiaries.
		1919		28,000				935,000	$907,000 owned by corporation and subsidiaries.
		1920		41,000				935,000	$894,000 owned by corporation and subsidiaries.
16. The Central California Electric Corporation first-lien 6 per cent bonds, dated Apr. 1, 1915; due Apr. 1, 1945.	3,000,000	1915					600,000	600,000	
		1916					600,000	600,000	
17. Coachella Valley Ice & Electric Co. first-mortgage 6 per cent bonds dated Jan. 1, 1912; due serially; interest payable Jan. 1 and July 1.	300,000	1912–1920						[b]300,000	Bonds guaranteed principal and interest by Holton Power Co.
18. Corona Gas & Electric Light Co. first-mortgage 6 per cent bonds dated July 1, 1915; due July 1, 1965; interest payable Jan. 1 and July 1.	1,000,000	1917–1918						[b] 58,500	
19. Bishop Light & Power Co. first-mortgage 6 per cent bonds dated July 1, 1915; due July 1, 1965; interest payable Jan. 1 and July 1.	1,000,000	1917–1918						[b] 4,500	
20. Interstate Telegraph Co. first-mortgage 6 per cent bonds dated Mar. 1, 1912; due Mar. 1, 1937; interest payable Mar. 1 and Sept. 1.	500,000	1912–1917						[b] 250,000	
		1918		3,000				[d] 250,000	
		1919		4,000				[d] 250,000	
		1920		6,000				[d] 250,000	

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[a] See note *a*, p. 1119.
[b] All owned by corporation and subsidiaries.
[c] Dec. 1.
[d] All outstanding owned by corporation and subsidiaries.

TABLE 269.—*Bonds of The Nevada-California Electric Corporation and its principal predecessors and subsidiaries*—Continued.

Issue.	Authorized.	Year (Dec. 31).	Reserved for prior liens.	In sinking funds.		In treasury.	Held by public.	Total issued.	Notes.
				Canceled.	Alive.				
1	6	7	8	9	10	11	12	13	14
21. Hillside Water Co. first-mortgage 6 per cent bonds dated Jan. 1, 1915; due Jan. 1, 1965; interest payable Jan. 1 and July 1.	$1,000,000	1915–1919						b $500,000	
		1920		$7,000				d 500,000	
22. Cain Irrigation Co. first-mortgage 6 per cent bonds dated Apr. 1, 1915; due Apr. 1, 1945; interest payable Apr. 1 and Oct. 1.	2,000,000	1915–1920						b 1,650,000	
23. The Imperial Ice & Development Co. first-mortgage 6 per cent bonds dated Oct. 1, 1916; due Oct. 1, 1966; interest payable Jan. 1 and July 1.	1,000,000	1916–1918						b 140,000	
		1919						b 348,000	
		1920						b 439,000	

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b All owned by corporation and subsidiaries.
d All outstanding owned by corporation and subsidiaries.

TABLE 270.—*Condensed comparative consolidated balance sheet of The Nevada-California Electric Corporation and subsidiary companies, 1916–1920.*

[Intercompany securities and debts eliminated.]

	1916	1917	1918
ASSETS.			
Permanent property, equipment, and other items	$24,236,491.60	$25,053,341.97	$24,272,997.56
Reduction due to revaluation of Pacific Power Corporation property	909,099.74	909,099.74	....
Permanent property, net	23,327,391.86	24,144,242.23	24,272,997.56
Investments	267,039.45	265,901.05	273,094.25
Special deposits and sinking funds	26,419.06	1,742.10	1,838.05
Inventories	234,617.16	310,810.64	376,511.17
Current assets	621,250.64	433,789.17	415,249.87
Due from employees on stock subscriptions	94,001.27	53,015.96	13,545.03
Due from employees on subscriptions United States Liberty bonds	....	....	19,327.80
Due from controlled companies	144,090.96	298,957.93	497,095.71
Prepaid insurance	61,606.18	73,361.09	82,444.80
Premiums paid on securities purchased and unamortized discounts and expenses	3,182,102.70	3,514,423.87	4,545,954.45
Total assets	27,958,519.28	29,096,244.04	30,498,058.69
LIABILITIES.			
Capital stock:			
The Nevada-California Electric Corporation	13,836,800.00	14,576,200.00	14,564,900.00
Subsidiary companies not held by The Nevada-California Electric Corporation	21,505.30	10,881.00	4,656.00
Total stock in hands of public	13,858,305.30	14,587,081.00	14,569,556.00
Bonded and debenture debt:			
First-lien bonds of The Nevada-California Electric Corporation	4,760,000.00	5,155,400.00	6,179,000.00
First-lien bonds of The Central California Electric Corporation	23,000.00	....	....
Second-lien bonds of The Central California Electric Corporation	11,569.55	....	....
First-mortgage bonds of The Nevada-California Power Co.	2,121,000.00	2,023,000.00	1,889,000.00
First-mortgage bonds of The Southern Sierras Power Co.	2,184,500.00	2,012,500.00	1,919,000.00
First-mortgage bonds of Coachella Valley Ice & Electric Co.	2,000.00	....	....
First-mortgage bonds of Imperial Ice & Development Co.	10,000.00	....	....
Convertible debentures of The Nevada-California Electric Corporation	1,456,800.00	990,800.00	986,400.00
Two-year secured notes of The Nevada-California Electric Corporation	....	....	1,097,000.00
Two-year convertible notes of The Nevada-California Electric Corporation	....	....	290,200.00
Total bonds, debentures, and two-year notes in hands of public	10,568,869.55	10,181,700.00	12,360,600.00
Current liabilities	606,466.42	1,395,668.42	646,504.24
Suspended credit items	....	166.68	1,560.17
Reserve for depreciation	592,248.73	469,344.22	544,179.97
Reserves for fire losses, etc	46,185.38	53,706.74	54,620.08
Surplus	2,282,205.85	2,405,771.13	2,314,321.38
Discounts in bond redemptions	4,238.05	2,805.85	6,716.85
Total liabilities	27,958,519.28	29,096,244.04	30,498,058.69

TABLE 270.—*Condensed comparative consolidated balance sheet of The Nevada-California Electric Corporation and subsidiary companies, 1916–1920*—Continued.

	1919	1920
ASSETS.		
Permanent property, equipment, and other items	$25,335,182.88	$27,119,551.00
Reduction due to revaluation of Pacific Power Corporation property		
Permanent property, net	25,335,182.88	27,119,551.00
Investments	330,460.69	292,358.45
Special deposits and sinking funds	946.26	1,353.52
Inventories	390,511.00	
Current assets	1,206,049.83	1,811,658.87
Due from employees on stock subscriptions	1,134.63	
Due from employees on subscriptions United States Liberty bonds	1,763.60	
Due from controlled companies	635,531.76	783,852.03
Prepaid insurance	53,554.07	57,324.81
Premiums paid on securities purchased and unamortized discounts and expenses	4,963,698.36	4,953,501.32
Total assets	32,918,833.08	35,019,600.00
LIABILITIES.		
Capital stock:		
The Nevada-California Electric Corporation	15,497,500.00	15,515,600.00
Subsidiary companies not held by the Nevada-California Electric Corporation	4,656.00	4,956.00
Total stock in hands of public	15,502,156.00	15,520,556.00
Bonded and debenture debt:		
First-lien bonds of The Nevada-California Electric Corporation	8,123,800.00	8,593,000.00
First-mortgage bonds of The Nevada-California Power Co.	1,783,000.00	1,621,000.00
First-mortgage bonds of The Southern Sierras Power Co.	1,904,000.00	1,833,000.00
Convertible debentures of The Nevada-California Electric Corporation	336,800.00	336,800.00
Ten-year secured notes of The Nevada-California Electric Corporation		1,500,000.00
Two-year secured notes of The Nevada-California Electric Corporation	687,000.00	
Two-year convertible notes of The Nevada-California Electric Corporation	197,200.00	
One-year convertible notes of The Nevada-California Electric Corporation		83,200.00
Total bonds, debentures, and notes in hands of public	13,031,800.00	13,967,000.00
Current liabilities	834,617.85	1,044,749.76
Payments by employees on stock subscription No. 3		14,327.34
Suspended credit items	1,454.93	48,579.29
Reserve for depreciation	743,291.50	930,893.02
Reserve for fire losses, etc	62,091.10	110,238.41
Surplus	2,736,924.40	3,383,256.18
Discounts in bond redemptions	6,497.30	
Total liabilities	32,918,833.08	35,019,600.00

NOTE.—The Nevada-California Electric Corporation began operations July 1, 1915, but balance sheet for 1915 does not eliminate intercompany accounts and is therefore omitted.

TABLE 271.—*Earnings and expenses of The Nevada-California Electric Corporation, 1916–1920.*

[Intercompany transactions eliminated.]

Classification.	Dec. 31, 1916.[a]	Dec. 31, 1917.[b]	Dec. 31, 1918.
Gross operating earnings:			
Lighting	$227,457.32	$231,116.66	$213,077.96
Power	1,232,125.27	1,461,871.32	1,591,012.34
Exchange and toll service	37,547.07	44,652.27	46,591.79
Ranch and live-stock operations	6,973.36	22,375.67	31,709.04
Ice, cold storage, and water	11,934.54	216,431.25	255,179.95
Miscellaneous	2,923.53	1,173.95	771.50
Profit on electric merchandise and jobbing	7,935.82	7,529.32	9,006.89
Total gross operating earnings	1,526,896.91	1,985,150.44	2,147,349.47

[a] The corporation has an interest in profits of other operating companies not included in above earnings. In 1916 its interest in the profits amounted to $12,372. This year was the first full year of operation for The Nevada-California Electric Corporation.

[b] The corporation has an interest in profits of other operating companies not included in above statement. In 1917 and 1918 the operations resulted in a loss and a consequent reduction in the combined surplus of those companies. The corporation's proportion of this loss in 1917 amounted to $2,414.65, and in 1918 it amounted to $27,526.71.

TABLE 271.—*Earnings and expenses of The Nevada-California Electric Corporation, 1916-1920*—Continued.

Classification.	Dec. 31, 1916.	Dec. 31, 1917.	Dec. 31, 1918.
Operating and general expenses and taxes:			
Production	$74,566.04	$129,260.73	$180,153.48
Electric energy purchased	4,467.30	25,811.45	5,215.60
Transmission	71,066.13	110,328.36	101,841.12
Distribution	70,819.02	69,536.17	80,228.64
Maintenance of Interstate Telegraph Co. lines	12,048.71	11,227.55	10,968.21
Operating expenses of ice company and other nonutilities	26,199.00	198,351.62	232,613.61
Commercial	64,514.06	69,865.12	70,354.54
Traffic (Interstate Telegraph Co. only)	7,630.42	8,491.70	10,895.92
General expenses and miscellaneous	157,586.38	139,628.79	158,337.24
Insurance	20,338.21	25,919.00	30,014.53
Extraordinary repairs	9,388.36		
Taxes	88,244.36	128,594.42	130,418.80
Total operating and general expenses and taxes	606,867.99	912,014.91	1,011,041.69
Operating profits	920,028.92	1,073,135.53	1,136,307.78
Uncollectible accounts	2,907.60	2,704.39	16,168.09
Net operating profits	917,121.32	1,070,431.14	1,120,139.69
Add nonoperating earnings (net):			
Nonoperating earnings—			
Rent	1,671.42	3,232.15	1,382.70
Income from bonds and war savings stamps	6,000.00	6,000.00	6,202.20
Crescent Garage operations	5,732.92	1,327.34	1,896.95
Miscellaneous		2,259.56	1,876.49
Ice and water profits (Coachella Co.)	10,473.84		
Total nonoperating earnings	23,878.18	12,819.05	11,357.34
Less nonoperating expenses:			
Rent	2,961.62	5,158.39	8,467.73
Uncollectible nonoperating accounts			514.80
Taxes			247.12
Miscellaneous			13.00
Total nonoperating earnings (net)	20,916.56	7,660.66	2,114.69
Total income	938,037.88	1,078,091.80	1,122,254.38
Deduct interest:			
On first-mortgage bonds	322,051.63	248,530.96	234,182.66
On first and second lien bonds	126,251.25	298,918.63	332,514.01
On 10-year convertible debentures	33,995.66	68,758.17	59,382.00
On 2-year secured notes			55,545.44
On 2-year convertible notes			13,696.03
On The Nevada-California Power Co. dividend scrip	18,833.03	5,576.14	227.30
On notes and accounts, etc	27,449.02	21,023.70	20,908.04
	528,580.59	642,807.60	716,455.48
Less interest credits:			
On notes and accounts, etc	64,994.87	34,496.49	41,493.58
Interest during construction charged to property		58,535.66	39,351.10
Net interest deductions	463,585.72	549,775.45	635,610.80
Balance before providing for depreciation	474,452.16	528,316.35	486,643.58
Deduct depreciation	95,370.12	110,546.72	118,553.18
Net earnings	379,082.04	417,769.63	368,090.40
Discount on securities sold, charged off (Dr.)	9,407.51		
Adjustments to profit and loss (net Cr.)	4,950.72		
Miscellaneous additions to surplus:			
Gains in realization of assets			5,611.63
Other miscellaneous additions		39,143.81	3,910.79
		456,913.44	377,612.82

TABLE 271.—*Earnings and expenses of The Nevada-California Electric Corporation 1916-1920*—Continued.

Classification.	Dec. 31, 1916.	Dec. 31, 1917.	Dec. 31, 1918.
Miscellaneous deductions from surplus:			
Amortization of organization expenses	....	....	$8,742.46
Amortization of discounts on securities sold	....	$17,334.21	50,198.79
Amortization of expenses on securities sold	....	2,568.12	12,234.85
Other miscellaneous deductions	....	3,535.62	1,789.79
Items applicable to prior accounting periods:			
Debit adjustments to profit and loss	....	19,489.10	3,687.80
Credit adjustments to profit and loss	....	5,584.83	4,774.47
Surplus earned	$364,723.81	419,571.22	305,733.60
Surplus appropriated for bond redemptions	71,203.77	83,354.35	91,843.31
Available surplus for the year	293,520.04	336,216.87	213,890.29
Surplus at beginning of year (not including amount appropriated for bond redemptions)	1,758,326.28	1,785,996.82	1,826,207.75
Surplus appropriated for bond redemptions to Dec. 31	496,209.03	579,563.38	671,406.69
Deficit of Central California & Pacific Power corporations at time of amalgamating the properties and securities of those companies in 1917 into The Nevada-California Electric Corporation and The Nevada-California Power Co., inserted for reconciling purposes	....	56,000.31	....
Deficit of Hydro-Electric Co. at time of dissolution in 1918 inserted for reconciling purposes	....	....	158.34
Surplus of Corona Gas & Electric Light Co., Bishop Light & Power Co., Coachella Valley Ice & Electric Co., and Rialto Light, Power & Water Co., at time of amalgamating the properties and securities of those companies in 1918 into The Southern Sierras Power Co., inserted for reconciling purposes	....	....	79,070.69
	2,548,055.35	2,757,777.38	2,632,592.38
Deduct dividends declared	265,849.50	352,006.25	318,271.00
Total surplus, Dec. 31 (as shown on balance sheet)	2,282,205.85	2,405,771.13	2,314,321.38

Classification.	1919	1920
Gross operating earnings:		
Lighting	$244,736.74	$296,893.67
Power	1,811,311.46	2,076,046.00
Exchange and toll service	48,853.66	70,810.35
Ranch and live-stock operations	35,217.21	34,694.72
Ice, cold storage, and water	417,864.36	573,308.84
Miscellaneous	2,797.40	19,201.37
Profit on electric merchandise and jobbing	9,835.49	7,562.11
Total gross operating earnings	2,570,616.32	3,074,517.06
Operating and general expenses and taxes:		
Production	203,573.22	216,149.69
Electric energy purchased	....	442.27
Transmission	88,876.33	92,071.13
Distribution	76,793.90	89,648.59
Maintenance of Interstate Telegraph Co. lines	11,148.91	14,987.96
Operating expenses of ice company and other nonutilities	317,444.48	456,065.17
Commercial	76,026.32	82,638.29
Traffic (Interstate Telegraph Co. only)	12,563.76	15,605.06
General expenses and miscellaneous	195,048.60	213,963.61
Insurance	30,510.54	40,040.53
Extraordinary repairs	....	....
Taxes	155,323.44	210,568.67
Total operating and general expenses and taxes	1,167,309.50	1,432,180.97
Operating profits	1,403,306.82	1,642,336.09
Uncollectible accounts	1,442.35	3,409.85
Net operating profits	1,401,864.47	1,638,926.24

Table 271.—*Earnings and expenses of The Nevada-California Electric Corporation, 1916–1920*—Continued.

Classification.	1919	1920
Add nonoperating earnings (net):		
Rent	$1,844.90	$2,147.55
Income from bonds and war savings stamps	9,121.60	
Crescent Garage operations	271.10	1,557.36
Miscellaneous	2,327.43	1,908.94
Total nonoperating earnings	13,565.03	5,613.85
Less nonoperating expenses:		
Rent	9,445.86	13,413.42
Uncollectible nonoperating accounts	8.27	254.20
Taxes	213.83	284.59
Total nonoperating earnings (net)	3,897.07	[c] 8,338.36
Total income	1,405,761.54	1,630,587.88
Deduct interest:		
On first-mortgage bonds	225,428.81	218,602.72
On first and second lien bonds	415,994.86	514,281.91
On 10-year convertible debentures	29,952.00	20,208.00
On 10-year secured notes		6,843.11
On 2-year secured notes	54,777.64	
On 2-year convertible notes	14,610.00	
On 1-year convertible notes		8,306.27
On notes and accounts, etc	11,312.73	32,597.45
	752,076.04	800,839.46
Less interest credits:		
On notes and accounts, etc	47,812.47	75,471.46
Interest during construction charged to property	18,616.81	
Income from bonds owned		9,000.00
Net interest deductions	685,646.76	716,368.00
Balance before providing for depreciation	720,114.78	914,219.88
Deduct depreciation	204,301.34	222,435.35
Net earnings	515,813.44	691,784.53
Miscellaneous additions to surplus:		
Interest during construction charged to property		24,227.00
Gains in realization of assets	6,300.00	
Discount on bonds redeemed		2,691.10
Other miscellaneous additions	86.09	20,764.60
	522,199.53	739,467.29
Miscellaneous deductions from surplus:		
Amortization of organization expenses	8,746.80	8,746.80
Amortization of discounts on securities sold	67,080.42	47,753.08
Amortization of expenses on securities sold	9,747.62	6,459.86
Amortization of premiums on securities acquired		5,409.72
Loss in realization of assets	1,576.47	
Fire losses		31,905.41
Other miscellaneous deductions	1,003.48	559.43
Items applicable to prior accounting periods:		
Debit adjustments to profit and loss	3,468.75	13,405.72
Credit adjustments to profit and loss	17,054.04	21,625.01
Surplus earned	447,630.03	646,852.28
Surplus appropriated for bond redemptions	109,364.95	209,717.56
Available surplus for the year	338,265.08	437,134.72
Surplus at beginning of year (not including amount appropriated for bond redemption)	[d] 1,642,914.69	2,946,641.96
Surplus appropriated for bond redemptions to Dec. 31	780,771.64	
	2,761,951.41	3,383,776.68
Expenditures reinvestigating proposed property acquisitions	24,918.51	
Deduct dividends declared	108.50	520.50
Total surplus, Dec. 31 (as shown on balance sheet)	2,736,924.40	3,383,256.18

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[c] Deficit.

[d] Surplus at beginning of year plus appropriations during current year for bond redemption.

TABLE 272.—*Comparative balance sheet of The Nevada-California Power Co. and The Southern Sierras Power Co., 1907–1920.*

	1907	1908	1909	1910
	The Nevada-California Power Co.	The Nevada-California Power Co.	The Nevada-California Power Co.	The Nevada-California Power Co.
ASSETS.				
Fixed capital	[a]$7,194,198	[a]$7,938,637	$8,231,319	$8,340,776
Cash	28,552	45,208	38,342	69,123
Notes receivable	43,099	...	...	108,855
Accounts receivable:				
Accounts with system corporation	...	7,512	33,816	41,932
Due from consumers and agents	47,615	67,807	63,577	73,383
Miscellaneous	32,270	3,599	2,535	6,157
	79,885	78,918	99,928	121,472
Investments:				
Securities of other corporations	...	35,922	136,845	187,683
Advances to system corporations for construction, equipment, and betterments	...	...	...	...
Miscellaneous	6,310	...	8,443	...
	6,310	35,922	145,288	187,683
Materials and supplies	125,207	112,562	90,523	84,879
Sinking funds	...	...	11,544	228
Treasury securities	308,000	337,000	100,000	...
Other suspense	...	...	...	...
Total assets	7,785,251	8,548,246	8,716,944	8,913,016
LIABILITIES.				
Capital stock	5,000,000	[b]5,000,000	[b]5,000,000	[b]5,000,000
Funded debt	2,319,000	2,912,000	3,000,000	2,936,000
Surplus invested in construction	...	408,792	472,653	603,181
Advances from system corporations for construction, equipment, betterments, etc	...	...	...	...
Notes payable	...	...	...	...
Accounts payable:				
Audited vouchers and wages unpaid	122,717	51,449	28,911	15,497
Consumers' deposits	23,601	28,769	49,738	38,726
Miscellaneous	10,000	...	...	...
	156,318	80,218	78,649	54,223
Interest accrued	30,165	38,625	43,500	42,540
Taxes accrued	4,090	2,098	8,626	16,828
Reserve for accrued depreciation	...	12,786	34	17,380
Insurance reserve	2,325	6,516	9,074	12,535
Reserve for purchase and cancellation of bonds	...	...	13,490	85,093
Dividend scrip certificates outstanding	...	...	...	...
Outstanding coupons on bonds	...	...	...	...
Reserve for injury and damages	4,817	6,896	5,235	9,710
Reserve for supply expense and emergency	...	...	7,511	10,742
Discount and premium on bonds redeemed	...	...	...	...
Corporate surplus unappropriated	268,537	80,315	78,172	124,784
Total liabilities	7,785,251	8,548,246	8,716,945	8,913,016

[a] Divided as follows: Cost of plant, $2,284,821; franchises, water rights, and real estate, $4,909,377.

[b] Not all in hands of public, the following amounts being in treasury: 1907, $861,300; 1908, $511,500; 1909, $433,500; 1910, $433,500.

Table 272.—*Comparative balance sheet of The Nevada-California Power Co. and The Southern Sierras Power Co., 1907–1920*—Continued.

	1911	1912		
	The Nevada-California Power Co.	The Nevada-California Power Co.	The Southern Sierras Power Co.	Total.
ASSETS.				
Fixed capital	$8,446,211	$8,160,589	$8,652,792	$16,813,381
Cash and deposits:				
Cash	313,492	46,508	32,034	78,542
Special deposits		262,242		262,242
	313,492	308,750	32,034	340,784
Notes receivable			28,392	28,392
Accounts receivable:				
Accounts with system corporation		1,013,960		1,013,960
Due from consumers and agents		119,376		119,376
Miscellaneous			17,193	17,193
	302,160	1,133,336	45,585	1,150,529
Investments:				
Securities of other corporations	198,694	266,142	100,000	366,142
Advances to system corporations for construction, equipment and betterments				
Miscellaneous				
	198,694	266,142	100,000	366,142
Materials and supplies	79,272	63,462	[c] 2,350	61,112
Sinking funds	479	813		813
Treasury securities				
Other suspense	3,396	3,650		3,650
Total assets	9,343,704	9,936,742	8,828,061	18,764,803
LIABILITIES.				
Capital stock	[d] 5,000,000	[d] 5,000,000	5,000,000	10,000,000
Funded debt	2,815,000	2,775,000	2,570,000	5,345,000
Surplus invested in construction				
Advances from system corporations for construction, equipment, betterments, etc.		118,309		118,309
Notes payable	104,915	130,000	139,570	269,570
Accounts payable:				
Audited vouchers and wages unpaid	20,721	24,748	17,194	41,942
Consumers' deposits	29,522	36,640		36,640
Miscellaneous		3,692	1,076,709	1,080,401
	50,243	65,080	1,093,903	1,158,983
Interest accrued	42,418	42,579	3,987	46,566
Taxes accrued	29,688	15,449	594	16,043
Reserve for accrued depreciation	67,299	152,745		152,745
Insurance reserve	16,454	17,990	58	18,048
Reserve for purchase and cancellation of bonds	155,496	237,253		237,253
Dividend scrip certificates outstanding	93,461	280,383		280,383
Outstanding coupons on bonds				
Reserve for injury and damages	14,232	16,539		16,539
Reserve for supply expense and emergency	13,658			
Discount and premium on bonds redeemed	6,995	7,203		7,203
Corporate surplus unappropriated	933,844	1,078,212	19,949	1,098,161
Total liabilities	9,343,704	9,936,742	8,828,061	18,764,803

[c] Credit item.

[d] Not all in hands of public, $433,500 being in treasury.

TABLE 272.—*Comparative balance sheet of The Nevada-California Power Co. and The Southern Sierras Power Co., 1907–1920*—Continued.

	1913			1914		
	The Nevada-California Power Co.	The Southern Sierras Power Co.	Total.	The Nevada-California Power Co.	The Southern Sierras Power Co.	Total.
ASSETS.						
Fixed capital	$8,529,925	$9,003,437	$17,533,662	$8,250,554	$9,437,197	$17,687,751
Cash and deposits:						
Cash	34,516	12,476	46,992	42,667	23,620	66,287
Special deposits	2,100	75,575	77,675	4,020	[e] 75,735	79,755
	36,616	88,051	124,667	46,687	99,355	146,042
Notes receivable	....	43,203	43,203	5,099	33,409	38,508
Accounts receivable:						
Accounts with system corporations	947,425	7,746	955,171	1,449,041	5,513	1,454,554
Due from consumers and agents	97,470	42,750	140,220	92,221	89,293	181,514
Miscellaneous accounts receivable	11,663	13,259	24,922	5,380	30,851	36,231
	1,056,558	63,755	1,120,313	1,546,642	125,657	1,672,299
Interest and dividends receivable	920	807	1,727	2,247	1,934	4,181
Investments:						
Securities of other corporations	318,051	100,000	418,051	318,508	100,000	418,508
Advances to system corporations for construction, equipment, and betterments	500,000	....	500,000	500,000	....	500,000
Miscellaneous	8,062	....	8,062	8,063	....	8,063
	826,113	100,000	926,113	826,571	100,000	926,571
Materials and supplies	51,900	72,444	124,344	9,404	63,062	72,466
Sinking funds	16	....	16	553	....	553
Prepaid expenses:						
Prepaid insurance	710	508	1,218	582	835	1,417
Other prepayments	....	....	....	149	129	278
	710	508	1,218	731	964	1,695
Other suspense	64	82	146	1,688	....	1,688
Construction work in progress	9,334	241,422	250,756	25,580	272,694	298,274
Corporate deficit	....	41,968	41,968	....	....	....
Total assets	10,512,156	9,655,677	20,167,833	10,715,756	10,134,272	20,850,028
LIABILITIES.						
Capital stock	5,000,000	5,000,000	10,000,000	5,000,000	5,000,000	10,000,000
Funded debt	2,696,000	2,570,000	5,266,000	2,633,000	2,570,000	5,203,000
Advances from system corporations for construction, equipment, betterments, etc	....	....	....	....	500,000	500,000
Notes payable	....	137,284	137,284	47,868	133,582	181,450
Accounts payable:						
System corporations	116,297	1,808,167	1,924,464	935	1,748,254	1,749,189
Audited vouchers and wages unpaid	31,367	53,044	84,411	22,170	35,598	57,768
Consumers' deposits	31,641	4,954	36,595	31,506	18,379	49,885
Miscellaneous	218	4,721	4,939	369	1,916	2,285
	179,523	1,870,886	2,050,409	54,980	1,804,147	1,859,127
Interest accrued	52,063	1,932	53,995	54,084	2,317	56,401
Taxes accrued	13,079	....	13,079	5,647	3,486	9,133
Reserve for accrued depreciation	299,849	....	299,849	412,095	....	412,095
Casualty and insurance reserve	33,739	....	33,739	42,821	....	42,821
Reserve for purchase and cancellation of bonds	312,310	....	312,310	375,690	....	375,690
Dividend scrip certificates outstanding	464,900	....	464,900	573,570	....	573,570
Outstanding coupons on bonds	2,100	75,575	77,675	3,420	75,735	79,155
Discount and premiums on bonds redeemed	7,330	....	7,330	7,797	....	7,797
Reserve for injuries and damages	....	....	....	....	4,922	4,922
Reserve for supply expense and emergency	....	....	....	....	1,674	1,674
Corporate surplus unappropriated	1,451,263	....	1,451,263	1,504,784	38,409	1,543,193
Total liabilities	10,512,156	9,655,677	20,167,833	10,715,756	10,134,272	20,850,028

[e] To pay outstanding coupons.

TABLE 272.—*Comparative balance sheet of The Nevada-California Power Co. and The Southern Sierras Power Co., 1907–1920*—Continued.

	1915			1916		
	The Nevada-California Power Co.	The Southern Sierras Power Co.	Total.	The Nevada-California Power Co.	The Southern Sierras Power Co.	Total.
ASSETS.						
Fixed capital	$8,253,890	$4,281,040	$12,534,930	$8,268,385	$4,408,821	$12,677,206
Cash and deposits:						
Cash	105,296	22,970	128,266	193,571	34,889	228,460
Special deposits	2,770	1,110	3,880	2,060	80,705	82,765
	108,066	24,080	132,146	195,631	115,594	311,225
Notes receivable	25,099	59,108	84,207	6,100	70,548	76,648
Accounts receivable:						
Accounts with system corporations	1,474,537	3,050	1,477,587	1,254,242	60,153	1,314,395
Due from consumers and agents	89,026	96,217	185,243	67,928	55,242	123,170
Miscellaneous accounts receivable	1,142	39,832	40,974	2,313,099	49,923	2,363,022
	1,564,705	139,099	1,703,804	3,635,269	165,318	3,800,587
Interest and dividends receivable	3,487	1,876	5,363	859	2,192	3,051
Investments:						
Securities of other corporations	292,259	87,015	379,274	102,010	....	102,010
Advances to system corporations for construction, equipment, and betterments	500,000	....	500,000	500,000	....	500,000
Miscellaneous	8,062	....	8,062	8,062	....	8,062
	800,321	87,015	887,336	610,072	....	610,072
Materials and supplies	8,441	71,726	80,167	6,251	116,070	122,321
Sinking funds	40	....	40	454	....	454
Prepaid expenses:						
Prepaid taxes	1,826	....	1,826	1,348	149	1,497
Prepaid insurance	547	154	701	521	1,153	1,674
Other prepayments	....	1,063	1,063	....	....	....
	2,373	1,217	3,590	1,869	1,302	3,171
Unamortized discount on securities and expenses:						
Stocks	....	4,995,350	4,995,350	....	4,995,350	4,995,350
Bonds	....	256,914	256,914	246,995	357,210	604,205
	....	5,252,264	5,252,264	246,995	5,352,560	5,599,555
Other suspense	....	17,418	17,418	....	13,155	13,155
Construction work in progress	67,616	189,207	256,823	22,191	226,693	248,884
Total assets	10,834,038	10,124,050	20,958,088	[f] 12,994,076	10,472,253	23,466,329
LIABILITIES.						
Capital stock	5,000,000	5,000,000	10,000,000	5,000,000	5,000,000	10,000,000
Funded debt	2,582,000	2,720,000	5,302,000	4,927,000	3,668,000	8,595,000
Advances from system corporations for construction, equipment, betterments, etc	....	500,000	500,000	....	500,000	500,000
Notes payable	....	103,960	103,960	....	2,600	2,600

[f] Total assets reported by company included in addition "Contingent equity in The Southern Sierras Power Co.'s assets, $3,598,000."

TABLE 272.—*Comparative balance sheet of The Nevada-California Power Co. and The Southern Sierras Power Co., 1907–1920*—Continued.

	1915			1916		
	The Nevada-California Power Co.	The Southern Sierras Power Co.	Total.	The Nevada-California Power Co.	The Southern Sierras Power Co.	Total.
LIABILITIES—continued.						
Accounts payable:						
System corporations	$4,552	$994,858	$999,410	$44,622	$796,861	$841,483
Audited vouchers and wages unpaid	8,919	26,105	35,024	8,947	32,578	41,525
Consumer's deposits	30,197	20,201	50,398	24,245	18,870	43,115
Miscellaneous	134,265	368,550	502,815	224	14,901	15,125
	177,933	1,409,714	1,587,647	78,038	863,210	941,248
Interest accrued	52,466	82,722	135,188	118,037	1,194	119,231
Taxes accrued	7,125	11,647	18,772	12,818	15,034	27,852
Dividends declared				50,000	12,500	62,500
Service billed in advance						
Reserve for accrued depreciation	481,213		481,213	539,995		539,995
Casualty and insurance reserve	47,285		47,285	38,644		38,644
Reserve for purchase and cancellation of bonds	425,005		425,005	486,761	9,807	496,568
Dividend scrip certificates outstanding	549,424		549,424	187,918		187,918
Outstanding coupons on bonds	1,770	1,110	2,880	1,560	109,145	110,705
Discount and premiums on bonds redeemed	7,771		7,771	4,238		4,238
Reserve for injuries and damages		949	949		8,242	8,242
Reserve for supply expense and emergency		1,206	1,206			
Corporate surplus unappropriated	1,502,046	292,742	1,794,788	1,549,067	282,521	1,831,588
Total liabilities	10,834,038	10,124,050	20,958,088	[g]12,994,076	10,472,253	23,466,329

	1917			1918		
	The Nevada-California Power Co.	The Southern Sierras Power Co.	Total.	The Nevada-California Power Co.	The Southern Sierras Power Co.	Total.
ASSETS.						
Fixed capital	$9,123,711.66	$4,667,600.79	$13,791,312.45	$9,900,247.12	$5,938,729.25	$15,838,976.37
Cash and deposits:						
Cash	81,158.20	16,068.61	97,226.81	39,833.01	48,801.75	88,634.76
Special deposits	4,508.96	495.00	5,003.96	1,966.48	79,575.00	81,541.48
	85,667.16	16,563.61	102,230.77	41,799.49	128,376.75	170,176.24
Notes receivable	6,958.69	24,357.13	31,315.82	9,858.34	11,940.11	21,798.45
Accounts receivable:						
Accounts with system corporations	3,448,993.28	232,420.52	3,681,413.80	3,149,192.69	175,621.44	3,324,814.13
Due from consumers and agents	77,254.93	50,792.41	128,047.34	57,741.25	89,083.64	146,824.89
Miscellaneous accounts receivable	11,479.61	103,911.21	115,390.82	5,544.52	499,803.41	505,347.93
	3,537,727.82	387,124.14	3,924,851.96	3,212,478.46	764,508.49	3,976,986.95
Interest and dividends receivable		56.93	56.93		16.60	16.60
Investments:						
Securities of other corporations	10,131.90		10,131.90			
Miscellaneous	6,507.20		6,507.20	4,174.40	1,000.00	5,174.40
	16,639.10		16,639.10	4,174.40	1,000.00	5,174.40
Materials and supplies	24,536.17	161,265.98	185,802.15	42,299.64	227,504.24	269,803.88
Sinking funds		88.09	88.09	739.75	227.45	967.20

[g] Total liability as reported by company included in addition "Contingent liabilities by reason of guaranty of The Southern Sierras Power Co.'s outstanding bonds, $3,598,000."

TABLE 272.—*Comparative balance sheet of The Nevada-California Power Co. and The Southern Sierras Power Co., 1907–1920*—Continued.

	1917			1918		
	The Nevada-California Power Co.	The Southern Sierras Power Co.	Total.	The Nevada-California Power Co.	The Southern Sierras Power Co.	Total.
ASSETS—continued.						
Prepaid expenses:						
Prepaid taxes	$475.25	$162.75	$638.00	$957.50	$162.75	$1,120.25
Prepaid insurance	611.44	1,618.76	2,230.20	960.86	1,812.09	2,772.95
Other prepayments	3,252.70	1,148.80	4,401.50	3,985.70	148.80	4,134.50
	4,339.39	2,930.31	7,269.70	5,904.06	2,123.64	8,027.70
Unamortized discount on securities and expenses:						
Stocks		4,995,350.00	4,995,350.00		4,995,350.00	4,995,350.00
Bonds	260,495.00	358,909.62	619,404.62	258,695.00	356,029.62	614,724.62
	260,495.00	5,354,259.62	5,614,754.62	258,695.00	5,351,379.62	5,610,074.62
Other suspense	29.22	9,487.30	9,516.52	22.83	9,013.90	9,036.73
Construction work in progress	729,494.20	250,322.62	979,816.82	335,720.35	251,932.76	587,653.11
Corporate deficit		361.50	361.50			
Total assets	13,789,598.41	10,874,418.02	24,664,016.43	13,811,939.44	12,686,752.81	26,498,692.25
LIABILITIES.						
Capital stock	5,000,000.00	5,000,000.00	10,000,000.00	5,000,000.00	5,000,000.00	10,000,000.00
Funded debt	5,937,000.00	3,668,000.00	9,605,000.00	5,873,000.00	4,003,000.00	9,876,000.00
Advances from system corporations for construction, equipment, betterments, etc		500,000.00	500,000.00		500,000.00	500,000.00
Notes payable	12,306.06	24,313.05	36,619.11	7,741.81	19,000.00	26,741.81
Accounts payable:						
System corporations	43,962.23	901,564.15	945,526.38	96,107.66	1,289,746.17	1,385,853.83
Audited vouchers and wages unpaid	21,539.41	73,287.62	94,827.03	34,943.32	52,849.46	87,792.78
Consumer's deposits	31,199.85	17,858.09	49,057.94	27,579.48	43,582.56	71,162.04
Miscellaneous	3,084.62	243,383.60	246,468.22	1,506.93	1,301,445.98	1,302,952.91
	99,786 11	1,236,093.46	1,335,879.57	160,137.39	2,687,624.17	2,847,761.56
Interest accrued	51,530.37	110,233.56	161,763.93	49,488.03	231.16	49,719.19
Taxes accrued	29,579.35	26,832.20	56,411.55	38,694.05	38,055.14	76,749.19
Reserve for accrued depreciation	404,495.17		404,495.17	479,430.11		479,430.11
Casualty and insurance reserve	26,801.63		26,801.63	28,670.56		28,670.56
Reserve for purchase and cancellation of bonds	548,373.96		548,373.96	619,054.57		619,054.57
Dividend scrip certificates outstanding	45,460.00		45,460.00			
Outstanding coupons on bonds	81,818.96	495.00	82,313.96	1,966.48	79,575.00	81,541.48
Discount and premiums on bonds redeemed	3,167.35		3,167.35	4,798.60	433.35	5,231.85
Reserve for injuries and damages	18,171.19	1,876.29	20,047.48	17,955.23	2,535.99	20,491.22
Reserve for supply expense and emergency	3,118.87	7,828.38	10,947.25	2,653.30	7,910.81	10,564.11
Corporate surplus unappropriated	1,527,989.39	298,746.08	1,826,735.47	1,315,849.31	848,387.29	1,876,736.60
Total liabilities	13,789,598.41	10,874,418.02	24,664,016.43	13,811,939.44	12,686,752.81	26,498,692.25

TABLE 272.—*Comparative balance sheet of The Nevada-California Power Co. and The Southern Sierras Power Co., 1907–1920*—Continued.

	1919			1920		
	The Nevada-California Power Co.	The Southern Sierras Power Co.	Total.	The Nevada-California Power Co.	The Southern Sierras Power Co.	Total.
ASSETS.						
Fixed capital	$9,973,668.26	$6,607,566.46	$16,581,234.72	$10,329,872.29	$7,425,524.23	$17,755,396.52
Cash and deposits:						
Cash	32,734.11	59,084.25	91,818.36	20,451.47	111,879.45	132,330.92
Special deposits	2,914.12	78,825.00	81,739.12	1,114.12	77,640.00	78,754.12
	35,648.23	137,909.25	173,557.48	21,565.59	189,519.45	211,085.04
Notes receivable	9,858.34	21,981.89	31,840.23	5,891.31	18,191.41	24,082.72
Accounts receivable:						
Accounts with system corporations	3,804,923.44	239,594.53	4,044,517.97	4,227,290.55	269,709.30	4,496,999.85
Due from consumers and agents	49,261.78	100,146.35	149,408.13	47,112.57	128,062.54	175,175.11
Miscellaneous accounts receivable	3,028.95	520,074.84	523,103.79	2,669.31	711,604.16	714,273.47
	3,857,214.17	859,815.72	4,717,029.89	4,277,072.43	1,109,376.00	5,386,448.43
Interest and dividends receivable	...	103.90	103.90	...	123.97	123.97
Investments, miscellaneous	2,760.80	...	2,760.80	2,760.80	...	2,760.80
Material and supplies	47,364.50	221,065.07	268,429.57	541.01	430,965.67	431,506.68
Sinking funds	696.14	151.83	847.97	310.40	178.51	488.91
Prepaid expenses:						
Prepaid taxes	...	...	...	1,773.50	489.46	2,262.96
Prepaid insurance	701.17	990.16	1,691.33	1,046.18	2,089.26	3,135.44
Other prepayments	4,652.50	4,892.50	9,545.00	45.00	2,371.90	2,416.90
	5,353.67	5,882.66	11,236.33	2,864.68	4,950.62	7,815.30
Unamortized discount on securities and expenses:						
Stocks	...	4,995,350.00	4,995,350.00	...	4,995,350.00	4,995,350.00
Bonds	331,000.00	423,654.37	754,654.37	376,675.00	599,677.70	976,352.70
	331,000.00	5,419,004.37	5,750,004.37	376,675.00	5,595,027.70	5,971,702.70
Other suspense	7.12	9,401.33	9,408.45	...	22,152.71	22,152.71
Construction work in progress	336,721.11	225,572.61	562,293.72	170,255.92	669,868.17	840,124.09
Corporate deficit	...	...	...	...	...	...
Total assets	14,600,292.34	13,508,455.09	28,108,747.43	15,187,809.43	15,465,878.44	30,653,687.87
LIABILITIES.						
Capital stock	5,000,000.00	5,000,000.00	10,000,000.00	6,500,000 00	5,000,000.00	11,500,000.00
Funded debt	6,527,000.00	4,637,000.00	11,164,000.00	6,848,000.00	6,078,500.00	12,926,500.00
Advances from system corporations for construction, equipment, betterments, etc	...	500,000.00	500,000.00	...	500,000.00	500,000.00
Notes payable	...	19,000.00	19,000.00	...	19,000.00	19,000.00

Table 272.—*Comparative balance sheet of The Nevada-California Power Co. and The Southern Sierras Power Co., 1907–1920*—Continued.

	1919			1920		
	The Nevada-California Power Co.	The Southern Sierras Power Co.	Total.	The Nevada-California Power Co.	The Southern Sierras Power Co.	Total.
LIABILITIES—contd.						
Accounts payable:						
System corporations	$215,964.40	$1,425,302 81	$1,641,267.21	$131,646.40	$1,999,086.80	$2,130,733.20
Audited vouchers and wages unpaid	19,558.71	49,289.14	68,847.85	5,518.32	159,169.76	164,718.08
Consumers' deposits	38,721.63	63,311.96	102,033.59	18,997.30	141,019.28	160,016.58
Miscellaneous	2,570 45	1,177,019.01	1,179,589.46	1,496.90	839,852.28	841,349.18
	276,995.19	2,714,922 92	2,991,738.11	157,688.92	3,139,128.12	3,296,817.04
Interest accrued	48,510.43	231.16	48,741.59	47,070.43	4,205.00	51,275.43
Taxes accrued	34,260.21	47,702.94	81,963.15	64,680 23	53,261.80	117,942.03
Consumers' deposits for capital purposes	....	....	....	48,339.06	....	48,339.06
Reserve for accrued depreciation	550,092.46	104,000.00	654,092.46	576,545.44	229,941.04	806,486.48
Casualty and insurance reserve	36,037.18	....	36,037.18	48,785.43	....	48,785.43
Reserve for purchase and cancellation of bonds	683,285.13	....	683,285.13	50,958.60	....	50,958.60
Outstanding coupons on bonds	2,914.12	78,825.00	81,739.12	1,114.12	77,640.00	78,754.12
Discount and premiums on bonds redeemed	6,497.30	....	6,497.30	....	....	....
Reserve for injuries and damages	17,852.88	1,439.21	19,292.09	12,942.23	2,063.98	15,006.21
Reserve for supply expense and emergency	305.87	5,243.37	5,549.24	663.18	29,661.00	30,324.18
Corporate surplus unappropriated	1,416,721.57	400,090.49	1,816,812.06	831,021.79	332,477.50	1,163.499.29
Total liabilities	14,600,292.34	13,508,455.09	28,108,747.43	15,187,809.43	15,465,878.44	30,653,687.87

Table 273.—*Earnings and expenses of The Nevada Power Mining & Milling Co. and The Nevada-California Power Co., 1905–1920.*

Year.	Gross earnings.	Operating maintenance, general expenses, and taxes.	Operating profit.	Interest on bonds and other interest.	Adjustments to profit and loss.	Net surplus.
1905 [a] [b]	$34,067.95	$14,444.59	$19,623.36	$9,000.00	[c] $675.00	$9,948.36
1906 [b]	300,868.05	[d] 118,750.00	182,118.05	47,500.00	6,000.00	134,618.05
1907	612,676.09	214,482.48	398,193.61	77,659.92	51,997.05	268,536.64
1908	651,056.29	214,739.27	436,317.02	138,405.62	11,273.67	286,637.73
1909	708,314.51	247,139.72	461,174.79	165,760.60	8,476.42	286,937.77
1910	744,644.24	232,193.02	512,451.22	175,083.07	[e] 2,040.75	339,408.90
1911	772,845.85	212,820.49	560,025.36	167,323.51	540.09	392,161.76
1912	872,843.93	292,271.44	580,572.49	157,438.21	....	423,134.28
	4,362,380.91	1,413,646.42	2,948,734.49	881,670.93	70,246.48	1,996,817.08

[a] From October to December.
[b] Totals for The Nevada Power Mining & Milling Co. not included in column footings.
[c] Taxes and insurance.
[d] December, estimated.
[e] Profit and loss credit adjustment.

TABLE 273.—*Earnings and expenses of The Nevada Power Mining & Milling Co. and The Nevada-California Power Co., 1905–1920*—Continued.

Net surplus (Dec. 31, 1912)	$1,996,817.08
Deduct amounts credited to reserve for emergencies	40,657.63
Discount on bonds sold	5,000.00
	45,657.63
Final net available surplus, in addition to the undermentioned reserves (set aside from income) in excess of various charges made against these reserve accounts	1,951,159.45
The reserve accounts are:	
For fire losses	17,989.69
For damages and personal injuries	16,539.38
For depreciation (including transfer from emergencies)	152,745.27
	187,274.34
Total of earned surplus and reserves	2,138,433.79
Deduct dividends to stockholders	635,695.00
Surplus to be accounted for	1,502,738.79
Add interest accretions to fund for construction of plant No. 3	3,692.20
Add discount on bonds redeemed	7,203.25
Add capital stock increased	1,650,000.00
Add first-mortgage bonds increased:	
Sold	2,300,000.00
Less redeemed	225,000.00
	2,075,000.00
Grand total	5,238,634.24
Used for:	
Additions to real estate, water rights, franchises, etc	1,859,892.00
Additions to plants and equipment	2,342,410.92
Additions to securities of other companies and land scrip	265,542.42
	4,467,845.43
Cash in special fund being used for completion of plant No. 3	262,241.97
	4,730,087.40
Leaving a balance of	508,546.84
Made up of:	
Cash in hands of trustee of bond sinking fund	812.96
Net increase in working capital accounts in six years since the organization of this company	507,733.88
	508,546.84

	1913	1914	1915	1916
Electric revenue:				
Operating revenue	$995,064	$960,431	$899,563	$788,082
Operating expenses	484,760	515,897	532,009	440,100
Net operating revenue	510,304	444,534	367,554	347,982
Add:				
Nonoperating revenue—				
Miscellaneous rent revenue	....	....	490	a 47,304
Interest and dividend revenues—				
Interest revenue on funded debt owned	2,760	5,820	5,820	1,455
Miscellaneous interest revenue	73,567	63,233	72,622	188,030
Dividend revenues	....	1,560	1,560	4,875
Total interest and dividend revenues	76,327	70,613	80,002	241,664
Miscellaneous nonoperating revenue	633	478	203	796
Total nonoperating revenues	76,960	71,091	80,695	242,460
Gross corporate income	587,264	515,625	448,249	590,442
Deduct:				
Deductions from gross corporate income	....	....	....	....
Uncollectible bills	727	81	148	521
Interest accrued on funded debt	164,635	160,235	156,801	239,480
Other interest deductions	29,160	35,345	40,524	28,742
Total deductions	194,522	195,661	197,473	268,743
Surplus for year	392,742	319,964	250,776	321,699

[a] Includes $46,944 rent accrued from lease of electric plant.

TABLE 273.—*Earnings and expenses of The Nevada Power Mining & Milling Co. and The Nevada-California Power Co., 1905–1920*—Continued.

	1917[b]	1918	1919	1920
Electric revenue:				
Operating revenue	$839,910	$751,920	$532,546	$561,695
Operating expenses	477,503	482,361	481,633	395,325
Net operating revenue	362,407	269,559	50,913	166,370
Add:				
Nonoperating revenue—				
Miscellaneous rent revenue	....	....	....	....
Interest and dividend revenues—				
Interest revenue on funded debt owned	....	....	....	....
Miscellaneous interest revenue	242,972	248,783	251,754	304,438
Dividend revenues	....	....	....	....
Total interest and dividend revenues	242,972	248,783	251,754	304,438
Miscellaneous nonoperating revenue	85,668	201,360	388,871	591,962
Total nonoperating revenues	328,640	450,143	640,625	896,400
Gross corporate income	691,047	719,702	691,538	1,062,770
Deduct:				
Deductions from gross corporate income	....	3,909	4,174	7,247
Uncollectible bills	254	808	174	1,175
Interest accrued on funded debt	350,976	354,666	356,759	401,387
Other interest deductions	27,454	5,768	11,530	11,919
Total deductions	378,684	365,151	372,637	421,728
Surplus for year	312,363	354,551	318,901	641,042

[b] Includes earnings of Pacific Power Corporation.

TABLE 274.—*Classified electric revenues of The Nevada-California Power Co., 1908–1920.*

Class of load.	1908		1909		1910		1911	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:								
Municipal street lighting—								
Arc	....	....	....	....	....	....	....	....
Incandescent	....	....	....	....	....	....	....	....
Municipal lighting, miscellaneous	....	....	....	....	....	....	....	....
Commercial lighting—								
Flat rate	$187,970	27.9	$154,421	21.7	$131,905	17.7	$121,316	15.9
Metered								
Commercial power, metered[a]	482,013	71.7	550,824	77.6	606,645	81.6	636,747	83.3
Other electrical corporations	2,771	.4	5,364	.7	5,447	.7	5,837	.8
Joint electric rent revenues	....	....	....	....	....	....	....	....
Commercial lighting, delinquent charge	....	....	....	....	....	....	....	....
Total operating revenues, electric	672,754	100.0	710,609	100.0	743,997	100.0	763,900	100.0
Other operating revenues:								
Rent of electric appliances	....	....	....	....	....	....	....	....
Electric merchandise and jobbing revenues	....	....	....	....	....	....	....	....
Total other operating revenues	....	....	....	....	....	....	....	....
Gross electric revenues	672,754	100.0	710,609	100.0	743,997	100.0	763,900	100.0

[a] In statement of this company commercial power means mining power.

TABLE 274.—*Classified electric revenues of The Nevada-California Power Co., 1908–1920*—Continued.

Class of load.	1912		1913		1914		1915	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:								
Municipal street lighting—								
Arc	$5,631	0.6	$2,920	0.3	$2,880	0.3	$2,880	0.2
Incandescent			4,284	.4	4,893	.5	4,929	.4
Municipal lighting, miscellaneous			......	......	......	......	......	......
Commercial lighting—								
Flat rate	113,835	13.1	1,387	.1	325	......	173	......
Metered			110,865	11.1	90,501	9.4	93,814	10.4
Commercial power, metered[a]	740,020	85.6	864,751	87.0	842,324	87.7	786,820	88.0
Other electrical corporations	6,270	.7	6,410	.6	4,978	.5	......	......
Joint electric rent revenues	......	......	......	......	10,320	1.3	10,348	1.0
Commercial lighting, delinquent charge	......	......	......	......	413	......	599	......
Total operating revenues, electric	865,756	100.0	990,617	99.5	956,634	99.7	899,563	100.0
Other operating revenues:								
Rent of electric appliances	......	......	389	......	882	......	......	......
Electric merchandise and jobbing revenues	......	......	4,058	.5	2,915	.3	......	......
Total other operating revenues	......	......	4,447	.5	3,797	.3	......	......
Gross electric revenues	865,756	100.0	995,064	100.0	960,431	100.0	899,563	100.0

Class of load.	1916		1917		1918	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue-	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting—						
Arc	$2,880	0.4	$735,966	87.0	$663,892	88.0
Incandescent	5,148	.6				
Municipal lighting, miscellaneous	......	......				
Commercial lighting—						
Flat rate	151	......	103,629	13.0	87,050	11.0
Metered	96,862	12.5				
Commercial power, metered[a]	679,558	86.1	......	......	......	......
Other electrical corporations	3,278	.4	......	......	......	......
Joint electric rent revenues	......	......	......	......	......	......
Commercial lighting, delinquent charge	......	......	......	......	......	......
Total operating revenues, electric	787,877	100.0	835,595	100.0	750,942	99.0
Other operating revenues:						
Rent of electric appliances	205	......	315	......	978	1.0
Electric merchandise and jobbing revenues	......	......	......	......	......	......
Total other operating revenues	205	......	315	......	978	......
Gross electric revenues	788,082	100.0	839,910	100.0	751,920	100.0

[a] In statement of this company commercial power means mining power.

TABLE 274.—*Classified electric revenues of The Nevada-California Power Co., 1908-1920*—Continued.

	1919		1920	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:				
Municipal street lighting—				
Arc	$447,924	84.1	$473,178	84.3
Incandescent				
Municipal lighting, miscellaneous				
Commercial lighting—				
Flat rate	81,622	15.9	88,517	15.7
Metered				
Commercial power, metered				
Other electrical corporations				
Joint electric rent revenues				
Commercial lighting, delinquent charge				
Total operating revenues, electric	532,546	100.0	561,695	100.0
Other operating revenues:				
Rent of electric appliances				
Electric merchandise and jobbing revenues				
Total other operating revenues				
Gross electric revenues	532,546	100.0	561,695	100.0

TABLE 275.—*Earnings and expenses of The Southern Sierras Power Co., 1912-1920.*

	1912	1913	1914	1915	1916
Electric revenue:					
Operating revenues	$99,022	$285,390	$458,363	$572,996	$589,512
Operating expenses	79,183	207,722	186,092	170,793	220,550
Net operating revenue	19,839	77,668	272,271	402,203	368,962
Add:					
Nonoperating revenue—					
Rents from lease of electric plant	1,502	396	1,275	1,931	1,523
Interest and dividend revenues—					
Miscellaneous interest revenues		2,903	313	543	382
Dividend revenues			2,000		
Total interest and dividend revenues.		2,903	2,313	543	382
Miscellaneous nonoperating revenues	2,691	1,815	452	[a] 660	847
Total nonoperating revenues	4,193	5,114	4,040	1,814	2,752
Gross corporate income	24,032	82,782	276,311	404,017	371,714
Deduct:					
Deductions from gross corporate income—					
Uncollectible bills		853	2,092	7,142	754
Interest accrued on funded debt		116,000	153,500	159,575	196,597
Other interest deductions	4,083	36,666	35,893	69,398	72,552
Rent deductions—					
Rent for lease of other electric plants					48,943
Rent for conduits, poles, and other supports (electric)			2,197	2,078	2,024
Total rent deductions			2,197	2,078	50,967
Miscellaneous deductions			10,320	10,349	
Total deductions	4,083	153,519	204,002	248,542	320,870
Surplus for year			72,309	155,475	50,844
Deficit for year	19,949	70,737			

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[a] Crescent Garage.

TABLE 275.—*Earnings and expenses of The Southern Sierras Power Co., 1912–1920*—Continued.

	1917	1918	1919	1920
Electric revenue:				
Operating revenues	$821,249	$1,147,324	$1,596,833	$1,861,735
Operating expenses	305,704	417,963	582,597	724,927
Net operating revenue	515,545	729,361	1,014,236	1,136,808
Add:				
Nonoperating revenue—				
Rents from lease of electric plant	359	....	3,000	6,000
Interest and dividend revenues—				
Miscellaneous interest revenues	16,465	43,392	18,255	3,734
Dividend revenues	....	....	....	....
Total interest and dividend revenues	16,465	....	18,255	3,734
Miscellaneous nonoperating revenues	2,766	4,669	1,962	4,248
Total nonoperating revenues	19,590	....	23,217	13,982
Gross corporate income	535,135	777,422	1,037,453	1,150,790
Deduct:				
Deductions from gross corporate income—				
Uncollectible bills	1,963	15,255	616	2,203
Interest accrued on funded debt	219,402	240,831	243,625	305,295
Other interest deductions	87,901	184,990	207,921	180,445
Rent deductions—				
Rent for lease of other electric plants	83,781	200,969	388,607	538,800
Rent for conduits, poles, and other supports (electric)	....	3,841	4,032	57,090
Total rent deductions	....	204,810	392,639	595,890
Amortization of debt and discount	....	....	....	26,360
Miscellaneous deductions	....	206	64	75
Total deductions	393,047	646,092	844,865	1,110,268
Surplus for year	142,088	131,330	192,588	40,522

TABLE 276.—*Classified electric revenues of The Southern Sierras Power Co., 1912–1920*

Class of load.	1912		1913		1914		1915	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:								
Municipal street lighting, incandescent	....	....	$2,369	0.8	$3,812	0.8	$6,155	1.1
Municipal power	....	....	7,047	2.5	21,912	4.8	19,120	3.3
Commercial lighting—								
Flat rate	$57,457	58.0	....	....	....	....	....	....
Metered			52,506	18.4	59,643	13.0	62,516	10.9
Commercial power, metered	....	....	117,065	41.0	210,828	46.1	229,975	40.2
Other electrical corporations	41,565	42.0	102,430	35.9	146,607	32.1	230,804	40.4
Joint electric rent revenue	....	....	307	.1	11,605	2.5	23,210	4.1
Customers' charge	....	....	....	....	647	....	....	....
Total operating revenues, electric	99,022	100.0	281,724	98.7	455,054	99.3	571,780	100.0
Other operating revenues:								
Rent of electrical appliances	....	....	....	....	....	....	89	....
Electric merchandise and jobbing revenues	....	....	3,665	1.3	3,309	.7	1,127	....
Total other operating revenues	....	....	3,665	1.3	3,309	.7	1,216	....
Gross electric revenues	99,022	100.0	285,389	100.0	458,363	100.0	572,996	100.0

TABLE 276.—*Classified electric revenues of The Southern Sierras Power Co., 1912–1920*—Continued.

Class of load.	1916		1917		1918	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:						
Municipal street lighting, incandescent	$7,098	1.2	$8,240	1.0	$11,634	1.1
Municipal power	19,163	3.2	24,024	3.0	27,675	2.4
Commercial lighting—						
Flat rate	....	....	....	....	2,400	....
Metered	74,738	12.7	78,607	9.5	111,994	9.7
Commercial power, metered	289,558	49.1	421,964	51.4	636,523	55.5
Other electrical corporations	172,466	29.3	262,287	32.0	337,611	29.4
Joint electric rent revenue	23,210	3.9	23,209	2.8	14,747	1.3
Total operating revenues, electric	586,233	99.4	818,331	....	1,142,584	....
Other operating revenues:						
Rent of electrical appliances	45	....	167	.0	210	.0
Electric merchandise and jobbing revenues.	3,234	.6	2,751	.3	4,530	.4
Total other operating revenues	3,279	.6	2,918	....	4,740	....
Gross electric revenues	589,512	100.0	821,249	100.0	1,147,324	100.0

Class of load.	1919		1920	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:				
Municipal street lighting, incandescent	$11,773	0.7	$11,828	0.6
Municipal power	35,562	2.2	35,398	1.9
Commercial lighting—				
Flat rate	2,675	.2	2,546	.2
Metered	145,667	9.1	194,003	10.4
Commercial power, metered	892,379	55.9	1,096,772	58.9
Other electrical corporations	491,107	30.8	498,664	26.7
Joint electric rent revenue	14,236	.9	18,261	1.0
Total operating revenues, electric	1,593,399	99.8	1,857,472	99.7
Other electric revenues:				
Rent of electrical appliances	330	....	189	....
Electric merchandise and jobbing revenues	3,103	.2	4,073	.3
Total other operating revenues	3,433	.2	4,262	.3
Gross electric revenues	1,596,832	100.0	1,861,734	100.0

TABLE 277.—*Comparative balance sheet, Pacific Power Co. and Corporation, 1912–1916.*

	1912	1913	1914	1915	1916
ASSETS.					
Fixed capital	$1,903,868	$1,926,025	$2,063,664	....	$2,409,637
Cash and deposits:					
Cash	....	3,197	2,140	....	5,525
Deposits	....	....	....	....	....
	1,505	3,197	2,140	....	5,525
Notes receivable	....	....	....	....	2,500
Accounts receivable:					
Accounts with system corporation	....	....	....	....	9,952
Due from consumers and agents	....	8,287	14,480	....	14,438
Miscellaneous accounts receivable	....	316	....	....	273,705
	3,165	8,603	14,480	....	298,095
Investments in securities of other corporations	....	1,606	1,606	....	....
Materials and supplies	7,025	5,176	4,714	....	16,724
Prepaid expenses:					
Taxes and other prepayments	....	....	185	....	554
Corporate deficit	44,674	91,018	92,340	....	....
Total assets	1,960,237	2,035,625	2,179,129	....	2,733,035
LIABILITIES.					
Capital stock	800,033	800,033	800,033	....	1,000,000
Funded debt	800,000	800,000	800,000	....	935,000
Advances from system corporations	....	155,139	217,459	....	667,927
Notes payable	135,000	135,711	142,000	....	....
Accounts payable:					
Accounts with system corporations	....	....	....	....	6,915
Audited vouchers and wages unpaid	9,885	14,122	9,963	....	21,574
Consumers deposits	....	4,029	100	....	70
Miscellaneous	213,535	4,628	30,631	....	1,313
	223,420	22,779	40,694	....	29,872
Interest accrued	1,233	5,630	15,233	....	98,175
Taxes accrued	551	623	....	....	1,822
Outstanding coupons on bonds	....	115,710	163,710	....	....
Corporate surplus unappropriated	....	....	....	....	240
Total liabilities	1,960,237	2,035,625	2,179,129	....	2,733,035

TABLE 278.—*Earnings and expenses, Pacific Power Co. and Corporation, 1912–1916.*

	1912	1913	1914	1915 [a]	1916
Electric operations:					
Operating revenues	$58,549	$73,040	$123,845	....	$140,348
Operating expenses	22,588	30,146	52,962	....	71,488
Net operating revenue, electric	35,961	42,894	70,883	....	68,860
Add: Miscellaneous nonoperating revenue	251	....	....	....	....
Gross corporate income	36,212	42,894	70,883	....	68,860
Deduct:					
Uncollectible bills	....	....	....	....	151
Interest accrued on funded debt	48,000	48,000	48,000	....	56,100
Other interest deductions	3	20,667	24,205	....	974
Amortization of discount and expense	....	....	....	....	67
Total deductions	48,003	68,667	72,205	....	57,292
Surplus for year	....	....	....	....	11,568
Deficit for year	11,791	25,773	1,322	....	....

[a] Figures not available.

TABLE 279.—*Classified electric revenues, Pacific Power Co. and Corporation (according to classification of Railroad Commission of California), 1913–1916.*

Class of load.	1913		1914		1915		1916	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:								
Municipal street lighting—								
Arc	....	....	....	....	....	....	....	....
Incandescent	....	....	....	....	....	....	....	....
Commercial lighting—								
Flat rate	$1,596	2.2	$2,982	2.4	....	....	} $2,626	1.9
Metered	337	.5	905	.7	....	....		
Commercial power, metered	71,038	97.3	118,649	95.9	....	....	133,476	95.1
Other electrical corporations	....	....	757	.6	....	....	....	....
Miscellaneous electric	....	....	....	....	....	....	4,246	3.0
Total operating revenues, electric	72,971	100.0	123,293	99.6	....	....	140.348	100.0
Electrical merchandise and jobbing revenues	69	....	552	.4	....	....	....	....
Gross electric revenues	73,040	100.0	123,845	100.0	....	....	140,348	100.0

TABLE 280.—*Income account, Pacific Power Co. and Corporation, 1911–1916.*

[As reported to Nevada Public Service Commission; years ending June 30.]

	1911 (6 months).	1912	1913	1914
Total operating revenues	$4,837.90	$48,638.25	$66,823,87	$92,778.42
Total operating expenses	5,871.34	16,418.15	25,989.78	35,081.37
Taxes	1,800.00	1,625.68	1,609.65	2,842.63
Total operating expenses and taxes	7,671.34	18,043.83	27,599.43	37,924.00
Net operating revenue	[a] 2,797.44	30,594.42	39,224.44	54,854.42
Nonoperating revenues	12.50	131.47	250.34	68.76
Gross corporate income or deficit	[a] 2,784.94	30,725.89	39,474.78	54,923.18
Interest on funded debt	24,000.00	48,000.00	48,000.00	48,000.00
Other deductions from gross corporate income	300.00	14.56	152.80	[b] 21,494.65
Net corporate income	[a] 27,084.94	[a] 17,288.67	[a] 8,678.02	[a] 14,571.47
Surplus for year	[a] 27,084.94	[a] 17,288.67	[a] 8,678.02	[a] 14,571.47
Total surplus at close of year	[a] 27,084.94	[a] 44,373.61	[a] 52,751.63	[a] 91,585.91

[a] Deficit.
[b] Interest on deposits $275.75; interest on floating debt, $21,218.90

TABLE 280.—*Income account, Pacific Power Co. and Corporation, 1911–1916*—Contd.

	1915	[d] 1916	[e] 1916
Total operating revenues	$137,857.31	$32,026.65	$101,991.70
Total operating expenses	64,502.44	6,216.35	71,320.61
Taxes	4,383.18	859.91	4,200.00
Total operating expenses and taxes	68,885.62	7,076.26	[c] 75,650.31
Net operating revenue	68,971.69	24,950.39	26,341.39
Nonoperating revenues	551.75	....	375.76
Gross corporate income or deficit	69,523.44	24,950.39	26,717.15
Interest on funded debt	48,000.00	12,000.00	42,075.00
Other deductions from gross corporate income	42,280.96	3,671.71	1,014.74
Net corporate income	[a] 20,757.52	9,278.68	[a] 16,372.59
Surplus for year	[a] 20,757.52	9,278.68	[a] 16,372.59
Total surplus at close of year	[a] 112,343.43	[f] 1,455,748.18	[a] 13,345.70

[a] Deficit.
[c] Includes $149.70 bad debts.
[d] Pacific Power Co., for July, August, and September, 1915.
[e] Pacific Power Corporation, successor to Pacific Power Co., for the period Oct. 1, 1915, to June 30, 1916.
[f] Accumulated deficit and loss of $1,352,683.43 on sale of property.

FINANCIAL TABLES FOR HOLTON POWER CO. AND PRINCIPAL SUBSIDIARIES.

TABLE 281.—*Capitalization, outstanding stock, and dividends of Holton Power Co. and subsidiary.*

[Term of incorporation, uniformly 50 years. Par value of all stock is $100.]

Holton Power Co., Redlands, Calif.

Company.	Capitalization.	Year (Dec. 31).	Par value of common stock outstanding.	Dividends.[a]	Notes.
Holton Power Co., Redlands, Calif., incorporated Sept. 16, 1903.	[b] $500,000	1903–1908	....	....	No data available except as shown below. Entries for years prior to 1911 not from official sources but believed to be correct.
		1909	$1,000,000	....	
		1910	1,000,000	....	
		1911–1920	[c] 1,250,000	....	

Subsidiary company.

Company.	Date of incorporation.	Capitalization.	Year (Dec. 31).	Par value of common stock outstanding.	Dividends.[d]
Holton Interurban Ry. Co., Redlands, Calif.	Dec. 31, 1903	$200,000	1903–1906	....	....
			1907–1920	$200,000	....

[a] No dividends have been paid on this stock except $25,000 in 1913.
[b] Capitalization increased to $1,000,000 on June 15, 1905; on July 18, 1911, to $1,500,000.
[c] Including $300,000 in treasury.
[d] No dividends have been paid on this stock.

TABLE 282.—*Bonds of Holton Power Co.*

Issue.	Callable.	Sinking-fund deposits.	Trustee.	Denomination.
1	2	3	4	5
1. Holton Power Co. first-mortgage 6 per cent bonds, dated Apr. 1, 1907; due serially, $25,000 Jan. 1, 1918, and each year thereafter to Jan. 1, 1937; interest payable Jan. 1 and July 1.	Not subject to call..........	$25,000 each year, from Jan. 1, 1918.	Southern Trust Co., Los Angeles.	Coupon, $250 and $1,000.
2. Holton Power Co. first and refunding mortgage 6 per cent bonds, dated Oct. 1, 1911; due serially, $50,000 Oct. 1, 1932, and each year thereafter to Oct. 1, 1951; interest payable Apr. 1 and Oct. 1.	At 105 and interest on any interest date.	$50,000 each year, from Oct. 1, 1932.	.....do..................	Coupon, $1,000 and $500
3. Holton Interurban Ry. Co. bonds, dated Apr. 1, 1907; due serially, $5,000 a year Jan. 1, 1918, to Jan. 1, 1937; interest payable Jan. 1 and July 1.	Serially $5,000 per annum Jan. 1, 1922, to Jan. 1, 1937.	....	.....do..................	Coupon, $250 and $1,000

Issue.	Authorized.	Bonded debt.							Note.
		Year.	Reserved for prior liens.	Canceled.	Alive.	In treasury.	Held by public.	Total authenticated.	
1	6	7	8	9	10	11	12	13	14
1. Holton Power Co. first-mortgage 6 per cent bonds, dated Apr. 1, 1907; due serially, $25,000 Jan. 1, 1918, and each year thereafter to Jan. 1, 1937; interest payable Jan. 1 and July 1.	$500,000	1907	....	....	....	....	$500,000	$500,000	
		1908	....	....	....	....	500,000	500,000	
		1909	....	....	....	....	500,000	500,000	
		1910	....	....	....	....	500,000	500,000	
		1911	....	....	....	....	500,000	500,000	
		1912	....	....	....	....	500,000	500,000	
		1913	....	....	....	....	500,000	500,000	
		1914	....	....	....	....	500,000	500,000	
		1915	....	....	....	....	500,000	500,000	
		1916	....	....	....	....	500,000	500,000	
		1917	....	....	....	....	500,000	500,000	
		1918	....	....	....	....	450,000	450,000	
		1919	....	....	....	....	425,000	425,000	
		1920	....	....	....	....	425,000	425,000	

NOTE.—No provisions for conversion made for an of the bonds included in this table.

TABLE 282.—*Bonds of Holton Power Co.*—Continued.

Issue.	Authorized.	Bonded debt.							Note.
		Year.	Reserved for prior liens.	Canceled.	Alive.	In treasury.	Held by public.	Total authenticated.	
1	6	7	8	9	10	11	12	13	14
2. Holton Power Co. first and refunding mortgage 6 per cent bonds, dated Oct. 1, 1911; due serially, $50,000 Oct. 1, 1932, and each year thereafter to Oct. 1, 1951; interest payable Apr. 1 and Oct. 1.	1,000,000	1912	$500,000				199,000	199,000	$301,000 unissued.
		1913	500,000				300,000	300,000	$200,000 unissued.
		1914	500,000				300,000	300,000	Do.
		1915	500,000				418,500	418,500	$81,500 unissued.
		1916	500,000				437,500	437,500	$62,500 unissued.
		1917	500,000				437,500	437,500	Do.
		1918	500,000				500,000	500,000	
		1919	450,000				550,000	550,000	
		1920	450,000				550,000	550,000	
3. Holton Interurban Ry. Co. bonds, dated Apr. 1, 1907; due serially, $5,000 a year Jan. 1, 1918, to Jan. 1, 1937; interest payable Jan. 1 and July 1.	100,000	1907					100,000	100,000	
		1908					100,000	100,000	
		1909					100,000	100,000	
		1910					100,000	100,000	
		1911					100,000	100,000	
		1912					100,000	100,000	
		1913					100,000	100,000	
		1914					100,000	100,000	
		1915					100,000	100,000	
		1916					100,000	100,000	
		1917					100,000	100,000	
		1918		10,000			90,000	90,000	
		1819		15,000			85,000	85,000	
		1920		19,000			81,000	81,000	

TABLE 283.—*Comparative balance sheet, Holton Power Co., 1909-1920.*

	1909 [a]	1910 [a]	1911	1912	1913
ASSETS.					
Fixed capital	$1,317,872	$1,425,285	$1,714,026	$1,851,579	$1,905,945
Cash and deposits	14,438	307	17,280	6,195	4,522
Notes receivable	6,119	11,934	29,752	35,995	19,760
Accounts receivable	56,088	53,155	68,884	79,067	34,221
Investments: Securities of other corporations	199,500	199,500	202,275	209,540	231,737
Materials and supplies					10,101
Unamortized discount on securities and expenses					10,000
Total assets	1,594,017	1,690,181	2,032,217	2,182,376	2,216,286
LIABILITIES.					
Capital stock	1,000,000	1,000,000	1,250,000	1,250,000	1,250,000
Funded debt	500,000	500,000	500,000	699,000	800,000
Notes payable	35,695	84,700	209,559	133,583	65,470
Accounts payable	23,471	69,160	40,828	23,424	46,512
Interest accrued	10,405	10,495	15,202	18,315	19,665
Other reserves from income or surplus				10,200	
Corporate surplus unappropriated	24,446	25,286	16,628	47,854	34,639
Total liabilities	1,594,017	1,690,181	2,032,217	2,182,376	2,216,286

	1914	1915	1916	1917	1918
ASSETS.					
Fixed capital	$1,749,446	$1,864,641	$1,832,906	$1,937,794	$1,503,649
Cash and deposits:					
Cash	20,018	10,706	9,387	33,717	17,013
Special deposits			1,326	16,730	40,925
	20,018	10,706	10,713	50,447	57,938
Notes receivable	16,995	16,892	284	273	184
Accounts receivable:					
Accounts with system corporations		4,956			
Due from consumers and agents	32,385	29,599	36,132	41,384	38,172
Miscellaneous	4,129	1,816	48,442	68,664	133,569
	36,514	36,371	84,574	110,048	171,741
Interest and dividends receivable				1,234	7
Investments:					
Securities of other corporations	233,811	236,811	216,558	208,453	201,669
Miscellaneous investments				1,255	
	233,811	236,811	216,558	209,708	201,669
Materials and supplies	11,788	24,413	20,769	50,372	55,723
Prepaid expense:					
Prepaid rents					75
Prepaid taxes				38	38
Prepaid insurance			1,213	1,362	2,301
			1,213	1,400	2,414
Treasury securities					300,000
Other suspense			[b] 37	189	225
Unamortized discount on securities and expenses:					
Stocks	200,000	200,000	200,000	200,000	200,000
Bonds	40,000	63,700	67,503	66,000	75,375
Miscellaneous					429,082
	240,000	263,700	267,503	266,000	704,457
Construction work in progress			111,214	73,771	49,853
Miscellaneous				15,248	
Corporate deficit					31,229
Total assets	2,308,572	2,453,534	2,545,697	2,716,484	3,079,089
LIABILITIES.					
Capital stock	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000
Funded debt	800,000	918,500	937,500	937,500	950,000
Notes payable	145,934	192,388	193,030	163,597	38,700

[a] As of Oct. 31.

[b] Credit item.

TABLE 283.—*Comparative balance sheet, Holton Power Co., 1909–1920*—Continued.

	1914	1915	1916	1917	1918
LIABILITIES—continued.					
Accounts payable:					
Accounts with system corporations	$18,587	$1,504			
Audited vouchers and wages unpaid	32,716	30,559	$13,080	$31,267	$6,265
Consumers' deposits	19,369	17,558	13,342	13,340	21,080
Miscellaneous accounts payable	7,712	2,865	82,046	233,326	505,948
	78,385	52,486	108,468	277,933	533,293
Interest accrued	19,530	22,373	9,288	12,834	8,547
Taxes accrued		5,795	6,486	8,547	9,849
Service billed in advance			20	56	
Reserve for accrued depreciation					194,506
Reserve for auto and supply expense			1,837	2,066	1,214
Corporate surplus unappropriated	14,723	11,992	39,068	48,703	
Miscellaneous				15,248	92,980
Total liabilities	2,308,572	2,453,534	2,545,697	2,716,484	3,079,089

	1919	1920
ASSETS.		
Fixed capital	$1,534,803	$1,601,831
Cash	18,284	25,781
Notes receivable		104
Accounts receivable:		
Accounts with system corporations		
Due from consumers and agents	38,505	60,603
Miscellaneous	95,836	128,379
	134,341	188,982
Investments, securities of other corporations	201,669	201,669
Materials and supplies	86,084	104,403
Prepaid expenses:		
Prepaid rents	75	75
Prepaid insurance	2,358	3,395
	2,433	3,470
Treasury securities	300,000	300,000
Unamortized discount on securities and expenses:		
Stocks	200,000	200,000
Bonds	82,875	79,021
Miscellaneous	429,082	429,082
	711,957	708,103
Construction work in progress	52,743	158,238
Corporate deficit	152,164	140,480
Total assets	3,194,478	3,433,061
LIABILITIES.		
Capital stock	1,250,000	1,250,000
Funded debt	975,000	750,000
Notes payable		8,662
Accounts payable:		
Audited vouchers and wages unpaid	21,109	10,924
Consumers' deposits	21,182	26,161
Miscllaneous accounts payable	557,062	755,519
	599,353	792,604
Interest accrued	8,910	9,022
Taxes accrued	10,354	16,771
Reserve for accrued depreciation	273,386	195,255
Reserve for auto and supply expense	2,167	9,585
Corporate surplus unappropriated		811
Miscellaneous	75,308	100,351
Total liabilities	3,194,478	3,433,061

TABLE 284.—*Earnings and expenses, Holton Power Co., 1909–1920.*

	Year ending Oct. 31, 1909.	Year ending Oct. 31, 1910.	Year ending Dec. 31, 1911.	Year ending Dec. 31, 1912.	Year ending Dec. 31, 1913.
Electric operations:					
Operating revenues	$135,477	$148,576	$152,771	$174,259	$128,787
Operating expenses	77,410	111,857	114,712	92,104	91,762
Net operating revenue	58,067	36,719	38,059	82,155	37,025
Add:					
Nonoperating revenues—					
Miscellaneous rent revenues, electric				2,045	2,585
Interest and dividend revenues—					
Miscellaneous interest revenues					2,287
Dividend revenues					304
Total interest and dividend revenues					2,591
Profits from other corporations operations					27,234
Total nonoperating revenues	2,835			2,045	32,410
Gross corporate income	60,902	36,719	38,059	84,200	69,435
Deduct:					
Uncollectible bills					75
Nonoperating revenue deductions—					
Miscellaneous nonoperating expenses				5,354	1,257
Interest accrued on funded debt	30,000	30,000	35,000	34,655	47,523
Other interest deductions		5,339	10,882	12,757	8,743
Rent deductions—					
Miscellaneous rent deductions					1
Total deductions	30,000	35,339	45,882	52,766	57,599
Surplus for year	30,902	1,380	[a] 7,823	31,434	11,836

	Year ending Dec. 31, 1914.	Year ending Dec. 31, 1915.	Year ending Dec. 31, 1916.	Year ending Dec. 31, 1917.	Year ending Dec. 31, 1918.
Electric operations:					
Operating revenues	$184,013	$225,123	$261,511	$338,845	$352,956
Operating expenses	157,687	177,978	209,771	258,132	304,075
Net operating revenue	26,326	47,145	51,740	80,713	48,881
Add:					
Nonoperating revenues—					
Miscellaneous rent revenues, electric	2,806	2,971	5,648	31,293	25,921
Interest and dividend revenues—					
Interest revenue on funded debt					17
Miscellaneous interest revenues	1,073	1,005	1,113		1,926
Dividend revenues					288
Total interest and dividend revenues	1,073	1,005	1,113		2,231
Profits from other corporations operations	32,379	16,916	34,229		316
Total nonoperating revenues	36,258	20,892	40,990		28,467
Gross corporate income	62,584	68,037	92,730	112,006	77,349
Deduct:					
Uncollectible bills	1,867	993	335	683	2,440
Nonoperating revenue deductions—					
Rent expenses	3		1,876	10,384	9,205
Miscellaneous nonoperating expenses			[b] 780		
Uncollectible other operating revenues	147	[c] 41			
Nonoperating taxes					4,296
Total nonoperating revenue deductions	150	[c] 41	2,656	10,384	13,501
Interest accrued on funded debt	48,000	51,746	55,319	56,250	58,187
Other interest deductions	9,203	13,910	18,306	20,488	25,687
Rent deductions—					
Rent for conduits, poles, and other supports, electric	58	16		49	35
Miscellaneous rent deductions		2	2		
Total rent deductions	58	18	2	49	35
Total deductions	59,278	66,626	76,618	87,854	99,851
Surplus for year	3,306	1,411	16,112	24,151	[a] 22,502

[a] Deficit.

[b] Listed as nonoperating taxes.

[c] Credit.

TABLE 284.—*Earnings and expenses, Holton Power Co., 1909–1920*—Continued.

	1919	1920
Electric operations:		
Operating revenues	$503, 224	$664, 064
Operating expenses	418, 270	532, 781
Net operating revenue	84, 954	131, 283
Add:		
Nonoperating revenues—		
Miscellaneous rent revenues	27, 017	27, 654
Miscellaneous interest revenues	1, 440	325
Profits from other operations and miscellaneous	265	1, 002
Total nonoperating revenues	28, 722	30, 981
Gross corporate income	113, 676	160, 264
Deduct:		
Uncollectible bills	720	905
Nonoperating revenue deductions—		
Rent expenses	12, 829	15, 004
Miscellaneous nonoperating expenses	634	1, 012
Uncollectible other operating expenses	....	87
Nonoperating taxes	3, 750	6, 450
Total nonoperating revenue deductions	17, 213	22, 553
Interest accrued on funded debt	58, 583	58, 475
Other interest deductions	32, 635	40, 069
Miscellaneous rent deductions	40	48
Total deductions	109, 191	122, 050
Surplus for year	4, 485	38, 214

TABLE 285.—*Classified electric revenues (according to classification of Railroad Commission of California), Holton Power Co., 1913–1920.*

Class of load.	1913		1914		1915	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenues, electric:						
Municipal street lighting—						
Arc	$2, 715. 22	2. 1	$1, 297. 76	0. 7	....	....
Incandescent	594. 97	. 5	4, 272. 37	2. 3	$7, 236	3. 2
Municipal lighting, miscellaneous	1, 790 69	1. 4	1, 757. 79	1. 0	920	. 4
Municipal power	7, 648. 10	5. 9	7, 842. 85	4. 3	7, 746	3. 4
Commercial lighting—						
Flat rate	454. 50	. 4	453. 00	. 2	226	....
Metered	78, 590. 31	61. 0	6, 231. 20	57. 8	101, 353	45. 2
Commercial power—						
Flat rate	7, 050. 00	5. 5	7, 050. 00	3. 8	....	....
Metered	24, 966. 78	19. 4	49, 565. 98	26. 9	99, 637	44. 3
Other electrical corporations	3, 132. 00	2. 4	3, 887. 00	2. 1	5, 687	2. 5
Total operating revenues, electric	126, 942. 57	98. 6	182, 357. 95	99. 1	222, 806	99. 1
Other operating revenues:						
Rent of electric appliances	27. 00	....	27. 00	....	26	....
Electric merchandise and jobbing revenues	1, 817. 65	1. 4	1, 619. 17	. 9	2, 145	. 9
Sale of by-products	....	....	9. 00	....	145	....
Total other operating revenues	1, 844. 65	1. 4	1, 655. 17	. 9	2, 316	. 9
Gross electric revenues	128, 787. 22	100. 0	184, 013. 12	100. 0	225, 122	100. 0

Table 285.—*Classified electric revenues (according to classification of Railroad Commission of California), Holton Power Co., 1913–1920*—Continued.

Class of load.	1916		1917		1918	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenues, electric:						
Municipal street lighting—						
Incandescent	$8,450	3.2	$10,760	3.1	$11,559	3.2
Municipal lighting, miscellaneous	1,120	.4				
Municipal power	10,085	3.9	11,981	3.2	10,085	3.0
Commercial lighting—						
Flat rate	150					
Metered	114,989	44.0	138,500	41.0	141,856	38.2
Commercial power—						
Metered	116,556	44.4	162,376	47.9	176,300	52.0
Other electrical corporations	8,087	3.1	12,320	4.0	10,137	2.8
Total operating revenues, electric	259,437	99.2	335.937	99.2	349,937	99.2
Other operating revenues:						
Rent of electric appliances	41					
Electric merchandise and jobbing revenues	2,032	.8	2,908	.8	3,019	.8
Total other operating revenues	2,073	.8	2,908	.8	3,019	.8
Gross electric revenues	261,510	100.0	338,845	100.0	352,956	100.0

Class of load.	1919		1920	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric:				
Municipal street lighting, incandescent	$13,868	2.8	$16,230	2.4
Municipal power	10,916	2.2	17,163	2.6
Commercial lighting, metered	199,268	39.6	270,360	40.7
Commercial power, metered	260,325	51.7	325,324	49.1
Other electrical corporations	14,803	2.9	32,745	4.9
Total operating revenues, electric	499,180	99.2	661,822	99.7
Other operating revenues, electric merchandise and jobbing revenues	4,044	.8	2,242	.3
Gross electric revenues	503,224	100.0	664,064	100.0

Table 286.—*Classified electric revenues (according to classification of Railroad Commission of California), Coachella Valley Ice & Electric Co., 1913–1918.*

Class of load.	1913		1914		1915	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenue, electric			$114	0.4	$2,401	2.4
Commercial power, metered			26		6,614	6.7
Other electric corporations			34,947	99.4	89,110	90.7
Total operating revenues, electric			35,087	99.8	98,125	99.8
Other operating revenues: Electric merchandise and jobbing revenues			87	.2	175	.2
Gross electric revenues			35,174	100.0	98,300	100.0

TABLE 286.—*Classified electric revenues (according to classification of Railroad Commission of California), Coachella Valley Ice & Electric Co., 1913–1918*—Continued.

Class of load.	1916		1917		1918 [a]	
	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.	Revenue.	Per cent of gross electric revenues.
Operating revenues, electric:						
Municipal street lighting, arc	....	....	....	....	$63	19.1
Commercial lighting, metered	$4,188	2.9	$4,909	1.9	1,035	1.3
Commercial power, metered	22,126	15.2	52,976	20.7	15,860	....
Other electrical corporations	118,104	71.0	196,557	76.8	65,505	78.7
Total operating revenues, electric	144,418	99.2	254,442	99.4	82,463	99.1
Other operating revenues: Electric merchandise and jobbing revenues	1,192	.8	1,480	.6	786	.9
Gross electric revenues	145,610	100.0	255,923	100.0	82,249	100.0

[a] For three months in 1918. Purchased by The Southern Sierras Power Co. Mar. 31, 1918.

TABLE 287.—*Capitalization, outstanding stock, and dividends of Sierra Pacific Electric Co. and principal subsidiaries.*

[Term of incorporation uniformly 50 years.]

Company and date of incorporation.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.		Dividends.			
					Common.		Preferred.	
			Common.	Preferred.	Rate	Amount.	Rate.	Amount.
					P. ct.		*P. ct.*	
Nevada Power, Light & Water Co., San Francisco (succeeded by Reno Power, Light & Water Co. in 1904); incorporated May 20, 1901.	$400,000	1902	$400,000	....	....	(a)	....	....
		1903	400,000	....	....	(a)	....	....
		1904	....	....	....	(a)	....	....
Truckee River General Electric Co., San Francisco (reincorporated in 1912 as The Truckee River General Electric Co.); incorporated July 1, 1899 (California).	[b]3,000,000	1901–1903	2,500,000	....	....	(a)	....	....
		1904	2,500,000	....	1.2	$30,000	....	....
		1905	3,000,000	....	2.03	61,000	....	....
		1906	3,000,000	....	.8	24,000	....	....
		1907	3,000,000	....	2.2	66,000	....	....
		1908	3,000,000	....	1.4	42,000	....	....
		1909	3,000,000	....	....	....	....	....
		1910	3,000,000	....	7.0	210,000	....	....
		1911	3,000,000	....	4.5	135,000	....	....
		1912	3,000,000	....	1.25	37,500	....	....
The Truckee River General Electric Co., Portland, Me.; incorporated Mar. 13, 1912 (Maine).	[c]3,000,000	1912	3,000,000	....	4.0	120,000	....	....
		1913	3,000,000	....	3.75	112,500	....	....
		1914	3,000,000	....	4.0	120,000	....	....
		1915	3,000,000	....	2.0	60,000	....	....
		1916	3,000,000	....	....	....	....	....
		1917	3,000,000	....	2.0	60,000	....	....
		1918	3,000,000	....	3.0	90,000	....	....
		1919	3,000,000	....	1.5	45,000	....	....
		1920	3,000,000	....	2.25	67,500	....	....
Loon Lake Water & Power Co.,[d] San Francisco; incorporated Nov. 18, 1904 (California).	200,000	1904–1912	200,000	....	....	....	(e)	....
Union Light & Water Co., San Francisco; incorporated Sept. 7, 1905 (California).	2,000,000	1905–1912	2,000,000	....	....	....	(e)	....

NOTE.—Dividend figures for various operating companies from 1913 to 1916 are for years ending June 30, not Dec. 31.

[a] No record.

[b] Originally incorporated for $2,500,000. Increased to $3,000,000 in 1905.

[c] All owned by Sierra Pacific Electric Co.

[d] Company no longer in existence.

[e] Dissolved about 1912.

TABLE 287.—*Capitalization, outstanding stock, and dividends of Sierra Pacific Electric Co. and principal subsidiaries*—Continued.

Company and date of incorporation.	Capitalization.	Year (Dec. 31).	Par value of stock outstanding.		Dividends.			
					Common.		Preferred.	
			Common.	Preferred.	Rate.	Amount.	Rate.	Amount.
					P. ct.		*P. ct.*	
California-Nevada Electric Power Co.,[f] San Francisco; incorporated Feb. 2, 1907 (California).	$10,000,000	1907–1912	$5,000,000	....	......	....	......	....
Sierra Pacific Electric Co., San Francisco; incorporated July 22, 1909 (Maine).	11,500,000	1909	8,000,000	$3,500,000	......	....	......	....
		1910	8,000,000	3,500,000	......	....	6	[g]$262,500
		1911–1914	8,000,000	3,500,000	......	....	6	210,000
		1915	8,000,000	3,500,000	......	....	5	175,000
		1916	8,000,000	3,500,000	......	....	4	140,000
		1917	8,000,000	3,500,000	......	....	6	210,000
		1918	8,000,000	3,500,000	......	....	6	210,000
		1919	8,000,000	3,500,000	......	....	6	210,000
		1920	8,000,000	3,500,000	......	....	6	210,000
Reno Power Light & Water Co., San Francisco; incorporated Mar. 7, 1904 (California).	[c]1,000,000	1905–1909	1,000,000	....	......	(a)	......	....
		1910	1,000,000	....	10.5	$105,000	......	....
		1911	1,000,000	....	7.5	75,000	......	....
		1912	1,000,000	....	8.0	80,000	......	....
		1913	1,000,000	....	4.5	45,000	......	....
		1914	1,000,000	....	9.0	90,000	......	....
		1915	1,000,000	....	10.25	102,500	......	....
		1916	1,000,000	....	9.5	95,000	......	....
		1917	1,000,000	....	10.0	100,000	......	....
		1918	1,000,000	....	10.0	100,000	......	....
		1919	1,000,000	....	7.5	75,000	......	....
		1920	1,000,000	....	10.0	100,000	......	....
Washoe Power & Development Co.; incorporated in 1905 (Nevada).	300,000	1905–1912	300,000	....	......	....	......	....
Hunter Creek Water Co.; incorporated in 1904 (Nevada).	....	1906–1912	321,050	....	......	....	......	....
		1913–1917	360,650	....	......	....	......	....
Washoe Deep Well Water Co.;[d] incorporated in 1904 (Nevada).	109,437	1905–1912	109,437	....	......	....	......	....
Carson City Coal Gas Co.; incorporated in 1874 (Nevada).	[c]50,000	1900–1920	50,000	....	......	....	......	....

[a] No record.

[c] All owned by Sierra Pacific Electric Co.

[d] Company no longer in existence.

[f] All property transferred in 1912 to The Truckee River General Electric Co.; company no longer in existence.

[g] Includes dividend not declared on Nov. 1, 1909.

TABLE 288.—*Bonds of Sierra Pacific Electric Co. and subsidiaries.*

Issue.	Callable or convertible.	Sinking-fund deposits.	Denomination.	Trustee.
1	2	3	4	5
1. Reno Power, Light & Water Co. first consolidated 6 per cent bonds, dated Mar. 16, 1904; due July 1, 1944; interest payable Jan. 1 and July 1.	As a whole or in part (also in part for sinking fund) at 110 and interest, decreasing to 100½ prior to maturity.	Mortgage provides for a sinking fund of 1 per cent per annum of bonds issued; payable Apr. 1, and increasing to 1.7 per cent at maturity.	....	Mercantile Trust Co., San Francisco.
2. Nevada Power, Light & Water Co. first-mortgage 6 per cent bonds (assumed by Reno Power, Light & Water Co.); bonds dated Apr. 1, 1902; due Apr. 1, 1932; interest payable Apr. 1 and Oct. 1.	As a whole or in part (also in part for sinking funds) at 107½ and interest, decreasing to 100¼ prior to maturity.	Mortgage provides for a sinking fund of 2 per cent per annum of bonds issued; payable Apr. 1, increasing to 3 per cent at maturity.	....	Do.

TABLE 288.—*Bonds of Sierra Pacific Electric Co. and subsidiaries*—Continued.

Issue.	Callable or convertible.	Sinking-fund deposits.	Denomination.	Trustee.
1	2	3	4	5
3. Sierra Pacific Electric Co. three-year 6 per cent gold notes, dated Sept. 2, 1913; due Sept. 1, 1916; interest payable Mar. 1 and Sept. 1.	As a whole or in part, at par and interest, at any time on 30 days' notice.	....	$1,000 and $500 coupon.	State Street Trust Co., Boston, Mass.
4. Sierra Pacific Electric Co. three-year 6 per cent gold notes, dated Apr. 1, 1916; due Apr. 1, 1919; interest payable Apr. 1 and Oct. 1.	.....do.....................	....	.....do........	Do.
5. Sierra Pacific Electric Co. three-year 7 per cent coupon notes, dated Feb. 1, 1919; due Feb. 1, 1922; interest payable Feb. 1 and Aug. 1.	As a whole or in part at 101 and interest prior to Feb. 1, 1921, and at par and interest thereafter.	....	$1,000, $500, $100; may be registered as to principal.	Do.

	Authorized.	Bonded debt.					Remarks.
		Year.	Reserved for prior liens.	Alive in sinking fund.	In hands of public.	Total authenticated.	
1	6	7	8	9	10	11	12
1	$750,000	1904–1912	$300,000	....	....	$450,000	Bonds of Reno Power, Light & Water Co. are reserved to cover outstanding bonds of Nevada Power, Light & Water Co.; these bonds are held in the treasury and have not been issued.
		1913	221,000	$4,000	$446,000	450,000	$79,000 unissued in addition to those reserved.
		1914	221,000	8,000	442,000	450,000	Do.
		1915	219,000	41,000	409,000	450,000	$81,000 unissued in addition to those reserved.
		1916	218,000	43,000	407,000	450,000	$82,000 unissued in addition to those reserved.
		1917	216,000	44,000	406,000	450,000	$84,000 unissued in addition to those reserved.
		1918	215,000	62,000	388,000	450,000	$85,000 unissued in addition to those reserved.
		1919	211,000	64,000	386,000	450,000	$89,000 unissued in addition to those reserved.
		1920	210,000	72,000	378,000	450,000	$90,000 unissued in addition to those reserved.
2	300,000	1902–1903	....	....	....	....	
		1904–1912	....	....	....	300,000	
		1913	....	79,000	221,000	300,000	
		1914	....	79,000	221,000	300,000	
		1915	....	81,000	219,000	300,000	
		1916	....	82,000	218,000	300,000	
		1917	....	84,000	216,000	300,000	
		1918	....	85,000	215,000	300,000	
		1919	....	90,000	210,000	300,000	
		1920	....	89,000	211,000	300,000	
3	600,000	1913	....	....	....	400,000	Not secured by mortgage, but no new mortgage can be placed on property unless these notes are secured equally with bonds issued thereunder.
		1914	....	....	....	400,000	
		1915	....	....	....	400,000	
4	500,000	1916	....	....	350,000	350,000	
		1917	....	....	350,000	350,000	
		1918	....	....	350,000	350,000	
5	500,000	1919–1920	....	....	400,000	400,000	

TABLE 289.—*Comparative balance sheet of Sierra Pacific Electric Co., 1910–1920.*

	1910	1911	1912	1913	1914
ASSETS.					
Plant and properties	$12,993,232.99	$13,841,788.28	$13,845,372.64	$13,922,999	$13,984,061
Materials and supplies	27,476.44	33,552.53	35,975.60	37,188	33,201
Advance payments	1,848.90	4,407.38	4,757.73	18,655	12,842
Notes receivable	....	....	....	193,762	164,335
Accounts receivable	122,348.05	98,974.79	122,597.09		
Accounts special	....	....	....	....	....
Sinking fund investments	61,903.51	72,638.51	87,458.51	98,979	115,629
Suspense	11,055.31	25,671.40	26,376.60	5,565	227
Cash	450,896.14	70,076.07	86,792.55	46,469	70,892
Total assets	13,668,761.34	14,147,108.96	14,209,330.72	14,323,617	14,381,187
LIABILITIES.					
Common stock	8,000,000.00	8,000,000.00	8,000,000.00	8,000,000	8,000,000
Preferred stock	3,500,000.00	3,500,000.00	3,500,000.00	3,500,000	3,500,000
Outstanding stock—subsidiary companies	5,500.00	5,500.00	5,500.00	5,500	5,500
Bonds:					
Reno Power, Light & Water Co	750,000.00	750,000.00	450,000.00	450,009	450,000
Nevada Power, Light & Water Co	....	....	300,000.00	300,000	300,000
	750,000.00	750,000.00	750,000.00	750,000	750,000
Coupon notes	....	....	....	400,000	400,000
Notes payable	....	350,000.00	385,000.00	16,142	125,361
Accounts payable	18,728.07	14,778.83	16,049.94		
Accounts not yet due	67,091.61	98,440.51	80,344.78	88,515	86,575
Suspense	47,981.83	39,987.51	45,215.30	44,483	91,869
Bond sinking fund	61,903.51	72,638.51	87,458.51	98,978	115,629
Replacement reserve	44,000.00	97,650.00	96,975.00	35,234	30,262
Reserves and surplus	1,173,556.32	1,218,113.60	1,242,787.19	1,334,762	1,275,991
Total liabilities	13,668,761.34	14,147,108.96	14,209,330.72	14,323,617	14,381,187

	1915	1916	1917	1918	1919	1920
ASSETS.						
Plant and properties	$13,771,446	$13,879,290	$13,994,030	$13,998,316	$14,046,019	$14,132,932
Materials and supplies	30,724	58,320	61,240	81,116	71,945	74,175
Advance payments	4,749	12,463	7,481	1,079	14,682	9,880
Notes receivable	209,571	2,939	2,974	70	495	9
Accounts receivable		67,723	86,203	101,220	87,520	101,855
Accounts special	....	194,574	259,656	318,578	7,374	....
Sinking-fund investments	131,393	148,821	169,074	190,178	212,079	235,529
Suspense	1,366	681	233	267	301	2
Cash	145,771	119,079	46,843	a 76,576	77,762	59,446
Investment securities	....	....	....	....	870	....
Total assets	14,295,019	14,483,890	14,627,734	14,767,401	14,519,047	14,613,828
LIABILITIES.						
Common stock	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000
Preferred stock	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000
Outstanding stock—subsidiary companies	5,500	5,500	5,500	5,500	5,500	5,500
Bonds:						
Reno Power, Light & Water Co	450,000	450,000	450,000	450,000	450,000	450,000
Nevada Power, Light & Water Co	300,000	300,000	300,000	300,000	300,000	300,000
	750,000	750,000	750,000	750,000	750,000	750,000
Coupon notes	400,000	350,000	350,000	350,000	400,000	400,000
Notes payable	149,971	25,000	30,000	30,000	....	50,000
Accounts payable		16,271	29,235	16,470	20,371	18,374
Accounts not yet due	105,554	87,103	69,527	62,729	70,996	74,521
Suspense	64,393	51,707	39,640	40,626	47,714	39,614
Accounts receivable not included in earnings	....	194,574	259,656	318,578	7,374	....
Bond sinking fund	131,393	....	....	....	....	....
Operating reserves	....	....	11,075	15,406	15,228	17,634
Replacement reserve	57,894	215,033	215,338	236,277	279,647	348,619
Reserves and surplus	1,130,314	1,288,702	1,367,763	1,441,814	1,422,218	1,409,567
Total liabilities	14,295,019	14,483,890	14,627,734	14,767,401	14,519,047	14,613,828

a Includes $11,096 Liberty bonds and war savings stamps.

TABLE 290.—*Earnings and expenses of Sierra Pacific Electric Co. and subsidiaries, 1909–1920.*

Sierra Pacific Electric Co., 1909–1920.

Year.	Gross earnings.	Operating expenses.	Net earnings.	Other income.	Bond interest, etc.	Sinking fund.	Preferred dividend.	Surplus for year.
1909	$519,839	a$208,941	$310,898	....	....	....	....	....
1910	558,508	a 202,961	355,547	....	$45,100	$7,500	$210,000	$92,947
1911	571,526	a 226,804	344,722	$18,657	46,725	8,625	210,000	98,029
1912	634,897	a 236,603	398,294	4,513	61,502	9,000	210,000	122,304
1913	647,571	a 262,119	385,452	4,513	70,770	9,675	210,000	99,520
1914	592,331	a 258,552	333,779	4,513	80,904	9,900	210,000	37,488
1915	494,770	a 215,059	279,710	4,512	15,531	13,430	175,000	20,262
1916	584,961	a 249,010	335,951	....	66,043	18,469	140,000	111,439
1917	681,133	a 317,696	363,437	....	62,956	18,993	210,000	71,488
1918	721,297	a 354,760	366,537	....	62,902	19,794	210,000	73,841
1019	681,891	379,752	302,139	....	71,229	....	210,000	20,910
1920	779,244	439,527	339,717	....	72,448	....	210,000	57,269

The Truckee River General Electric Co. and Reno Power, Light & Water Co., 1911–1920.

	1911			1912		
	Truckee River General Electric Co.	Reno Power Light & Water Co.	Total.	The Truckee River General Electric Co.	Reno Power, Light & Water Co.	Total.
Operating revenues, electric:						
Commercial lighting earnings	$53,404.79	$127,731.02	$181,135.81	$52,973.00	$133,473.09	$186,446.09
Municipal contract lighting earnings	2,511.00	10,558.80	13,069.80	3,090.30	9,666.75	12,757.05
Commercial power earnings	180,536.55	36,801.75	217,338.30	225,768.41	32,163.08	257,931.49
Sales of electric current to other public utilities	15,000.00	....	15,000.00	15,000.00	....	15,000.00
Total operating revenues, electric	251,452.34	175,091.57	426,543.91	296,831.71	175,302.92	472,134.63
Operating revenues, gas: Commercial earnings	....	40,235.55	40,235.55	....	42,054.80	42,054.80
Operating revenues, water:						
Industrial sales earnings	....	85,906.40	85,906.40	....	87,838.28	87,838.28
Rent from municipal hydrant	....	3,246.10	3,246.10	....	3,401.50	3,401.50
Total operating revenues, water	....	89,152.50	89,152.50	....	91,239.78	91,239.78
Gross operating revenue	251,452.34	304,479.62	555,931.96	296,831.71	308,597.50	605,429.21
Operating expenses, electric:						
Power	23,099.40	31,450.65	54,550.05	29,866.25	28,955.43	58,821.68
Transmission and transformation	6,369.17	3,392.28	9,761.45	7,673.43	2,807.57	10,481.00
Distribution	8,086.07	10,037.06	18,123.13	11,312.34	11,421.00	22,733.34
Consumption	1,968.73	3,588.43	5,557.16	1,770.66	2,921.92	4,692.58
Commercial	1,500.00	1,970.40	3,470.40	1,500.00	2,000.00	3,500.00
General	16,822.80	19,795.12	36,617.92	21,939.34	21,764.84	43,704.18
Undistributed	1,911.25	1,394.13	3,305.38	5,855.49	1,502.67	7,358.16
Total operating expenses, electric	59,757.42	71,628.07	131,385.49	79,917.51	71,373.43	151,290.94

a Includes taxes.

TABLE 290.—*Earnings and expenses of Sierra Pacific Electric Co. and subsidiaries, 1909–1920*—Continued.

	1911			1912		
	Truckee River General Electric Co.	Reno Power, Light & Water Co.	Total.	The Truckee River, General Electric Co.	Reno Power, Light & Water Co.	Total.
Operating expenses, gas:						
Production	....	$17,570.81	$17,570.81	....	14,971.65	14,971.65
Distribution	....	5,519.19	5,519.19	....	9,066.71	9,066.71
Commercial	....	443.71	443.71	....	1,778.83	1,778.83
General	....	6,627.46	6,627.46	....	5,571.54	5,571.54
Undistributed	....	226.23	226.23	....	150.58	150.58
Total operating expenses, gas	....	30,387.40	30,387.40	....	31,539.31	31,539.31
Operating expenses, water						
Distribution	....	15,320.09	15,320.09	....	$14,725.56	$14,725.56
Commercial	....	1,130.80	1,130.80	....	1,000.00	1,000.00
General	....	8,230.30	8,230.30	....	10,011.65	10,011.65
Undistributed	....	63.38	63.38	....	65.00	65.00
Total operating expenses, water	....	24,744.57	24,744.57	....	25,802.21	25,802.21
Taxes	$8,902.71	11,044.64	19,947.35	$11,888.94	11,618.20	23,507.14
Gross operating expenses	68,660.13	137,804.68	206,464.81	91,806.45	140,333.15	232,139.60
Net operating revenue	182,792.21	166,674.94	349,467.15	205,025.26	168,264.35	373,289.61
Nonoperating revenues:						
Electric	282.92	9,961.73	10,244.65	681.86	14,339.77	15,021.63
Gas	....	176.72	176.72	....	268.92	268.92
Water	....	382.20	382.20	....	497.15	497.15
Gross income	183,075.13	177,195.59	360,270.72	205,707.12	183,370.19	389,077.31
Deductions from gross income:						
Loss on operation of water company in California	....	....	....	469.84	....	469.84
Interest on funded debt	....	45,000.00	45,000.00	....	45,000.00	45,000.00
Interest on floating debt	11,844.19	4,596.00	16,440.19	43,434.23	1,101.31	44,535.54
Miscellaneous deductions, replacement reserve	....	....	....	31,000.00	....	31,000.00
Contractual sinking fund requirements	....	7,875.00	7,875.00	....	9,000.00	9,000.00
Rental Washoe Power & Development Co	....	12,500.00	12,500.00	....	12,500.00	12,500.00
Rental Washoe Deep Well Water Co	....	2,500.00	2,500.00	....	2,500.00	2,500.00
Total deductions	11,844.19	72,471.00	84,315.19	74,904.07	70,101.31	145,005.38
Net income	171,230.94	104,724.59	275,955.53	130,803.05	113,268.88	244,071.93
Disposition of net income:						
Common stock dividends	135,000.00	75,000.00	210,000.00	157,500.00	80,000.00	237,500.00
Replacement reserve	6,000.00	....	6,000.00	....	24,000.00	24,000.00
Total	141,000.00	75,000.00	216,000.00	157,500.00	104,000.00	261,500.00
Surplus for year	30,230.94	29,724.59	59,955.53	....	9,268.88	....
Deficit for year	....	....	....	26,696.95	....	17,428.07

TABLE 290.—*Earnings and expenses of Sierra Pacific Electric Co. and subsidiaries, 1909–1920*—Continued.

	1913			1914		
	The Truckee River General Electric Co.	Reno Power, Light & Water Co.	Total.	The Truckee River General Electric Co.	Reno Power Light & Water Co.	Total.
Operating revenues, electric:						
Commercial lighting earnings	$48,763.29	$130,142.97	$178,906.26	$44,470.29	$130,230.69	$174,700.98
Municipal contract lighting earnings	3,469.50	11,425.45	14,894.95	3,429.85	10,410.65	13,840.50
Commercial power earnings	263,950.82	40,450.35	304,401.17	271,404.29	28,159.05	299,563.34
Municipal power earnings	....	....	....	....	365.30	365.30
Sales of electric current to other public utilities	15,000.00	....	15,000.00	15,000.00	8,856.95	23,856.95
Miscellaneous earnings from operation	36.16	....	36.16	29.50	....	29.50
Total operating revenues, electric	331,219.77	182,018.77	513.238.54	334,333.93	178,022.64	512,356.57
Operating revenues, water	....	93,156.75	93,156.75	....	95,567.62	95,567.62
Gross operating revenue	331,219.77	275,175.52	606,395.29	334,333.93	273,590.26	607,924.19
Operating expenses, electric:						
Power	36,180.33	32,159.78	68,340.11	28,581.85	27,625.71	56,207.36
Transmission and transformation	11,012.12	2,879.01	13,891.13	13,609.61	3,074.32	16,683.93
Distribution	9,866.98	10,320.69	20,187.67	6,603.89	8,155.52	14,759.41
Consumption	1,973.27	2,460.90	4,434.17	1,515.22	2,008.82	3,524.04
Commercial	3,775.24	2,370.60	6,145.84	6,169.28	8,526.75	14,696.03
General	26,941.44	21,810.43	48,751.87	27,320.06	19,186.90	46,506.96
Undistributed	1,698.58	1,440.86	3,139.44	8,748.48	2,803.25	11,551.73
Total operating expenses, electric	91,447.96	73,442.27	164,890.23	92,548.39	71,381.27	163,929.66
Operating expenses, water:						
Distribution	....	15,851.21	15,851.21	....	21,047.65	21,047.65
Commercial	....	2,000.00	2,000.00	....	2,000.00	2,000.00
General	....	9,732.49	9,732.49	....	9,591.66	9,591.66
Undistributed	....	69.16	69.16	....	447.56	447.56
Total operating expenses, water	....	27,652.86	27,652.86	....	33,086.87	33,086.87
Taxes	15,102.73	9,952.58	25,055.31	18,837.32	17,596.02	36,433.34
Gross operating expenses	106,550.69	111,047.71	217,598.40	111,385.71	122,064.16	233,449.87
Net operating revenue	224,669.08	[b]174,975.09	[b]399,644.17	[b]222,948.22	[c]169,996.00	[c]392,944.22
Nonoperating revenues:						
Electric	236.91	7,727.22	7,964.13	[d]656.85	5,239.78	5,896.63
Water	....	60.46	60.46	....	3,188.60	3,188.60
Gross income	224,905.99	182,762.77	407,668.76	223,605.07	178,424.38	402,029.45
Deductions from gross income:						
Loss on operation of water company in California	[e]909.82	....	[e]909.82	[f]92,853.26	....	92,853.26
Interest on funded debt	....	45,000.00	45,000.00	....	45,000.00	45,000.00
Interest on floating debt	89,470.79	1,272.69	89,743.48	87,263.01	472.41	87,735.42
Miscellaneous deductions, replacement reserve	....	....	....	979.35	....	979.35
Contractual sinking-fund requirements	....	9,225.00	9,225.00	....	9,900.00	9,900.00
Rental Washoe Power & Development Co	....	12,500.00	12,500.00	....	12,500.00	12,500.00
Rental Washoe Deep Well Water Co	....	2,500.00	2,500.00	....	2,500.00	2,500.00
Total deductions	88,560.97	70,497.69	159,058.66	181,095.62	70,372.41	251,468.03
Net income	136,345.02	112,265.08	248,610.10	42,509.45	108,051.97	150,561.42
Disposition of net income:						
Common stock dividends	112,500.00	45,000.00	157,500.00	120,000.00	90,000.00	210,000.00
Replacement reserve	....	4,559.00	4,559.00	....	6,362.50	6,362.50
Total	112,500.00	49,559.00	162,059.00	120,000.00	96,362.50	216,362.50
Surplus for year	23,845.02	62,706.08	86,551.10	....	11,689.47	....
Deficit for year	....	....	....	77,490.55	....	65,801.08

[b] Including $10,847.28 net earnings of gas department.
[c] Including $18,469.90 net earnings of gas department.
[d] Including $414.42 net earnings of water department.
[e] Credit item.
[f] $92,853.26 uncollectible accounts.

Table 290.—*Earnings and expenses of Sierra Pacific Electric Co. and subsidiaries, 1909–1920*—Continued.

	1915			1916		
	The Truckee River General Electric Co.	Reno Power, Light & Water Co.	Total.	The Truckee River General Electric Co.	Reno Power, Light & Water Co.	Total.
Operating revenues, electric:						
Commercial lighting earnings	$42,208.48	$131,596.03	$173,804.51	$39,448.36	$141,264.46	$180,712.82
Municipal contract lighting earnings	3,641.00	10,612.00	14,253.00	2,728.90	10,162.30	12,891.20
Commercial power earnings	113,472.11	28,724.61	142,196.72	127,093.05	31,687.38	158,780.43
Municipal power earnings	....	161.60	161.60	....	10.60	10.60
Sales of electric current to other public utilities	15,000.00	6,280.45	21,280.45	15,000.00	8,082.35	23,082.35
Miscellaneous earnings from operation	201.49	....	201.49	....	....	....
Total operating revenues, electric	174,523.08	177,374.69	351,897.77	184,270.31	191,207.09	375,477.40
Operating revenues, water	....	98,623.35	98,623.35	....	102,756.35	102,756.35
Gross operating revenue	174,523.08	275,998.04	450,521.12	184,270.31	293,963.44	478,233.75
Operating expenses, electric:						
Power	20,105.50	24,608.49	44,713.99	18,657.89	26,917.66	45,575.55
Transmission and transformation	4,837.79	3,245.58	8,083.37	5,880.31	3,038.39	8,918.70
Distribution	3,707.18	8,394.57	12,101.75	5,124.47	6,300.65	11,425.12
Consumption	635.80	1,195.79	1,831.59	1,243.02	1,451.15	2,694.17
Commercial	7,580.88	8,644.68	16,225.56	9,989.24	12,248.36	22,237.60
General	20,064.15	18,047.99	38,112.14	18,793.92	20,856.25	39,650.17
Undistributed	5,017.57	1,553.78	6,571.34	1,741.65	1,512.74	3,254.39
Total operating expenses, electric	61,948.87	65,690.88	127,639.74	61,430.50	72,325.20	133,755.70
Operating expenses, water:						
Distribution	....	13,628.85	13,628.85	....	19,455.62	19,455.62
Commercial	....	2,000.00	2,000.00	....	2,225.12	2,225.12
General	....	9,773.90	9,773.90	....	10,933.46	10,933.94
Undistributed	....	333.21	333.21	....	335.19	335.19
Total operating expenses, water	....	[g] 25,774.05	[g] 25,774.05	....	[h] 33,628.21	[h] 33,628.21
Taxes	17,902.92	25,211.71	43,114.63	13,315.82	24,533.24	37,849.06
Gross operating expenses	79,851.79	116,676.63	196,528.42	74,746.32	130,486.65	205,232.97
Net operating revenue	94,671.29	[i]161,915.15	[i]256,586.44	109,523.99	[j]187,513.37	297,037.36
Nonoperating revenues:						
Electric	[k] 151.04	4,317.32	4,166.28	3,149.19	9,392.21	12,541.40
Water	....	3,040.23	3,040.23	....	102.84	102.84
Gross income	94,520.25	169,272.70	263,792.95	112,673.18	197,008.42	309,681.60
Deductions from gross income:						
Interest on funded debt	....	45,000.00	45,000.00	....	37,760.00	37,760.00
Interest on floating debt	93,046.25	896.12	93,942.37	87,163.61	15,401.87	102,565.48
Miscellaneous deductions, replacement reserve	30,000.00	....	30,000.00	....	....	....
Contractual sinking fund requirements	....	9,900.00	9,900.00	....	17,515.00	17,515.00
Rental Washoe Power & Development Co	....	12,500.00	12,500.00	....	1,250.00	1,250.00
Rental Washoe Deep Well Water Co	....	2,500.00	2,500.00	....	....	....
Total deductions	123,046.25	70,796.12	193,842.37	87,163.61	71,926.87	159,090.48
Net income	[k]28,526.00	98,476.58	69,950.58	25,509.57	125,081.55	150,591.12
Disposition of net income:						
Common stock dividends	60,000.00	102,500.00	162,500.00	....	95,000.00	95,000.00
Replacement reserve	....	4,615.09	4,615.09	29,615.64	2,500.00	32,115.64
Total	60,000.00	107,115.09	167,115.09	29,615.64	97,500.00	127,115.64
Surplus for year	....	....	....	....	27,581.55	....
Deficit for year	88,526.00	8,638.51	97,164.51	4,106.07	....	23,475.48

[g] Including $38.09 pumping expenses.
[h] Including $678.82 pumping expenses.
[i] Including $2,593.74 net earnings of gas departmetnt.
[j] Including $24,036.58 net earnings of gas department.
[k] Deficit.

TABLE 290.—*Earnings and expenses of Sierra Pacific Electric Co. and subsidiaries, 1909–1920*—Continued.

	1917			1918		
	The Truckee River General Electric Co.	Reno Power, Light & Water Co.	Total.	The Truckee River General Electric Co.	Reno Power, Light & Water Co.	Total.
Operating revenues, electric:						
Commercial lighting earnings	$44,174.61	$154,487.52	$198,662.13	$41,967.84	$148,600.90	$190,568.74
Municipal contract lighting earnings	2,935.19	11,103.75	14,038.94	2,712.17	11,727.50	14,439.67
Commercial power earnings	234,011.18	33,643.67	267,654.85	268,279.04	35,773.14	304,052.18
Municipal power earnings	....	475.55	475.55	....	405.40	405.40
Sales of electric current to other public utilities	15,000.00	8,370.45	23,370.45	15,000.00	9,029.88	24,029.88
Miscellaneous earnings from operation	[l] 6,550.61	[m] 1,638.44	[l m] 8,189.05	[m] 7,189.62	[m] 1,541.74	[m] 8,731.36
Total operating revenues, electric	289,570.37	206,442.50	496,012.87	320,769.43	203,995.08	524,764.51
Operating revenues, water	....	103,152.70	103,152.70	....	112,233.41	112,233.41
Gross operating revenue	289,570.37	309,595.20	599,165.57	320,769.43	316,228.49	636,997.92
Operating expenses, electric:						
Power	29,149.51	32,211.66	61,361.17	37,354.11	35,642.69	72,996.80
Transmission and transformation	17,152.65	4,630.07	21,782.72	19,910.14	4,393.38	24,303.52
Distribution	8,160.12	7,621.81	15,721.93	6,735.28	9,110.55	15,845.83
Consumption	1,908.27	2,525.25	4,433.52	659.43	2,382.20	3,041.63
Commercial	8,923.07	11,590.79	20,513.86	8,219.32	10,796.92	19,016.24
General	21,788.32	20,486.57	42,274.89	23,932.40	21,812.84	45,745.24
Undistributed	1,767.52	1,501.71	3,269.23	3,700.20	1,673.22	5,373.42
Total operating expenses, electric	88,849.46	80,567.86	169,417.32	100,690.88	85,811.80	186,502.68
Operating expenses, water:						
Pumping	....	222.80	222.80	....	1,012.54	1,012.54
Distribution	....	31,895.54	31,895.54	....	25,509.56	25,509.56
Commercial	....	3,971.96	3,971.96	....	1,958.08	1,958.08
General	....	14,948.37	14,948.37	....	14,940.49	14,940.49
Undistributed	....	551.94	551.94	....	620.19	620.19
Total operating expenses, water	....	51,590.61	51,590.61	....	44,040.86	44,040.86
Taxes	19,850.98	31,995.60	51,846.58	27,789.25	41,938.90	69,728.15
Gross operating expenses	108,700.44	164,154.07	272,854.51	128,480.13	171,791.56	300,271.69
Net operating revenue	180,869.93	145,441.13	326,311.06	192,289.30	144,436.93	336,726.23
Nonoperating revenues:						
Electric	9,759.99	4,581.07	14,341.06	7,475.04	7,484.03	14,959.07
Water	....	103.53	103.53	....	724.26	724.26
Gross income	190,629.92	150,125.73	340,755.65	199,764.34	152,645.22	352,409.56
Deductions from gross income:						
Interest on funded debt	....	37,407.33	37,407.33	....	36,606.33	36,606.33
Interest on floating debt	89,017.70	13,891.64	102,909.34	87,231.73	21,641.33	108,873.06
Miscellaneous deductions, replacement reserve	....	18,992.67	18,992.67	....	19,793.67	19,793.67
Total deductions	89,017.70	70,291.64	159,309.34	87,231.73	78,041.33	165,273.06
Net income	101,612.22	79,834.09	181,446.31	112,532.61	74,603.89	187,136.50
Disposition of net income: Common stock dividends	60,000.00	100,000.00	160,000.00	90,000.00	100,000.00	190,000.00
Surplus for year	41,612.22	[k] 20,165.91	21,446.31	22,532.61	[k] 25,396.11	[k] 2,863.50

[k] Deficit.
[l] Miscellaneous adjustments during year.
[m] Discounts and adjustments.

TABLE 290.—*Earnings and expenses of Sierra Pacific Electric Co. and subsidiaries, 1909–1920*—Continued.

	1919			1920		
	The Truckee River General Electric Co.	Reno Power, Light & Water Co.	Total.	The Truckee River General Electric Co.	Reno Power, Light & Water Co.	Total.
Operating revenue, electric:						
Commercial lighting earnings	$44,828.78	$152,217.79	$197,046.57	$48,053.35	$178,273.75	$226,327.10
Municipal contract lighting earnings	2,693.08	11,870.40	14,563.42	3,327.80	12,036.50	15,364.30
Commercial power earnings	207,772.34	40,618.76	248,391.10	214,138.88	48,662.92	262,801.80
Municipal power earnings	....	184.30	184.30	193.57	409.95	603.52
Sales of electric current to other public utilities	15,000.00	7,072.90	22,072.90	16,150.60	4,652.41	20,803.01
Miscellaneous earnings from operation	....	....	....	....	102.00	102.00
Discounts and adjustments	k12,894.84	k2,414.87	k15,309.71	k7,473.05	k2,279.27	k9,752.32
Total operating revenues, electric	257,399.30	209,549.28	466,948.58	274,391.15	241,858.26	516,249.41
Operating revenues, water	....	114,452.51	114,452.51	....	128,816.00	128,816.00
Operating revenues, gas:						
Commercial earnings	....	92,083.02	92,083.02	....	118,887.86	118,887.86
Discounts and adjustments	....	k6,901.24	k6,901,24	....	k8,678.61	k8,678.61
Total operating revenues, gas	....	85,181.78	85,181.78	....	110,209.25	110,209.25
Gross operating revenue	257,399.30	409,183.57	666,582.87	274,391.15	480,883.51	755,274.66
Operating expenses, electric:						
Power	26,261.09	32,160.70	58,421.79	32,273.83	33,393.46	65,667.29
Transmission and transportation	14,106.80	3,661.36	17,768.16	12,191.05	5,333.64	17,524.69
Distribution	7,709.67	9,719.46	17,429.13	8,774.73	12,069.40	20,844.13
Consumption	548.44	1,992.19	2,540.63	872.76	2,732.75	3,605.51
Commercial	8,086.55	11,257.39	19,343.94	9,253.80	13,262.02	22,515.82
General	21,777.51	21,707.51	43,485.02	25,130.45	22,869.85	48,000.30
Undistributed	3,220.30	1,582.17	4,802.47	4,393.42	1,787.93	6,181.35
Total operating expenses, electric	81,710.36	82,080.78	163,791.14	92,890.04	91,449.05	184,339.09
Operating expenses, water:						
Pumping	....	646.48	646.48	....	570.81	570.81
Distribution	....	25,265.86	25,265.86	....	30,940.58	30,940.50
Commercial	....	1,936.42	1,936.42	....	728.40	728.40
General	....	15,590.94	15,590.94	....	26,385.95	26,385.95
Undistributed	....	535.25	535.25	....	1,310.81	1,310.81
Total operating expenses, water	....	43,974.95	43,974.95	....	59,936.55	59,936.55
Operating expenses, gas:						
Production	....	40,260.89	40,260.89	....	48,675.85	48,675.85
Distribution	....	10,352.04	10,352.04	....	14,856.20	14,856.20
Commercial	....	6,468.91	6,468.91	....	9,214.31	9,214.31
General	....	6,520.13	6,520.13	....	9,753.09	9,753.09
Undistributed	....	489.77	489.77	....	592.16	592.16
Total operating expenses, gas	....	64,091.74	64,091.74	....	83,091.61	83,091.61
Taxes	43,287.73	57,693.15	100,980.88	35,419.33	61,037.13	96,456.46
Gross operating expenses and taxes	124,998.09	247,840.62	372,838.71	128,309.37	295,514.34	423,823.71
Net operating revenue	132,401.21	161,342.95	293,744.16	146,081.78	185,369.17	331,450.95
Nonoperating revenues:						
Gas	....	209.59	209.50	....	1,834.03	1,834.03
Water department, California	k3,691.37	....	k3,691.37	k54.63	....	k54.63
Electric	8,200.06	6,997.93	15,198.79	8,818.61	7,997.98	16,816.59
Water	....	83.56	83.56	....	30.39	30.39
Gross income	136,910.70	168,634.03	305,544.73	154,845.76	195,231.57	350,077.33
Deductions from gross income:						
Contractural sinking-fund requirements	....	3,370.00	3,370.00	....	....	....
Interest on funded debt	....	35,972.16	35,972.16	....	35,489.32	35,489.32
Interest on floating debt	87,556.16	24,211.99	111,768.15	87,668.91	24,558.19	112,227.10
Total deductions	87,556.16	63,554.15	151,110.31	87,668.91	60,047.51	147,716.42
Net income	49,354.54	105,079.88	154,434.42	67,176.85	135,184.06	202,360.91

k Deficit.

TABLE 290.—*Earnings and expenses of Sierra Pacific Electric Co. and subsidiaries, 1909–1920*—Continued.

	1919			1920		
	The Truckee River General Electric Co.	Reno Power, Light & Water Co.	Total.	The Truckee River General Electric Co.	Reno Power, Light & Water Co.	Total.
Disposition of net income:						
Dividends on capital stock	$45,000.00	$75,000.00	$120,000.00	$67,500.00	$100,000.00	$167,500.00
Appropriation from replacement reserve	20,000.00	20,000.00	40,000.00	35,000.00	35,000.00	70,000 00
Total	65,000.00	95,000.00	160,000.00	102,500.00	135,000.00	237,500.00
Surplus or deficit	[k]15,645.46	10,079.88	[k]5,565.58	[k]35,323.15	184.06	[k]35,139.09
Direct credits to surplus	2,186.81	574.43	2,761.24	[k]323.40	403.65	80.25
Surplus for the year	[k]13,458.65	10,654.31	[k]2,804.34	[k]35,646.55	587.71	[k]35,058.84

[k] Deficit.

TABLE 291.—*Condensed financial data, distributing companies and steam-electric and isolated hydroelectric utilities reporting to California Railroad Commission, Dec. 31, 1913–1920.*

Data.	Alturas Electric Power Co.	Amador Electric Light & Power Co.	Bay Point Light & Water Co.	Bell Electric Co.	Bishop Light & Power Co. (sold to Southern Sierras Power Co., Mar. 31, 1918).
Date of incorporation	May 17, 1909	Apr. 12, 1909	Mar. 8, 1911	1889	Apr. 23, 1902
Assets, Dec. 31, 1920	$361,218.02	$196,427.18	$57,788.98	$87,347.26	[a] $54,410.84
Stock outstanding, Dec. 31, 1920	250,000.00	90,000.00	50,000.00	[b] 65,982.98	[a] 15,600.00
Funded debt, Dec. 31, 1920	61,000.00	60,000.00	....	....	[a] 4,500.00
Electric operating revenues and expenses:					
1913:					
Revenues	13,526.05	32,629.01	5,620.09	12,318.78	14,597.39
Expenses	5,935.47	20,915.54	3,109.26	8,674.43	11,531.13
Net revenue	7,590.58	11,713.47	2,510.83	3,644.35	3,066.26
1914:					
Revenues	13,608.66	34,750.20	6,586.11	12,734.90	14,605.51
Expenses	8,046.55	22,050.94	3,987.10	10,269.76	11,248.21
Net revenue	5,562.11	12,699.26	2,599.01	2,464.14	3,357.30
1915:					
Revenues	14,614.31	35,309.30	5,260.57	24,226.80	14,103.08
Expenses	7,941.40	23,189.92	4,121.56	20,670.39	11,985.92
Net revenue	6,672.91	12,119.38	1,139.01	3,556.41	2,117.16
1916:					
Revenues	14,495.32	39,427.72	5,535.08	24,638.59	15,831.02
Expenses	9,109.71	23,975.55	6,388.72	21,210.21	13,177.39
Net revenue	5,385.61	15,452.17	[c] 853.64	3,428.38	2,653.63
1917:					
Revenues	13,883.56	38,471.59	7,540.40	24,630.25	16,158.99
Expenses	8,177.81	25,332.93	6,111.70	22,931.06	12,948.92
Net revenue	5,705.75	13,138.66	1,428.70	1,698.19	3,210.07
1918:					
Revenues	16,175.38	32,093.93	14,416.01	22,120.86	4,148.62
Expenses	7,298.83	27,840.22	13,509.21	19,400.06	3,291.52
Net revenue	8,876.55	4,283.71	906.83	2,720.80	857.10

[a] Mar. 31, 1918.

[b] Investment.

[c] Loss.

TABLE 291.—*Condensed financial data, distributing companies and steam-electric and isolated hydroelectric utilities reporting to California Railroad Commission, Dec. 31, 1913–1920*—Continued.

Data.	Alturas Electric Power Co.	Amador Electric Light & Power Co.	Bay Point Light & Water Co.	Bell Electric Co.	Bishop Light & Power Co. (sold to The Southern Sierras Power Co., Mar. 31, 1918).
Electric operating revenues and expenses—Continued.					
1919:					
Revenues	$16,898.45	$38,934.50	$19,920.14	$25,855.21	...
Expenses	9,356.79	28,281.78	15,615.76	18,866.52	...
Net revenue	7,541.66	10,652.72	4,304.38	6,988.69	...
1920:					
Revenues	17,011.04	41,229.41	26,893.29	30,448.45	...
Expenses	10,389.27	31,581.58	23,021.95	22,328.38	...
Net revenue	6,621.77	9,647.83	3,871.34	8,120.07	...

Data.	Boulder Creek Electric Light & Water Co. (name changed to Santa Cruz County Utilities, 1920).	Butte County Power, Light & Water Co. (sold Feb., 1916).	California Telephone & Light Co.	California Power & Manufacturing Co.	Calistoga Electric Co. (sold).
Date of incorporation	May 21, 1903	May 27, 1903	Nov. 23, 1911	Feb. 2, 1911	Sept. 14, 1911
Assets, Dec. 31, 1920	$152,591.03	[d] $165,671.90	$1,928,870.22	$309,398.31	[e] $48,595.37
Stock outstanding, Dec. 31, 1920	57,000.00	[d] 100,000.00	1,108,736.66	500.00	[e] 13,500.00
Funded debt, Dec. 31, 1920	50,000.00	...	557,900.00	...	...
Electric operating revenues and expenses:					
1913:					
Revenues	1,379.25	2,268.20	46,573.89	...	4,622.74
Expenses	1,491.27	1,384.30	27,804.45	...	4,595.01
Net revenue	[c] 112.02	883.90	18,769.44	...	27.73
1914:					
Revenues	1,506.80	2,017.20	69,819.47	847.45	5,861.11
Expenses	1,957.89	1,373.07	37,064.75	674.51	4,943.02
Net revenue	[c] 451.09	644.13	32,754.72	172.94	918.09
1915:					
Revenues	2,232.07	1,572.35	73,535.68	1,750.79	9,202.71
Expenses	2,683.09	1,756.75	43,727.93	4,669.02	6,623.70
Net revenue	[c] 451.02	[c] 184.40	29,807.75	[c] 2,918.23	2,579.01
1916:					
Revenues	2,062.78	...	78,962.47	4,491.19	10,047.88
Expenses	2,293.26	...	45,299.51	5,969.81	6,956.86
Net revenue	[c] 230.48	...	33,662.96	[c] 1,478.62	3,091.02
1917:					
Revenues	1,881.79	...	87,470.65	4,946.21	10,733.52
Expenses	2,193.43	...	57,400.81	8,435.98	7,759.50
Net revenue	[c] 311.64	...	30,069.84	[c] 3,489.77	2,974.02
1918:					
Revenues	1,621.95	...	107,999.50	6,335.05	...
Expenses	1,978.38	...	71,176.35	9,276.25	...
Net revenue	[c] 356.43	...	36,823.15	[c] 2,941.20	...
1919:					
Revenues	1,956.80	...	118,394.34	6,454.89	...
Expenses	2,023.11	...	78,123.84	10,060.49	...
Net revenue	[c] 66.31	...	40,270.50	[c] 3,605.60	...
1920:					
Revenues	4,387.18	...	176,238.33	...	...
Expenses	5,023.27	...	120,025.48	...	...
Net revenue	[c] 636.09	...	56,212.85	...	...

[c] Loss.

[d] 1916.

[e] 1917.

TABLE 291.—*Condensed financial data, distributing companies and steam-electric and isolated hydroelectric utilities reporting to California Railroad Commission, Dec. 31, 1913–1920*—Continued.

Data.	Callayonia Electric Plant (S. H. McKinley, lease of McKinley Bros.).	Central Oakland Light & Power Co. (sold to Consolidated Electric Co.).	Consolidated Securities Co. (now Maclay Rancho Water Co.).	Consolidated Utilities Co.	Consumers' Light & Power Co.
Date of incorporation	June, 1905	Jan. 25, 1909	Feb. 10, 1912	Oct. 8, 1907	Feb. 26, 1908
Assets, Dec. 31, 1920		[f] $2,105,788.61	$370,334.87	[g] $10,999.49	[f] $637,673.16
Stock outstanding, Dec. 31, 1920		[f] 1,194,300.00	150,000.00		[f] 100,000.00
Funded debt, Dec. 31, 1920		[f] 493,000.00	146,500.00		[f] 100,000.00
Electric operating revenues and expenses:					
1913:					
Revenues	1,014.91	116,703.38	1,920.00	5,556.03	145,501.82
Expenses	720.00	105,579.66	2,239.58	4,068.09	116,166.01
Net revenue	294.91	11,123.72	[c] 319.58	1,487.94	29,335.81
1914:					
Revenues	677.44	120,440.31	[h] 494.60		164,038.14
Expenses		105,759.99	[h] 554.49		120,846.24
Net revenue		14,680.32	[c] 59.89		43,191.90
1915:					
Revenues	[i] 1,182.65				
Expenses	490.71				
Net revenue	691.94				
1916:					
Revenues	1,057.20				
Expenses					
Net revenue					
1917:					
Revenues	798.36				
Expenses					
Net revenue					
1918:					
Revenues	888.38				
Expenses	486.67				
Net revenue	401.71				
1919:					
Revenues	1,011.92				
Expenses	640.55				
Net revenue	371.37				
1920:					
Revenues	1,071.00				
Expenses	713.95				
Net revenue	357.05				

[c] Loss.
[f] 1914.
[g] 1913.
[h] Four months only.
[i] $1,272.96 revenues appear in 1916 report for 1915 entry.

TABLE 291.—*Condensed financial data, distributing companies and steam-electric and isolated hydroelectric utilities reporting to California Railroad Commission, Dec. 31, 1913-1920*—Continued.

Data.	Corona Gas & Electric Light Co. (sold to Southern Sierras Power Co., Mar. 31, 1918).	Crescent City Light, Water & Power Co.	Del Mar Water, Light & Power Co. (sold to San Diego Consolidated Gas & Electric Co. May 1, 1918).	Del Monte Light & Power Co.	Downey Light, Power & Water Co.	Durham Light & Power Co.
Date of incorporation	July 10, 1903	1902	1908	Mar. 13, 1919	Not given.	(j)
Assets, Dec. 31, 1920	a $165,823.86	f $26,034.45	$369,586.87	$36,496.44	g $65,422.98	$23,334.68
Stock outstanding, Dec. 31, 1920	a 50,000.00	f 20,000.00	100,000.00	25,000.00	g 40,000.00	b 2,752.56
Funded debt, Dec. 31, 1920	a 58,500.00		740,000.00			
Electric operating revenues and expenses:						
1913:						
Revenues	23,136.76				11,477.10	3,616.35
Expenses	21,653.03				10,914.90	4,076.64
Net revenue	1,483.73				562.20	d 460.29
1914:						
Revenues	24,052.69	2,686.55	3,269.22			3,996.42
Expenses	20,007.52	3,988.85	5,850.52			4,735.58
Net revenue	4,045.17	c 1,302.30	c 2,581.30			c 739.16
1915:						
Revenues	24,842.00		4,423.92			4,384.31
Expenses	19,681.21		5,323.58			4,901.71
Net revenue	5,160.79		c 899.66			c 517.40
1916:						
Revenues	26,012.45		3,623.89			4,355.42
Expenses	19,615.03		4,128.65			4,861.77
Net revenue	6,397.42		c 504.76			c 506.35
1917:						
Revenues	25,363.30		3,612.24			4,451.79
Expenses	18,891.40		2,963.42			4,443.01
Net revenue	6,471.90		648.82			8.78
1918:						
Revenues	k 6,172.82		1,207.94			5,487.76
Expenses	k 4,633.91		1,184.21			4,545.46
Net revenue	1,538.91		23.73			942.30
1919:						
Revenues				4,484.99		
Expenses				3,683.98		
Net revenue				801.01		
1920:						
Revenues				10,166.79		
Expenses				7,980.32		
Net revenue				2,186.47		

[a] Mar. 31, 1918.
[b] Investment.
[c] Loss.
[f] 1914.
[g] 1913.
[j] Not incorporated; started in business in 1906.
[k] Three months only.

TABLE 291.—*Condensed financial data, distributing companies and steam-electric and isolated hydroelectric utilities reporting to California Railroad Commission, Dec. 31, 1913–1920*—Continued.

Data.	Equitable Light & Power Co. (sold to Consolidated Electric Co.).	Escondido Utilities Co.	Exchequer Mining & Power Co.	Fort Bragg Electric Co.	Glendora Light & Power Co. (sold to Pacific Light & Power Co.).
Date of incorporation	Mar. 22, 1909	Nov. 22, 1909	June 4, 1907	June 7, 1901	May 15, 1908
Assets, Dec. 31, 1920	[f] $1,656,002.53	[l] $131,765.04	....	$229,452.23	[g] $27,136.97
Stock outstanding, Dec. 31, 1920	[f] 750,000.00	[l] 92,200.00	....	100,000.00	[g] 20,000.00
Funded debt, Dec. 31, 1920	[f] 365,000.00	[l] 5,000.00	....	44,000.00	....
Electric operating revenues and expenses:					
1913:					
Revenues	108,655.91	5,663.81	....	30,676.45	3,395.05
Expenses	90,663.08	5,130.62	....	16,779.78	1,859.12
Net revenue	17,992.83	533.19	....	13,896.67	1,535.93
1914:					
Revenues	120,136.33	10,046.46	....	30,913.47	....
Expenses	88,818.34	8,981.33	....	16,633.78	....
Net revenue	31,317.99	1,065.13	....	14,279.69	....
1915:					
Revenues	....	9,607.70	....	28,217.48	....
Expenses	....	9,281.30	....	16,226.87	....
Net revenue	....	326.40	....	11,990.61	....
1916:					
Revenues	....	....	....	29,338.97	....
Expenses	....	....	....	20,764.49	....
Net revenue	....	....	....	8,574.48	....
1917:					
Revenues	....	....	....	33,814.36	....
Expenses	....	....	....	22,555.47	....
Net revenue	....	....	....	11,258.89	....
1918:					
Revenues	....	....	....	33,999.63	....
Expenses	....	....	....	27,131.54	....
Net revenue	....	....	....	6,868.09	....
1919:					
Revenues	....	....	....	34,654.41	....
Expenses	....	....	....	31,217.20	....
Net revenue	....	....	....	3,437.21	....
1920:					
Revenues	....	....	....	40,383.24	....
Expenses	....	....	....	38,720.44	....
Net revenue	....	....	....	1,662.80	....

[f] 1914.

[g] 1913.

[l] July 31, 1916.

TABLE 291.—*Condensed financial data, distributing companies and steam-electric and isolated hydroelectric utilities reporting to California Railroad Commission, Dec. 31, 1913–1920*—Continued.

Data.	Half Moon Bay Light & Power Co. (sold during 1916 to Great Western Power Co.).	Hemet Milling & Power Co.	Huntington Beach Co. (sold Mar. 1, 1917; run as water company after 1914).	Indian Valley Electric Light & Power Co. (taken over by Plumas Electric Co.).	Invincible Mines (Cons.).
Date of incorporation	May 18, 1911	Not given.	May 4, 1903		Jan. 18, 1907
Assets, Dec. 31, 1920	[m] $121, 457. 36	[m] $31, 493. 60	[n] $115, 571. 82		[g] $389, 804. 68
Stock outstanding, Dec. 31, 1920	[m] 84, 850. 00	[m] 25, 190. 83			[g] 338, 500. 00
Electric operating revenues and expenses:					
1913:					
Revenues	19, 231. 13	2, 498. 73	15, 157. 86	$3, 035. 22	2, 610. 10
Expenses	20, 092. 79	5, 142. 23	13, 098. 03	4, 187. 31	5, 880. 26
Net revenue	[c] 861. 66	[c] 2, 643. 50	2, 059. 83	[c] 1, 152. 09	[c] 3, 270. 16
1914:					
Revenues	20, 650. 16	3, 289. 80	5, 607. 23		
Expenses	21, 325. 71	5, 408. 72	5, 381. 05		
Net revenue	[c] 675. 55	[c] 2, 118. 92	226. 18		
1915:					
Revenues	17, 423. 24	3, 423. 58			
Expenses	15, 953. 73	4, 902. 62			
Net revenue	1, 469. 51	[c] 1, 479. 04			

Data.	H. G. Lacey Co.	Lassen Electric Co.	Lompoc Light & Power Co.	Los Angeles Gas & Electric Co.	Loyalton Electric Light Co.
Date of incorporation	Nov. 24, 1897	Jan. 18, 1911	Oct. 15, 1906	June 22, 1909	1907
Assets, Dec. 31, 1920	$254, 954. 31	$82, 952. 37	$50, 134. 90	$30, 536, 651. 84	[f] $46, 356. 89
Stock outstanding, Dec. 31, 1920	[b] 46, 951. 97	25, 000. 00	27, 150. 00	10, 000, 000. 00	[f] 20, 000. 00
Funded debt, Dec. 31, 1920				10, 969, 000. 00	[f] 80, 000. 00
Electric operating revenues and expenses:					
1913:					
Revenues	71, 293. 21	13, 230. 31	12, 247. 75	1, 438, 857. 85	4, 053. 55
Expenses	54, 013. 91	5, 706. 76	11, 284. 24	1, 036, 564. 06	5, 010. 86
Net revenue	17, 279. 30	7, 523. 55	963. 51	402, 293. 79	[c] 957. 31
1914:					
Revenues	74, 976. 11	14, 032. 82	12, 989. 29	1, 495, 979. 63	3, 630. 09
Expenses	58, 660. 56	10, 084. 53	11, 497. 96	1, 083, 539. 97	3, 769. 16
Net revenue	16, 315. 55	3, 948. 29	1, 491. 33	412, 439. 66	[c] 139. 07
1915:					
Revenues	81, 404. 35	13, 192. 83	12, 473. 61	1, 560, 039. 85	
Expenses	58, 753. 49	9, 619. 33	10, 788. 92	1, 092, 987. 72	
Net revenue	22, 650. 86	3, 573. 50	1, 684. 69	467, 052. 13	
1916:					
Revenues	77, 780. 66	12, 485. 85	13, 198. 23	1, 655, 582. 15	
Expenses	54, 229. 74	8, 463. 45	11, 743. 68	1, 147, 660. 46	
Net revenue	23, 550. 92	4, 022. 40	1, 454. 55	507, 921. 69	
1917:					
Revenues	73, 428. 96	12, 620. 66	14, 712. 93	1, 628, 214. 43	
Expenses	54, 020. 63	8, 513. 68	13, 665. 99	1, 265, 012. 91	
Net revenue	19, 408. 33	4, 106. 98	1, 046. 94	363, 201. 52	
1918:					
Revenues	81, 558. 48	13, 317. 00	15, 175. 48	1, 485, 814. 43	
Expenses	72, 468. 74	9, 910. 84	20, 920. 28	1, 069, 906. 65	
Net revenue	9, 089. 74	3, 406. 16	[c] 5, 744. 80	415, 907. 78	

[b] Investment.
[c] Loss.
[f] 1914.
[g] 1913.
[m] 1915.
[n] Feb. 28, 1917.

TABLE 291.—*Condensed financial data, distributing companies and steam-electric and isolated hydroelectric utilities reporting to California Railroad Commission, Dec. 31, 1913–1920*—Continued.

Data.	H. G. Lacey Co.	Lassen Electric Co.	Lompoc Light & Power Co.	Los Angeles Gas & Electric Co.	Loyalton Electric Light Co.
Electric operating revenues and expenses—Continued.					
1919:					
Revenues		$16,631.10	$16,069.46	$1,650,481.97	
Expenses		11,634.64	13,003.00	1,218,434.55	
Net revenue		4,996.46	3,066.46	432,050.42	
1920:					
Revenues		23,453.36	20,141.70	2,135,655.83	
Expenses		17,512.13	16,373.56	1,620,590.95	
Net revenue		5,941.23	3,768.14	515,064.88	

Data.	Mendocino Electric Light & Power Co.	Middle Yuba Hydroelectric Power Co.	Mount Konocti Light & Power Co. (sold to California Telephone & Light Co. Nov. 28, 1919).	Mountain Light & Water Co. (consolidated with Santa Cruz County Utilities May 1, 1920).	Napa Valley Electric Co.
Date of incorporation	Feb. 29, 1904	June 15, 1909	Apr. 27, 1911	July 6, 1914	Sept. 10, 1907
Assets, Dec. 31, 1920	$50,032.05	$514,339.26	$194,099.00	$70,770.28	$161,880.29
Stock outstanding, Dec. 31, 1920	15,000.00	151,600.00	75,000.00	25,000.00	59,300.00
Funded debt, Dec. 31, 1920				18,500.00	40,000.00
Electric operating revenues and expenses:					
1913:					
Revenues	10,353.64	7,619.43	10,735.15		20,443.77
Expenses	6,818.46	4,445.99	10,233.09		13,295.21
Net revenue	3,535.18	3,173.44	502.06		7,148.56
1914:					
Revenues	9,227.77	9,768.51	13,328.73		21,299.95
Expenses	6,494.02	6,312.98	11,532.54		6,153.72
Net revenue	2,733.75	3,455.53	1,796.19		15,146.23
1915:					
Revenues	5,668.40	10,241.21	15,487.49		23,106.79
Expenses	2,879.03	6,353.93	12,681.44		9,676.57
Net revenue	2,789.37	3,887.28	2,806.05		13,430.22
1916:					
Revenues	5,720.95	12,851.24	16,308.03	1,403.68	26,389.71
Expenses	3,002.77	7,755.70	13,775.88	1,726.09	18,897.06
Net revenue	2,718.18	5,095.54	2,532.15	[c] 322.41	7,492.65
1917:					
Revenues	6,144.13	14,400.97	17,651.61	1,497.49	26,485.61
Expenses	4,470.26	7,238.12	14,655.33	2,697.87	20,539.14
Net revenue	1,673.87	7,162.85	2,996.28	[c] 1,200.38	5,946.47
1918:					
Revenues	5,962.99	6,176.71	18,306.92	1,524.44	30,972.91
Expenses	3,243.42	6,451.17	14,699.76	1,623.75	21,629.56
Net revenue	2,719.57	[c] 274.46	3,606.16	[c] 99.31	9,343.35
1919:					
Revenues	6,700.22	26,883.55	21,009.77	1,922.80	32,116.19
Expenses	4,251.60	23,932.10	12,916.83	2,151.79	25,618.64
Net revenue	2,448.62	2,951.45	8,092.94	[c] 228.99	6,497.55
1920:					
Revenues	7,656.85	34,180.61		[h] 635.23	38,046.03
Expenses	3,931.31	26,560.84		447.83	28,540.83
Net revenue	3,725.54	7,619.77		187.40	9,505.20

[c] Loss.

[h] Four months only.

TABLE 291.—*Condensed financial data, distributing companies and steam-electric and isolated hydroelectric utilities reporting to California Railroad Commission, Dec. 31, 1913–1920*—Continued.

Data.	Needles Gas & Electric Co.	Novato Light & Power Co. (in 1917 changed to Novato Utilities Co.).	Oceanside Electric & Gas Co.	Ojai Power Co.	Pinole Electric Light & Power Co.
Date of incorporation	Nov. 28, 1911	[o]May 29, 1917	Oct. 22, 1904	July 22, 1912	Sept. 4, 1903
Assets, Dec. 31, 1920	$265,715.08	$45,907.47	[m]$38,006.40	$58,103.19	$18,134.24
Stock outstanding, Dec. 31, 1920	100,000.00	20,000.00	[m]18,190.00	48,400.00	2,000.00
Funded debt, Dec. 31, 1920	100,000.00	....	....	....	....
Electric operating revenues and expenses:					
1913:					
Revenues	18,038.28	2,310.75	7,113.99	....	6,721.87
Expenses	14,398.71	1,600.13	6,233.74	....	2,909.75
Net revenue	3,639.57	710.62	880.25	....	3,812.12
1914:					
Revenues	18,433.30	3,289.71	7,403.55	4,636.98	8,701.17
Expenses	17,316.26	2,068.38	7,399.08	3,497.84	4,350.58
Net revenue	1,117.04	1,221.33	4.77	1,139.14	4,350.59
1915:					
Revenues	21,319.70	3,397.68	7,103.15	2,603.21	7,791.28
Expenses	17,099.44	2,307.03	6,522.29	2,048.00	6,491.64
Net revenue	4,220.26	1,090.65	580.86	555.01	1,299.64
1916:					
Revenues	26,314.55	3,780.53	....	7,242.80	9,086.03
Expenses	22,002.68	2,408.01	....	3,573.60	6,880.00
Net revenue	4,311.87	1,372.52	....	3,669.20	2,206.03
1917:					
Revenues	27,473.00	4,321.82	....	10,852.36	9,310.00
Expenses	21,068.10	3,513.46	....	10,108.89	8,558.79
Net revenue	6,404.90	808.36	....	743.47	751.21
1918:					
Revenues	27,240.56	4,767.16	....	9,780.88	11,080.68
Expenses	23,703.12	3,634.23	....	8,380.20	11,367.76
Net revenue	3,537.44	1,132.93	....	1,400.68	[d]287.08
1919:					
Revenues	26,466.71	5,542.95	....	16,333.67	15,592.93
Expenses	24,602.73	4,143.48	....	12,494.12	10,353.13
Net revenue	1,863.98	1,399.47	....	3,839.55	5,239.80
1920:					
Revenues	32,385.28	6,858.90	....	24,491.04	13,580.60
Expenses	29,861.46	4,326.07	....	19,756.66	10,588.97
Net revenue	2,523.82	2,532.83	....	4,734.38	2,991.63

[m] 1915.

[o] Novato Utilities.

TABLE 291.—*Condensed financial data, distributing companies and steam-electric and isolated hydroelectric utilities reporting to California Railroad Commission, Dec. 31, 1913–1920*—Continued.

Data.	Plumas Light & Power Co.	Point Arena Electric Light Co.	Quincy Electric Light & Power Co.	Rialto Light, Power & Water Co. (sold Mar. 31, 1918, Southern Sierras Power Co.).	San Diego Consolidated Gas & Electric Co.
Date of incorporation	Oct. 7, 1909	(p)	Dec. 15, 1915	Oct., 1907	Apr. 1, 1905
Assets, Dec. 31, 1920	$517,753.31	$15,402.59	$34,601.44	[a]$25,151.21	$12,945,418.64
Stock outstanding, Dec. 31, 1920	65,847.00			[a]10,000.00	4,442,300.00
Funded debt, Dec. 31, 1920					6,782,000.00
Electric operating revenues and expenses:					
1913:					
Revenues	3,035.22	2,965.35	4,200.00	5,207.14	712,267.39
Expenses	4,187.31	3,829.14	3,030.00	4,231.80	307,149.44
Net revenue	[c]1,152.09	[c]863.79	1,170.00	975.34	405,117.95
1914:					
Revenues	2,796.79	3,000.80		6,231.39	752,395.53
Expenses	6,245.05	3,263.11		3,679.34	335,268.40
Net revenue	[c]3,448.26	[c]262.31		2,552.05	417,127.13
1915:					
Revenues	2,870.20	2,978.80	2,378.11	7,392.02	924,993.56
Expenses	4,544.17	2,917.96	1,902.55	4,373.62	372,820.64
Net revenue	[c] 1,673.97	60.84	475.56	3,018.40	552,172.92
1916:					
Revenues	3,589.70	3,218.37	5,746.57	7,297.29	930,713.05
Expenses	3,182.89	3,670.70	5,737.09	5,986.43	484,422.44
Net revenue	406.81	[c]452.33	9.48	1,310.86	446,290.61
1917:					
Revenues	4,250.94	2,550.48	6,175.67	7,865.78	926,668.93
Expenses	3,966.18	3,877.17	5,779.20	6,081.65	507,331.14
Net revenue	284.76	[c]1,326.69	396.47	1,784.13	419,337.79
1918:					
Revenues	4,259.80	2,484.00	6,284.93	[k]1,808.11	1,116,090.55
Expenses	4,451.47	3,567.04	5,619.28	[k]1,497.70	710,950.92
Net revenue	[c]191.67	[c]1,083.04	665.65	[k]310.41	403,139.63
1919:					
Revenues	3,739.26	2,330.81	8,011.10		1,220,221.99
Expenses	3,687.31	3,326.28	5,709.93		794,103.73
Net revenue	51.95	[c]995.47	2,301.17		426,118.26
1920:					
Revenues	4,028.56	2,863.80	9,797.63		1,518,361.48
Expenses	4,249.52	4,373.91	5,548.75		996,393.72
Net revenue	[c]220.96	[c]1,510.11	4,248.88		521 967.76

[a] Mar. 31, 1918. [c] Loss. [k] Three months only. [p] Not incorporated.

TABLE 291.—*Condensed financial data, distributing companies and steam-electric and isolated hydroelectric utilities reporting to California Railroad Commission, Dec. 31, 1913–1920*—Continued.

Data.	Santa Barbara Gas & Electric Co.	Santa Catalina Island Co. (mostly resort).	Southside Light & Power Co.	Surprise Valley Electric Light & Power Co.	Truckee Electric Light & Power Co.
Date of incorporation	Aug., 1909	Oct. 26, 1894	May 3, 1910	May 25, 1905	Oct. 1, 1888
Assets, Dec. 31, 1920	$2,001,598.45	[m]$74,111.96	[f]$1,441,668.25	$31,888.02	$24,970.92
Stock outstanding, Dec. 31, 1920	800,900.00	....	[f]1,000,000.00	15,400.00	10,000.00
Funded debt, Dec. 31, 1920	760,700.00	....	[f]400,000.00	....	....
Electric operating revenues and expenses:					
1913:					
Revenues	165,396.59	6,077.03	50,223.82	3,617.11	10,410.90
Expenses	115,672.19	8,678.41	51,797.45	2,692.79	9,389.17
Net revenue	49,724.40	[c]2,601.38	[c]1,573.63	924.32	1,021.73
1914:					
Revenues	183,964.12	10,658.52	57,580.30	3,584.53	10,695.93
Expenses	119,914.44	9,327.22	56,234.13	3,152.02	9,739.66
Net revenue	64,049.68	1,331.30	1,346.17	432.51	956.27
1915:					
Revenues	205,825.94	11,943.65	....	3,946.17	10,186.40
Expenses	128,237.34	10,548.29	....	3,255.78	9,529.64
Net revenue	77,588.60	1,395.36	....	690.39	656.76
1916:					
Revenues	232,978.48	1,923.08	....	3,935.32	9,420.18
Expenses	144,716.92	3,244.90	....	3,345.07	8,808.79
Net revenue	88,261.56	[c]1,321.82	....	590.25	611.39
1917:					
Revenues	266,921.45	....	....	4,713.28	9,165.65
Expenses	170,369.59	....	....	3,315.32	8,633.77
Net revenue	96,551.86	....	....	1,397.96	531.88
1918:					
Revenues	281,210.86	....	....	4,196.30	8,143.58
Expenses	203,126.81	....	....	3,040.73	7,711.88
Net revenue	78,084.05	....	....	1,155.57	431.70
1919:					
Revenues	317,085.19	....	....	5,416.96	7,593.21
Expenses	226,490.71	....	....	4,416.85	7,579.28
Net revenue	90,594.48	....	....	1,000.11	13.93
1920:					
Revenues	398,003.33	....	....	5,249.86	7,162.10
Expenses	305,164.74	....	....	3,581.93	7,029.35
Net revenue	92,838.59	....	....	1,667.93	132.75

[c] Loss. [f] 1914. [m] 1915.

TABLE 291.—*Condensed financial data, distributing companies and steam-electric and isolated hydroelectric utilities reporting to California Railroad Commission, Dec. 31, 1913–1920*—Continued.

Data.	Tuolumne Electric Co. (ceased operation Dec., 1916).	Tuolumne County Electric Power & Light Co.	Tuolumne Transmission Co.	United Light, Fuel & Power Co.	United Light & Power Co.
Date of incorporation	Mar. 18, 1903	1896	Feb. 20, 1908	Dec. 19, 1904	May 4, 1910
Assets, Dec. 31, 1920	$133,217.34	$1,023,602.06	[e] $35,234.20	$241,106.47	[f] $10,398,084.04
Stock outstanding, Dec. 31, 1920		1,000,000.00		207,000.00	[f] 5,978,230.00
Funded debt, Dec. 31, 1920					3,060,000.00
Electric operating revenues and expenses:					
1913:					
Revenues	2,414.04	21,167.94	5,599.67	36,368.50	160,045.78
Expenses	5,580.14	19,527.86	6,751.94	34,526.05	97,518.50
Net revenue	[c] 3,166.10	1,640.08	[c] 1,152.27	1,842.45	62,527.28
1914:					
Revenues	4,652.12	21,823.91	8,233.55	43,009.15	151,532.19
Expenses	6,653.64	19,856.23	9,324.29	40,582.50	105,701.64
Net revenue	[c] 2,001.52	1,967.68	[c] 1,090.74	2,426.65	45,830.55
1915:					
Revenues	2,807.59	22,239.38	6,877.04	52,269.32	
Expenses	6,230.90	20,358.67	7,418.32	41,623.78	
Net revenue	[c] 3,423.31	1,880.71	[c] 541.28	10,645.54	
1916:					
Revenues	1,517.44	26,098.47	2,127.58	54,723.26	
Expenses	6,157.45	24,898.64	3,277.19	44,860.40	
Net revenue	[c] 4,640.01	1,199.83	[c] 1,149.61	9,862.86	
1917:					
Revenues		31,062.04		58,249.65	
Expenses		28,728.49		48,709.43	
Net revenue		2,333.55		9,540.22	
1918:					
Revenues		27,719.54		65,594.48	
Expenses		26,035.76		61,526.10	
Net revenue		1,683.78		4,068.38	
1919:					
Revenues		31,403.24		74,665.32	
Expenses		29,829.33		63,878.84	
Net revenue		1,573.91		10,786.48	
1920:					
Revenues		39,298.40		89,716.06	
Expenses		37,891.08		70,420.59	
Net revenue		1,407.32		19,295.47	

[c] Loss.

[e] 1917.

[f] 1914.

TABLE 291.—*Condensed financial data, distributing companies and steam-electric and isolated hydroelectric utilities reporting to California Railroad Commission, Dec. 31, 1913–1920*—Continued.

Data.	Universal Electric & Gas Co.	Vacaville Water & Light Co.	Vacaville Water & Power Co.	Vallejo Electric Light & Power Co.	Weaverville Electric Co.	West Sacramento Electric Co.
Date of incorporation	Feb. 27, 1912	Mar. 2, 1890	Feb. 6, 1919	June 18, 1897	July 27, 1893	Sept. 5, 1911
Assets, Dec. 31, 1920	$8,934,959.56	$62,305.62	$88,494.75	$382,164.29	$19,963.08	[m] $142,990.70
Stock outstanding Dec. 31, 1920	5,000,000.00	25,000.00	69,000.00	100,000.00	10,000.00	[m] 100,000.00
Funded debt, Dec. 31, 1920	2,500,000.00	....	....	....	....	....
Electric operating revenues and expenses:						
1913:						
Revenues	127,764.70	14,823.01	....	79,199.50	3,860.54	32,521.19
Expenses	114,040.34	11,538.83	....	58,149.64	2,489.06	21,127.33
Net revenue	13,724.36	3,284.18	....	21,049.86	1,371.48	11,393.86
1914:						
Revenues	126,102.79	15,225.18	....	84,342.97	4,330.38	22,398.97
Expenses	112,560.62	11,079.26	....	64,807.31	3,083.51	17,385.34
Net revenue	13,542.17	4,145.92	....	19,533.66	1,246.87	5,013.63
1915:						
Revenues	135,818.16	15,623.29	....	87,597.86	4,772.80	18,161.54
Expenses	118,598.91	11,822.62	....	67,484.72	2,857.15	16,167.31
Net revenues	17,219.25	3,800.67	....	20,113.14	1,915.65	1,994.23
1916:						
Revenues	180,976.86	14,585.49	....	90,811.09	4,053.70	....
Expenses	159,013.90	11,860.85	....	68,654.31	3,328.62	....
Net revenue	21,962.96	2,724.64	....	22,156.78	725.08	....
1917:						
Revenues	240,149.56	15,524.56	....	103,989.10	2,982.45	....
Expenses	222,484.91	12,255.96	....	70,314.37	2,148.24	....
Net revenue	17,664.65	3,268.60	....	33,674.73	834.21	....
1918:						
Revenues	322,483.35	17,233.92	....	84,032.86	3,539.05	....
Net revenue	27,791.40	5,304.71	....	36,669.48	1,632.50	....
1919:						
Revenues	525,382.78	6,014.37	$12,977.28	143,148.15	3,366.35	....
Expenses	458,248.38	5,345.47	7,525.37	105,806.88	2,772.70	....
Net revenue	67,134.40	668.90	5,451.91	37,341.27	593.65	....
1920:						
Revenues	647,781.19	....	24,393.57	193,039.29	4,030.05	....
Expenses	567,019.51	....	15,316.95	139,022.39	2,854.35	....
Net revenue	80,761.68	....	9,076.62	54,016.90	1,175.70	....

[m] 1915.

APPENDIX B.—RATES.

Rates have naturally varied in different parts of the State, not only with the class of service but with the local conditions of regulation and of industry. The charges of electric companies up to the time the public utilities act went into effect, March 23, 1912, were not subject to public control except that certain rights of regulation were granted municipalities under the constitution and certain others by specific charter provision. (See pole and wire franchises, pp. 59–62). On March 23, 1912, the Railroad Commission of the State of California assumed control of rates of the electric utilities in territory outside of municipalities, and later, from time to time, within municipalities that by special elections delegated their powers of control to the commission.

By amendment to section 23 of article 12 of the constitution of California, adopted November 3, 1914, and the revised public utilities act, effective August 8, 1915, the powers of the Railroad Commission were extended to include regulation of public utility rates within all incorporated cities and towns in the State.

By order of the commission, all electric utilities furnished their schedules of charges on March 23, 1912, together with such changes as had been made since the previous October when the public utilities act was passed by the legislature.

In the 10 years which have elapsed since these schedules were filed the commission has revised rates, after investigation of several companies, instituted either upon its own initiative or upon the complaint of rate payers. Many other changes have been made in rates of the various systems by the operating companies themselves, with the approval of the commission. Complete schedules of rates in effect are at all times on file with the commission's rate department, and from these records the following tables of electric rates effective November 15, 1919, were prepared. No attempt has been made to revise these rates fully to November 30, 1921, but notes have been placed at the head of several tables to show the general trend of important recent changes.

TABLE 292.—*Electric rates of California-Oregon Power Co. in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise specified. Between Nov. 15, 1919, and Nov. 30, 1921, meter rates were substituted for flat rates on this system and schedule 5 was canceled.]

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Lighting, residence (flat rate).	A	Apr. 4, 1912	First 60-watt lamp, $1		$1	
			2 lamps, $1.20			
			3 and 4 lamps, increase, 10 cents each.			
			5, 6, 7, 8, 9, 10 lamps, increase, 15 cents each.			
			11, 12, 13 lamps, increase, 10 cents each.			
			20 cents each for 14–60 watt lamps or over.			
Lighting, commercial (flat rate)	B	do	One 60-watt lamp, $1		$1	
			Two 60-watt lamps, $1.60			
			Three 60-watt lamps, $1.95			
			Four 60-watt lamps, $2.50			
			Five 60-watt lamps, $2.80			
			Each 60-watt lamp over 5, 50 cents.			
Lighting, commercial closing after 9 p. m. (flat rate).	C	do	One 60-watt lamp, $1		$1	
			Two 60-watt lamps, $1.80			
			Three 60-watt lamps, $2.25			
			Four 60-watt lamps, $2.75			
			Five 60-watt lamps, $3			
			Each 60-watt lamp over 5, 60 cents.			
Lighting, hotel and lodging house (flat rate—hotel bars not included).	N	Aug. 1, 1913	35 cents per 60-watt lamp		$1	
Lighting, signs (flat rate)[a]	Rule 12.	Apr. 1, 1917	One-half the rate under schedule B or C, according to schedule under which balance of customer's service is furnished.		$1	
Miscellaneous appliances (flat rate per appliance). (See note 3.)	D	Aug. 1, 1913	Chafing dishes, domestic, 50 cents.			
			Coffee mill (motors), commercial, 50 cents.			
			Coffee pot (percolators), domestic, 8-cup, 25 cents.			

[a] Sign lamp rated by actual watt consumption.

TABLE 292.—*Electric rates of California-Oregon Power Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Miscellaneous appliances (flat rate per appliance). (See note 3.)	D	Aug. 1, 1913	Dental and jewelers' motors, $1			
			Disk stove, 6-inch, domestic, 75 cents.[b]			
			Disk stove, 7-inch, domestic, 90 cents.[b]			
			Disk stove, 8-inch, domestic, $1.[b]			
			Disk stove, 9-inch, domestic, $1.25.[b]			
			Disk stove, 10-inch, domestic, $1.50.[b]			
			Irons, 6-pound or under, domestic, 50 cents.[b]			
			Irons, 7½-pound, domestic, 75 cents.[b]			
			Irons, 12-pound or under, commercial, $2.			
			Irons, 16-pound or under, commercial, $2.50.			
			Piano motors, commercial, $1.			
			Ranges, kitchen, capacity, 6,200-watt or less, $5.			
			Sewing-machine motor, commercial, one-eighth horsepower, 50 cents.[c]			
			Vacuum-cleaner motor, one-fourth horsepower, $1.[c]			
			Washing-machine motor, one-fourth horsepower, $1.[c]			
			Tea pots, domestic, 25 cents			
			Toasters, 50 cents			
			Toaster stoves, 75 cents			
			Fan motors, 12-inch fan, per season, payable July 1, $5.			
			Fan motors, 16-inch fan, per season, payable July 1, $10.			
			Fan motors, ceiling fans, per season, payable July 1, $10.			
Small power motors (flat rate).	E	do	One-sixth horsepower, $2.50.[d]			
			One-fourth horsepower, $3[d]			

			Each additional one-fourth horsepower, increase up to 1 horsepower, 50 cents.		
Air and water heaters (flat rate) (see note 4).	F	do	1,000-watt air heater $3.		
			Each additional 500-watt increase up to 3,000 watts, 50 cents.		
			500-watt circulating water heater, $2.50.		
			1,000-watt circulating water heater, $3.75.		
			1,500-watt circulating water heater, $4.25.		
			2,000-watt circulating water heater, $5.		
Ranch and orchard irrigation and power (flat rate), with transformer service.	P	July 22, 1916	$27.50 per horsepower for 5-month season.		
			$35 per horsepower for 12-month season.		
Ranch and orchard irrigation and power without transformer service (flat rate).	R	July 23, 1916	$25 per horsepower for 5-month season.		
			$27.50 per horsepower for 6-month season.		
			$32 per horsepower for 12-month season.		
Residence and commercial lighting.	1	July 15, 1919	$0.12 for first 10 kilowatt hours $0.10 for next 30 kilowatt-hours.	$0.03 for all over 2,000 kilowatt-hours.	$1 per meter in incorporated cities or towns; $1.25 per meter outside incorporated cities or towns, plus $1 per horsepower installed over 1 horsepower where monthly consumption is within the indicated maximum rates of this schedule.
Heating and cooking	2	do	$0.03 for first 150 kilowatt-hours.	$0.01 for all over 500 kilowatt-hours.	$2.50 plus 50 cents per kilowatt of active installed capacity over 5 kilowatts.
Heating, cooking, and lighting	3	do	$0.10 for first 30 kilowatt-hours	$0.01 for all over 500 kilowatt-hours.	$2.50 plus 50 cents per kilowatt of active installed heating and cooking capacity over 5 kilowatts.
General power service—connected load.	4	July 15, 1917			$1.25 per horsepower per year for 4 horsepower or less connected load, but not less than $2.50; $1 additional for each horsepower over 4 horsepower.

[b] Commercial rate double the domestic rate for the same size disk stoves and irons.
[c] Domestic rate one-half the commercial rate regardless of capacity.

[d] Twelve-hour service one-half the maximum.

TABLE 292.—*Electric rates of California-Oregon Power Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
General power service—connected load—Continued.						
5 horsepower or less			$0.06 for first 150 kilowatt-hours	$0.015 for all over 500 kilowatt-hours.		
5 to 14 horsepower			$0.05 for first 50 kilowatt-hours	$0.0175 for all over 150 kilowatt-hours.		
15 to 39 horsepower			$0.04 for first 50 kilowatt-hours	$0.0100 for all over 150 kilowatt-hours.		
40 to 74 horsepower			$0.035 for first 50 kilowatt-hours	do		
75 to 149 horsepower			$0.030 for first 50 kilowatt-hours	$0.0075 for all over 150 kilowatt-hours.		
Over 150 horsepower			$0.025 for first 50 kilowatt-hours	do		
General power (optional)	5	July 15, 1919	$0.02 for first 1,000 kilowatt-hours, plus the minimum bill.	$0.0075 for all over 20,000 kilowatt-hours, plus the minimum bill.	$60 per year for 5 horsepower or less connected load, plus $12 for each additional horsepower over 5 horsepower.	
Lumber and box factory, 300 horsepower or more (see note 6).	6	July 15, 1917			$1 per kilowatt of maximum demand up to 200 kilowatts, plus 80 cents for all over 200 kilowatts.	
High tension			$0.01 for first 25,000 kilowatt-hours.	$0.007 for all over 150,000 kilowatt-hours.	do	
Low tension			do	$0.008 for all over 25,000 kilowatt-hours.		
Gold dredging, 300 horsepower or over.[e]	7	July 15, 1919	$0.01 for first 50,000 kilowatt-hours.	$0.007 for all over 100,000 kilowatt-hours.	$1 per horsepower of connected load.	

[e] This service supplied only at high-tension voltage.

NOTES.

1. All rates are for continuous 24-hour service per month, unless otherwise specified.
2. All flat rates (lighting), except sign-lighting rates, i. e., schedules A, B, C, and N, based on 60-watt lamps. All lamps up to 60-watt capacity rated as one lamp; from 61 to 100 watt capacity rated as two lamps, and all over 100-watt capacity an additional lamp per 50 watts. All live sockets counted in rating. Schedule A applies also to professional offices and barns.
3. Schedule D, rates not charged unless appliances are in use.
4. Schedule F, air-heater rate, based on 12-hour continuous service.
5. Schedules 2 and 3, active installed capacity considered as the maximum capacity that may be connected and in use at any given instant.
6. Schedule 6, maximum demand, is the highest average demand measured in kilowatts over a period of 15 minutes, and occurring during the month for which the bill is rendered, but the demand must not be less than 50 per cent of the installed transformer capacity. At the option of the company the maximum demand may be based on the average of a 20-minute reading, or on 80 per cent of the average of a 15-minute volt-ampere reading.
7. California-Oregon Power Co. serves Shasta, Siskiyou, and Trinity counties, and all schedules apply throughout this territory.

TABLE 293.—*Electric rates of Pacific Gas & Electric Co. in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise specified.]

Character or service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Lighting:						
Residence	100	Mar. 15, 1919	$0.08 for first 30 kilowatt-hours.	$0.05 for all over 200 kilowatt-hours.	$1 per meter	Note 1.
Do	101	Dec. 1, 1911	$0.07 for first 100 kilowatt-hours.	$0.03 for all over 400 kilowatt-hours.	do	Note 2.
Do	127	Oct. 10, 1911	$0.09 per kilowatt-hour		do	Former Stanislaus district.
Domestic	174	May 1, 1915	$0.08 for first 30 kilowatt-hours	$0.05 for all over 200 kilowatt-hours.[a]	do	Oro electric territory.
Commercial	104	Mar. 15, 1919	$0.06 for first 150 kilowatt-hours.	$0.03 for all over 1.050 kilowatt-hours.	do	Note 1.
Do. (optional)	105	do	$0.0575 when guaranteed minimum consumption equals $9.	$0.03 when guaranteed minimum consumption equals $90.	$9 to $90	Do.
Do	106	July 1, 1912	$0.05 for first 100 kilowatt-hours.	$0.02 for all over 10,000 kilowatt-hours.	$1 per meter	Note 2.
Do	107	Oct. 10, 1911	$0.08 on minimum charge of $1 per meter per month.	$0.03 when guaranteed minimum consumption equals $150.	$7.50 to $150 (guaranteed 12 months).	Former Stanislaus district.
Do	173	May 1, 1915	$0.06 for first 150 kilowatt-hours.	$0.03 for all over 1,050 kilowatt-hours.[b]	$1 per meter	Oro electric territory.
General	132	July 26, 1914	$0.07 for first 20 kilowatt-hours	$0.03 for all over 1,000 kilowatt-hours.	do	Antioch.
Residence and commercial	148	Dec. 20, 1915	do	$0.03 for all over 350 kilowatt-hours.	do	San Jose district.
General	159	Sept. —, 1916	do	$0.02 for all over 2,220 kilowatt-hours.	do	Chico district.
Do	202	Aug. 1, 1919	$0.10 per kilowatt-hour		$1.50 on 2,200-volt line [b]; $2.50 on 11,000-volt line.	Durham Light & Power territory.
Flat rate	206	do	$0.01 per watt per month of the rated capacity of lamps or other electrical appliances used or installed.		$1.25 for residence; $1.50 for commercial.	Do.
Municipal street	149	Dec. 20, 1915				San Jose district.

[a] Bills subject to 10 per cent discount if paid on or before the 15th of month succeeding that in which current is used.

[b] $1.50 for meter and $1.25 for each separate occupancy.

TABLE 293.—*Electric rates of Pacific Gas & Electric Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Lighting—Continued.						
Moonlight and all-night schedule: [c]						
Four-ampere direct-current luminous series arcs.			$33 per lamp per year, plus $0.45 per 100 lamp-hours of burning under schedule.			
Multiple inclosed carbon arcs.			$31.80 per lamp per year, plus $0.45 per 100 lamp-hours of burning under schedule.			
Electroliers:						
200-300 watt tungstens.			$18 per electrolier per year, plus $0.015 per 1,000 watt-hours based upon rated capacity of lamps.			
80-candlepower (manufacturing rating), series or 100-watt multiple tungsten incandescent lamps.[d]			$16.20 per lamp per year, plus $0.15 per 100 lamp-hours, burning under schedule.			
Multiple 60-watt carbon incandescent lamps.[d]			$10.80 per lamp per year			
Public outdoor	161	Sept. —, 1916				Chico district.
6.6-ampere luminous arc lamps.			$36.40 per lamp per year, plus $0.50 per 100 lamp-hours.			
4-ampere luminous arc lamps.			$33 per lamp per year, plus $0.45 per 100 lamp-hours.			
600-candlepower series and 400-watt multiple incandescent lamp.			$29.50 per lamp per year, plus $0.60 per 100 lamp-hours.			
400-candlepower series and 200-watt multiple incandescent lamp.			$27 per lamp per year, plus $0.40 per 100 lamp-hours.			
250-candlepower series and 150-watt multiple incandescent lamps.			$23 per lamp per year, plus $0.30 per 100 lamp-hours.			

100-candlepower series and 80-watt multiple incandescent lamps.			$16.20 per lamp per year, plus $0.15 per 100 lamp-hours.			
80-candlepower series and 60-watt multiple incandescent lamps.			$13.40 per lamp per year, plus $0.10 per 100 lamp-hours.			
60-candlepower series and 40-watt multiple incandescent lamps.			$11.50 per lamp per year, plus $0.08 per 100 lamp-hours.			
25-watt multiple incandescent lamps.			$10 per lamp per year, plus $0.05 per 100 lamp-hours.			
Municipal street	180	May 1, 1915				Oro Electric territory (city of Oroville).
32-candlepower incandescent lights.			$1.10 per lamp per month [e]			
6.6-ampere multiple inclosed arc lamps.			$6 per lamp per month [e]			
County road	181	May 1, 1915	$0.60 per month for 32-candlepower lamps.			Oro Electric territory.
Electric street	187	July 1, 1917	Special rates for less than 25 lamps.	For 25 or more lamps		All except cities of San Francisco and Oroville.
Carbon arcs, series or multiple.				$5.40 per lamp per month		
4-ampere luminous arcs, pendent.				$5.50 per lamp per month		Town of Antioch and the San Jose and Chico district.
32-candlepower series Mazda, type C. [f]				$1.35 per lamp per month [g]		
60-candlepower series Mazda.				$1.75 per lamp per month [g]		
80-candlepower series Mazda.				$2 per lamp per month [g]		
100 candlepower series Mazda.[h]				$2.15 per lamp per month [g]		
250-candlepower series Mazda.				$3.15 per lamp per month [g]		
400-candlepower series Mazda.				$4.15 per lamp per month [g]		
600-candlepower series Mazda.				$4.90 per lamp per month [g]		
1,000-candlepower series Mazda.				$6 per lamp per month [g]		

[c] All-night schedule, 4,000 hours burning; moonlight schedule, 2,240 hours burning.

[d] All-night schedule only.

[e] Company furnishes lamp renewals and original fixtures, taking care of operation and maintenance.

[f] Reflector only.

[g] Reflector and refractor.

[h] Deduction of $0.15 for each lamp not equipped with either refractor or diffusing globe.

TABLE 293.—*Electric rates of Pacific Gas & Electric Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Lighting—Continued.						
Sign, window or decorative.	147	Apr. 7, 1915	$0.025 per kilowatt-hour		Guaranteed monthly minimum use varying from 600 watt-hours per 5-watt lamp in June up to 1,050 watt hours in December.	Sacramento.
Sign (optional)	158	Apr. 4, 1916	$0.03 per kilowatt-hour (use of installation at least 152 hours per month).	$3 per month per sign		All except cities of San Francisco and Sacramento.
Municipal street	208	Aug. 1, 1919				Durham Light & Power territory.
40-watt lamp, moonlight schedule.			$0.80 per lamp per month			
60-watt lamp, moonlight schedule.			$1 per lamp per month			
100-watt lamp, moonlight schedule.			$1.50 per lamp per month			
Light and power	137	July 1, 1913				Berkeley.
Domestic			$0.07 for first 50 kilowatt-hours.	$0.03 for all over 400 kilowatt-hours.	$1 per meter	
Commercial			$0.04 for first 300 kilowatt-hours.	$0.02 for all over 10,000 kilowatt-hours.	do	
Power			$0.03 for less than 108 kilowatt-hours.	$0.02 for over 215 kilowatt-hours.	$1 per horsepower in motor or motors installed.	
Light and power	139					Roseville.
Residence, no contract (flat rates).			Three 16-candlepower lamps, $1 per month; each additional, $0.25 per month.			
Residence, contract			Four 16-candlepower lamps, $1 per month; up to 9 or 10, $2 per month: each additional, $0.15 per month.			
Commercial			16-candlepower lamps, $0.70 per month; 32-candlepower lamps, $1 per month; electric irons, $0.50 per month; fans, $1.50 per month or $5 per season.			
Restaurants and saloons.			Per 16-candlepower, $0.35 per month.			
Other buildings			Per 16-candlepower, $0.25 per month.			

Light, heat, and power	141	July 1, 1914	$0.07 for first 50 kilowatt-hours.	$0.035 for all over 500 kilowatt-hours.	$0.75 per meter	San Francisco.
Power only			do	do	$0.75 per horsepower installed.	
Light, heat, and power	146	July 1, 1915				Sacramento.
Domestic—						
Lighting			$0.07 per kilowatt-hour		$1 per meter	
Heating			$0.03 per kilowatt-hour			
Commercial			$0.06 for first 50 kilowatt-hours.	$0.03 for all over 1,050 kilowatt-hours.	do	
Power, industrial—						
1 to 9 horsepower			$0.0375		$1 per installed horsepower	
10 to 50 horsepower			$0.03			
Over 50 horsepower			$0.0250			
Light and power	153	Mar. 15, 1919				
General lighting			$0.10 for first 30 kilowatt-hours.	$0.06 for all over 30 kilowatt-hours.	$1.25 per meter	Paradise, de Sabla district.
Commercial power—						
1 to 10 horsepower			$0.06 for first 54 kilowatt-hours.	$0.015 for all over 108 kilowatt-hours.	$1 per horsepower	
11 to 25 horsepower			$0.05 for first 54 kilowatt-hours.	do	do	
Combination, lighting, cooking, and heating.	160	Sept. —, 1916	$0.07 for first 20 kilowatt-hours.	$0.01 for all over 170 kilowatt-hours.	$2 per meter	Chico district.
Light, heat, and power (optional in lieu of 141).[i]	183	May 7, 1917	$0.03 for first 60 kilowatt-hours per horsepower.	$0.01 for all over 120 kilowatt-hours per horsepower.	$10 per meter or $5 per horsepower connected load at 746 watts per horsepower.	
Commercial light and power (optional in lieu of 141).	185	Apr. 11, 1919	$0.04 for first 200 kilowatt-hours.	$0.0225 for all over 3,000 kilowatt-hours.	$0.75 per horsepower connected load but not less than $2.50.	Specified district of San Francisco.
Do	186	do	$0.03 for first 500 kilowatt-hours.	do	$0.75 per horsepower connected load but not less than $5.	Do.
Company employees	188	Nov. 3, 1918	$0.04[j]		$1	All territory.
Optional general charge[k]	194	Dec. 24, 1918				San Francisco.
Readiness to serve charge.			$1.60 for first 25 kilowatts (maximum demand).	$1 all over 75 kilowatts maximum demand.	$1.60 per kilowatt of 75 per cent of total connected load	
Energy charge[l]			$0.02 for first 1,000 kilowatt-hours.	$0.01 all over 6,000 kilowatt-hours.		
Combined lighting and power.	205	Aug. 1, 1919	$0.10 per kilowatt-hour		$48 per meter per year	Durham Light & Power territory.
Power:						
General power	112	July 1, 1912	$0.03 for first 240 kilowatt-hours.	$0.02 for all over 399 kilowatt-hours.	$1 per horsepower of installed motors.	See note 2.

[i] High-load factor.
[j] Light, heat, and power service. Heating and cooking only, 33⅓ per cent discount from regular schedule.
[k] For installations of over 7.5 kilowatts (10 horsepower) except when consumption is in excess of 400 kilowatts per kilowatt (1.34 horsepower) of rated capacity.
[l] Additional to readiness-to-serve charge.

TABLE 293.—*Electric rates of Pacific Gas & Electric Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Power—Continued. Miscellaneous, commercial, and industrial.	133	July 26, 1914				Antioch.
Less than 1 horsepower			$0.07 for first 50 kilowatt-hours	$0.01 for all over 100 kilowatt-hours per horsepower.	$1 per horsepower for first 10 horsepower.	
1 and less than 3 horsepower.			$0.05 for first 50 kilowatt-hours	do.	$0.75 per horsepower for over 10 horsepower.	
3 and less than 9 horsepower.			$0.04 for first 50 kilowatt-hours	do.		
9 and less than 27 horsepower.			$0.03 for first 50 kilowatt-hours	do.		
27 and less than 81 horsepower.			$0.025 for first 50 kilowatt-hours.	do.		
81 horsepower and over			$0.02 for first 50 kilowatt-hours	do.		
General power, for installations up to and including 10 horsepower.	142	Mar. 15, 1919	$0.04 for first 54 kilowatt-hours per horsepower.	$0.01 for all over 162 kilowatt-hours per horsepower per month.	$1 per month per horsepower for first 50 horsepower and $0.50 for each additional horsepower.	See note 3
Over 10 and including 25 horsepower.			$0.035 for first 54 kilowatt-hours per horsepower.	$0.0095 for all over 162 kilowatt-hours per horsepower per month.		
Over 25 and including 50 horsepower.			$0.030 for first 54 kilowatt-hours per horsepower.	$0.0090 for all over 162 kilowatt-hours per horsepower per month.		
Over 50 and including 100 horsepower.			$0.025 for first 54 kilowatt-hours per horsepower.	$0.0085 for all over 162 kilowatt-hours per horsepower per month.		
Over 100 and including 200 horsepower.			$0.020 for first 54 kilowatt-hours per horsepower.	$0.0080 for all over 162 kilowatt-hours per horsepower per month.		
Over 200 and including 300 horsepower.			$0.0195 for first 54 kilowatt-hours per horsepower.	$0.0070 for all over 162 kilowatt-hours per horsepower per month.		
Over 300 and including 400 horsepower.			$0.0190 for first 54 kilowatt-hours per horsepower.	$0.0065 for all over 162 kilowatt-hours per horsepower per month.		
Over 400 and including 500 horsepower.			$0.0185 for first 54 kilowatt-hours per horsepower.	$0.0065 for all over 162 kilowatt-hours per horsepower per month.		
General power [m].	143	Mar. 15, 1919				Do.
Demand up to 100 horsepower.			$0.025 for first 54 kilowatt-hours per horsepower of maximum demand.	$0.0085 for all over 162 kilowatt-hours per horsepower of maximum demand.	$1 per horsepower of maximum demand. Never less than $5 or less than 20 per	

					cent of installed horsepower at $1 per horsepower. Maximum demand is for maximum 15 minutes.	
Maximum demand 100 to 200 horsepower.	....	....	$0.02 for first 54 kilowatt-hours per horsepower of maximum demand.	$0.0080 for all over 162 kilowatt-hours per horsepower of maximum demand.	....	
Maximum demand 200 to 300 horsepower.	....	....	$0.0195 for first 54 kilowatt-hours per horsepower of maximum demand.	$0.0070 for all over 162 kilowatt-hours per horsepower of maximum demand.	....	
Maximum demand 300 to 400 horsepower.	....	....	$0.0190 for first 54 kilowatt-hours per horsepower of maximum demand.	$0.0065 for all over 162 kilowatt-hours per horsepower of maximum demand.	....	
Maximum demand 400 to 500 horsepower.	....	....	$0.0185 for first 54 kilowatt-hours per horsepower of maximum demand.	$0.0065 for all over 162 kilowatt-hours per horsepower of maximum demand.	....	
General power, installations having demand exceeding 500 horsepower.	143-x	Mar. 15, 1919	....	....	....	Do.
Maximum demand from 501 to 600 horsepower.	....	....	$0.0175 for first 54 kilowatt-hours per horsepower.	$0.0064 for all over 162 kilowatt-hours per horsepower.	$1 per horsepower of maximum demand but not less than $50. Never less than 20 per cent of installed horsepower at $1 per horsepower. Maximum demand is for maximum 15 minutes.	
Maximum demand from 601 to 700 horsepower.	....	....	$0.0170 for first 54 kilowatt-hours per horsepower.	$0.0063 for all over 162 kilowatt-hours per horsepower.	....	
Maximum demand from 701 to 800 horsepower.	....	....	$0.0165 for first 54 kilowatt-hours per horsepower.	$0.0062 for all over 162 kilowatt-hours per horsepower.	....	
Maximum demand from 801 to 1,000 horsepower.	....	....	$0.0155 for first 54 kilowatt-hours per horsepower.	$0.0060 for all over 162 kilowatt-hours per horsepower.	....	
Maximum demand over 1,000 horsepower.	....	....	$0.0145 for first 54 kilowatt-hours per horsepower.	$0.0060 for all over 162 kilowatt-hours per horsepower.	....	
General power (optional demand rate).	144	July 8, 1913	....	....	A monthly demand and readiness to serve charge of $150 plus $1 per horsepower per month for each horsepower of maximum demand in excess of 150 horsepower plus 1 cent per kilowatt-hour for all current used monthly. Maximum demand average of maximum 15 minutes.	San Francisco.

[m] Optional maximum demand. Where installation exceeds 50 horsepower and this schedule is requested in place of schedule 142 at time of signing contract.

TABLE 293.—*Electric rates of Pacific Gas & Electric Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Power—Continued.						
General power, installation up to 10 horsepower.	156	July 10, 1918	$0.0375 for first 60 kilowatt-hours per horsepower.	$0.01 for all over 180 kilowatt-hours per horsepower.	$1 per horsepower for first 50 horsepower; $0.50 per horsepower for each additional horsepower.	See note 4.
Over 10 and including 25 horsepower.			$0.0330 for first 60 kilowatt-hours per horsepower.	$0.0095 for all over 180 kilowatt-hours per horsepower.		
Over 25 and including 50 horsepower.			$0.0280 for first 60 kilowatt-hours per horsepower.	$0.0090 for all over 180 kilowatt-hours per horsepower.		
Over 50 and including 100 horsepower.			$0.0235 for first 60 kilowatt-hours per horsepower.	$0.0085 for all over 180 kilowatt-hours per horsepower.		
Over 100 and including 200 horsepower.			$0.0195 for first 60 kilowatt-hours per horsepower.	$0.0080 for all over 180 kilowatt-hours per horsepower.		
Over 200 and including 300 horsepower.			$0.0190 for first 60 kilowatt-hours per horsepower.	$0.0070 for all over 180 kilowatt-hours per horsepower.		
Over 300 and including 400 horsepower.			$0.0185 for first 60 kilowatt-hours per horsepower.	$0.0065 for all over 180 kilowatt-hours per horsepower.		
Over 400 and including 500 horsepower.			$0.0180 for first 60 kilowatt-hours per horsepower.	$0.0065 for all over 180 kilowatt-hours per horsepower.		
General power (optional maximum demand) optional in lieu of schedule 156 for installation of over 50 horsepower.	157	July 10, 1918	Same rates for 50 to 500, but based on maximum demand, not on installed capacity as in schedule 156.			Do.
General power, for installations having demands in excess of 500 horsepower.	157-x	do.				Do.
Maximum demand, 501-600 horsepower.			$0.0170 for first kilowatt-hour per horsepower demand.	$0.0064 for all over 180 kilowatt-hours per horsepower demand.	$1 per horsepower of the maximum demand, but not less than $50 nor less than 20 per cent of installed capacity at $1 per horsepower. Maximum demand is for maximum 15 minutes.	
Maximum demand, 601-700 horsepower.			$0.0165 for first 60 kilowatt-hours per horsepower demand.	$0.0063 for all over 180 kilowatt-hours per horsepower demand.		
Maximum demand, 701-800 horsepower.			$0.0160 for first 60 kilowatt-hours per horsepower demand.	$0.0062 for all over 180 kilowatt-hours per horsepower demand.		

Maximum demand, 801-1,000 horsepower.			$0.0150 for first 60 kilowatt-hours per horsepower demand.	$0.0060 for all over 180 kilowatt-hours per horsepower demand.		
Maximum demand, over 1,000 horsepower.			$0.0140 for first 60 kilowatt-hours per horsepower demand.	$0.0060 for all over 180 kilowatt-hours per horsepower demand.		
General power	162	Sept., 1916	$0.04 for first 50 kilowatt-hours.	$0.01 for all over 150 kilowatt-hours.[a]	$1 per horsepower for installations of 25 horsepower or less; $1 per horsepower of maximum demand for installations over 25 horsepower.	Chico district.
Commercial power	171	July 9, 1912	$0.03 per kilowatt-hour		$1 per horsepower	West Sacramento electric territory.
Commercial power (optional in lieu of 141).	182	May 7, 1917	$0.06 for first 50 kilowatt-hours.	$0.0225 for all over 6,000 kilowatt-hours.	$0.75 per horsepower connected load, but not less than $5.	San Francisco.
General power	203	Aug. 1, 1919				Durham Light & Power territory.
Up to 5 horsepower			$0.05 for first 50 kilowatt-hours.	$0.03 for all over 100 kilowatt-hours.	$1.50 for 1 horsepower, $1 per horsepower for 2 horsepower and over.	
6 to 20 horsepower			$0.04 for first 50 kilowatt-hours.	$0.02 for all over 100 kilowatt-hours.		
21 to 50 horsepower			$0.03 for first 50 kilowatt-hours.	$0.015 for all over 100 kilowatt-hours.		
Industrial power	120	July 1, 1912	$0.03 for first 500 kilowatt-hours.	$0.0125 for all over 4,000 kilowatt-hours.	$1 per horsepower installed up to 50 horsepower and $0.50 for each horsepower over 50.	Alameda County district, except in Livermore, Pleasanton, and adjacent territory.
Industrial power (optional in lieu of 162).	163	Sept., 1916	$4 per horsepower for 1 month continuous service.	$20.35 per horsepower for 12 months' continuous service.	If demand charge is based upon maximum demand, in no event will such maximum be taken as less than 50 per cent of connected load.	Chico district.
Industrial power	175	May 1, 1915				Oro electric territory.
2 to 2.9 horsepower			$0.050 for first 100 kilowatt-hours per horsepower.	$0.03 for all over 200 kilowatt-hours per horsepower.	$1 per horsepower	
3 to 4.9 horsepower			$0.045 for first 100 kilowatt-hours per horsepower.	do		
5 to 7.4 horsepower			$0.04 for first 100 kilowatt-hours per horsepower.	$0.0275 for all over 200 kilowatt-hours per horsepower.		
7.5 to 9.9 horsepower			$0.035 for first 100 kilowatt-hours per horsepower.	$0.025 for all over 200 kilowatt-hours per horsepower.		
10 to 19.9 horsepower			$0.03 for first 100 kilowatt-hours per horsepower.	$0.0225 for all over 200 kilowatt-hours per horsepower.		
20 to 29.9 horsepower			$0.0275 for first 100 kilowatt-hours per horsepower.	$0.02 for all over 200 kilowatt-hours per horsepower.		

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[a] Discounts for installations over 5 horsepower: 1 per cent for each additional horsepower over 5 horsepower up to and including 25 horsepower; 1 per cent for each additional 5 horsepower over 25 horsepower up to and including 50 horsepower; 1 per cent for each additional 10 horsepower over 50 horsepower up to and including 100 horsepower; 1 per cent for each additional 100 horsepower over 100 horsepower up to and including a maximum discount of 50 per cent.

TABLE 293.—*Electric rates of Pacific Gas & Electric Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Power—Continued.						
Industrial power—Contd.						
30 to 39.9 horsepower			$0.02375 for first 100 kilowatt-hours per horsepower.	$0.0175 for all over 200 kilowatt-hours per horsepower.		
40 to 49.9 horsepower			$0.0225 for first 100 kilowatt-hours per horsepower.	$0.0175 for all over 200 kilowatt-hours per horsepower.		
50 to 99.9 horsepower			$0.02 for first 100 kilowatt-hours per horsepower.	$0.0125 for all over 200 kilowatt-hours per horsepower.		
Industrial and manufacturing power.	190	July 10, 1918				All territory.
Maximum demand less than 3,000 kilowatts:						
Readiness to serve.			$1.70 per kilowatt for first 200 kilowatts of the maximum demand during each month.	$0.50 per kilowatt for all over 500 kilowatts of the maximum demand during each month.	Maximum demand is for maximum 15 minutes.	
Energy charge[a]			$0.007 per kilowatt for first 100,000 kilowatt-hours.	$0.0045 for all over 300,000 kilowatt hours.	Minimum yearly charge, an amount equal to 12 times the maximum monthly readiness to serve charge, but not less than $6,000, payable one-twelfth monthly.	
Maximum demand in excess of 3,000 kilowatts:						
Readiness to serve.			$0.59 per kilowatt of maximum demand.			
Energy charge[a]			$0.007 for first 33⅓ kilowatt-hours per kilowatt of maximum demand.	$0.0045 for all over 100 kilowatt-hours per kilowatt of maximum demand.		
Agricultural power (optional in lieu of 114).	115	Nov. 14, 1912	$0.03 for first 29 kilowatt-hours per horsepower.	$0.01 for all over 538 kilowatt-hours per horsepower.	$6 per horsepower per year	All territory except cities of San Francisco, Sacramento, Antioch, and town of Esparto. In Santa Rosa and Petaluma district may be applied to less than 5 horsepower.
Reclamation power	116	do				All territory.
Less than 25 horsepower.			$0.03 for first 1,000 kilowatt-hours.	$0.02 for all over 2,000 kilowatt hours.	$12 per horsepower per year.	
25 to 49 horsepower			$0.015 per kilowatt-hour		do	

50 horsepower and over.			$0.02 per kilowatt hour	$0.01 per kilowatt-hour	From no minimum to $12 per horsepower per year.	
Agricultural power	164	Jan. 1, 1917	$0.03 for first 60 kilowatt-hours.	$0.0075[p] for all over 180 kilowatt-hours per horsepower.	$12 per horsepower per year	Chico district.
Intermediate development.[q]			$0.035 for first 60 kilowatt-hours.	$0.0090 for all over 180 kilowatt-hours per horsepower.	$9 per horsepower per year	
Primary development[r]			$0.04 for first 60 kilowatt-hours.	$0.01 for all over 180 kilowatt-hours per horsepower.	$6 per horsepower per year	
Agricultural power, contract basis.	165	do	$4.25 for 1 month of continuous service to $18.25 per horsepower for 12 months of continuous service; demand charge plus 5 mills per kilowatt-hour energy charge.		Demand charges based on maximum connected load or upon measured maximum monthly demand, for which the demand charges will be increased by factor 1.065, but the maximum demand will not be less than 50 per cent of the connected load. No minimum rate for less than 1 horsepower.	Do.
Noncontract basis			$4.25 for first month's service to $0.85 for twelfth months' service per horsepower; demand charge plus 5 mills per kilowatt-hour energy charge.			
Agricultural power	170	July 9, 1912	$0.03 for first 1,000 kilowatt-hours.	$0.02 for all over 1,000 kilowatt-hours.	$5 per meter from 5 to 20 horsepower and $1 per meter for less than 5 horsepower.	West Sacramento Electric Co. territory.
Agricultural and pumping	177	May 1, 1915	$0.0275 for first 1,000 kilowatt-hours.	$0.0175 for all over 2,000 kilowatt-hours.	$6 per year per horsepower installed.	Oro Electric Corporation territory.
Do	178	do	$0.0275 for first 50 kilowatt-hours per horsepower.	$0.015 for all over 200 kilowatt-hours per horsepower.	do	Do.
Agricultural power	179	do				
50 to 74 horsepower			$0.015 per kilowatt-hour[s]		$6 per year per horsepower installed.	Do.
75 to 99 horsepower			$0.0125 per kilowatt-hour[s]			
Over 100 horsepower			$0.01125 per kilowatt hour[s]			
Agricultural power[t]	200	Mar. 15, 1919				All territory except Chico district, Oro Electric territory, and cities of San Francisco and Antioch.
1 to 29 horsepower			$0.03 for first 500 kilowatt-hours.	$0.015 for all over 3,000 kilowatt-hours.	$6 per horsepower per year, but not less than $24.	

[o] In addition to readiness-to-serve charge.
[p] First two years of development period.
[q] First year of development period.
[r] Discounts on energy rates; 5 horsepower, net; 1 per cent for each additional horsepower up to and including 20 horsepower; and 1 per cent for each additional 5 horsepower over 20 horsepower up to and including 70 horsepower.
[s] Ten per cent discount if paid within 10 days after date of bill.
[t] Installation of any size may operate under schedule of rates for a larger installation, provided the minimum for the larger installation is guaranteed.

TABLE 293.—*Electric rates of Pacific Gas & Electric Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Power—Continued.						
Agricultural power—Con.						
30 to 49 horsepower			$0.02 for all current consumed.		$6 per horsepower per year	
50 to 99 horsepower			$0.015 for all current consumed.		do	
Over 99 horsepower			$0.0125 for all current consumed.		do	
100 to 499 horsepower[u]			$0.001 for all current consumed.		$12 per horsepower per year.	
500 to 1,499 horsepower.[u]			$0.009 for all current consumed.		do	
Over 1,499 horsepower			$0.008 for all current consumed.		do	
Agricultural power (optional in lieu of 200).	201	Mar. 15, 1919	$0.03 for less than 30 kilowatt-hours per horsepower.	$0.01 for equal or greater consumption than 538 kilowatt-hours per horsepower.	$6 per horsepower per year, but not less than $24.	All territory except Chico district, Oro Electric territory, and cities of San Francisco and Antioch.
Irrigation power, 5 to 14 horsepower.	204	Aug. 1, 1919	$0.04 for first 500 kilowatt-hours.	$0.02 for all over 3,000 kilowatt-hours.	$6 per horsepower per year.	Durham Light & Power territory.
15 to 49 horsepower			$0.03 for all current			
50 horsepower and over			Special rates on application		$6 per horsepower per year	
Mining power	118	July 1, 1913	$0.015 for hoisting	$0.0125 for all other purposes	$1 per installed horsepower	All except Electra district.
Do	129	Apr. 1, 1914			do	Electra district.
100 horsepower or less			$0.0092 per kilowatt-hour			
Over 100 horsepower			$0.00826 per kilowatt-hour		$1 per installed horsepower	
Gold-dredging power	196	July 10, 1918	$0.0075		$1 per horsepower	All rural territory.
Electric cooking, heating, and power.	152	July 1, 1917	$0.04 for first 30 kilowatt-hours per kilowatt connected load.	$0.015 for all over 120 kilowatt-hours per kilowatt connected load.	Under contract, $24 per 12 months for first 5 kilowatts and $12 for each additional kilowatt; noncontract, $2 for first 5 kilowatts and $1 for each additional kilowatt.	All territory except San Francisco, Sacramento, and Chico district.
Cooking and heating power	191	Sept. 15, 1918	$0.03 per kilowatt-hour		$1 per meter for electric range only; with heating or auxiliary cooking equipment, $1 per kilowatt connected load, but not less than $3.	San Francisco and Roseville, in the Napa, Contra Costa, Santa Rosa, and Petaluma districts, and in all of the Alameda County district except in Pleasanton, Livermore, and adjacent territory.
Ice-plant service	121	July 1, 1917	$0.03, with guaranteed revenue of $1.	$0.01, with guaranteed revenue of $1.	$1 to $4	All except San Francisco and Antioch.

Resale service, 5,000 kilowatts or less.	189	Nov. 3, 1918	$1.70 for first 200 kilowatts of maximum demand; readiness-to-serve charge.[v]	$0.50 for all over 500 kilowatts maximum demand; readiness-to-serve charge.	12 times the maximum monthly.	All except San Francisco.
			$0.007 for first 100,000 kilowatt-hours.	$0.0045 for all over 300,000 kilowatt-hours.[l]	Readiness-to-serve charge...	
Over 5,000 kilowatts...	....	....	$0.554 per kilowatt maximum demand; readiness-to-serve charge.	....	Maximum demand is for the maximum 15 minutes.	
			$0.007 for first 20 kilowatt-hours per kilowatt maximum demand.[l]	$0.0045 for all over 60 kilowatt-hours per kilowatt maximum demand.[l]	....	
Seasonal power (optional)[w]	192	Sept. 15, 1918	....	....	....	All.
X-ray service.........	193	.....do.......	Classed as power on separate service or if combined at regular lighting rate.	....	$0.50 per kilowatt capacity, but not less than $0.75.	Do.
Stand-by or auxiliary[x]....	199	Feb. 20, 1919	$2 per kilowatt for first 20 kilowatts of maximum load.	$1.25 per kilowatt for all over 100 kilowatts of maximum load.	$20........................	Do.
Moving-picture machine...	207	Aug. 1, 1919	$0.10 metered or flat rate of $1 per show of 5 reels or less, and $0.25 for each additional reel.	....	$0.50 per night in addition to energy charge when metered.	Durham Light & Power territory.
Cold storage, 5 horsepower or less.	209	.....do.......	$0.03 for first 100 kilowatt-hours.	$0.02 for all over 200 kilowatt-hours.	$1 per horsepower per month.	Do.

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[l] Additional to readiness-to-serve charge.

[u] Central power plant or central point for measuring energy.

[v] The maximum charge not to exceed $0.015 per kilowatt-hour.

[w] Seasonal power service regularly operating not more than 10 months per year. This schedule provides an annual minimum in lieu of monthly minimum provisions of any appropriate rate schedule. Bills rendered as usual and at end of year the kilowatt-hour would be computed. Total of monthly minimum charges properly computed for 12 months shall also be computed and taken as the annual minimum charge under this schedule. If annual kilowatt-hour cost of current equals or exceeds the annual minimum charge as thus computed, then all bills paid at the monthly minimum charge during the year shall be adjusted; also if the annual kilowatt-hour cost of current is less than annual minimum charge but actual bills paid exceed the annual minimum charge.

[x] Maximum load, 1,000 kilowatts. This schedule used in connection with such other rate schedule, applicable to class of business if continuously supplied.

NOTES.

1. This rate applies in all territory served, with following exceptions: Alameda County district outside of Pleasanton and Livermore and adjacent territory; Chico, San Francisco, and San Jose districts, and that part of San Joaquin district formerly known as Stanislaus district; the cities of Sacramento and Antioch and town of Paradise; territory served from lines formerly owned by Oro Electric Corporation and extensions therefrom in Marysville and San Joaquin district.

1a. This company serves all or parts of the following counties in central California: Alameda, Amador, Butte, Calaveras, Colusa, Contra Costa, Eldorado, Glenn, Marin, Mariposa, Napa, Nevada, Placer, Sacramento, San Francisco, San Joaquin, San Mateo, Santa Clara, Santa Cruz, Sierra, Solano, Sonoma, Stanislaus, Sutter, Tuolumne, Yolo, and Yuba.

2. This rate applies in all of Alameda County district, except in the city of Berkeley and in Pleasanton and Livermore and adjacent territory.

3. This rate applies in Colgate, De Sabla, Drum, Electra, Marin, Marysville, Nevada, Placer, Redwood, San Joaquin, San Jose, Solano, and Yolo districts, except in Paradise-De Sabla district, and consumers supplied from lines heretofore owned by Oro Electric Corporation and extension thereto in Marysville and San Joaquin districts.

4. This rate applies in San Francisco, Alameda County, Contra Costa, Napa, Petaluma, Sacramento, and Santa Rosa districts, except in the town of Antioch.

5. Rates do not apply in territory formerly supplied by Durham Light & Power Co. except as specifically stated.

6. The California Railroad Commission has authorized the company to increase the rates affecting all territory, excepting the Durham Light & Power territory, here published by a surcharge ranging according to class of service from 1 mill to 10 mills per kilowatt-hour, to cover in part the increased cost of production due to conditions brought about by the war.

TABLE 294.—*Electric rates of Northern California Power Co. Consolidated in effect Nov. 15, 1919.*

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Employees' rates:						
Class 1 [a]			$0.02 for current between 31 and 330 kilowatt-hours.	Free for first 30 kilowatt-hours		All.
Class 2 [a]			Free.			Do.
General lighting	1	Sept. 15, 1916	$0.07 for first 20 kilowatt-hours.	$0.02 for all over 2,200 kilowatt-hours.	$1	Entire territory except as noted under other rates.
Lighting, heating, and cooking where rated capacity exceeds 3 kilowatts.	2	do	do	$0.01 for all over 170 kilowatt-hours.	$2	All.
Heating (rated capacity 1,000 watts or over; not connected to lighting circuit).	2a	Dec. 8, 1916	$0.03 for first 150 kilowatt-hours.	$0.01 for all over 150 kilowatt-hours.	$2	Do.
Heating [b]	2b	Oct. 31, 1917	$4 for the first 2 kilowatts or less; $2 per kilowatt capacity or fraction over 2 kilowatts.		$4	Do.
General power	5	Oct. 15, 1916	$0.04 for first 50 kilowatt-hours per horsepower connected.	$0.01 for all over 150 kilowatt-hours per horsepower connected.	$1 per horsepower connected load, but not less than $2 per meter. [c]	
Industrial power: Connected load applicable to all power installations not elsewhere specifically provided for.	6	do	$4 per horsepower demand charge for one month's continuous service plus $0.005 per kilowatt-hour energy rate.	$20.35 per horsepower demand charge for 12 months' continuous service, plus $0.005 per kilowatt-hour.		Do.
Industrial power	7	Nov. 1, 1916	$6.75 per horsepower of connected load for 1 month's continuous service.	$40 per horsepower of connected load for 12 months' continuous service.		Do.
Power: Optional rate for box factories and other items. Installation of 100 horsepower or over.	8	do	$0.01 per kilowatt-hour		$12 per horsepower installed per year.	Entire territory.
Agricultural power	9	Jan. 1, 1917				
General			$0.03 for first 60 kilowatt-hours	$0.0075 [d] for all over 180 kilowatt-hours.	$12 per horsepower per year	All.
Intermediate development. [e]			$0.035 for first 60 kilowatt-hours.	$0.009 [d] for all over 180 kilowatt-hours.	$9 per horsepower per year	
Primary development [f]			$0.04 for first 60 kilowatt-hours	$0.01 [d] for all over 180 kilowatt-hours.	$6 per horsepower per year	
Agricultural power	10	Jan. 1, 1917				All.
Contract basis			$4.25 per horsepower of connected load demand charge for 1 month's continuous	$18.25 per horsepower connected load, demand charge for 12 months' continuous	Rate for 1 horsepower	

			service plus $0.005 per kilowatt-hour for energy consumed.	service, plus $0.005 per kilowatt-hour for energy consumed.		
Noncontract basis			do	Down to $0.85 per horsepower connected load, demand charge for 12 months' continuous service plus $0.005 per kilowatt-hour for energy consumed.	do	
Agricultural power, flat	11	Jan. 1, 1917				All.
Contract basis			$7 per horsepower of connected load for 1 month.	$36.75 per horsepower connected load for 12 months.	Rate for 1 horsepower	
Noncontract basis [g]			do	Down to $1.80 per horsepower connected load for 12 months of continuous service.	do	
Public outdoor lighting [h]	3	Sept. 15, 1916				All except Redding.
6.6-ampere luminous arcs			$36.40 per lamp per year plus $0.50 per 100 lamp-hours.			
4-ampere luminous arcs			$33 per lamp per year plus $0.45 per 100 lamp-hours.			
500-watt multiple incandescent lamps.			$31 per lamp per year plus $0.70 per 100 lamp-hours.			
600-candlepower series and 400-watt multiple incandescent lamps.			$29.50 per lamp per year plus $0.60 per 100 lamp-hours.			
300-watt multiple incandescent lamps.			$28 per lamp per year plus $0.50 per 100 lamp-hours.			
400-candlepower series and 200-watt multiple incandescent lamp.			$27 per lamp per year plus $0.40 per 100 lamp-hours.			
250-candlepower series and 150-watt multiple incandescent lamp.			$23 per lamp per year plus $0.30 per 100 lamp-hours.			
100-watt multiple incandescent lamps.			$18 per lamp per year plus $0.20 per 100 lamp-hours.			
100-candlepower series and 80-watt multiple incandescent lamps.			$16.20 per lamp per year plus $0.15 per 100 lamp-hours.			
80-candlepower series and 60-watt multiple incandescent lamps.			$13.40 per lamp per year plus $0.10 per 100 lamp-hours.			

[a] Class 1, employees of distributing department; class 2, employees of generating department.

[b] This rate is given only where continuous service is wanted during October, November, December, January, February, and March, and no additional investment is required of the company.

[c] Discount from energy rate as follows: 5 horsepower or less, none; from 6 to 25 horsepower, 1 per cent for each horsepower; from 26 to 50 porsepower, 1 per cent for each 5 horsepower; from 51 to 100 horsepower, 1 per cent for each 10 horsepower; over 100 horsepower, 1 per cent for each 100 horsepower up to a maximum of 50 per cent.

[d] Discounts except for minimum charge as follows: 1 per cent per horsepower for 6 to 20 horsepower, and 1 per cent for each 5 horsepower from 21 to 70 horsepower.

[e] First two years of development period.

[f] During first year of development period.

[g] Consumer pays for cost of service connection and disconnection.

[h] All-night lamps will be considered as burning 4,000 hours per year.

TABLE 294.—*Electric rates of Northern California Power Co. Consolidated in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Public outdoor lighting—Con.						
50-watt multiple incandescent lamps.			$12.50 per lamp per year plus $0.09 per 100 lamp-hours.			
60-candlepower series and 40-watt multiple incandescent lamp.			$11.50 per lamp per year plus $0.08 per 100 lamp-hours.			
40-candlepower series incandescent.			$10 per lamp per year plus $0.07 per 100 lamp-hours.			
Special street lighting	4	Sept. 15, 1916	$0.03 for first 100 kilowatt-hours.	$0.0075 for all over 300 kilowatt-hours per kilowatt.	$16 per kilowatt per year	Redding.
Wholesale power (contract meter rates 50 horsepower or over).[i]	12	Oct. 15, 1916	$0.02 for first 100 kilowatt-hours per kilowatt.	$0.005 for all over 300 kilowatt-hours per kilowatt.	$12 per horsepower per year.	All.
Special power [j]	14	do	$33.50 per year per kilowatt of maximum demand based on highest 30-minute peak.			Do.
Flat-rate lighting:[k]						
Class 1: Residence lighting.	1a	Oct. 1, 1916	$1 for first three lamps	$0.25 per lamp for over three lamps.	All-night lights used in connection with class 1 and class 2 rates will be charged for at rate of $0.60 per month.	Effective only in the towns of De La Mar, Ingot, Keswick, Manton, Millville Old Diggings, Shasta, Boram, Lewiston, Palo Cedro, and Heroult.
Class 2: General commercial lighting.			$1.50 for first three lamps	$0.50 per lamp over three lamps.		
Class 3: All-night rate			$1.50 for first two lamps	$0.60 per lamp over two lamps.		
Agricultural power, optional on long term contract.	9a	Jan. 1, 1917				Wher same schedule is maintained by Pacific Gas & Electric Co.
5 to 29 horsepower installation.			$0.03 for the first 500 kilowatt-hours.	$0.015 for all over 3,000 kilowatt-hours.	$6 per horsepower per year	
30 to 49 horsepower installation.			$0.02 per kilowatt-hour		do	
50 to 99 horsepower installation.			$0.015 per kilowatt-hour		do	
100 or over horsepower installation.			$0.0125 per kilowatt-hour		do	
100 or over horsepower installation in central pumping station.			$0.01 per kilowatt-hour		$12 per horsepower per year	

Agricultural power, optional.	9b	.....do........	$0.03 per kilowatt hour if monthly consumption is less than 30 kilowatt-hours per horsepower.	$0.01 per kilowatt-hour if monthly consumption is 538 kilowatt-hours or over, per horsepower installation.	$6 per horsepower per year..	Do.
General power rate, optional...	5a	Oct. 15, 1916	$0.04 per kilowatt-hour if consumption is less than 20 kilowatt-hours per month per horsepower installation.	$0.01 per kilowatt-hour if monthly consumption is 540 kilowatt-hours or over per month per horsepower.	$1 per horsepower per year..	Do.
General power rate, optional [l].	5b	.....do.......	....	....	....	Do.
1 to 10 horsepower.........	....	....	$0.04 for first 54 kilowatt-hours per horsepower.	$0.011 for all over 108 kilowatt-hours per horsepower.	$1 per horsepower per month.	
10 to 25 horsepower........	....	....	$0.035 for first 54k ilowatt-hours per horsepower.	.....do........	.....do........	
25 to 50 horsepower........	....	....	$0.03 for first 54 kilowatt-hours per horsepower.	.....do........	.....do........	
50 to 100 horsepower.......	....	....	$0.025 for first 54 kilowatt-hours per horsepower.	.....do........	.....do........	
100 to 200 horsepower......	....	....	$0.02 for first 54 kilowatt-hours per horsepower.	$0.01 for all over 108 kilowatt-hours per horsepower.	.....do........	
Wholesale power (contract meter rates 100 horsepower or over).[m]	13	June 20, 1917	Demand charge of $2.50 per month per kilowatt of maximum demand plus an energy charge of $0.0025 per kilowatt-hour.	....	One-half the demand charge.	All.
Special power [n]...............	15	Oct. 15, 1916	$2.9375 per month per kilowatt of maximum demand based on highest 30 minute peak.	....	....	

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[i] Discounts for substation rates: First 75 horsepower or less, net; next 50 horsepower, 1 per cent for each 10 horsepower; next 125 horsepower, 1 per cent for each 25 horsepower; next 250 horsepower, 1 per cent for each 50 horsepower; next 500 horsepower, 1 per cent for each 100 horsepower; over 1,000 horsepower to and including a maximum discount of 30 per cent, 1 per cent for each 1,000 horsepower. Additional discount for transmission-line rate: 670 horsepower or less, 10 per cent; from 671 horsepower to 1,340 horsepower, 7½ per cent; over 1,340 horsepower, 5 per cent.

[j] Installation in excess of 500 kilowatts and power factor, or approximately 100 per cent.

[k] Any lighting unit rated at 60 watts per hour or less shall be considered as one lamp. Rates applying to units rated at over 60 watts per hour shall be determined as follows: From 61 to 120 watts, 2 lamps; from 121 to 180 watts, 3 lamps; from 181 to 240 watts, 4 lamps; from 241 to 300 watts, 5 lamps; over 300 watts in same proportion.

[l] In this rate the horsepower taken is installed, rating up to 50 horsepower, and maximum demand in single installations of 50 horsepower or over or more than one motor.

[m] Discounts applicable to demand charge only for substation rate: First 500 kilowatts or less, net; next 500 kilowatts, 1 per cent for each 50 kilowatts; next 1,000 kilowatts 1 per cent for each 100 kilowatts; next 2,000 kilowatts, 1 per cent for each 200 kilowatts; all over 4,000 kilowatts, 30 per cent discount. Additional discount for transmission-line rate: 500 kilowatts or less, 10 per cent; from 501 to 1,000 kilowatts, 7½ per cent; over 1,000 kilowatts, 5 per cent.

[n] Special experimental rate where total installation exceeds 1,000 kilowatts and where amount used for experimental purposes exceeds 500 kilowatts.

NOTES.

1. The California Railroad Commission has authorized the company to increase the rates affecting all territory here published by a surcharge ranging according to class of service from 2 mills to 10 mills per kilowatt-hour or 10 per cent of monthly bill to cover in part the increased cost of production due to conditions brought about by the war.

2. This company serves all or portions of Shasta, Tehama, Glenn, Colusa, Butte, Yolo, and Trinity counties; and service is rendered in the towns of Ingot, De la Mar, Heroult, Kenneth, Coram, Keswick, Old Diggings, Shasta, Millville, Palo Cedro, Redding, Anderson, Cottonwood, Mammoth Mine, Balaklala, Gladstone, Washington, Iron Mountain, Red Bluff, Proberta, Gerber, Vina, Los Molinos, Bohemia, Corning, Richfield, Orland, Germantown, Hamilton City, Willows, Jacinto, Butte City, Maxwell, Princeton, Williams, Arbuckle, College City, Chico, Dunnigan, Lewiston, and all surrounding and adjacent territory.

TABLE 295.—*Electric rates of Sierra & San Francisco Power Co. in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise specified.]

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Lighting:						
Residence, employees	R-1	Oct. 10, 1917	$0.03 for 41 to 140 kilowatt-hours.	Free for first 40 kilowatt hours.		All.
Lighting and motors, 1 horsepower or less.	B	Oct. 10, 1911	$0.07 for first 100 kilowatt-hours.	$0.03 for all over 1,000 kilowatt-hours.	$1	Modesto.
Street	T	Oct. , 1917	6.6-amperes series direct-current magnetic lamps $54 each per year, 100 candle-power incandescent street lamps, $21.60 each per year.			Turlock.
Power:						
Installations over 1 horse-power.[a]	D-1	do	$0.04 for first 50 kilowatt-hours per horsepower of rated capacity.	0.01 for all over 150 kilowatt-hours per horsepower of rated capacity.	$0.50 per horsepower rated capacity.	All.
Mining rate (installations of 100 horsepower or more.	I	Oct. 10, 1911	$0.00972 where load factor is 30 to 40 per cent.	$0.00754 where load factor is 60 per cent or over.	$1.50 per horsepower of rated capacity of installation.	Calaveras and Tuolumne County mining district.
Municipal pumping plant.	U	Oct. 1, 1917	$0.02 per kilowatt-hour			Turlock water works.
Service plus energy rate[a].	S-1	do				All.
Installations:						
1 to 9 horsepower			$0.015 for all energy plus $1 per month per horsepower connected.[b]			
10 to 49 horsepower			$0.0125 for all energy plus $1 per month per horsepower connected.			
50 to 99 horsepower			$0.01 for all energy plus $1 per month per horsepower connected.[b]			
100 horsepower or over			$0.0075 for all energy plus $1 per month per horsepower connected.[b]			
			$0.025 for all energy consumed outside the period to which service charge applies.			
Electric cooking and heating	C-1	Jan. 1, 1913	$0.05 for first 50 kilowatt-hours.	$0.03 for all over 150 kilowatt-hours	$3 per meter	Do.
Power (flat rate)	F	Mar. 22, 1913	Daylight hours service: Entire year period, $36 per horsepower period.	24-hour service: Entire year period $50 per horsepower.		

			6 months ending July 31, $22.50. 5 months' period ending July 31, $20. 4 months' period ending July 31, $18. 3 months' period ending July 31, $16.50. 2 months' period ending July 31, $16.50. 1 month's period ending July 31, $16.50. For service 24 hours during August and September and midnight to sundown during October following all but first rate above $0.025 per kilowatt-hour (metered).	6 months' period ending July 31, $31.20. 5 months' period ending July 31, $27.75. 4 months' period ending July 31, $25. 3 months' period ending July 31, $22.50. 2 months' period ending July 31, $22.50. 1 month's period ending July 31, $22.50.	$1 per horsepower installed capacity per month.	
			Daylight hours service: 8 months' period ending September 30, $31.50. 7 months' period ending Sept. 30, $29. 6 months' period ending Sept. 30, $27. 5 months' period ending Sept. 30, $22.50. 4 months' period ending Sept. 30, $18. 3 months' period ending Sept. 30, $16.50. 2 months' period ending Sept. 30, $16.50. 1 month's period ending Sept. 30. $16.50.	24-hour service: 8 months' period ending September 30, $43.70. 7 months' period ending Sept. 30, $40.25. 6 months' period ending Sept. 30, $37.50. 5 months' period ending Sept. 30, $31.25. 4 months' period ending Sept. 30, $25. 3 months' period ending Sept. 30, $22.50. 2 months' period ending Sept. 30, $22.50. 1 month's period ending Sept. 30, $22.50.		
Development rate modification of F for new territory to be followed by F rate after one or two years.	G........	...do.......	12 months, $0.025 per kilowatt-hour. 9 months, $0.025 per kilowatt-hour. 8 months, $0.025 per kilowatt-hour. 7 months, $0.025 per kilowatt-hour. 6 months, $0.025 per kilowatt-hour. 5 months, $0.025 per kilowatt-hour. 4 months, $0.025 per kilowatt-hour.	Motor operation limited as follows: January, 12.01 a. m. to 4.40 p. m. February, 12.01 a. m. to 5.25 p. m. March to September, inclusive, continuously. October 12.01 a. m. to 5 p. m. November 12.01 a. m. to 4.30 p. m. December, 12.01 a. m. to 4.20 p. m.	12-month users, $1.75 per installed horsepower. 9-month users, $2 per installed horsepower. 8-month users, $2 per installed horsepower. 7-month users, $2 per installed horsepower. 6-month users, $2.25 per installed horsepower. 5-month users, $2.25 per installed horsepower. 4-month users, $2.25 per installed horsepower.	San Joaquin district.

[a] Three-phase current limited to 5 horsepower or over.

[b] Service charge or $1.25 per horsepower per month for not less than 6 specified months.

TABLE 295.—*Electric rates of Sierra & San Francisco Power Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Temporary, flat rate	H	Mar. 22, 1913	For use in October, November, or December, or fraction of either.			San Joaquin district.
			24-hour, $10 per horsepower	12 hours, $8 per horsepower	Guaranty of 1 month's use per year, 30 consecutive days to constitute 1 month. Following the above period, 2½ cents per kilowatt-hour with minimum of $1 per month per horsepower while connected.	
			Prior to Sept. 30: First month or fraction, $10 per horsepower. Second month or fraction, $8 per horsepower. Third month or fraction, $6 per horsepower. Any succeeding month or fraction, $4 per horsepower.	First month or fraction, $8 per horsepower. Second month or fraction, $6 per horsepower. Third month or fraction, $4 per horsepower. Any succeeding month or fraction, $3 per horsepower.		
Temporary power service [a]	J-1	Oct. 1, 1917	$0.04 for first 50 kilowatt-hours per horsepower rated capacity.	$0.01 for all over 150 kilowatt-hours per horsepower rated capacity.	$1 per horsepower per month on rated capacity.	All.
Combined lighting and cooking.	L	Jan. 1, 1916	$0.10 for 25 kilowatt-hours or less.	$0.03 for all over 25 kilowatt-hours.	$1	San Joaquin division.
General lighting, commercial, and small motors. [c]	M-1	Oct. 1, 1917	$0.10 for first 50 kilowatt-hours.	$0.03 for all over 1,000 kilowatt-hours.		All.
Domestic lighting, cooking, and small motors. [d]	N-1	do	$0.10 for first 25 kilowatt-hours.	$0.03 for all over 25 kilowatt-hours.		Do.
Commercial lighting [e]	O	Jan. 27, 1916	do	$0.03 for all over 100 kilowatt-hours.		Oakdale.
Mining power service, low tension.	P	Feb. 25, 1916	Installations of not over 100 horsepower, $0.0092 per kilowatt-hour.	Over 100 horsepower, $0.00825 per kilowatt-hour.	$1 per horsepower per month installations of 50 horsepower or less, plus $0.50 per month for each additional horsepower.	Calaveras, Tuolumne, and Stanislaus counties mining districts.

[a] Three-phase current limited to 5 horsepower or over.

[c] Applicable to all lighting services not covered by schedule N-1.

[d] Applicable only for domestic use in residences, flats, and apartments occupied by single families. Schedules M-1 and N-1 limited to motors of 1 horsepower or less. Schedule N-1 limited to 1,000-watt capacity heating and cooking device without special permission.

[e] Not applicable to residences, flats, or apartments occupied by single families.

NOTES.

1. Territory includes parts of Tuolumne, Calaveras, Stanislaus, San Joaquin, Contra Costa, Alameda, Santa Clara, San Mateo, and San Francisco counties.
2. The California Railroad Commission has authorized the company to increase the rates affecting all territory here published by a surcharge ranging according to class of service from 1 mill to 10 mills per kilowatt-hour, or 15 per cent of monthly bills to cover in part the increased cost of production due to conditions brought about by the war.

TABLE 296.—*Electric rates of Coast Valleys Gas & Electric Co. in effect Nov. 15, 1919.*

[Rates are per kilowatt-hour per meter per month unless otherwise specified.]

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Lighting and small motors	A	Nov. 30, 1917	$0.08 for first 20 kilowatt-hours	$0.03 for all over 350 kilowatt-hours.	$1 per meter	Monterey, Pacific Grove, Salinas.
Do.[a]	B	do	$0.10 for first 50 kilowatt-hours.	$0.03 for all over 1,000 kilowatt-hours.	do	All not covered by Schedule A.
Lighting, cooking, and heating, optional.[b]	C	do	$0.10 for first 25 kilowatt-hours.	$0.03 for all over 25 kilowatt-hours.	$2.50 per meter (discount of 10 per cent for payment before 10th).	All.
Cooking and heating only	D	do	$0.035 for first 50 kilowatt-hours.	$0.03 for all over 150 kilowatt-hours.	$2.50 per meter	Do.
Commercial power, block system.[c]	E	do	$0.04 for first 50 kilowatt-hours per month per horsepower rated capacity.	$0.01 for all over 150 kilowatt-hours per horsepower rated capacity.	Full minimum when use has been for less than 30 days, per rates for fraction of month when use is over 30 days.	
Power (service and energy rate) optional.[d]	F	do	$0.01 per kilowatt-hour where rated capacity is 15 horsepower or less; $0.006 per kilowatt-hour where rated capacity is 501 to 1,000 horsepower; service charge of $2 per month per horsepower rated capacity plus rate for energy.			Do.
Commercial power, flat rate (optional).[c]	G	do	$10 per horsepower rated capacity for first month's service.	$7.50 per horsepower rated capacity for each additional consecutive month.	Shown in rate	Do.

[a] No motor in excess of 1 horsepower capacity may be installed under this rate.

[b] Also applicable to commercial lighting and power consumers whose installed capacity does not exceed 5 kilowatts on the basis of 50 watts for each socket.

[c] Following discounts are allowed on an installation of over 15 horsepower as follows: 1 per cent per horsepower for 16 to 25 horsepower capacity; 1 per cent for each 5 horsepower for next 50 horsepower; 1 per cent for each 10 horsepower for next 50 horsepower; 1 per cent for each 25 horsepower for next 125 horsepower; 1 per cent for each 50 horsepower for next 250 horsepower; 1 per cent for each 100 horsepower for next 500 horsepower; special rates for installations over 1,000 horsepower capacity. In addition the following gross revenue discount is allowed over and above $10 per horsepower per year; 10 per cent for second $10 per horsepower per year; 20 per cent for next $10 per horsepower per year; increasing 10 per cent for each $10 per horsepower per year up to a maximum discount of 90 per cent.

[d] This rate is allowed where consumer contracts for at least 6 months' service per year. The same discounts are allowed as for Schedule E.

TABLE 296.—*Electric rates of Coast Valleys Gas & Electric Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Series street lighting (flat rate) all-night every-night service.	H	Nov. 30, 1917	6.6-ampere arcs, $54 per lamp per year; 100 candlepower increase, $21.60 per lamp per year; 60 candlepower increase, $17.40 per lamp per year; 40 candlepower increase, $15 per lamp per year.		Shown in rate	Salinas, Monterey, Pacific Grove, King City.
Lighting, municipal, electroliers.	I	do	$0.05 for first 500 kilowatt-hours.	$0.03 for all over 1,000 kilowatt-hours.	$1 per lamp plus energy consumed.	Salinas.
Company's employees, lighting, heating, and cooking.	J	do	$0.03 for 41 to 140 kilowatt-hours.	Free for first 40 kilowatt-hours.	None	All territory.
Power for street railways	K	Dec. 1, 1917	$0.015 per kilowatt-hour			All.

NOTES.

1. The company serves the towns of Monterey, Pacific Grove, Carmel, Salinas, Spreckels, Chualar, Soledad, Kings City, and contiguous territory north of 5th standard parallel in Monterey County.

2. The California Railroad Commission has authorized the company to increase the rates affecting all territory here published by a surcharge ranging according to class of service from 5 mills up to 15 mills per kilowatt-hour, or a net increase of 15 or 20 per cent on the monthly bill, to cover in part the increased cost of production due to conditions brought about by the war.

TABLE 297.—*Electric rates of Great Western Power Co. and Great Western Power Co. of California in effect Nov. 15, 1919.*

(Per kilowatt-hour per meter per month unless otherwise specified.)

Great Western Power Co.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Domestic service:						
Residence lighting	101	Oct. 15, 1917	$0.08 for first 30 kilowatt-hours.	$0.05 for all over 200 kilowatt-hours.	$1 per meter	All except city of Sacramento and San Francisco, Alameda, San Mateo, and Plumas counties.
Do	102	Nov. 1, 1912	$0.07 for first 100 kilowatt-hours.	$0.03 for all over 400 kilowatt-hours.	do	Alameda County except city of Berkeley.
Do	103	Dec. 19, 1913	$0.07 for first 50 kilowatt-hours.	do	do	Municipality of Berkeley.
Residence lighting and heating.[a]	104	do	$0.07 per kilowatt-hour (lighting); $0.03 per kilowatt-hour (heating).		do	City of Sacramento.
General lighting	140	Sept. 1, 1917	$0.10 for first 50 kilowatt-hours.	$0.05 for all over 1,000 kilowatt-hours.	$1.50 per kilowatt of connected load but not less than $1.50 per month.	Plumas County.
Commercial service:						
Commercial lighting	201	Oct. 15, 1917	$0.06 for less than 159 kilowatt-hours.	$0.03 for 3,000 kilowatt-hours or over.	$1 per meter	All except city of Sacramento and the counties of San Francisco, Alameda, San Mateo, and Plumas.
Do	202	Nov. 1, 1912	$0.05 for first 100 kilowatt-hours.	$0.02 for all over 10,000 kilowatt hours.	do	Alameda County except municipality of Berkeley.
Do	203	Dec. 19, 1913	$0.04 for first 300 kilowatt-hours.	do	do	Municipality of Berkeley.
Do	206	Oct. 1, 1915	$0.06 for first 50 kilowatt-hours.	$0.03 for all over 1,050 kilowatt-hours.	do	Municipality of Sacramento.
Cooking and heating:						
Cooking and heating	301	Dec. 19, 1914	$0.03		do	All.
Radiators	302	Dec. 19, 1913	do		do	City of Sacramento.
Commercial heating	303	do	Regular power rate	Regular power rate	Regular power rate	All except San Francisco and Sacramento.
Incubating and breeding	304	Jan. 9, 1914	do	Regular power rate for 1 horsepower.	$1 per month per horsepower of rated installation but not less than $12 per horsepower per year.	All.

[a] Separate meters are installed for heating and lighting load.

TABLE 297.—*Electric rates of Great Western Power Co. and Great Western Power Co. of California in effect Nov. 15, 1919*—Continued.

Great Western Power Co.—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Cooking and heating—Contd. Water heating service (controlled).	305	Oct. 15, 1917				All.
With electric range			$2.50 for 1,500 watts capacity heater.	$8.50 for 5,000 watts capacity heater.	Same as flat rate but not less than $2.50 per month.	
Without electric range			$4	$27 for 10,000 watts capacity heater.		
Electric sign	401	Oct. 15, 1917				All except city of San Francisco.
Sign, window and decorative lighting; flat rate per lamp per month:[b]						
Dusk to midnight			$0.07 per 5-watt lamp	$4.55 per 500-watt lamp	$3 per meter per month	
Dusk to dawn			$0.11 per 5-watt lamp	$6.85 per 500-watt lamp	do	
Optional-commercial sign, window or decorative lighting.	402	Oct. 16, 1918	$0.025 per kilowatt-hour		Consumer guarantees per 5-watt lamp installed consumption during: January and November, 975 watt-hours. February and October, 900 watt-hours. March and September, 825 watt-hours. April and August, 750 watt-hours. May and July, 675 watt-hours. December, 1,050 watt-hours. June, 600 watt-hours.	City of Sacramento.
Power service: General	500	Oct. 15, 1917				All except San Francisco, San Mateo, and Plumas counties.
1 to 10 horsepower installed capacity.			$0.0375 for first 60 kilowatt-hours per horsepower.	$0.01 for all over 180 kilowatt-hours per horsepower.	$1 per horsepower rated capacity up to 50 horsepower plus $0.50 per horsepower over 50 horsepower.	
11 to 25 horsepower installed capacity.			$0.033 for first 60 kilowatt-hours per horsepower.	$0.0095 for all over 180 kilowatt-hours per horsepower.		

26 to 50 horsepower installed capacity.			$0.028 for first 60 kilowatt-hours per horsepower.	$0.0090 for all over 180 kilowatt-hours per horsepower.		
51 to 100 horsepower installed capacity.			$0.0235 for first 60 kilowatt-hours per horsepower.	$0.0085 for all over 180 kilowatt-hours per horsepower.		
101 to 200 horsepower installed capacity.			$0.0195 for first 60 kilowatt-hours per horsepower.	$0.0080 for all over 180 kilowatt hours per horsepower.		
201 to 300 horsepower installed capacity.			$0.0190 for first 60 kilowatt-hours per horsepower.	$0.0070 for all over 180 kilowatt-hours per horsepower.		
301 to 400 horsepower installed capacity.			$0.0185 for first 60 kilowatt-hours per horsepower.	$0.0065 for all over 180 kilowatt-hours per horsepower.		
401 to 500 horsepower installed capacity.			$0.0180 for first 60 kilowatt-hours per horsepower.	$0.0065 for all over 180 kilowatt-hours per horsepower.		Do.
Maximum demand (optional).	500D	Oct. 15, 1917			$1 per horsepower of maximum demand but not less than $50 per meter nor less than $1 per horsepower for 20 per cent of the total rated capacity installed. Maximum demand shall be for the maximum 15-minute period or for the maximum 3-minute period in special cases.	
51 to 100 horsepower			$0.0235 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0085 for all over 180 kilowatt-hours per horsepower of maximum demand.		
101 to 200 horsepower			$0.0195 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0080 for all over 180 kilowatt-hours per horsepower of maximum demand.		
201 to 300 horsepower			$0.0190 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0070 for all over 180 kilowatt hours per horsepower of maximum demand.		
301 to 400 horsepower			$0.0185 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0065 for all over 180 kilowatt-hours per horsepower of maximum demand.		
401 to 500 horsepower			$0.0180 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0065 for all over 180 kilowatt-hours per horsepower of maximum demand.		
501 to 600 horsepower			$0.0170 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0064 for all over 180 kilowatt-hours per horsepower of maximum demand.		
601 to 700 horsepower			$0.0165 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0063 for all over 180 kilowatt-hours per horsepower of maximum demand.		
701 to 800 horsepower			$0.0160 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0062 for all over 180 kilowatt-hours per horsepower of maximum demand.		
801 to 1,000 horsepower.			0.0150 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0060 for all over 180 kilowatt-hours per horsepower of maximum demand.		

mps renewed by the company free.

TABLE 297.—*Electric rates of Great Western Power Co. and Great Western Power Co. of California in effect Nov. 15, 1919*—Continued.

Great Western Power Co.—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Mimimum monthly bill.	Territory.
			Maximum.	Minimum.		
Power service—Continued.						
Over 1,000 horsepower			$0.0140 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0060 for all over 180 kilowatt-hours per horsepower of maximum demand.		
General	502	July 10, 1918	$0.03 for less than 240 kilowatt-hours per horsepower.	$0.02 if over 400 kilowatt-hours per horsepower.	$1 per horsepower up to 50 horsepower plus $0.50 for each additional horsepower.	Alameda County except Berkeley.
Do	503	Dec. 19, 1913	$0.03 for first 108 kilowatt-hours per horsepower.	$0.02 for all over 216 kilowatt-hours per horsepower.	$1 per horsepower installed.	Berkeley.
Do	504	do	$0.0375 per kilowatt-hour for installations up to 10 horsepower.	$0.025 for installations over 50 horsepower.	do	Sacramento.
Do	505	do	$0.04 for first 100 kilowatt-hours.	$0.02 for all over 2,000 kilowatt-hours.	do	Napa, Sonoma, and Solano counties.
Do (10 horsepower and over).	516	July 10, 1918	$0.03 for first 500 kilowatt-hours.	$0.0125 for all over 4,000 kilowatt-hours.	$1 per horsepower installed up to 50 horsepower and $0.50 per horsepower for each additional horsepower.	Alameda County.
Agricultural	506	Oct. 15, 1917	$0.03 for less than 31 kilowatt-hours per horsepower.	$0.01 for over 540 kilowatt-hours per horsepower.	$6 per year per horsepower but not less than $12 per year.	All except San Francisco, San Mateo, and Plumas counties.
Irrigation and reclamation	507	do	$0.01 per kilowatt-hours at primary voltage.		$12 per year per horsepower installed.	Do.
Ice and refrigerating	508	do	$0.03 where $1 per horsepower per month guaranteed.	$0.01 where $4 per horsepower per month guaranteed.	do	Do.
Lighting and power for canneries.c	509	do	$0.015 per kilowatt-hour		do	Do.
Mining and gold dredging, installations over 200 horsepower.	510	do	Rates for this class of service will be made upon investigation.			
Preferential minimum for seasonal power service.	511	Oct. 31, 1912	As per appropriate schedule.		$12 per year per horsepower installed.	
Temporary service, domestic, commercial, lighting, street-lighting, and power.	512	Sept. 1, 1915	As per appropriate schedule plus estimated cost of connection and disconnection.		As per appropriate schedule but not less than $1 for domestic or $5 for commercial and power service.	All.

Electrochemical and electrometallurgical service.[d]	513	July 10, 1918	$2.50 per kilowatt of maximum demand plus $0.06 per kilowatt of maximum demand for each 1 per cent the average power factor is less than 90 per cent.	$2.50 per kilowatt of maximum demand with 100 per cent average monthly power factor.	50 per cent of rated capacity of transformer installation at discounts listed and at assumed power factory of 100 per cent but not less than $1,250.	Do.
General small power	540	Sept. 1, 1917				Plumas County.
Yearly service			$2 per kilowatt connected load plus $0.015 energy charge.		$1.50 per meter when readiness to serve charge is made.	
Seasonal service[e]			$2.50 per kilowatt connected load plus $0.015 energy charge applicable during months readiness to serve charge is made and $0.03 during months when no readiness to serve charge is made.			
Large power service	541	Aug. 22, 1919	$1.50 per kilowatt for first 200 kilowatts of maximum demand plus $0.01 for first 100,000 kilowatt-hours.	$1 per kilowatt for all over 1,000 kilowatt of maximum demand plus $0.007 for all over 500,000 kilowatt-hours.	Highest monthly demand charge billed during preceding 12 months but not less than $50.	Do.
Stand-by or auxiliary service[f].	601	Feb. 20, 1919	Same as schedule applicable to character of service required.	$2 for first 20 kilowatts of maximum load down to $1.25 for all over 100 kilowatt of maximum load.	$20	All.

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[c] Rates are optional for one or more canneries under one management where the demand exceeds 100 horsepower per installation.

[d] Energy will be applied at not less than 22,000 volts. Schedule is experimental and intended to foster and develop electrochemical and electrometallurgical industries but not for remelting apparatus and will be granted at option of the power company or on order of the California Railroad Commission. It is applicable only when the maximum demand is 500 to 5,000 kilowatts and the average monthly power factor is 85 per cent or more.

[e] Not less than 6 consecutive months.

[f] Not over 250 kilowatts maximum demand.

NOTES.

1. The California Railroad Commission has authorized the company to increase the rates here published affecting all territory by a surcharge according to class of service ranging from 2 to 10 mills per kilowatt-hour to cover in part the increased cost of production due to conditions brought about by the war.

2. The territory served by this company compromises Alameda, Contra Costa, Eldorado, Napa, Placer, Sacramento, San Joaquin, Solano, Sonoma, and Yolo counties, in which are located the municipalities of Albany, Berkeley, Concord, Emeryville, Fruitvale, Martinez, Napa, Oakland, Petaluma, Pittsburg, Richmond, Rio Vista, Sacramento, Santa Rosa, and San Leandro.

TABLE 297.—*Electric rates of Great Western Power Co. and Great Western Power Co. of California in effect Nov. 15, 1919*—Continued.

Great Western Power Co. of California.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.
			Maximum.	Minimum.	
Residence lighting	130	Sept. 1, 1917	$0.12 for less than 50 kilowatt-hours	$0.09 for over 150 kilowatt hours	$1.50 per meter.
Commercial lighting	230	do	do	do	Do.
Cooking and heating	[a] 301	do	$0.03		$1 per meter.
Water heating	[a] 305	do			
With electric range			$2.50 for 1,500 watts capacity heater.	$8.50 for 5,000 watts capacity heater.	Same as flat rate but not less than $2.50 per month.
Without electric range			$4 for 1,500 watts capacity heater	$27 for 10,000 watts capacity heater	Do.
Commercial heating	[a] 303	Sept. 1, 1917	Regular power rate	Regular power rate	Regular power rate.
Incubating and brooding heating	[a] 304	do	do	Regular power rate for horsepower	$1 per month per horsepower of rated installation but not less than 12,000 per horsepower per year.
Industrial power	530	do	$1 per horsepower of maximum demand plus $0.025 energy charge.		$1 per horsepower but not less than $1.50 per meter.
Industrial power	531	do			Do.
From 50 to 200 horsepower			$8.50 per horsepower installed per year plus $0.013 energy charge.		
Over 200 horsepower	531	do	$4.50 per horsepower installed per year plus $0.011 energy charge.		
Industrial power (optional)	532	do	$0.03 if monthly consumption is less than 31 kilowatt hours per horsepower.	$0.025 if monthly consumption is between 86 and 540 kilowatt-hours per horsepower.	Do.
Agricultural power	533	do	$1 per horsepower of maximum demand plus $0.025 energy charge.		
Agricultural power (optional)	534	do	$0.03 for less than 31 kilowatt-hours per horsepower.	0.025 if monthly consumption is between 86 and 540 kilowatt-hours per horsepower.	$5 per horsepower per year but not less than $18.
Temporary service: Domestic, commercial lighting, street lighting, and power.	[a] 512	do	As per appropriate schedule plus estimated cost of connection and disconnection.		As per appropriate schedule but not less than $1 for domestic or $5 for commercial and power service.
Municipal street lighting [b]	730	do			
All-night service [c]			$1.65 per 60-watt lamp		
Dusk to midnight [d]			$2.50 per 100-watt lamp; $0.8516 per 60-watt lamp.		

[a] Same rate as for the Great Western Power Co.

[b] All maintenance, operation, and lamp renewals at expense of company.

[c] 4,000 hours per year.

[d] 2,000 hours per year.

NOTES.

1. The California Railroad Commission has authorized the company to increase the rates here published affecting all territory by a surcharge according to class of service, ranging from 2 to 10 mills per kilowatt-hour, to cover in part the increased cost of production due to conditions brought about by the war.
2. These rates are applicable only in San Mateo County.

TABLE 298.—*Electric rates of Great Western Power Co. of California, San Francisco division, in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise specified.]

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
General lighting	106	Aug. 7, 1915	$0.07 for first 50 kilowatt-hours	$0.035 for all over 500 kilowatt-hours.	$0.75 per meter	San Francisco.
Commercial light and power	207	June 15, 1919	$0.04 for first 200 kilowatt-hours.	$0.0225 for all over 3,000 kilowatt-hours.	$0.75 per horsepower installed but not less than $2.50.	Special district in city of San Francisco.
Commercial (optional in lieu of 106).	208	do	$0.03 for first 500 kilowatt-hours.	do	$0.75 per horsepower installed but not less than $5.	All.
Cooking and heating	301	Dec. 19, 1914	$0.03		$1 per meter	Do.
Commercial heating	303	Dec. 19, 1913	Regular power rate	Regular power rate	$1 for each 750-watt rated capacity installed but not less than $3 per meter.	Do.
Incubating and brooding	304	Jan. 9, 1914	do	Regular power rate for 1 horsepower.	$1 per horsepower of rated installation, but not less than $12 per year per horsepower for seasonal power.	Do.
Water heating service	305	Sept. 28, 1917				
With electric range			$2.50 for 1,500-watt capacity heater.	$8.50 for 5,000-watt capacity heater.	Same as flat rate but not less than $2.50 per month.	Do.
Without electric range			$4 for 1,500-watt capacity heater.	$27 for 10,000-watt capacity heater.		
General power service	500	July 10, 1918			$1 per horsepower rated capacity up to 50 horsepower plus $0.50 per horsepower over 50 horsepower.	Do.
Power service:						
1 to 10 horsepower installed capacity.			$0.0375 for first 60 kilowatt-hours per horsepower.	$0.01 for all over 180 kilowatt-hours per horsepower.		
11 to 25 horsepower installed capacity.			$0.033 for first 60 kilowatt-hours per horsepower.	$0.0095 for all over 180 kilowatt-hours per horsepower.		
26 to 50 horsepower installed capacity.			$0.028 for first 60 kilowatt-hours per horsepower.	$0.0090 for all over 180 kilowatt-hours per horsepower.		
51 to 100 horsepower installed capacity.			$0.0235 for first 60 kilowatt-hours per horsepower.	$0.0085 for all over 180 kilowatt-hours per horsepower.		
101 to 200 horsepower installed capacity.			$0.0195 for first 60 kilowatt-hours per horsepower.	$0.0080 for all over 180 kilowatt-hours per horsepower.		
201 to 300 horsepower installed capacity.			$0.0190 for first 60 kilowatt-hours per horsepower.	$0.0070 for all over 180 kilowatt-hours per horsepower.		
301 to 400 horsepower installed capacity.			$0.0185 for first 60 kilowatt-hours per horsepower.	$0.0065 for all over 180 kilowatt-hours per horsepower.		
401 to 500 horsepower installed capacity.			$0.0180 for first 60 kilowatt-hours per horsepower.	do		

TABLE 298.—*Electric rates of Great Western Power Co. of California, San Francisco division, in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Maximum demand (optional).	500D	Oct. 15, 1917			$1 per horsepower of maximum demand but not less than $50 per meter nor less than $1 per horsepower for 20 per cent of the total rated capacity installed. Maximum demand shall be for the maximum 15-minute period or for the maximum 3-minute period in special cases.	All.
51 to 100 horsepower			$0.0235 for first 60 kilowatt-hour per horsepower of maximum demand.	$0.0085 for all over 180 kilowatt-hours per horsepower of maximum demand.		
101 to 200 horsepower			$0.0195 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0080 for all over 180 kilowatt-hours per horsepower of maximum demand.		
201 to 300 horsepower			$0.0190 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0070 for all over 180 kilowatt-hours per horsepower of maximum demand.		
301 to 400 horsepower			$0.0185 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0065 for all over 180 kilowatt-hours per horsepower of maximum demand.		
401 to 500 horsepower			$0.0180 for first 60 kilowatt-hours per horsepower of maximum demand.	do		
501 to 600 horsepower			$0.0170 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0064 for all over 180 kilowatt-hours per horsepower of maximum demand.		
601 to 700 horsepower			$0.0165 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0063 for all over 180 kilowatt-hours per horsepower of maximum demand.		
701 to 800 horsepower			$0.0160 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0062 for all over 180 kilowatt-hours per horsepower of maximum demand.		
801 to 1,000 horsepower			$0.0150 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0060 for all over 180 kilowatt-hours per horsepower of maximum demand.		
Over 1,000 horsepower			$0.0140 for first 60 kilowatt-hours per horsepwper of maximum demand.	do		

Temporary domestic, commercial lighting, street lighting, and power service.	512	Sept. 1, 1915	As per appropriate schedule plus estimated cost of connection and disconnection.	....	As per appropriate schedule but not less than $1 for domestic service nor $5 for commercial and power service.	
General power..............	514	Aug. 7, 1915	$0.07 for first 50 kilowatt-hours	$0.35 for all over 500 kilowatt-hours.	$0.75 per horsepower installed but not less than $0.75 per meter.	San Francisco.
Combined refrigeration and ice-making machines.	519	Sept. 1, 1915	$0.03 for first 60 kilowatt-hours per horsepower.	$0.01 for all over 120 kilowatt-hours per horsepower.	$5 per horsepower installed..	Do.
General service [a]..............	520	Jan. 15, 1919	$1.60 each for first 25 kilowatts of maximum demand plus $0.02 for first 1,000 kilowatt-hours consumed.	$1 each for all over 75 kilowatts of maximum demand plus $0.01 for all over 6,000 kilowatt-hours consumed.	$5 per horsepower installed readiness to serve charge applied to 75 per cent of connected load in kilowatts.	Do.
Commercial power (optional in lieu of 514).	521	May 8, 1917	$0.06 for first 50 kilowatt-hours.	$0.0025 for all over 6,000 kilowatt-hours.	$0.75 per horsepower of connected load but not less than $5.	Do.
Stand-by or auxiliary (optional in lieu of 106).	601	Feb. 20, 1919	Same as schedule applicable to the character of service required.	$2 for first 20 kilowatts of maximum load down to $1.25 for all over 100 kilowatts of maximum load.	$20..........................	All.

[a] Installations of 10 horsepower or over or where the monthly consumption is in excess of 400 kilowatt-hours per kilowatt of rated capacity.

NOTES.

1. The California Railroad Commission has authorized the company to increase the rates affecting all territory by a surcharge, according to class of service, ranging from 2 to 10 mills per kilowatt-hour to cover in part the increased cost of production due to conditions brought about by the war.
2. The territory served by this company comprises a portion of the city of San Francisco.
3. Territory formerly served by City Electric Co.

TABLE 299.—*Electric rates of Western States Gas & Electric Co. in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise specified. Rates on the Eureka and Richmond divisions remained practically unchanged Nov. 30, 1921. Rates on the Stockton division were raised Dec. 30, 1920.]

Eureka division.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Lighting:						
Domestic and commercial.	1-E	July 20, 1919	$0.10 for first 50 kilowatt-hours	$0.045 for all over 1,000 kilowatt-hours.	$1.10	All.
Sign	3-E	do	$0.07 per kilowatt-hour		$1.10	Do.
Municipal street (4-ampere 90-volt magnetite arcs or 600 candlepower incandescent lamps).	7-E	do	$5.25 per light for first 200 arcs.	$5 per light for all over 200 arcs	Shown in rate	Eureka.
Municipal street	8-E	do	$1.35 per 60 candlepower lamp		$125	Arcata.
Do	9-E	do	$0.065 per kilowatt-hour		None	Loleta, Fortuna, Ferndale Blue Lake.[a]
Heating and cooking (separate wiring from lighting circuit).	2-E	do	$0.035 per kilowatt-hour for first 150 kilowatt-hours.	$0.02 per kilowatt-hour for all over 150 kilowatt-hours.	$3 for 7 or less kilowatts active connected load, $1 for each additional kilowatt.	All.
Power, general	4-E	do			$1 per horsepower connected load, but not less than $1.50.	Do.
Less than 5 horsepower			$0.06 per kilowatt-hour for first 100 kilowatt-hours.	$0.02 per kilowatt-hour all over 500 kilowatt-hours.		
5 to 19 horsepower			$0.05 per kilowatt-hour for first 50 kilowatt-hours.	$0.015 per kilowatt-hour all over 200 kilowatt-hours.		
20 to 39 horsepower			$0.045 per kilowatt-hour for first 50 kilowatt-hours.	$0.015 per kilowatt-hour all over 200 kilowatt-hours.		
40 to 74 horsepower			$0.04 per kilowatt-hour for first 50 kilowatt-hours.	$0.015 per kilowatt-hour all over 200 kilowatt hours.		
75 horsepower and over			$0.035 per kilowatt-hour for first 50 kilowatt-hours.	$0.015 per kilowatt-hour all over 200 kilowatt-hours.		
Power, optional[b]	5-E	do	$1 per horsepower of connected load plus $0.03 for first 400 kilowatt-hours.	$1 per horsepower connected load plus $0.014 for all over 20,000 kilowatt-hours.	$5	Do.
Power, maximum demand (average over highest 15-minute period).	6-E	do	Service rate: $1 per horsepower maximum demand. Energy rate: Optional as in schedule 4-E or 5-E.	Service rate: $1 per horsepower of maximum demand. Energy rate: Optional as in schedule 4-E or 5-E.	$5 plus $7.50 per annum for the use of maximum demand meter.	Do.
Power, special:						
Humboldt Francis Co.	10-E	do	$0.0135 per kilowatt-hour		$125	Special.
Valdor Dredging Co.	10-E	do	$0.00975 per kilowatt-hour		$125	Do.

Stockton division.

Lighting:						
Residence	A	Sept., 1913	$0.065 for first 100 kilowatt-hours.	$0.034 for all over 300 or under 501 kilowatt-hours; $0.046 if consumption exceeds 500 kilowatt-hours.	$1	Stockton suburbs.
Commercial	B	do	$0.06 for first 100 kilowatt-hours.	$0.025 for all over 3,000 kilowatt-hours.	$1	Do.
Sign and display	E	Dec., 1912	$0.05 per kilowatt-hour (measure computed from the number and size of lamps and the average hours in use per month).			Do.
Rural	I	Dec., 1910	$0.08 per kilowatt-hour		$1	Lodi, Galt, Florin.
Residence and commercial	K	Apr. 24, 1913	do		$1	Placerville and Camino.
Heating and cooking	H	Apr. 1, 1917	$0.033 for first 150 kilowatt-hours.	$0.016 for all over 150 kilowatt-hours.	(c)	All.
Power:						
Domestic						
Less than 5 horsepower	L	Apr. 24, 1913	$0.05 for first 500 kilowatt-hours.	$0.03 for all over 1,000 kilowatt-hours.	$1 per horsepower installed.	Placerville and Camino.
5 horsepower and over			$0.04 for first 500 kilowatt-hours.	$0.025 for all over 1,000 kilowatt-hours.	$2 per horsepower installed. Polyphase motors limited to less than 5 horsepower.	
Rural	J	Sept. 1, 1913			$1 per horsepower installed.	Lodi, Galt, Florin.
Less than 5 horsepower			$0.05 for first 500 kilowatt-hours.	$0.035 for all over 1,500 kilowatt-hours.		
5 to 49 horsepower			$0.04 for first 500 kilowatt-hours.	$0.025 per kilowatt-hour for all over 1,500 kilowatt-hours.		
50 horsepower and over			$0.025 per kilowatt-hour			
Alternating-current motors	C	Sept., 1913			$1 per horsepower installed.	Stockton and suburbs.
1 to 5 horsepower			$0.045 for first 100 kilowatt-hours.	$0.0375 for all over 200 kilowatt-hours.		
5 to 7½ horsepower			$0.04 for first 100 kilowatt-hours.	$0.0275 for all over 200 kilowatt-hours.		
7½ to 10 horsepower			$0.035 for first 100 kilowatt-hours.	$0.025 for all over 200 kilowatt-hours.		
10 to 20 horsepower			$0.03 for first 100 kilowatt-hours.	$0.0225 for all over 200 kilowatt-hours.		
20 to 30 horsepower			$0.275 for first 100 kilowatt-hours.	$0.02 for all over 200 kilowatt-hours.		
30 to 40 horsepower			$0.02375 for first 100 kilowatt-hours.	$0.0175 for all over 200 kilowatt-hours.		

[a] Service through 75-watt Mazda-type lamps furnished and maintained by the towns.

[b] Limitation of demand: Where double-throw switches or other devices approved by the company limiting the maximum demand are installed, the connected load is considered the maximum load which may be connected at one time.

[c] Minimum monthly charge for electric range, $3 per meter for 7 kilowatts or less connected load and $1 for each additional kilowatt. No minimum increase for kitchen water or air heater up to 5 kilowatts connected load installed in connection with kitchen electric range, provided the range and heater can not be used simultaneously. If the heater load exceeds 5 kilowatts, $1 is charged for each additional kilowatt; or if range and heater can be used simultaneously, $1 per kilowatt of total connected load is charged.

TABLE 299.—*Electric rates of Western States Gas & Electric Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Power—Continued. Alternating-current motors—Continued.						
40 to 50 horsepower			$0.0225 for first 100 kilowatt-hours.	$0.0175 for all over 200 kilowatt-thours.		
50 to 100 horsepower			$0.02 for first 100 kilowatt-hours. Special for installations over 100 horsepower based upon load factor, etc.	$0.015 for all over 200 kilowatt-hours.		
Direct-current motors	D	Sept., 1913	$0.005 more than for each unit in each division of schedule C. No rates on installations over 100 horsepower.		$1 per horsepower installed	Stockton and suburbs.
Irrigation [d]	F	June 1, 1915	$0.03 for first 1,000 kilowatt-hours; $0.015 for 50 horsepower or more connected load at point of delivery.	$0.02 for all over 2,000 kilowatt-hours.	$6 per horsepower installed per year or prorated for fraction thereof.	All.
Optional	F-3	do	$0.02 for 5 horsepower or more connected load at point of delivery.		$12 per horsepower installed per year guaranteed.	
Optional (service and energy).	F-4	do	$0.01 for 5 horsepower or more connected load at point of delivery plus monthly minimum.		$8 per horsepower installed per year guaranteed.	
Do	F-5	do	$0.015 for 50 horsepower or more connected load at point of delivery.		$300 per annum	
Do	F-6	do	Schedule F-3 applicable to less than 5 horsepower; schedule F-4 applicable to less than 5 horsepower.		$60 per annum guaranteed; $40 per annum guaranteed.	
Winery	G	July 11, 1913	$0.04 for first 500 kilowatt-hours.	$0.025 for all over 1,500 kilowatt-hours.	$3 per horsepower installed.	Do.

Richmond division.

Lighting:						
Residence	A	Oct. 1, 1916	$0.07 for first 100 kilowatt-hours.	$0.03 for all over 400 kilowatt-hours.	$1	Richmond and suburbs.
Commercial	B	Dec. 1, 1915	$0.06 for first 158 kilowatt-hours.	$0.03 for all over 2,999 kilowatt-hours.	$1	Do.
Commercial (optional)	C	do	$0.0575 per kilowatt-hour where average monthly bill of $9 is guaranteed.	$0.03 per kilowatt-hour where average monthly bill of $90 is guaranteed.		Do.
Power:						
10 horsepower or less installation.	D	June 1, 1916	$0.0375 for first 60 kilowatt-hours per horsepower installed.	$0.01 for all over 180 kilowatt-hours per horsepower installed.	$1 per horsepower installed up to 50 horsepower and $0.50 for each additional horsepower.	All.
11 to 25 horsepower installation.			$0.033 for first 60 kilowatt-hours per horsepower installed.	$0.0095 for all over 180 kilowatt-hours per horsepower installed.		
26 to 50 horsepower installation.			$0.028 for first 60 kilowatt-hours per horsepower installed.	$0.0090 for all over 180 kilowatt-hours per horsepower installed.		
51 to 100 horsepower installation.			$0.0235 for first 60 kilowatt-hours per horsepower installed.	$0.0085 for all over 180 kilowatt-hours per horsepower installed.		
101 to 200 horsepower installation.			$0.0195 for first 60 kilowatt-hours per horsepower installed.	$0.0080 for all over 180 kilowatt-hours per horsepower installed.		
201 to 300 horsepower installation.			$0.0190 for first 60 kilowatt-hours per horsepower installed.	$0.0070 for all over 180 kilowatt-hours per horsepower installed.		
301 to 400 horsepower installation.			$0.0185 for first 60 kilowatt-hours per horsepower installed.	$0.0065 for all over 180 kilowatt-hours per horsepower installed.		
401 to 500 horsepower installation.			$0.0180 for first 60 kilowatt-hours per horsepower installed.	do		
Power (optional):						
10 horsepower or less maximum demand.	E	June 1, 1916	$0.0375 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.01 for all over 180 kilowatt-hours per horsepower of maximum demand.	$1 per horsepower of maximum demand: not less than $1 per horsepower on the basis of 20 per cent of connected load; not less than $50; maximum demand measured over the greatest monthly 15-minute period.	Do.

[d] Irrigation power may be taken by two or more irrigation plants combined, provided one point of delivery, one bank of transformers, and one meter installation only is required of power company. Connected load is the maximum installation which can be connected at any one time. These rates are based on the calendar year. The annual minimum where service rendered upon request prior to Jan. 15 is $6 per horsepower; prior to Feb. 15 is $5.97 per horsepower; prior to Mar. 15 is $5.94 per horsepower; prior to Apr. 15, $5.70 per horsepower; prior to May 15, $5.10 per horsepower; prior to June 15, $4.50 per horsepower; prior to July 15, $3.30 per horsepower; prior to Aug. 15, $2.10 per horsepower; prior to Sept. 15, $0.90 per horsepower; prior to Oct. 15, $0.30 per horsepower; prior to Nov. 15, $0.06 per horsepower; prior to Dec. 15, $0.03 per horsepower.

TABLE 299.—*Electric rates of Western States Gas & Electric Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Power (optional)—Continued.						
11 to 25 horsepower			$0.033 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0095 for all over 180 kilowatt-hours per horsepower of maximum demand.		
26 to 50 horsepower			$0.028 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0090 for all over 180 kilowatt-hours per horsepower of maximum demand.		
51 to 100 horsepower			$0.0235 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0085 for all over 180 kilowatt-hours per horsepower of maximum demand.		
101 to 200 horsepower			$0.0195 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0080 for all over 180 kilowatt-hours per horsepower of maximum demand.		
201 to 300 horsepower			$0.0190 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0070 for all over 180 kilowatt-hours per horsepower of maximum demand.		
301 to 400 horsepower			$0.0185 for first 60 kilowatt-hours per horsepower of maximum demand.	$0.0065 for all over 180 kilowatt-hours per horsepower of maximum demand.		
401 to 500 horsepower			$0.0180 for first 60 kilowatt-hours per horsepower of maximum demand.	do.		
Irrigation	F	June 1, 1916	$0.03 if monthly consumption is less than 31 kilowatt-hours per horsepower installed.	$0.01 if monthly consumption is 540 kilowatt-hours or more per horsepower installed.	$6 per horsepower per year.	All.
Signs and display window lighting (flat rate).	G	Dec. 1, 1915	$0.01 per connected watt per month.		$1	Do.
Heating and cooking	H	Mar. 1, 1917	$0.033 for first 150 kilowatt-hours.	$0.016 for all over 150 kilowatt-hours.	(c)	Do.

NOTES.

1. The California Railroad Commission has authorized the company to increase the rates affecting all territory here published by a surcharge ranging according to class of service from 1 mill to 10 mills per kilowatt-hour, to cover in part the increased cost of production due to conditions brought about by the war.

2. The territory supplied by this company comprises parts of San Joaquin, Amador, Calaveras, and Eldorado counties, and the cities of Stockton, Placerville, Richmond, Eureka, Sheldon, and Florin.

TABLE 300.—*Electric rates of Snow Mountain Water & Power Co. in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise specified.]

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
To California Telephone & Light Co.:						
At Potter Valley (2,300 volts).	....	Aug. 9, 1912	$0.015 for all	$0.01 when purchaser installs its own substation.	$1,500 per year	
At Talmage	....	do	$0.01 for all	....	do	
At Asti	....	July 22, 1913	do	....	$400	
To Mendocino State Hospital	....	July 1, 1914	$4 per horsepower demand (average over a 30-minute maximum demand period).	....	$200	
To Ukiah City (contract expired).	....	May 1, 1914	$0.029514 [a]	$0.012762 [a]	....	
To Mount Konocti Light & Power Co.	....	Mar. 3, 1911	$0.01	....	$200	
To Napa Valley Electric Co.	....	....	$0.0125 for 16½ per cent load factor.[b]	$0.01 on 33 per cent load factor [b].	....	
To Pacific Gas & Electric Co.[c]	....	Aug. 25, 1908	$0.00505 for 5,000 or less horsepower per 24-hour day.	....	....	

[a] Rate paid is one of or between the two extremes and is determined from a curve furnished by the Railroad Commission. See decision on case 483, order dated Feb. 27, 1914.
[b] Load factor determined by dividing the readings of three watt-hour meters by the product of the maximum demand and the hours of the month.
[c] Snow Mountain Co. may purchase from Pacific Gas & Electric Co. at the same rate for 4,000 horsepower or less per 24-hour day.

NOTE.—This company wholesales to the following: California Telephone & Light Co., Mendocino State Hospital, Town of Ukiah, Mount Konocti Light & Power Co., Napa Valley Electric Co., and Pacific Gas & Electric Co.

TABLE 301.—*Electric rates of Coast Counties Gas & Electric Co. in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise specified.]

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Lighting[a]	A	Mar. 5, 1916	$0.07 gross and net for first 200 kilowatt-hours.	$0.04 for all over 600 kilowatt-hours.	$1 per meter; not less than $1 per kilowatt-hour of transformer capacity.	Santa Cruz.
Do.	B	do	$0.075 gross and net for first 200 kilowatt-hours.	do	do	Watsonville.
Do.	C	do	$0.08 net for first 100 kilowatt-hours.	$0.03 net for all over 1,000 kilowatt-hours.	do	Outside of Santa Cruz an Watsonville.
Commercial power[b]	D-1	Feb. 24, 1913	$0.05 for first 300 kilowatt-hours.	$0.03 for all over 2,000 kilowatt-hours.	$2. (See note 1)	All.
Do.[a]	D-2	do	$0.04 net for first 1,000 kilowatt-hours.	$0.03 net for all over 2,000 kilowatt-hours.	$10. (See note 1)	Do.
Do.[a]	D-3		$0.03 net for first 4,000 kilowatt-hours.	$0.02 net for all over 6,000 kilowatt-hours.	$30 per month	Do.
House lighting, with pump or heating device off same meter.[a]	E	Aug 5, 1912	$0.09 net for first 20 kilowatt-hours.	$0.05 gross and net for all over 20 kilowatt-hours.	$1 per meter but not less than $1 per kilowatt of transformer capacity.	Do.
Irrigation (consumer furnishing transformers).	F	May 2, 1912	$0.05 where $25 per season is guaranteed.	$0.03 where $450 per season guaranteed.	$1 per month per meter; $6 per year per kilowatt of transformer capacity.	Do.
Irrigation (consumer furnishing transformers).[ac]	G	Feb. 24, 1913	$0.04 net for first 1,000 kilowatt-hours.	$0.02 net for over 6,000 kilowatt-hours.	$75 per year and $6 per horsepower installed.	Do.
Do.[ac]	G-2	May 30, 1913	$0.035 net for first 2,000 kilowatt-hours.	do	$150 per year, but not less than $6 per horsepower installed.	Do.
Do.[ac]	H	Feb. 24, 1913	$0.02 net for first 4,000 kilowatt-hours.	do	$250 per year and $10 per horsepower installed.	Do.
Irrigation with reservoir[a]	I[d]	Aug. 8, 1913	do	do	$6 per year per horsepower installed where consumer furnishes transformers, or $12 per horsepower per year where company furnished transformers. In either case not less than $60 per year.	Do.
Cooking and heating (appliances over 660 watts).[a]	J	May 12, 1915	$0.04 net for first 100 kilowatt-hours.	$0.03 net for all over 100 kilowatt-hours.	$1 per meter and not less than $1 per kilowatt of transformer capacity, less $1.	Do.
Lighting, summer, transients (flat rate).[e]	K	Apr. 1, 1912	$2 per month or fraction thereof.		$2	Santa Cruz and vicinity.

Power, agricultural (4,000 volts).[a] [f]	L......	Sept. 27, 1916	$0.03 for first 4,000 kilowatt-hours.	$0.02 for all over 6,000 kilowatt-hours.	$10 per kilowatt of transformer capacity, but not less than $250 per year.	All.
Agricultural and rural[a] [g]......	M......	May 3, 1917	$8 per horsepower for first 5 horsepower and $6 per horsepower for all over 5 horsepower connected load plus $0.02 net for first 3,000 kilowatt-hours energy charge.	Demand charge plus $0.0125 net for all over 30,000 kilowatt-hours.	....	Do.

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[a] Schedules A, B, C, D-2, D-3, E, G, G-2, H, I, J, L, and M, net rates are in effect if bills are paid on or before the 10th of the month following the month billed. Otherwise the gross rate (1 cent higher under schedules A, B, C, and E, or one-half cent higher under schedules D-2, D-3, G, G-2, H, I, J, L, and M) is charged.

[b] $12 per year per kilowatt of transformer capacity where company furnishes transformers and monthly minimum of 50 cents per kilowatt of capacity, but no monthly minimum will be less than $1 per meter; $6 per year per kilowatt of transformer capacity where consumer furnishes transformers, but no monthly minimum will be less than $1 per meter installed. May be computed either monthly or yearly for schedules D-2 and D-3.

[c] Company will furnish transformers with yearly guaranty of $12 per horsepower installed in 5-year guaranties.

[d] Schedule I: This rate is optional where pumping as continuously as possible, especially at night into a reservoir with 16-hour pumping capacity.

[e] Company reserves right to serve consumer under schedules A or C.

[f] Schedule L applies to lighting only when consumer has connected load of 10 kilowatts transformer capacity for light and lamp-socket devices.

[g] Schedule M: Connected load means capacity of motors that may be connected at any one time. The service charge is payable quarterly and the rates indicated apply if bill is paid before 10th of March, June, September, and December for the quarters ending the last day of those months.

NOTES.

1. Surcharges effective Sept 20, 1918: $0.015 in addition to rates in schedules A, B, C; $0.005 in addition to rates in schedules D-1, 2, 3, E, F, G, G-2, H, I, J, L, M; 10 per cent in addition to charges for energy sold for municipal street lighting; 20 per cent in addition to charges for energy sold for electric railways.
2. Territory served by the company comprises Santa Cruz, Watsonville, Hollister, San Juan, Gilroy, Morgan, Hill, and contiguous territory in Santa Cruz, San Benito, and Santa Clara counties.

TABLE 302.—*Electric rates of Utica Mining Co. in effect Nov. 15, 1919.*

[Per kilowatt-hour unless otherwise specified. The company's rates are now (1921) on a meter basis.]

Character of service.	Monthly rates.	Territory.
Schedule A:		
General lighting	$0.10 per lamp	Angels Camp.
Street lighting	$0.50 per lamp	Do.
Fire house, city hall, and churches	Free	Do.
Power—		
5 horsepower or less	$7 per horsepower installed	Do.
6 to 10 horsepower	$6 per horsepower installed	Do.
11 to 50 horsepower	$5 per horsepower installed	Do.
Over 50 horsepower	$4.50 per horsepower installed	Do.
Motor generator moving-picture machine	$10	Do.
Schedule B:		
Lighting, commercial	$0.25 per lamp for cellar, basement, and toilet lights	Murphy, Vallecito, and Carson.
	$0.50 per lamp for office lights and lights about mines not using power	
	$1 per lamp for saloon, store, barber shop, public garage, public stable, and street	
Lighting, residence	$0.25 per lamp for bathroom and cellar	Do.
	$0.30 per lamp for bedroom, kitchen, and parlor	
	$0.40 per lamp for sitting room and dining room	
	$0.50 per lamp for porch, hall, stable, and garage	

NOTE.—Above rates became effective May 1, 1915. Minimum rate is $1 per month under Schedule A except for motor-generator sets.

TABLE 303.—*Electric rates of San Joaquin Light & Power Corporation in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise specified. A general revision of this company's rates, effective Apr. 1, 1920, increased lighting rates and put power service on a meter basis.]

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.
			Maximum.	Minimum.	
General lighting	1	Aug. 1, 1916	$0.08 for first 20 kilowatt-hours	$0.04 for all over 20 kilowatt-hours	$0.75 per meter.
Do	2	do	$2.25 per kilowatt of maximum 15-minute demand plus $0.01 per kilowatt-hour.	$17.50.	
Public outdoor [a]	3	May 1, 1916			
6.6-ampere luminous arc lamp			$36.40 per lamp per year plus $0.50 per 100 lamp-hours.		
4-ampere luminous arc lamp			$33 per lamp per year plus $0.45 per 100 lamp-hours.		
6.6 ampere inclosed alternating current arc lamps.			$31.80 per lamp per year plus $0.45 per 100 lamp-hours.		
600 candlepower series and 400-watt multiple incandescent lamps.			$29.50 per lamp per year plus $0.60 per 100 lamp-hours.		
500-watt multiple incandescent lamps.			$30.35 per lamp per year plus $0.70 per 100 lamp-hours.		
400-candlepower series and 250-watt multiple incandescent lamps.			$27 per lamp per year plus $0.40 per 100 lamp-hours.		
300-watt multiple incandescent lamps.			$28.20 per lamp per year plus $0.50 per 100 lamp-hours.		
250 candlepower series and 150-watt multiple incandescent lamps.			$23 per lamp per year plus $0.30 per per 100 lamp-hours.		
100-watt multiple incandescent lamps.			$18.70 per lamp per year plus $0.20 per 100 lamp-hours.		
100 candlepower series and 80-watt multiple incandescent lamps.			$16.20 per lamp per year plus $0.15 per 100 lamp-hours.		
80 candlepower series and 60-watt multiple incandescent lamps.			$13.40 per lamp per year plus $0.10 per 100 lamp-hours.		
60 candlepower series and 40-watt multiple incandescent lamps.			$11.50 per lamp per year plus $0.08 per 100 lamp-hours.		
32 candlepower series incandescent lamps.			$11 per lamp per year plus $0.08 per 100 lamp-hours.		
Electrolier system	3a	July 1, 1917	$0.04 for first 50 kilowatt-hours per kilowatt of maximum demand.[b]	$0.01 for all over 125 kilowatt-hours per kilowatt of maximum demand.[b]	$36 per kilowatt installed per year.

[a] All-night lamps considered as burning 4,000 hours.

[b] Maximum demand is greatest average kilowatt demand delivered during any 15-minute interval in the month.

TABLE 303.—*Electric rates of San Joaquin Light & Power Corporation in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.
			Maximum.	Minimum.	
Agricultural service	4	May 20, 1917	$16.45 horsepower installed for 3 months or less continuous service.	$42.30 per horsepower for 12 months' continuous service.	Flat rate for 1 horsepower.
Agricultural service (noncontract)	5	do.	do.	$2.30 per horsepower for the twelfth month.	Do.
Agricultural service (contract)	6-A	do.	$9.80 maximum demand[b] charge for 3 months or less continuous service plus $0.005 per kilowatt-hour for energy consumed.	$22.50 maximum demand[b] charge for 12 months' continuous service plus $0.005 per kilowatt-hour energy charge.	Demand charge for 1 horsepower.
Agricultural service (noncontract)	6-B	do.	do.	$1 per horsepower maximum demand[b] charge for twelfth month plus $0.005 energy charge.	Do.
Special oil-fields rate	7	do.	$2.75 per kilowatt of maximum demand[b] plus $0.005 per kilowatt-hour energy charge.		
Special oil-fields rate (optional)	7-A	July 1, 1917	$0.0095 per kilowatt-hour		$1 per horsepower installed.
General power (50 horsepower or less)	8	May 20, 1917	$0.04 for first 200 kilowatt-hours	$0.02 for all over 200 kilowatt-hours	$1 per meter from secondary distribution system or $9.75 for seasonal bills; $2.50 from rural lines.
Industrial power (20 horsepower or less).	9-A	do.	$1.50 per horsepower installed plus $0.005 per kilowatt-hour energy charge.		$5 when installation is connected for entire year. For less than year varies from $1.05 per horsepower per month for 11 months' period up to $3.25 per horsepower per month for 3 months' period.
Industrial power (20 horsepower or less) (optional).	9-AA	do.	$1.90 per horsepower of maximum demand[b] plus $0.005 per kilowatt-hour energy charge.		Do.
Industrial power (over 20 horsepower).	9-B	do.	$2.50 per kilowatt of maximum demand[b] plus $0.004 per kilowatt-hour energy charge.		$20 when installation is connected for entire year. For less than year varies from $1.05 per horsepower up to $3.25 per horsepower.[c]
Industrial power (over 50 horsepower).	9-C	do.	$1 per kilowatt of maximum demand plus $0.01 per kilowatt-hour energy charge.		Do.
Industrial power (100 horsepower and over).	9-D	May 1, 1916	$0.015 for first 135 kilowatt hour per kilowatt of maximum demand.[b]	$0.0075 for all over 405 kilowatt-hours per kilowatt of maximum demand.[b]	$1 per kilowatt per month for 12 months' service of maximum demand[b] during immediately preceding 12 months up to $4 per kilowatt per month for 3 months' service of maximum demand[b] during immediately preceding 12 months.

Primary voltage service (maximum demand of at least 125 kilowatt).	10	do	$2.70 per kilowatt of maximum demand [b] plus $0.0025 per kilowatt-hour energy charge.		$1 per kilowatt of substation capacity used [c] for 12 months' service to $4 per kilowatt of substation capacity used.[c]
Transmission service	11	Aug. 1, 1916	$2.50 per kilowatt of maximum demand [b] plus $0.002 per kilowatt-hour energy charge.		$1 per kilowatt [c] for 12 months' service to $4 per kilowatt [c] for 3 months' service.
Special power [d]	12	May 1, 1916	$0.02 per kilowatt-hour		
Oil-drilling rate	13	do	$0.015 per kilowatt-hour		$25.00.
Combination lighting, cooking, and heating.[e]	14	July 1, 1917	$0.08 for first 20 kilowatt-hours; $0.035 for first 125 kilowatt-hours (commercial installations).	$0.01 for all over 145 kilowatt-hours; $0.01 for all over 125 kilowatt-hours (commercial installations).	$2.00.
Cooking and heating (over 20 kilowatt capacity).	14-A	do	$1 per kilowatt of maximum demand [b] plus $0.0075 per kilowatt-hour energy charge.		$5.00.
Special power [f]	15	May 1, 1916	$0.0085 per kilowatt-hour		

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[b] Maximum demand is greatest average kilowatt demand delivered during any 15-minute interval in the month.

[c] Maximum demand previously established during the immediately preceding 12 months' period.

[d] Applicable to power service supplied to the Fresno Water Co.

[e] Installed capacity of cooking and heating equipment between 3 and 20 kilowatts with a double-throw switch between cookstove and water heater.

[f] Power service supplied to Fresno Traction Co. for its electric railway business or to other companies for similar conditions of use.

NOTES.

1. The California Railroad Commission has authorized the company to increase the rates here published affecting all territory by a surcharge according to class of service of 15 per cent per kilowatt-hour to cover in part the increased cost of production due to conditions brought about by the war.

2. San Joaquin Light & Power Co. serve the following counties: Merced, Mariposa, Madera, Fresno, Tulare, Kings, and Kern; all rates are effective throughout its territory.

TABLE 304.—*Electric rates of Midland Counties Public Service Corporation in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise specified.]

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.
			Maximum.	Minimum.	
Lighting	1	May 28, 1914	$0.10 for first 60 kilowatt-hours per kilowatt of maximum demand; for bills of less than $50.	$0.03 for all over 210 kilowatt-hours per kilowatt of maximum demand; less 20 per cent for monthly bills over $300.	$1 per meter.
Lighting	2	July 1, 1914			
Residence			$0.095 for first 20 kilowatt-hours	$0.03 for all over 450 kilowatt-hours per month.	$1 per month.
Commercial			$0.10 per kilowatt-hour for consumption, equal to 60 hours or less per month's use of maximum demand.	$0.03 per kilowatt-hour for consumption in excess of 210 hours per month's use of maximum demand.	
Oil-well lighting, optional (flat rate)	3	Oct. 10, 1911	$0.40 per month per 60 watts in excess of 120 watts in addition to charge due to currents passing through power meters.		
Oil-well lighting, optional	4	Oct. 1, 1912	$0.10 per kilowatt-hour for first 60 kilowatt-hours per kilowatt of maximum demand.	$0.03 per kilowatt-hour for all over 210 kilowatt-hours per kilowatt of maximum demand.	
Electric signs	5	May 28, 1914	$0.10 per kilowatt-hour for first 60 kilowatt-hours per kilowatt of maximum demand for monthly bills of less than $50.	$0.03 per kilowatt-hour for all over 210 kilowatt-hours per kilowatt of maximum demand less 20 per cent for monthly bills over $300.	$6 per kilowatt of maximum demand but not less than $2.
Power (maximum demand not over 25 horsepower.)	6	Oct. 10, 1911	$0.06 per kilowatt-hour for first 45 kilowatt-hours per kilowatt of maximum demand.	$0.0175 less 20 per cent for over 195 kilowatt-hours per kilowatt of maximum demand.	$1 per installed horsepower but not less than $1.50.
Power (maximum demand 26 to 50 horsepower.)	7	Apr. 6, 1914	do	$0.015 less 20 per cent for over 195 kilowatt-hours per kilowatt of maximum demand.	$1 per horsepower installed for single motor; $1 per horsepower of maximum demand for aggregate capacity of 50 horsepower or more.
Power (maximum demand 5 to 150 horsepower).	8	do		$0.015 for all over 45 kilowatt-hours per kilowatt of maximum demand.	Do.
Power (full yearly service)	9	Oct. 10, 1911	$5.50 per horsepower maximum 5-minute demand.		60 per cent rated capacity if but one motor.
Power (from sunup to 25 minutes before sundown).	10	do	$3.333 per horsepower maximum 5-minute demand.		Do.
Power—Oil wells: 19 motors or less	11	do	$0.015 per kilowatt-hour		$10 per motor.
20 to 29 motors	12	do	$0.014 per kilowatt-hour		Do.
30 to 39 motors	13	do	$0.013 per kilowatt-hour		Do.
40 to 60 motors	14	do	$0.012 per kilowatt-hour		Do.
Over 60 motors	15	do	$0.010 per kilowatt-hour		Do.
Oil-well power, optional	16	do	$5.50 per horsepower, maximum 5-minute demand.		Do.

Do	17	Mar. 1, 1915	$0.015 for first 100 kilowatt-hours per kilowatt of maximum demand.	$0.008 for over 260 kilowatt-hours per kilowatt of maximum demand.	Do.
Commercial oil-dehydrating plants	18	Oct. 10, 1911	$0.06 for first 45 kilowatt-hours per kilowatt of maximum demand.	$0.015 per kilowatt of maximum demand.	$1.333 per kilowatt of maximun demand.
Cooking and heating	19	Oct. 1, 1913	$0.06 for first 45 kilowatt-hours per kilowatt of installed capacity.	$0.0175 per kilowatt of installed capacity for over 195 kilowatt-hours.	$2.
Automatic water heaters	20	Jan. 1, 1915	do	do	$1.333 per kilowatt installed.
Irrigation pumping: Single motor; maximum demand not over 20 horsepower.	21	Oct. 1, 1913	$0.02 per kilowatt-hour		$1 per horsepower installed but not less than $1.50 each month of year.
Maximum demand over 20 horsepower.	a 22	do	$0.015 per kilowatt-hour		$1 per horsepower installed each month of year.
Maximum demand not over 25 horsepower.	b 23	do	$0.025 per kilowatt-hour		$1.50 to $2 per horsepower installed; depending on length of service connection.
Maximum demand 26–50 horsepower.	b 24	do	$0.02 per kilowatt-hour		Do.
Over 50 horsepower	b 25	do	$0.016 per kilowatt-hour		Do.
Single motor	26	Oct. 10, 1911	$4.167 per horsepower of 5-minute maximum demand.		75 per cent of ratedcapacityinstalled,
Daylight hours	27	do	$3 per horsepower of 5-minute maximum demand.		Do.
Single motor	28	do	$22.50 per horsepower of maximum demand where service is for 24 hours a day and from July 1 to July 31.[c]	$3.75 per horsepower of maximum demand, where service is for daylight hours, and from Feb. 1 to July 31.[c]	Do.
Do	29		$22.50 per horsepower of maximum demand where service is for 24 hours a day and from Sept. 1 to Sept. 30.[c]	$3.94 per horsepower of maximum demand, where service is for daylight hours, and from Feb. 1 to Sept. 30.[c]	
Motor on double-throw switch, with motor of schedules 21–29, so that both can not be operated at same time.[d]	30	Mar. 1, 1915	$0.02 per kilowatt-hour		$0.50 per horsepower installed.
Street arcs, municipal (not over 50 lamps).	31	July 1, 1914	$6.50 per 6.6-ampere alternating current or 4-ampere direct-current arc per month, including equipment, installation, and maintenance.		
Street arcs, municipal (more than 50 lamps).	32	do	$6.00 per 6.6-ampere alternating current or 4-ampere direct-current arc per month, including equipment, installation, and maintenance.		

[a] Colonization rates; shall not continue longer than 2 years, after which customer may operate under schedule 26 or 27 for balance of contract period (at least 5 years).

[b] Colonization rates; shall not continue longer than 2 years, after which customer may operate under schedule 28 or 29 for balance of contract period (at least 5 years).

[c] During other periods of year customer may operate on meter-rate basis, rate varying from 2½ cents per kilowatt-hour where maximum load is not over 25 horsepower to 1.6 cents where maximum load is over 50 horsepower; minimum charge during such meter-rate basis, $1 per installed horsepower per month.

[d] Applicable only during period specified for irrigation motor.

TABLE 304.—*Electric rates of Midland Counties Public Service Corporation in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.
			Maximum.	Minimum.	
Street incandescent	33	Feb. 15, 1918	$2.50 per 6.6-ampere 100 candlepower incandescent lamp per month, including equipment, installation, and maintenance.		
Combination lighting, cooking, and heating.[e]	34	Dec. 1, 1916	$0.10 for first 25 kilowatt-hours	$0.01 for all over 150 kilowatt-hours	$2.
Commercial cooking and heating			$0.035 for first 125 kilowatt-hours	do	
Cooking and heating (over 20 kilowatt capacity).	35	Dec. 21, 1917	$1 per kilowatt of 15-minute maximum demand plus $0.015 per kilowatt-hour energy charge.		

[e] Installed capacity of 3 kilowatts or over with a double-throw switch between cookstove and water heater so that both can not be used simultaneously.

NOTES.

1. This company serves the counties of Fresno, Monterey, San Luis Obispo, and Santa Barbara, and the following cities and centers of population in these counties: Coalinga, Nacimiento, San Miguel, Paso Robles, Templeton, Atascadero, Santa Margarita, San Luis Obispo, Pismo, Oceano, Arroyo Grande, Guadalupe, Santa Maria, and kieselguhr plant at Lompoc, and the rates here given, except schedules 1 and 2, are effective throughout this territory. Schedule 1 is effective in all except the city of San Luis Obispo, where schedule 2 applies.

2. There is no surcharge imposed above these rates.

TABLE 305.—*Electric rates of Southern California Edison Co. in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise specified. For a general revision of the rates on this system see California Railroad Commission decision 8815.]

Character of service.	Schedule.	Rates.		Minimum monthly bill.	Territory.
		Maximum.	Minimum.		
General lighting	L-1	$0.07 for first 100 kilowatt-hours	$0.025 for all over 5,000 kilowatt-hours.	$0.75 in certain cities and $1 per meter in all other territory.	Los Angeles, San Bernardino, Riverside, and Orange counties; excepting city of Pasadena and adjacent territory, Belvedere district, and Antelope Valley.
Porch lighting		$0.60 per 16-candle power lamp when current is not measured by meter.			
Incandescent lighting	L-2	$0.05 for first 100 kilowatt-hours	$0.03 for all over 2,000 kilowatt-hours but when total consumption exceeds 15,000 kilowatts then rate shall be $0.0265 for entire amount.	$0.50 per meter for 3 kilowatt capacity or less and $0.30 for each additional kilowatt.	City of Pasadena.
Arc lighting		$0.049 for first 100 kilowatt-hours	$0.04 for all over 500 kilowatt-hours.		
General lighting	L-3	Same as L-2	Same as L-2	$0.75 per meter	Territory adjacent to city of Pasadena, including South Pasadena, Altadena, Lamada Park, San Rafael Heights, and Linda Vista.
Alternating current [a]	L-4	$0.055 for first 100 kilowatt-hours.	$0.021 for all over 3,000 kilowatt-hours.	$0.65 per meter	District A, Los Angeles except zones 1 and 3.
General domestic and commercial lighting.	L-5	$0.05 for first 100 kilowatt-hours	$0.018 for all over 3,000 kilowatt-hours.	$0.50 per meter	Zones 1 and 2, city of Los Angeles.
General lighting	L-6	$0.08 for first 100 kilowatt-hours	$0.025 for all over 5,000 kilowatt-hours.	$1 per meter	Ventura, Kern, and Fresno counties and Antelope Valley.
General lighting in connection with oil well operation.[b]	L-7	$0.04 per kilowatt-hour		$20 per meter	Los Angeles, San Bernardino, Riverside, Ventura, and Orange counties, excepting Pasadena and Los Angeles, district A.
Municipal lighting[c]	L-8	$2.25 per 300-watt lamp;[d] $3.75 per 500-watt lamp.[d]			City of Long Beach.
Electric signs	L-9	$0.06 per kilowatt hour		$1 per meter	Ventura County.

[a] When consumer chooses direct current instead of alternating, then the rates will be increased by 10 per cent; but there will be no increase if the consumer is required to take direct current. Emergency or breakdown service under this schedule will be at rate of $0.50 per month per kilowatt of maximum demand plus an energy charge.

[b] Current will be delivered at a central point and consumers shall install and maintain their own distribution systems.

[c] Flat rate for type C mazda lamps, outside only, burning until 10 p. m.

[d] Includes charges for installation and renewals.

TABLE 305.—*Electric rates of Southern California Edison Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Rates.		Minimum monthly bill.	Territory.
		Maximum.	Minimum.		
General lighting	L-10	$0.055 for first 100 kilowatt-hours	$0.021 for all over 3,000 kilowatt-hours.	$0.75 per meter	Belvedere district.
Combined lighting and heating including electric range.[e]	C-1			$2.50 per meter	Los Angeles, San Bernardino, Riverside, Orange, Kern, and Ventura counties, excepting Pasadena and District A, Los Angeles.
5 rooms or less		Regular lighting rate for first 20 kilowatt-hours.	$0.035 for all over 20 kilowatt-hours.		Do.
6 and 7 rooms		Regular lighting rate for first 30 kilowatt-hours.	$0.035 for all over 30 kilowatt-hours.		
8 rooms and over		Regular lighting rate for first 40 kilowatt-hours.	$0.035 for all over 40 kilowatt-hours.		
Combined lighting, heating and power (irrigation).	C-2			$3 per meter	Do.
5 rooms or less		Regular lighting rate for first 20 kilowatt-hours.	Regular pumping rate for all over 20 kilowatt-hours.		
6 and 7 rooms		Regular lighting rate for first 30 kilowatt-hours.	Regular pumping rate for all over 30 kilowatt-hours.		
8 rooms and over		Regular lighting rate for first 40 kilowatt-hours.	Regular pumping rate for all over 40 kilowatt-hours.		
General power[f]	P-1			$1 per horsepower connected load but not less than $2.	Do.
1 to 4 horsepower		$0.06 for first 50 kilowatt-hours per horsepower.	$0.011 for all over 100 kilowatt-hours per horsepower.		
5 to 9 horsepower		$0.05 for first 50 kilowatt-hours per horsepower.	$0.0105 for all over 100 kilowatt-hours per horsepower.		
10 to 24 horsepower		$0.04 for first 50 kilowatt-hours per horsepower.	$0.01 for all over 100 kilowatt-hours per horsepower.		
25 to 49 horsepower		$0.03 for first 100 kilowatt-hours per horsepower.	$0.0095 for all over 100 kilowatt-hours per horsepower.		
50 to 99 horsepower		$0.0275 for first 100 kilowatt-hours per horsepower.	$0.0090 for all over 100 kilowatt-hours per horsepower.		
100 to 199 horsepower		$0.025 for first 100 kilowatt-hours per horsepower.	$0.0085 for all over 100 kilowatt-hours per horsepower.		
200 to 499 horsepower		$0.0225 for first 100 kilowatt-hours per horsepower.	$0.0080 for all over 100 kilowatt-hours per horsepower.		
500 horsepower and over		$0.02 for first 100 kilowatt-hours per horsepower.	$0.0075 for all over 100 kilowatt-hours per horsepower.		
Pumping plants[f]	P-2			$1 per horsepower for less than 5 horsepower capacity but not less than $2.	Do.

4 horsepower or less		$0.035 per kilowatt-hour	Optional minimum charge of $0.0175 for a guaranteed minimum of $1 per horsepower, but not less than $200 for irrigation season of six consecutive months.		
5 to 14 horsepower		$0.030 per kilowatt-hour [g]		For 5 horsepower and over $6 per horsepower for irrigation season of 6 consecutive months payable at rate of $1 per horsepower.	
15 horsepower and over		$0.025 per kilowatt-hour			
Industrial plants [h]	P-3				Do.
1 to 99 horsepower		$0.025 per kilowatt-hour		$1 per horsepower but not less than $75.	
1 to 199 horsepower		$0.020 per kilowatt-hour		$1 per horsepower but not less than $100.	
Any size installation		$0.0175 per kilowatt-hour		$1 per horsepower but not less than $200.	
Commercial cooking and heating	P-4	$0.03 per kilowatt-hour		$10 per meter	Los Angeles, San Bernardino, Riverside, Orange, Kern, Ventura, and Fresno counties, excepting Pasadena and District A, Los Angeles.
Packing houses:					
General	P-5	$0.05 per kilowatt-hour		$1.50 per horsepower but not less than $2 and for three consecutive months.	Do.
Optional		$0.05 for first 400 kilowatt-hours	$0.02 for all over 1,600 kilowatt-hours.	$9 per horsepower for packing season of six consecutive months; payable at $1.50 per month.	
Optional pumping plant	P-6				
10 horsepower		$15 demand charge per year [i]	Demand charge plus $0.0150 for all over 7,000 kilowatt-hours per calendar year. [i]		Santa Ana, Pomona, and Whittier districts.
11 to 15 horsepower		$20 demand charge per year [i]			
16 to 20 horsepower		$25 demand charge per year [i]			
21 to 25 horsepower		$30 demand charge per year [i]			
26 to 30 horsepower		$35 demand charge per year [i]			
31 to 35 horsepower		$40 demand charge per year [i]			
36 to 40 horsepower		$45 demand charge per year [i]			
41 to 50 horsepower		$50 demand charge per year [i]			
Over 50 horsepower		$1 per horsepower demand charge per year plus $0.0200 for first 2,000 kilowatt-hours per calendar year.			

[e] When installation includes a water heater, the charge will be $0.02 per kilowatt-hour for all over 120, 130, or 140 kilowatt-hours, respectively.

[f] Any installation may obtain rates for larger-size installation by guaranteeing the rates and minimum under the larger installation.

[g] For installations of 5 horsepower and over and for a guaranteed minimum of $12 per horsepower per year payable at the rate of $2 per horsepower per month for an irrigation season of six consecutive months the energy charge will be $0.02 per kilowatt-hour.

[h] Refrigerating plants, rock-crushing plants, brickyards, planing mills, machine shops, and others.

[i] Demand charge to be paid in one amount at the beginning of the pumping season.

TABLE 305.—*Electric rates of Southern California Edison Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Rates.		Minimum monthly bill.	Territory.
		Maximum.	Minimum.		
Optional pumping plant	P-7	Demand charge per year [i]			Pomona district.
25 to 29 horsepower		$35			
30 to 34 horsepower		$40			
35 to 39 horsepower		$45			
40 to 49 horsepower		$50			
50 to 54 horsepower		$55			
55 horsepower and over		$1 per horsepower per year plus $0.02 for first 3,000 kilowatt-hours per year.	$0.01 for all over 60,000 kilowatt-hours per year.		
Optional pumping plant	P-8	Stand-by charge per month [j]	$0.40 per horsepower per month for all over 100 horsepower stand-by charge.		Los Angeles, San Bernardino, Riverside, and Orange counties, excepting Antelope Valley, District A, and cities of Los Angeles and Pasadena.
25 horsepower or less		$38			
26 to 30 horsepower		$39.50			
31 to 35 horsepower		$41			
36 to 40 horsepower		$42.50			
41 to 50 horsepower		$44			
51 to 60 horsepower		$15			
		Plus $0.01 per kilowatt-hour energy charge during months stand-by charge applies or $0.02 during other months.			
Optional pumping plant	P-9	Stand-by charges same as for schedule P-8, but energy charge is $0.012 during months when stand-by charge applies or $0.02 during other months.			Ventura and Kern counties and Antelope Valley.
Load-factor schedule 50 horsepower and over.	P-10	$0.02 for first 219 kilowatt-hours per kilowatt of connected load.	$0.01 for all over 693 kilowatt-hours per kilowatt of connected load.	$2 per horsepower of connected load.[k]	Same as C-1.
Power for ship-building plants.	P-11	$0.025 between 5.30 p. m. and 10 p. m. of same day.	$0.015 between 10 p. m. and 5.30 p. m. of following day.	$150 for first 200 horsepower of connected load plus $1 per horsepower.	Los Angeles and Orange counties excepting District A and cities of Los Angeles and Pasadena.
Wholesale power [l]	P-12	$0.02 for first 5,000 kilowatt-hours.	$0.008 for all over 75,000 kilowatt-hours.	$1 per horsepower connected load, but not less than $300.	Same as C-1.
Power for dredges	P-13	$0.045 for first 100 kilowatt-hours.	$0.016 for all over 3,000 kilowatt-hours but only $0.01 if total for month is 200,000 kilowatt-hours.	$0.35 per horsepower connected load.	San Pedro Harbor, Los Angeles County.

Optional recreational	P-14				Same as P-11.
Rate A		$0.06 for first 500 kilowatt-hours.	$0.02 for all over 4,500 kilowatt-hours.	$1,200 per year in 12 equal installments.	
Rate B		$0.03 for first 1,500 kilowatt-hours.	$0.02 for all over 3,000 kilowatt-hours.	$3,000 per year in 12 equal installments.	
Power for cement plants	P-15	$0.0089 when load factor for month is 64 per cent or less.[m]	$0.00625 when load factor is over 90 per cent for month.[m]	$1 per kilowatt of connected load but not less than $4,000.	San Bernardino and Riverside counties.
Iron works, rolling mills, and furnaces.	P-16	$0.0125 for first 10,000 kilowatt-hours.	$0.0075 for all over 70,000 kilowatt-hours.	$1 per horsepower of maximum demand but not less than $2,000.[n]	Los Angeles County except cities of Los Angeles and Pasadena, and Antelope Valley.
Refrigeration, battery charging, and machine shops.	P-17	$0.04 for first 45 kilowatt-hours per horsepower of connected load.	$0.025 for all over 90 kilowatt-hours per horsepower of connected load.	$2.50 per horsepower of connected load but not less than $5.	Same as P-8.
Charging storage batteries for motor cars.	P-18	$0.025 per kilowatt-hour[o]		$1 per horsepower connected load but not less than $20.	Orange County.
Developing and operating oil wells.[j]	P-19	Stand-by charge of $1 per horsepower plus $0.01 per kilowatt-hour energy charge.		$15 for motors or $3 for lighting, cooking, and heating.	Los Angeles, San Bernardino, Riverside, Ventura, and Orange counties excepting district A, and cities of Los Angeles and Pasadena.
Optional for moving-picture studios and plants.[l]	P-20	$0.02 per kilowatt-hour		$1 per horsepower connected load but not less than $300.	Los Angeles, San Bernardino, Riverside, Orange, Ventura, Kern, and Fresno counties excepting district A and cities of Los Angeles and Pasadena.
Commercial power[p]	P-21	$0.04 for first 100 kilowatt-hours.[q]	$0.0105 for 3,001 to 6,000 kilowatt-hours.[q]	$0.30 per horsepower installed but not less than $1.	Zone 3, city of Los Angeles.
Industrial service[r]	P-22	$0.0156 for 6,000 kilowatt-hours.[q s]	$0.0076 for 1,500,000 kilowatt-hours or more.[q s]	$0.35 per horsepower installed	Do.
Power service	P-23	$0.045 for first 100 kilowatt-hours.[t]	$0.0116 for all over 3,000 kilowatt-hours.[t]	$0.35 per horsepower installed but not less than $1.	District A, city of Los Angeles excepting zones 1 and 3.

[i] Demand charge to be paid in one amount at the beginning of the pumping season.

[j] Stand-by charge to apply for at least six consecutive months in each year.

[k] Connected load is based on lower rating for special two-rating motors, but the maximum demand will be used in calculating the monthly bill.

[l] Consumer furnishes substation equipment and distribution lines upon his own property.

[m] Exclusive of starting peaks.

[n] Maximum demand considered as 50 per cent of installed capacity of motors and furnaces.

[o] Conditional upon 75 per cent of energy used between 9 p. m. and 9 a. m. of succeeding day.

[p] Total consumption not to exceed 6,000 kilowatt-hours per month.

[q] Alternating-current rates; rates for direct current are 15 per cent higher. Discount of 20 per cent allowed, provided maximum demand between 4.30 p. m. and 10.30 p. m. does not exceed 10 per cent of maximum demand during month.

[r] Total consumption not less than 6,000 kilowatt-hours per month.

[s] Discount of 1 per cent allowed for increase in load factor for each 2½ per cent above 35 per cent up to a maximum discount of 16 per cent.

[t] Charge for direct current is 10 per cent higher if consumer has choice between direct current and alternating current. Discount of 20 per cent allowed, provided no energy is used between 4.30 p.m. and 9.30 p. m. of any day during month.

TABLE 305.—*Electric rates of Southern California Edison Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Rates.		Minimum monthly bill.	Territory.
		Maximum.	Minimum.		
Optional load-factor schedule [u]	P-24				District A, city of Los Angeles.
Less than 50 per cent load factor.		$0.045 for first 100 kilowatt-hours.	$0.0116 for all over 3,000 kilowatt-hours.	$0.35 per horsepower installed but not less than $52.50.	
Annual consumption at 50 per cent load factor or better:					
50 to 59 per cent		$0.0124 per kilowatt-hour			
60 to 64 per cent		$0.0110 per kilowatt-hour			
65 to 69 per cent		$0.0100 per kilowatt-hour			
70 to 74 per cent		$0.0095 per kilowatt-hour			
75 to 79 per cent		$0.00925 per kilowatt-hour			
80 to 84 per cent		$0.0090 per kilowatt-hour			
85 per cent and over		$0.00875 per kilowatt-hour			
Power, heating, and service other than lighting.	P-25	$0.04 for first 100 kilowatt-hours.	$0.012 for all over 3,000 kilowatt-hours.	$1 per meter of 1.5 kilowatt capacity and $0.75 for each additional kilowatt.	Pasadena.
Power service	P-26	do	do	do	Same as L-3.
Optional factories and business concerns.[v]	P-27	$0.025 for first 500 kilowatt-hours.	$0.015 for all over 1,500 kilowatt-hours.	$1 per horsepower installed but not less than $100.	San Bernardino County.
Ice and precooling plants	P-28	$0.01 for energy used between 10 p. m. and 6 p. m. of following day.	$0.01 when total exceeds 50,000 kilowatt-hours per month.	$250 for first 100 horsepower installed plus $2 for each additional horsepower.	Los Angeles, San Bernardino, Riverside, Orange, Kern, and Ventura counties, excepting District A, and cities of Los Angeles and Pasadena.
		$0.0175 for energy used between 6 p. m. and 10 p. m. same day.		$300 for first 150 horsepower and $2 for each additional horsepower.	
Optional power	P-29	$0.045 for first 100 kilowatt-hours.	$0.0116 for all over 3,000 kilowatt-hours.	$0.35 per horsepower installed but not less than $2.	Culver City and Palms within limits of city of Los Angeles.
Optional for irrigation	P-30	$0.02 for first 200 kilowatt-hours per horsepower of connected load base rate.	$0.01 base rate for all over 200 kilowatt-hours per horsepower connected load.	$12 per horsepower of connected load but not less than $120 per year.	Same as P-28.
Less than 100 horsepower		Base rate			
100 to 199 horsepower		Base rate less 5 per cent			
200 to 299 horsepower		Base rate less 10 per cent			
300 to 399 horsepower		Base rate less 15 per cent			
400 to 499 horsepower		Base rate less 20 per cent			
500 horsepower and over		Base rate less 25 per cent			
General power [w]	P-31				Cities of Vernon, Huntington, and Laguna, in Los Angeles County.

Less than 50 per cent load factor.		$0.05 for first 100 kilowatt-hours.	$0.012 for all over 3,000 kilowatt-hours.	$0.35 per horsepower connected load but not less than $1.	
Annual consumption of 50 per cent or greater load factor:					
50 to 59 per cent		$0.0124			
60 to 64 per cent		$0.0110			
65 to 69 per cent		$0.0100			
70 to 74 per cent		$0.0095			
75 to 79 per cent		$0.00925			
80 to 84 per cent		$0.0090			
85 per cent and over		$0.00875			
Alternating-current power [w]	P-32	$0.04 for first 100 kilowatt-hours.	$0.01 for all over 6,000 kilowatt-hours.	$0.30 per horsepower connected load but not less than $1.	Zone 1, city of Los Angeles.
General power	P-33	$0.045 for first 100 kilowatt-hours.	$0.0116 for all over 3,000 kilowatt-hours.	$0.35 per horsepower connected load but not less than $1.	District of Belvedere, Los Angeles County.

[u] Installations of 150 horsepower or over.

[v] Sixty per cent of energy must be used for power purposes.

[w] Discounts allowed same as under schedule P-21.

NOTES.

1. All above rates became effective Jan. 2, 1919.
2. The California Railroad Commission has authorized the company to increase the rates here published affecting all territory by a surcharge, according to class of service, ranging from 1 to 10 mills per kilowatt-hour, or from no surcharge up to 10 per cent of monthly bill to cover in part the increased cost of production due to conditions brought about by the war.
3. This company serves Los Angeles, San Bernardino, Riverside, Orange, and Ventura counties and parts of Kern and Fresno counties.

TABLE 306.—*Electric rates of Mount Whitney Power & Electric Co. in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise specified. For a general revision of the rates on this system see California Railroad Commission decision 8815.]

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Lighting, general (including appliances and small motors).	1	June 1, 1917	$0.08 for first 20 kilowatt-hours.	$0.04 for all over 20 kilowatt-hours.	$0.75 for installations of 5 kilowatts or less plus $1 per kilowatt over 5.	
Lighting, optional (including appliances and small motors).	2	.....do.......	$2.25 per kilowatt of maximum demand. (See note 1.)	$0.01 energy charge...........	$10..........................	
Lighting, outdoors, public, general.	3	May 1, 1916	All night (rates per year): $56.40 per 6.6-ampere luminous arc; $51 per 4-ampere luminous arc; $53.50 per 600-candlepower and 400-watt incandescent; $43 per 400 candlepower and 200-watt incandescent; $35 per 250 candlepower and 150-watt incandescent; $22.20 per 100 candlepower and 80-watt incandescent; $17.40 per 80 candlepower and 60-watt incandescent; $14.70 per 60 candlepower and 40-watt incandescent.	Dark hours (rates per year): $36 plus $0.50 per 100 lamp-hours; $33 plus $0.45 per 100 lamp-hours; $29.50 plus $0.60 per 100 lamp-hours; $27 plus $0.40 per 100 lamp-hours; $23 plus $0.30 per 100 lamp-hours; $16.20 plus $0.15 per 100 lamp-hours; $13.40 plus $0.10 per 100 lamp-hours; $11.50 plus $0.08 per 100 lamp-hours.	....	
Lighting, special contract for town of Lindsay.	12	.....do.......	$52 per lamp per year........	....	....	
Lighting, cooking, heating, 5 or less kilowatt capacity, exclusive of lamp-socket devices, domestic.	11	June 1, 1917	$0.08 for first 20 kilowatt-hours.	$0.01 all over 170 kilowatt-hours.	$2 per meter................	
Lighting, cooking, heating (commercial), 5 or more kilowatts installed; metered separately from lighting.	11	.....do.......	$0.03 for first 150 kilowatt-hours.	$0.01 all over 150 kilowatt-hours.	.....do.....................	
Power, agricultural, flat contract rate. (See notes 2 and 3.)	4	.....do.......	Continuous service: 1 month, $7 per horsepower; 2 months, $12.15; 3 months, $16.45; 4 months, $20.25; 5 months, $23.65; 6 months, $26.80; 7 months, $29.75; 8 months,	....	The minimum monthly bills is the flat rate for 1 horsepower. In no event shall the monthly minimum be based on less than 50 per cent of connected load.	

			$32.50; 9 months, $35.10; 10 months, $37.60; 11 months, $40; 12 months, $42.30.		
Energy rate applicable under schedule 4 during noncontract period where contract period is 3 months or more.	4	.....do.......	$0.08 for first 20 kilowatt-hours.	$0.02 for all over 70 kilowatt-hours.	$0.50 per horsepower connected but not less than $1.
Power, agricultural, flat....... Noncontract rates. (See notes 2 and 4.)	5	.....do.......	Monthly charges which cumulatively are equal to those in schedule 4. There is no energy rate under this schedule.	....	Not less than 50 per cent connected load at rates shown.
Power, agricultural...........	6	.....do.......	Demand charge: If contract period is 3 months or less, $9.80 per horsepower; 4 months, $11.75; 5 months, $13.45; 6 months, $15; 7 months, $16.40; 8 months, $17.70; 9 months, $18.90; 10 months, $20; 11 months, $21.05; 12 months, $22.05; plus energy rate $0.005 per kilowatt-hour for all. Payable in equal monthly installments.	....	Based on not less than 50 per cent of the connected but never less than the demand charge for 1 horsepower.
At expiration of contract period these rates apply for the balance of the year.	....	....	$0.08 for the first 20 kilowatt-hours.	$0.02 for all over 70 kilowatt-hours.	$0.50 per horsepower connected but not less than $1.
Power, agricultural, noncontract rates. (See notes 2 and 4.)	6-A	June 1, 1917	Demand charge: If period of service is first month, $4.50 per horsepower; second month, $3; third month, $2.30; for fourth month and succeeding months the rates cumulatively are equal to those in schedule 6, plus energy rate, $0.005 per kilowatt-hour.	....	Based on not less than 50 per cent of the connected load but never less than the demand charge for 1 horsepower.
Power, agricultural, all classes except heating, cooking, and lighting. (See note 5.)	6-B	July 15, 1919	$0.02 for first 100 kilowatt-hours per horsepower of active connected load.	$0.0125 for all over 100 kilowatt-hours per horsepower of active connected load.	$18 per horsepower per year. Not less than $54 per year in six equal monthly installments. Maximum monthly, $5 per horsepower connected load.

TABLE 306.—*Electric rates of Mount Whitney Power & Electric Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
General rate, seasonal service (continuous) from secondary distribution lines.	7	June 1, 1917	$0.04 for the first 200 kilowatt-hours.	$0.02 for all over 200 kilowatt-hours.	$1 per horsepower connected.	
3 months' continuous service.			$3.25 per month per horsepower connected load.			
4 months' continuous service.			$2.50 per month per horsepower connected load.			
5 months' continuous service.			$2.05 per month per horsepower connected load.			
6 months' continuous service.			$1.75 per month per horsepower connected load.			
7 months' continuous service.			$1.55 per month per horsepower connected load.			
8 months' continuous service.			$1.40 per month per horsepower connected load.			
9 months' continuous service.			$1.25 per month per horsepower connected load.			
10 months' continuous service.			$1.15 per month per horsepower connected load.			
11 months' continuous service.			$1.05 per month per horsepower connected load.			
12 months' continuous service.			$1 per month per horsepower connected load.			
Power, industrial, seasonal service. (See notes 2 and 6.)[a]	8	June 1, 1917	$1.50 per month per horsepower connected load plus $0.005 energy charge.		$5	
3 months' continuous service.			$3.25 per month per horsepower connected load.			
4 months' continuous service.			$2.50 per month per horsepower connected load.			
5 months' continuous service.			$2.05 per month per horsepower connected load.			
6 months' continuous service.			$1.75 per month per horsepower connected load.			
7 months' continuous service.			$1.55 per month per horsepower connected load.			
8 months' continuous service.			$1.40 per month per horsepower connected load.			
9 months' continuous service.			$1.25 per month per horsepower connected load.			

10 months' continuous service.			$1.15 per month per horsepower connected load.				
11 months' continuous service.			$1.05 per month per horsepower connected load.				
12 months' continuous service.			$1 per month per horsepower connected load. Plus $0.005 energy charge.				
Power, industrial. (See notes 1 and 6.) [b]	8-A	June 1, 1917	$2.50 per month per kilowatt of measured maximum demand plus $0.004 energy charge.		$20 based on 50 per cent of connected load.		
Power (substation). (See notes 1 and 7.)	9	do	Continuous service. $2.70 per month per kilowatt of measured maximum demand plus $0.0025 energy charge.				
Power (substations), seasonal.			$12 per kilowatt per year or fraction, payable in equal monthly installments during the period of use.		$12.		
Power, contract irrigation development rate. (See note 8.)	9-A	June 1, 1917	$2.70 per month per kilowatt of measured maximum demand plus $0.0025 energy charge.		The minimum yearly charge per kilowatt installed is as follows: 5-year contract.	8-year contract.	
First year					$6.00	No. minimum.	
Second year					9.00	$6.00	
Third year					12.00	9.00	
Fourth year					15.00	12.00	
Fifth year					18.00	15.00	
Sixth, seventh, and eighth years.					....	18.00	
Average					12.00	12.00	Also the average minimum for all contracts with a development period.
Minimum after the contract period.					12.00	12.00	
Power, contract, irrigation, development rate, optional. (See note 8.) [c]	9-B	June 1, 1917	$2.70 per month per kilowatt of measured maximum demand plus $0.0025 energy charge. During a development period of not more than three years a minimum guaranty of less than $12 per year may be selected. The additional energy charge is as follows (p. 1228):		$12 per year		

[a] Where the demand factor is established by means of meters 79 per cent of the actual demand is used.

[b] Seasonal service under this schedule is furnished at the same demand rate plus an energy charge of $0.004.

[c] A contract for not less than three times the development period is required.

TABLE 306.—*Electric rates of Mount Whitney Power & Electric Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.				Minimum monthly bill.	Territory.
			Maximum.		Minimum.			
			Yearly minimum per kilowatt.	Energy charge per kilowatt-hour.	Yearly minimum per kilowatt.	Additional charge per kilowatt hour.		
Power, contract, irrigation, development rates, optional. (See note 8.)	9-B	June 1, 1917	$11	$0.00275	$11	$0.00275		
			10	.003	10	.003		
			9	.00325	9	.00325		
			8	.00375				
			7	.004				
			6	.0045				
			5	.0048				
			4	.0053				
			3	.00585				
			2	.0064				
			1	.0071				
			0	.0078				
Transmission service	10	Oct. 9, 1917	$2.50 per month per kilowatt of measured maximum demand plus $0.002 energy charge.				$12 per year	

NOTES.

1. Maximum demand based on average over the greatest 15-minute period each month measured by a demand-indicating meter.

2. These rates are based upon the connected load in motors or other utilization equipment, except lamps and devices for domestic service, which can be operated at any one time. Unnecessary meters will not normally be installed on flat rate or demand plus energy business, but at consumer's request demand-indicating and watt-hour meters will be supplied, in which event the demand will be determined as in note 1. Where meters are furnished at request of consumer, under schedules 4 and 5 a charge of $7.50 per year or fraction, under schedules 6 and 6a $3 per year, or under schedule 8, 25 cents per month, all payable in advance, is made. They may at the option of the company be installed without charge.

3. Where meters are installed, consumer is permitted to use cooking and heating devices but not lighting.

4. Consumers taking service under this rate are required to pay connect and disconnect costs.

5. When motors operate in excess of 600 kilowatt-hours monthly consumption per horsepower of rated capacity, the connected load for that month is taken as the total consumption divided by 600.

6. Seasonal rates of less than the monthly minimum though published are probably inoperative.

7. The annual minimum is based upon the greatest monthly maximum previously established during the 12-month period immediately preceding.

8. In this schedule, applicable only here, the aggregate installed capacity is 1,000 horsepower or more, and the average capacity of all separate plants equals 100 horsepower, with no separate delivery point of less than 30 horsepower.

9. The Mount Whitney Power & Electric Co. serves the following territory: The incorporated cities of Visalia, Tulare, Porterville, Lindsay, and Exeter, in Tulare County, and the towns of Lemon, Cove, Woodlake, Venice, Hill, Klink, Farmersville, Tipton, Earlimart, Richgrove, Ducor, Terra Bella, Poplar, Plano, Strathmore, Globe, and Springville, in Tulare County, and the city of Delano and a part of the town of McFarland, in Kern County.

10. The California Railroad Commission has authorized the company to increase the rates affecting all territory here published by a surcharge of 15 per cent of monthly bills, except for street lighting, in the town of Hanford, to cover in part the increased cost of production due to conditions brought about by the war.

TABLE 307.—*Electric rates of Ontario Power Co. in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise specified.]

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.
			Maximum.	Minimum.	
Lighting, cooking, heating, and power, general.[a]	A	Mar. 1, 1915	$0.09 for first 50 kilowatt-hours [b]	$0.05 for over 1,000 kilowatt-hours [b]	$1.
Lighting, cooking, and heating, residence.	B	do	$0.037 for first 150 kilowatt-hours [b]	$0.02 for over 150 kilowatt-hours [b]	$5.
Power:					
Consumption not over 200 kilowatt-hours per month.	C	do	$0.09 for first 50 kilowatt-hours [b]	$0.05 for over 150 kilowatt-hours [b]	$0.50 per horsepower connected load but not less than $1.
Consumption 200 to 2,000 kilowatt-hours per month.	D	do	$0.0675 for first 200 kilowatt-hours [b]	$0.02 for over 1,300 kilowatt-hours [b]	Do.
Consumption over 2,000 kilowatt-hours per month.	N	Jan. 24, 1917	$0.027 for first 2,000 kilowatt-hours [c]	$0.02 for all over 13,500 and under 20,000 kilowatt-hours.	$0.50 per horsepower connected load up to 200 horsepower.
Lighting and operating moving-picture shows.	F	Mar. 1, 1915	$0.08 for first 150 kilowatt-hours [b]	$0.05 for over 150 kilowatt-hours [b]	$1.
Irrigation pumping	G	do	$0.0233 per kilowatt-hour [b]		
Private-garage battery charging	H	do	$0.055 for first 50 kilowatt-hours	$0.04 for over 150 kilowatt-hours	
Tailors' irons	I	do	$0.0467 per kilowatt-hour [b]		$1.
Power, optional pumping rate	13	June 1, 1916	$0.022 for first 1,000 kilowatt-hours [b]	$0.018 for all over 15,000 kilowatt-hours.[b]	$1 net per horsepower connected load, 6 months.
Lighting, cooking, heating, optional	14-E	do	$0.09 for first 20 kilowatt-hours [b]	$0.02 for all over 150 kilowatt-hours[b]	$2 net.
Cooking and heating	15-E	do	$0.035 for first 50 kilowatt-hours [b]	do	$1.50 net.
Power, wholesale	M	Sept. 16, 1916	$0.025 for first 1,000 kilowatt-hours	$0.0175 for all over 10,000 kilowatt-hours.	$1,500 per annum.
Power, irrigation	O	July 1, 1919		Annual demand charge same as under maximum rate, plus $0.012 consumption rate for all over 60,000 kilowatt-hours.	
Less than 30 horsepower			$35 annual demand charge		
30 to 34 horsepower			$40 annual demand charge		
35 to 39 horsepower			$45 annual demand charge		
40 to 49 horsepower			$50 annual demand charge		
50 to 54 horsepower			$55 annual demand charge		
55 horsepower and over			$1 annual demand charge per horsepower connected load, plus $0.022 consumption rate for first 2,500 kilowatt-hours.		

[a] Supplying Ontario, Upland, Cucamonga, and adjacent territory.

[b] Ten per cent off rates for prompt payment.

[c] Discounts for prompt payment, 10 per cent if consumption is less than 25,000; 10 per cent and 10 per cent if consumption is less than 30,000 but exceeds 25,000; 10 per cent and 10 per cent and 10 per cent if consumption exceeds 30,000.

TABLE 307.—*Electric rates of Ontario Power Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.
			Maximum.	Minimum.	
Power, irrigation, seasonal	P	July 1, 1919	Demand charge for at least 6 consecutive months:		
Less than 25 horsepower			$38		
26 to 30 horsepower			$39.50		
31 to 35 horsepower			$41		
36 to 40 horsepower			$42.50		
41 to 50 horsepower			$44		
51 to 60 horsepower			$45		
61 to 100 horsepower			$45, plus $0.50 for each horsepower over 60.		
100 horsepower and over			$65, plus $0.40 for each horsepower over 100, plus $0.012 energy charge; $0.022 when demand charge is inoperative.		
Power, optional	Q	July 1, 1919	$0.025 for first 1,000 kilowatt-hours	$0.0145 for over 10,000 kilowatt-hours	$2,500 per annum.

TABLE 308.—*Electric rates of Holton Power Co. in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise specified. For a general revision of rates effective Sept. 20, 1920, see California Railroad Commission decision 8119.]

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
General lighting	2-A	Jan. 2, 1919	$0.10 (net) for first 100 kilowatt-hours.[a]	$0.04 for over 1,000 kilowatt-hours.[a]	$1.25; less $0.10 for prompt payment.	
Miscellaneous	D	Oct. 1, 1917				All.
Municipal lighting— Multiple system			$0.05, city to maintain and replace lamps.		$3 for each 300 to 500-watt lamp, $1 for each 100-watt lamp, $0.50 for each 40-watt lamp.	
Series system— All-night schedule			$9 per month for each 600-candlepower lamp.	$2 per month for each 100-candlepower lamp.		
Moonlight schedule.			$6.50 per month for each 600-candlepower lamp.	$1.50 per month for each 100-candlepower lamp.		
Outside lamps, general.			$1 per month for each 16-candlepower or 40-watt or under incandescent or mazda lamp (street lights, arcades, porches, etc.).			
Lighting, heating, and cooking.[b] [c]	B-A	Oct. 15, 1917			$3.50 plus $1 per horsepower capacity of motors installed.	
Range, 1 to 7 kilowatt capacity.			$0.10 for first 25 kilowatt-hours	$0.03 for over 125 kilowatt-hours.		
Range and water heater			do.	$0.025 for over 125 kilowatt-hours.		
Heating and cooking, water heating:[b] [c] Domestic power for residences.	B-W	Oct. 15, 1917	$0.05 for first 50 kilowatt-hours	$0.025 for all over 100 kilowatt-hours.	$2.50 plus $1 per horsepower capacity of motors installed.	
Heating and cooking: Single phase; separate circuit for lighting.	E	Sept. 1, 1917	$0.05 for first 50 kilowatt-hours	$0.03 for all over 100 kilowatt-hours.	$2.50 for range or small cooking devices plus $1 per horsepower demand charge for heaters and motors operated simultaneously.	
Power, optional	B-1	Jan. 1, 1918	$0.10 for first 20 kilowatt-hours	$0.02 for over 10,000 kilowatt-hours.	$1.20 for less than 2 horsepower; $1 per horsepower for over 2 horsepower.	

[a] Where a net rate is given a gross rate $0.01 higher per kilowatt-hour is charged unless bills are paid within 12 days of the delivery of bill.

[b] Single-phase motors 5 horsepower or less may be operated under this schedule. Where electric range and water heater are both used they must operate alternately through a mechanical device. This rate applies only where the range and heater combined are 1 to 12 kilowatt capacity.

[c] The minimum monthly bill applies to seasonal power only during the period of use, but will not be less than 6 months' charge prorated over the period of use under schedule B-1 or 6 consecutive months under schedule 2-C.

TABLE 308.—*Electric rates of Holton Power Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Power [c]	2-C	Oct. 1, 1914	$0.08 for installations not over 5 horsepower guaranteeing $10 per month.	$0.02 for 500 horsepower installations guaranteeing $1,000 per month.		
Power:						
200 or more horsepower installations.	G	Sept. 1, 1916				
12 months' contract			$0.05 for first 1,000 kilowatt-hours.	$0.0165 for all over 100,000 kilowatt-hours.	$2 per horsepower installed, payable and cumulated over any specified 7-months' period.	
5-year contract			do	$0.011 for all over 150,000 kilowatt-hours.		
Irrigation power-pumping plant. [d]	F	May 1, 1916				
12-month year			$0.04 where 5 horsepower or less installed.		$2.50	
6-month year			$0.035 where 5 to 15 horsepower installed.		$1 per horsepower connected load.	
Do				$0.02 where 5 horsepower or more is installed.	$2 per horsepower connected load.	
Do			$0.03 where 15 horsepower or less installed.		$15 per horsepower connected load.	
Do			$0.025 where 15 to 99 horsepower installed.		$1 per horsepower connected load.	
Do			$0.0225 where 25 horsepower or over installed.		$12 per horsepower connected load.	
6-month year (high-tension service).			$0.02 where 50 horsepower or over installed.		$1,200 per annum guaranteed	
Power, municipal pumping	H	Sept. 1, 1917	$0.04 for first 1,000 kilowatt-hours.	$0.016 for all over 3,000 kilowatt-hours.	$1 per horsepower installed	

[c] The minimum monthly bill applies to seasonal power only during the period of use, but will not be less than 6 months' charge prorated over the period or use under schedule B-1 or 6 consecutive months under schedule 2-C.

[d] All bills plus 10 per cent unless promptly paid.

NOTES.

1. Rates apply to all territory served by Holton Power Co., namely, the towns of Holtville, Heber, Calexico, Imperial, Brawley, Seeley, Dixieland, Calipatria, Niland, El Centro, and adjacent territory, as well as that lying between the last-named city and the others named.
2. Discounts for prompt payment allowed on following schedules: B-1, 5 per cent, and B-A, B-W, and E, 5 per cent from all bills over the monthly minimum.
3. The California Railroad Commission has authorized the company to increase the rates here published affecting all territory by a surcharge according to class of service ranging from $0.0015 to $0.005 per kilowatt-hour, or 15 per cent of the monthly bill, to cover in part the increased cost of production due to conditions brought about by the war.

TABLE 309.—*Electric rates of The Southern Sierras Power Co. in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise specified. For a general revision of rates effective Sept. 20, 1920, see California Railroad Commission decision 8119.]

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.[a]
			Maximum.	Minimum.		
Lighting	A	May 1, 1917	$0.10 for first 15 kilowatt-hours.	$0.03 for all over 500 kilowatt-hours.	$1.25	1, 2, 3.
	A	Jan. 2, 1919	do	do	$1	4, 5.
	A	July 1, 1918	$0.07 for first 100 kilowatt-hours.	$0.025 for all over 5,000 kilowatt-hours.	$0.75	6.
	A[b]	Jan. 2, 1919	$0.13 net for first 30 kilowatt-hours.[c]	$0.07 for all over 1,000 kilowatt-hours.	$1.60 gross; $1.50 net for prompt payment.	7.
	A	June 1, 1918	$0.10 for first 150 kilowatt-hours.	$0.08 for all over 150 kilowatt-hours.	$1.20 gross; $1.15 net for prompt payment.	8.
Heating, cooking, small industrial and domestic appliances, and sign lighting.	B[b]	do	$0.04 for first 50 kilowatt-hours.	$0.03 for all over 100 kilowatt-hours.	$1.50 to $1 per horsepower or fraction, which may be connected at any one time.	1, 2, 3, 4, 5, 6.
	B[b]	do	$0.05 for first 50 kilowatt-hours.	$0.05 for all over 100 kilowatt-hours.	$2.50 to $1 per horsepower or fraction which may be connected at any one time, plus $1 per horsepower connected load in water heaters not equipped with double-throw switch.	8.
Lighting, heating, cooking, water heating, and domestic power, residences only.	BA[b]	Oct. 1, 1917			$3.75 plus $1 per horsepower rated capacity for motors operated under the same schedule.	1, 2, 3.
Electric ranges, 1 to 7 kilowatt capacity.			$0.10 for first 25 kilowatt-hours.	$0.03 for all over 125 kilowatt-hours.		
Electric ranges and water heaters with double-throw switch, 12 kilowatts or less.			do	$0.02 for all over 125 kilowatt-hours.		

[a] The territory served under each schedule comprises and is identified by numbers, as follows:
1. Inyo County—in and adjacent to Bishop, Big Pine, and Keeler.
2. Kern County—in the Indian Wells Valley and in and adjacent to Randsburg and Johannesburg.
3. San Bernardino County—in and adjacent to Victorville, Oro Grande, Barstow, and intermediate territory.
4. San Bernardino County—in and adjacent to Colton, Redlands, Rialto, Bloomington, Loma Lunda, and intermediate territory.
5. Riverside County—directly or indirectly in and adjacent to Riverside, Arlington, Corona, Highgrove, Perris, Hemet, San Jacinto, and Elsinor.
6. San Bernardino County—city of San Bernardino.
7. Riverside County—Blythe and vicinity.
8. Riverside County—Coachella, Indio, Thermal, Hamilton, and vicinity.

This company also indirectly supplies the following by wholesaling: To the Holton Power Co. for the Imperial Valley, Ghriest & Son for Banning, the Yuma Light, Gas & Water Co., and Sanguinette and Ewing for Yuma, Ariz., and vicinity.

[b] These schedules apply to small single-phase power and heating service. Under schedules BA the motor load is specifically limited to 5 horsepower.

[c] Net rates are effective when payment is made within 12 days of the delivery of bill. The gross rate unless otherwise specified is 1 cent higher than the net.

TABLE 309.—*Electric rates of The Southern Sierras Power Co. in effect Nov. 15, 1991*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.[a]
			Maximum.	Minimum.		
Lighting, heating, cooking, water heating, and domestic power. Residences only.	BA[b]	June 1, 1918	$0.10 for first 25 kilowatt-hours.	$0.03 for all over 125 kilowatt-hours.	$3.50 plus $1 per horsepower rated capacity for motors operated under the same schedule.	4, 5.
Electric ranges, 1 to 7 kilowatt capacity.	....	....	....	....	....	
Electric ranges and water heaters with double-throw switches, 12 kilowatts or less.	....	....	$0.10 for first 25 kilowatt-hours.	$0.02 for all over 125 kilowatt-hours.	....	
Lighting, heating, water heating, and domestic power. Residences only.	BA [b]	June 1, 1918	....	....	$3.50 plus $1 per horsepower of rated capacity of motors installed.	8.
Electric ranges, 1 to 7 kilowatt capacity.	....	....	$0.10 for first 25 kilowatt-hours.	$0.03 for all over 125 kilowatt-hours.	....	
Electric ranges and water heaters with double-throw switches, 12 kilowatts or less.	....	....	...do...	$0.025 for all over 125 kilowatt-hours.	....	
Lighting, heating, cooking, and water heaters.	BA [b]	Jan. 2, 1919	$0.07 for first 20 kilowatt-hours. for 5-room house or less.[d]	$0.02 for all over 120 kilowatt-hours.	$2.50........	6.
			$0.07 for first 30 kilowatt-hours. for 6 and 7 room houses.[d]	$0.02 for all over 130 kilowatt-hours.	....	
			$0.07 for first 40 kilowatt-hours. for 8-room house or more.[d]	$0.02 for all over 140 kilowatt-hours.	....	
Heating, cooking, water heating, and domestic power service. Residences only. Double-throw switch between cooking and water heating devices.	BW [b]	Oct. 1, 1917	$0.04 for first 50 kilowatt-hours.	$0.02 for all over 100 kilowatt-hours.	$2.75 plus $1 per horsepower rated capacity of motors installed.	1, 2, 3.
	BW [b]	June 1, 1918	...do...	...do...	$2.50 plus $1 per horsepower rated capacity of motors installed.	4, 5.
	BW [b]	...do...	$0.05 for first 50 kilowatt-hours.	$0.025 for all over 100 kilowatt-hours.	...do...	8.
Power (all classes except that covered by schedule F).	C [e]	Apr. 1, 1912	$0.06 for first 100 kilowatt-hours.	$0.012 for all over 25,000 kilowatt-hours.	$0.25 per month customer's charge. $1 per horsepower capacity of motors installed.	1, 2, 3.
	C	June 1, 1918	...do...	...do...	$1 per horsepower capacity of motors installed but not less than $2.	4, 5.

Load:	C	Jan. 2, 1919				6.
1 to 4 horsepower			$0.06 for first 50 kilowatt-hours.	$0.011 for all over 100 kilowatt-hours.	$1 per horsepower capacity of motors installed but not less than $2.	
5 to 9 horsepower			0.05 for first 50 kilowatt-hours.	$0.0105 for all over 100 kilowatt-hours.		
10 to 24 horsepower			0.04 for first 50 kilowatt-hours.	$0.01 for all over 100 kilowatt-hours.		
25 to 49 horsepower			0.03 for first 100 kilowatt-hours.	$0.0095 for all over 100 kilowatt-hours.		
50 to 99 horsepower			0.0275 for first 100 kilowatt-hours.	$0.009 for all over 100 kilowatt-hours.		
100 to 199 horsepower			$0.025 for first 100 kilowatt-hours.	$0.0085 for all over 100 kilowatt-hours.		
200 to 499 horsepower			$0.0225 for first 100 kilowatt-hours.	$0.008 for all over 100 kilowatt-hours.		
Over 500 horsepower			$0.02 for first 100 kilowatt-hours.	$0.0075 for all over 100 kilowatt-hours.		
Power	C[e] [f]	Jan. 2, 1919	$0.12 for first 50 kilowatt-hours.	$0.04 for all over 1,000 kilowatt-hours.	$1.50 per horsepower capacity of motors installed, but not less than $2.	7.
Do	C[e]	June 1, 1918	$0.10 for first 20 kilowatt-hours.	$0.02 for all over 10,000 kilowatt-hours.	$1 per horsepower capacity for motors of 200 or more horsepower, but not less than $1.20.	8.
Irrigation pumping (optional), installation.	E	do				1, 2, 3, 4, 5, 6.
5 horsepower or less			$0.03 per kilowatt-hour		$2.50 for 6 months each year.	
5 to 99 horsepower			$0.025 per kilowatt-hour		$1 per horsepower connected for 6 months each year.	
Do			$0.02 per kilowatt-hour		$12 per horsepower connected per annum.[g]	
100 horsepower or over			do		$1 per horsepower for 6 months each year.	
Irrigation pumping (optional), installation.	E	June 1, 1918				8.
5 horsepower or less			$0.04 per kilowatt-hour		$2.50 for 12 months each year.	
5 to 14 horsepower			$0.035 per kilowatt-hour		$1 per horsepower connected for 6 months each year.	
15 horsepower or less			$0.03 per kilowatt-hour		$15 per horsepower connected for 6 months each year.	

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[a] See note *a*, p. 1243.

[b] These schedules apply to small single-phase power and heating service. Under schedules BA the motor load is specifically limited to 5 horsepower.

[d] Bathrooms, halls, and cellars classified as rooms.

[e] This schedule applies to seasonal power contracted for 6 months or more. Where so used the minimum bill is rendered only during the period of contract. Schedule C in territory 8 also applies for shorter periods, but where so applied the 6-months' minimum prorated over the period of use is charged.

[f] This schedule may also apply to heating and cooking; where so used an additional monthly minimum of $2.50 is charged.

[g] No minimum payment shall exceed $100 per month on installations less than 100 horsepower. The minimum of $12 per annum is payable at the rate of $2 per horsepower per month during a specified 6 consecutive months. Any excess so paid above the actual consumption shall be applied in payment of power used during the remainder of the year at the rate of $0.02 per kilowatt-hour.

TABLE 309.—*Electric rates of The Southern Sierras Power Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.[a]
			Maximum.	Minimum.		
Irrigation pumping (optional), installation—Continued.						
15 to 99 horsepower			$0.025 per kilowatt-hour		$1 per horsepower connected for 6 months each year.	
25 horsepower or over			$0.0225 per kilowatt-hour		$12 cumulative minimum per horsepower connected during 6 months each year.	
50 horsepower or over			$0.02 per kilowatt-hour (high tension).		$12 per annum	
5 horsepower or over			$0.02 per kilowatt-hour (long-term contract).		$2 per horsepower connected for 6 months each year.	
All					$2.50 during noncontract period unless service is disconnected.	
Mining, to consumers whose operations involve considerable extra installation or uncertainty of continuous service.	F	Feb. 20, 1915	Intermittent service $2 per horsepower measured maximum demand plus $0.04 per kilowatt-hour.			1.
	F	Apr. 1, 1915				2, 3.
Mining, constant-speed motors, long-term contracts, large consumers.	F	do	Continuous service $0.04 for first 2,500 kilowatt-hours. Intermittent service $0.08 for first 500 kilowatt-hours. $0.0375 for first 2,500 kilowatt-hours.	$0.03 for 2,500 to 8,168.7 kilowatt-hours (short-term contracts for small consumers). $0.03 for 27,229 to 54,458 kilowatt-hours.[h] $0.014 for all over 544,580 kilowatt-hours.	$1 per horsepower of motors installed guaranteed. Based on per cent of total installed capacity of motors under continuous operation.	
Optional-load factor applicable only to installations of 15 horsepower and under on long-term contracts.	G	do	$0.03 for 182 kilowatt-hours consumed per kilowatt of maximum demand.[i]	$0.02 for over 600 kilowatt-hours per kilowatt of maximum demand.	$12 per year per horsepower of motors installed.	1, 2, 3, 4, 5, 7.
Power, optional-load factor 15 horsepower and over on long-term contracts.	H	June 1, 1918			$12 per year horsepower of motors installed.	1, 2, 3, 4, 5, 7.
Kilowatt of maximum demand:						
19 or less			$0.025 for first 229 kilowatt-hours per kilowatt of maximum demand.	$0.015 for 680 kilowatt-hours or more per kilowatt of maximum demand.		
20 to 27			$0.024 for first 229 kilowatt-hours per kilowatt of maximum demand.	$0.014 for 680 kilowatt-hours or more per kilowatt of maximum demand.		

28 to 36			$0.023 for first 229 kilowatt-hours per kilowatt of maximum demand.	$0.013 for 680 kilowatt-hours or more per kilowatt of maximum demand.		
37 to 48			$0.022 for first 229 kilowatt-hours per kilowatt of maximum demand.	$0.012 for 680 kilowatt-hours or more per kilowatt of maximum demand.		
49 to 60			$0.021 for first 229 kilowatt-hours per kilowatt of maximum demand.	$0.011 for 680 kilowatt-hours or more per kilowatt of maximum demand.		
60 or over			$0.02 for first 229 kilowatt-hours per kilowatt of maximum demand.	$0.01 for 680 kilowatt-hours or more per kilowatt of maximum demand.		
Flat rate, agricultural, applicable only under contract for 4 months' or more service per year for 5 years or more.[j]	I	June 1, 1918	First option-operating period guaranteed: 12 months' continuous service at $50 per year per horsepower.[k] 11 months' continuous service at $49 per year per horsepower. 10 months' continuous service at $48 per year per horsepower. 9 months' continuous service at $47 per year per horsepower. 8 months' continuous service at $45 per year per horsepower. 7 months' continuous service at $42 per year per horsepower. 6 months' continuous service at $38 per year per horsepower. 5 months' continuous service at $33 per year per horsepower. 4 months' continuous service at $27 per year per horsepower.		Monthly proportion of the annual rate during the guaranteed period of operation.	1, 2, 3, 4, 5, 6.

[a] See note a, p. 1243.

[h] Consumers taking over 54,458 kilowatt-hours will have charges modified to conform to Schedule F (long-term contract—large consumers).

[i] In the case of seasonal load the average rate obtained during any specified six consecutive months shall apply to current used during the remainder of the service year.

[j] Consumer must select in advance with the privilege of changing at the beginning of each year a specified number of months at the flat-rate period. This period may not be reduced during the year, but may be extended, in which case additional service shall be paid for at the rate in the second option beginning with the monthly rate progressively following the period selected. Decrease in maximum demand not credited in billing until the first of the month following change. Increase in maximum demand not exceeding 20 per cent, and not caused by increase in installation billed proportionately higher, effective the first of the month in which the increase occurred. Where the increase exceeds 20 per cent or is caused by change in installation the increase is billed at the rate specified in the second option for the first and succeeding months of operation, the billing continuing through each 12-months' period of plant operation thereafter.

[k] The billing period begins the first of the month. The current used before the first of the month at the beginning of the flat-rate period is billed at $7.50 per horsepower per month prorated for continuous service, or at $0.02 per kilowatt-hour for intermittent service. $0.02 per kilowatt-hour is charged for current consumed after the close of the flat-rate period, but the total monthly bill will not be rendered to exceed the regular monthly rate during the flat-rate period.

TABLE 309.—*Electric rates of The Southern Sierras Power Co. in effect Nov. 15, 1919*—Continued.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Flat rate, agricultural, applicable only under contract for 4 months' or more service per year for 5 years or more.	I	June 1, 1918	Second option-operating rate, month to month:			
			1 month continuous service, $7.50 per horsepower.			
			2 months continuous service, $6.75 per horsepower.			
			3 months continuous service, $6.50 per horsepower.			
			4 months continuous service, $6.25 per horsepower.			
			5 months continuous service, $6 per horsepower.			
			6 months continuous service, $5 per horsepower.			
			7 months continuous service, $4 per horsepower.			
			8 months continuous service, $3 per horsepower.			
			9 months continuous service, $2 per horsepower.			
			10 months continuous service, $1 per horsepower.		Monthly proportion of annual minimum.	4, 5.
			11 months continuous service, $1 per horsepower.			
			12 months continuous service, $1 per horsepower.			
Industrial	J	June 1, 1918	$0.02 per kilowatt-hour where the minimum is not less than $300 per service year			

			and equals $1 per horsepower per month rated capacity.			
Rock-crushing plants of 750 horsepower or over, operating 8 or more months per year.	K	do	$0.04 for first 2,000 kilowatt-hours.	$0.012 for all over 40,000 kilowatt hours.	$1 per horsepower connected for first 200. $0.50 per horsepower connected for all over 200. Main plant may suspend operation 4 months each year during which minimum is based on motors actually operating, but not less than $200.	5.
Optional temporary service, or service not covered by other schedules.	L	do	220 or 440 volt service, $0.035 per kilowatt-hour, cost of extension, connection, and disconnection to be paid by consumer in advance.	2,200-volt service, $0.03 per kilowatt hour.	$5	1, 2, 3, 4, 5, 6.
Power	N	Mar. 15, 1919				8.
Guaranteed minimum bill operating 6 consecutive months or more. Installation may be one or more motors through one meter:						
Not over 5 horsepower			$0.08 per kilowatt-hour		$10 guaranteed	
Not over 10 horsepower			.05 per kilowatt-hour		$23.75 guaranteed	
Not over 25 horsepower			.04 per kilowatt-hour		$50 guaranteed	
Not over 50 horsepower			.03 per kilowatt-hour		$75 guaranteed	
Not over 75 horsepower			.0275 per kilowatt-hour		$100 guaranteed	
Not over 100 horsepower			.025 per killowatt-hour		$150 guaranteed	
Not over 150 horsepower			.024 per killowatt-hour		$200 guaranteed	
Not over 200 horsepower			.023 per kilowatt-hour		$250 guaranteed	
Not over 250 horsepower			.022 per kilowatt-hour		$300 guaranteed	
Not over 400 horsepower			.021 per kilowatt-hour		$500 guaranteed	
Not over 500 horsepower			.02 per kilowatt-hour		$1,000 guaranteed	
Not over 200 horsepower			.0175 per kilowatt-hour		$600 guaranteed	

j See note *j*, p. 1247.

NOTES.

1. The maximum demand as applied to load-factor schedules is determined by the company by test from time to time as it may elect. The maximum demand as thus determined remains in force from the first of the month following the test. Upon request and at the expense of consumer (or in the discretion of the company at its own expense) demand indicating meters may be installed in which case the 15-minute integrated peak during the month constitutes the maximum demand.

2. The following discounts are allowed for prompt payment of bills: 10 per cent from schedules A, BA, and BW in territory 1, 2, 3, 4, and 5, and B in territory 1, 2, 3, 4, 5, and 6; 5 per cent from schedules A, B, BA, BW, and C in territory 8, with 5 per cent discount from the minimum bill under schedule A, territory 8.

3. The California Railroad Commission has authorized the company to increase the rates affecting all territory here published by a surcharge ranging according to class of service from 2 to 10 mills per kilowatt-hour, or for unmetered street lighting 15 per cent of monthly bills, to cover in part the increased cost of production due to conditions brought about by the war.

TABLE 310.—*Electric rates of The Nevada-California Power Co. in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise noted.]

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.[a]
			Maximum.	Minimum.		
Lighting	4-A	Mar. 15, 1914	$0.09 for first 50 kilowatt-hours.	$0.035 for all over 1,000 kilowatt-hours.	$1.50	4.
Cooking, heating	5-B	Mar. 1, 1919	$0.05 for first 50 kilowatt-hours.	$0.03 for all over 100 kilowatt-hours.	$2.50 when range, water heater, or motor is used; $1.50 when above are not used.	5.
Commercial, power	4-C	Mar. 5, 1914	$0.06 for first 100 kilowatt-hours.	$0.035 for all over 500 kilowatt-hours.	$0.25 per rated horsepower but not less than $1.50 per month.	4.
Industrial	4-D	do	$0.0325 for first 1,000 kilowatt-hours.	$0.0114 for all over 327,000 kilowatt-hours.	$0.25 per connected horsepower of motor.	4.
Mining, milling, and industrial receiving secondary measurement.	4-E	Oct. 1, 1915	$0.05 for first 150 kilowatt-hours.	$0.03 for all over 4,000 kilowatt-hours.	do	4.
Lighting:[b]						
Short-hour service	A	Jan. 1, 1913	$0.20 for first 50 kilowatt-hours.	$0.15 for all over 100 kilowatt-hours.	$2; 10 per cent discount for prompt payment.	Pacific district.
Long-hour service		do	$0.15 for first 50 kilowatt-hours.	$0.09 for all over 500 kilowatt-hours.		
Cooking and heating	B	do	$0.05 per kilowatt-hour		$3	Do.
Mining camps	C[c]	do				Do.
Intermittent service			$2 per horsepower per month, readiness to serve charge, based on rated horsepower of motor plus 4 cents per kilowatt-hour for all power actually consumed.			
Continuous service (4.6 to 15 horsepower.			$0.04 for first 2,500 kilowatt-hours.	$0.03 for all over 2,500 kilowatt-hours.		
Long-term contracts (15 to 1,000 horsepower.			$0.03 for first 13,614.50 kilowatt-hours.	$0.014 for all over 326,748 kilowatt-hours.	([d]).	

[a] The territory served under each schedule comprises and is identified by numbers as follows:
4. Goldfield, Tonopah, Manhattan, Round Mountain, Blair, Silver Peak, Rhyolite, Pioneer, Bonnie Clair, Nev., and adjacent territory.
5. Goldfield, Tonopah, Manhattan, Round Mountain, Nev., and adjacent territory.

[b] These are meter rates. Flat-rate consumers are charged as follows: Business houses, first 10 60-watt lights, $1 each; additional, 75 cents each. Residences, first 2 lights, $1 each; additional, 50 cents each. Flatirons, $1 each.

[c] Applying to mining camps in vicinity of Aurora, Rawhide, Wonder, and Fairview, Nev.

[d] Special contracts are made for mining and milling low-grade ores when more than 400 horsepower is used.

TABLE 311.—*Electric rates of Sierra Pacific Electric system in effect Nov. 15, 1919.*

[Per kilowatt-hour per meter per month unless otherwise specified.]

The Truckee River General Electric Co.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory:
			Maximum.	Minimum.		
Power	1	July 1, 1914	$0.045 for first 300 kilowatt-hours.[a]	$0.015 for all over 50,000 kilowatt-hours.	$1.10 per rated horsepower; 10 per cent discount for use of 2,200-volt current; 10 per cent for payment within 15 days.	All.
Power — Prospector's and small users.	2	do	$0.05 for first 300 kilowatt-hours.	$0.02 for all over 2,000 kilowatt-hours.	$0.25 per rated horsepower; discount as above.	
Any and all purposes	3	do	$0.07 for first 150 kilowatt-hours.	$0.045 for all over 550 kilowatt-hours.	$1; no discounts.	
Irrigation power [b]	4	do	$0.017 for first 5,000 kilowatt-hours.	$0.012 for all over 30,000 kilowatt-hours.	$3 per season per rated horsepower of motor, or per rated kilovolt-ampere of transformer if it exceeds by 50 per cent the capacity of motors connected; discount 10 per cent for payment within 15 days.	
Large reduction work and mines connected therewith.[c]	5	do	$0.0107 per kilowatt-hour plus $2.25 per month per maximum horsepower input to each motor.	....	$1 per rated horsepower and a total of not less than $500 per month, April and November; 10 per cent discount for payment within 15 days.	
Supplementary [d]	6	do	$0.012 for first 50,000 kilowatt-hours.	$0.01 for all over 50,000 kilowatt-hours plus $2.25 per month per maximum horsepower input to each motor when operating full speed with load.	$1 per month per rated horsepower, and a total of not less than $500; 10 per cent discount for payment within 15 days.	

[a] Additional charge of $1.25 per average maximum horsepower per month for each hoist motor, operating at full speed and load.

[b] April to October each year; no use between 6 and 11 p. m.; power to be supplied and metered at 2,200 volts or consumer to furnish stepdown transformers.

[c] Current to be furnished and metered at 2,200 volts, or consumers to furnish transformers.

[d] For power and all other purposes, except that connected lighting load shall not exceed 10 per cent of other connected load. Plant to run full 24 hours, and all motors running only part time not to run from 5 to 10 p. m. from November to March. Current furnished and metered at 2,200 volts.

TABLE 311.—*Electric rates of Sierra Pacific Electric system in effect Nov. 15, 1919*—Continued.

Reno Power, Light & Water Co.

Character of service.	Schedule.	Date effective.	Rates.		Minimum monthly bill.	Territory.
			Maximum.	Minimum.		
Meter rates	1	July 1, 1914	For first 150 kilowatt-hours, $0.07 per kilowatt-hour.	In excess of 550 kilowatt-hours, $0.02 per kilowatt-hour.	$1, no discounts	Reno only.
Do			$0.05 for first 300 kilowatt-hours.	$0.15 in excess of 50,000 kilowatt-hours.	$1 per connected horsepower and not less than $3. Discount of 10 per cent when consumer uses and company meters current at 4,000 or 2,200 volts or for payment within 15 days.	
Flat rates			Residence, $0.30 per 16 candlepower equivalent per month.			
Do			Business, over 10 hours burning per day, $0.70 per 16 candlepower equivalent per month.	Business, under 10 hours burning per day, $0.50 per candlepower equivalent per month.	$0.90; no discounts.	
Do			Business arc lamps; over 10 hours burning, $8 per month.	Business arc lamps; under 10 hours burning per day, $6 per month.	do	
Do			Commercial series and multiple arc lighting, burning over 10 hours per night, $8 net per month.	Commercial series and multiple arc lighting, burning less than 10 hours per night, $7 per month.		
Meter rates			For any or all purposes, $0.10 per kilowatt-hour.		$1	Outside corporate limits of cities of Reno and Sparks. Sparks.
Do	2	July 1, 1914	$0.07 for first 150 kilowatt-hours.	$0.045 in excess of 550 kilowatt-hours.	$1	
Flat rates—Incandescent lighting.			$0.70 per month per 50 watts.		$1	
Flat rates—Municipal lighting.[a]			Less than 50 lights in use. During first year each light is installed, $6 per month.	Less than 50 lights in use. During first year each light is installed, $5 per month.		
Do			More than 50 lights in use. For each light installed $5 per month.[b]	More than 50 lights in use. For each light installed, $5 per month.		
Incandescent lighting			For each 60-watt installed, $1 net per month.			

Supplementary to above...... For consumers operating plants principally for refrigeration and compressor motors to take current at primary voltage. (Contract 10 years.)	2	Aug. 1, 1912	....	$1.25 per kilowatt-hour.......	$1 per horsepower of connected motor, and not less than $200 when plant is operated. No discounts.
Supplementary—Power except connected load.[c]	3	Nov. 15, 1914	$0.012 for first 50,000 kilowatt-hours.	$0.01 in excess of 50,000 kilowatt-hours.	$1 per month per rated horsepower of connected motors and not less than $450. (This charge to be eliminated upon 30 days' notice that plant is to be discontinued during any certain month.) 10 per cent discount for payment before the 15th.

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[a] Lights to burn from half an hour after sundown to half an hour before sunrise each night.

[b] Rebate of 25 cents on above rates for each night a light is out for over 1 hour.

[c] Connected lighting load shall not exceed 10 per cent of other connected load. No power to be used between 5 p. m. to 10 p. m. daily during months of March to November, inclusive. Current to be furnished and metered at 2,200 or 4,000 volts or furnished at transmission voltage and metered on low-tension side of consumer's high-tension transformers. Term of contract, not less than 5 years.

APPENDIX C.—PHYSICAL AND OPERATING DATA.

TABLE 312.—*Physical and operating data of isolated hydroelectric utilities reporting to California Railroad Commission, Dec. 31, 1913–1920.*

	Alturas Electric Power Co.	California Power & Manufacturing Co.	Plumas Electric Light & Power Co.).[a]	Lassen Electric Co.
Name of plant and capacity	No. 1 Hydro, 300 kilowatts.	No. 1 Fall River Mills Hydro, 200 kilovolt-amperes.	No. 1 Greenville Hydro, 60 horsepower; operated 1913–1915.	No. 1 Bunnell Springs Hydro, 150 kilowatts: No. 2 Susan River Hydro, 50 kilowatts.
Output (kilowatt-hours):				
1913. Generated	[b] 224,463		16,596	Not reported.
1914. Generated	248,050	(c)	23,169	
1915. Generated	286,453	42,494	13,280	
1916. Generated	265,343	103,650	(d)	
1917. Generated	225,000	107,730		
Purchased			64,786	
1918. Generated	300,000	166,707		
Purchased			76,480	
1919. Generated	339,000	139,120		
Purchased			46,660	
1920. Generated	307,595	(e)		
Purchased			48,440	
Number of substations	1	3	1	1
Capacity of substations, kilowatts.	225			150
Miles of high-tension transmission line.	8⅜	18½	11	8
Miles of primary distribution line.	4½			7
Miles of secondary distribution line.	5	6.75		12½

	Quincy Electric Light & Power Co.	Truckee Electric Light & Power Co.	Tuolumne Electric Co.	Weaverville Electric Co.
Name of plant and capacity	No. 1 Quincy Hydro, 175 kilowatts.	Truckee Hydro, 150 kilowatts.	No. 1 Hydro, 600 kilowatts; operated 1913–1916.	No. 1 Weaverville Hydro, 50 kilowatts.
Output (kilowatt-hours):				
1913. Generated	Not reported	Not reported	707,100	Not reported.
1914. Generated			1,174,250	
1915. Generated			658,700	
1916. Generated			372,650	
1917. Generated			(d)	
1918. Generated			(d)	
1919. Generated			414,340	
1920. Generated			504,318	
Number of substations				1
Capacity of substations, kilowatts.				50
Miles of high-tension transmission line.	2	5		
Miles of primary distribution line.				3
Miles of secondary distribution line.				3

[a] Formerly Indian Valley Electric Light & Power Co.
[b] An estimate; part of business being done on flat rate.
[c] No record.
[d] Generating plant closed down.
[e] Sold to Pacific Gas & Electric Co.

TABLE 313.—*Physical and operating data of steam-electric and distributing utilities reporting to California Railroad Commission, Dec. 31, 1913–1920.*

	Central Oakland Light & Power Co.	Consumers Light & Power Co.	Equitable Light & Power Co.
Name of plant and capacity	No 1 steam, 2,000 kilowatts. No. 2 steam, 75 kilowatts.	No. 1 steam, 725 kilowatts.	No. 1 steam, 1,500 kilovolt-amperes.
Output (kilowatt-hours):			
1913. Generated	1,655,610	2,413,540	4,599,470
Purchased	3,350,950		
	5,006,560	2,413,540	4,599,470
1914. Generated	624,675	2,457,395	4,207,640
Purchased	3,553,600		1,263,500
	4,178,275	2,457,395	5,471,140
1915. Generated	Sold in 1915 to Consolidated Electric Co.	Sold in 1915 to Consolidated Electric Co.	Sold in 1915 to Consolidated Electric Co.
Purchased			
Dec. 31, 1914:			
Number of substations	1	[a]	1
Capacity of substations in kilowatts.	300		600
Miles of primary distribution line.	21		
Miles of secondary distribution line.	32		

	Fort Bragg Electric Co.	Hemet Milling & Power Co.	Huntington Beach Co.	Lompoc Light & Power Co.
Name of plant and capacity	No. 1 steam, 940 kilovolt-amperes, 300 kilowatts.	No. 1 Latham Avenue steam, 75 kilowatts.	No. 1 Huntington Beach gas engine, 60 kilowatts.	Lompoc steam, 105 kilowatts.
Output (kilowatt-hours):				
1913. Generated		20,252	45,315	762,600
Purchased		[b] 17,610	124,245	
		37,862	169,560	762,600
1914. Generated	1,526,582		[b] 46,687	220,800
Purchased		46,070		
1915. Generated	1,367,532			178,360
Purchased		46,940		
1916. Generated	1,486,943	[c]		189,092
1917. Generated	1,770,591		[d]	215,700
1918. Generated	1,436,580			176,828
Purchased				[e] 44,728
1919. Generated	1,515,500			
Purchased				166,560
1920. Generated	1,643,405			
Purchased				221,360
Dec. 31, 1920:				
Number of substations			1	1
Capacity of substations in kilowatts.			60	150
Miles of high-tension transmission line.	5			
Miles of primary distribution line.	14		30.94	6.75
Miles of secondary distribution line.	11		15.63	14.84

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[a] Included with Equitable Light & Power Co.
[b] For 5 months only.
[c] Sold to Southern Sierra Power Co. Mar. 30, 1916.
[d] Sold in 1917.
[e] Plant closed down in 1918.

TABLE 313.—*Physical and operating data of steam-electric and distributing utilities reporting to California Railroad Commission, Dec. 31, 1913–1920*—Continued.

	Los Angeles Gas & Electric Corporation.	Loyalton Electric Light Co.	Napa Valley Electric Co.	Needles Gas & Electric Co.
Name of plant and capacity	No. 1 plant, steam, 19,710 kilovolt-amperes.	No. 1 Loyalton, steam, 162 kilowatts.		No. 1 Needles, oil, 375 kilovolt-amperes.
Output (kilowatt-hours):				
1913. Generated	$31,457,345	(*f*)	$371,116	
Purchased			462,275	
	31,457,345		833,841	
1914. Generated	34,443,927		397,239	
Purchased			572,600	
	34,443,927		969,839	
1915. Generated	36,381,712	(*g*)	500,440	
Purchased			735,100	
	36,381,712		1,235,540	
1916. Generated	40,169,737		561,251	$206,878
Purchased			798,100	
	40,169,737		1,259,351	206,878
1917. Generated	42,152,000		629,004	207,900
Purchased			865,050	
	42,152,000		1,494,054	207,900
1918. Generated	41,010,000		(*f*)	305,416
Purchased			907,900	
1919. Generated	40,714,000		708,669	310,297
Purchased	3,313,000		994,940	
	44,027,000		1,703,609	310,297
1920. Generated	57,626,627		840,834	
Purchased	1,995,556		1,101,100	
	59,622,283		1,941,934	
Dec. 31, 1920:				
Number of substations	6		1	
Capacity of substations in kilowatts.	9,219		300	
Miles of high-tension transmission line.	24.57	(1914) 6		
Miles of primary distribution line.	1,785		85	6.5
Miles of secondary distribution line.	1,185		30	13.6

f No record kept.
g Abandoned May 5, 1915.

TABLE 313.—*Physical and operating data of steam-electric and distributing utilities reporting to California Railroad Commission, Dec. 31, 1913–1920*—Continued.

	Oceanside Electric & Gas Co.	Ojai Power Co.	Point Arena Electric Co.	San Diego Consolidated Gas & Electric Co.
Name of plant and capacity	No. 1 Oceanside, steam, 125 kilowatts.	No. 1 Ojai, oil, 100 kilovolts.	No. 1 Point Arena, gas engine, 60 kilowatts.	No. 1 San Diego, steam, 13,750 kilowatts.
Output (kilowatt-hours):				
1913. Generated	(*f*)		$296,535	$18,931,466
1914. Generated			30,008	20,847,915
1915. Generated		$67,790	*h* $2,978.80	27,114,691
1916. Generated			*h* $3,218.37	29,282,023
1917. Generated			*h* $2,550.48	28,726,000
Purchased				1,296,000
			h $2,550.48	30,022,000
1918. Generated		(*e*)	*h* $2,484.00	27,003
Purchased		*b* 92,470		13,267,000
1919. Generated			2,330,810	43,547,000
Purchased		542,810		15,007,000
		542,810	2,330,810	58,554,000
1920. Generated			2,863,800	53,276,067
Purchased		798,947		2,044,830
		798,947	2,863,800	55,320,897
Dec. 31, 1920:				
Number of substations			1	
Capacity of substations in kilowatts				60
Miles of high-tension transmission line.	1915 7½		2	72.52
Miles of primary distribution line.		12	2	3,762.58
Miles of secondary distribution line.		3½	2	

	Santa Barbara Gas & Electric Co. [i]	Santa Catalina Island Co.	Southside Light & Power Co.
Name of plant and capacity	No. 1 Santa Barbara, steam, 2,120 kilowatts.	No. 1 Avalon, steam, 320 kilowatts.	No. 1 Minna Street, steam, 1,000 kilovolt-amperes.
Output (kilowatt-hours):			
1913. Generated	$3,339,352		$87,890
1914. Generated	4,057,025	$200,663	2,313,254
1915. Generated	4,470,318	232,275	
1916. Generated	5,040,004	*j* 161,695	
1917. Generated	5,906,596	175,790	
1918. Generated	3,866,000	1[illegible]1,600	
Purchased	4,190,000		
	8,056,000	171,600	
1919. Generated	810,000	*k* 285,820	
Purchased	7,836,000		
	8,646,000		
1920. Generated	816,000		
Purchased	9,615,000		
	10,431,000		
Dec. 31, 1920:			
Number of substations	5		(*l*)
Capacity of substations in kilowatts.	4,100		
Miles of high-tension transmission line.	18.92		
Miles of primary distribution line.	352.36		
Miles of secondary distribution line.	213.20		

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[b] For five months only. [e] Plant closed down in 1918. [f] No record kept. [h] Earnings.
[i] For further information see Table 102 and text covering Southern California Edison Co.
[j] Sold to Wilmington Transportation Co. June 16, 1916.
[k] Sold to city of Avalon Oct. 15, 1919.
[l] Substation equipment included with Equitable Light & Power Co.

TABLE 313.—*Physical and operating data of steam-electric and distributing utilities reporting to California Railroad Commission, Dec. 31, 1913–1920*—Continued.

	United Light & Power Co.	Universal Electric & Gas Co.
Name of plant and capacity	No. 1 Hannah Street, steam, 7,350 kilowatts.	No. 1 steam, 2,240 kilowatts.
Output (kilowatt-hours):		
1913. Generated	14,800,826	4,532,975
1914. Generated	13,455,161	4,445,469
1915. Generated	(*m*)	4,835,140
Purchased	....	279,014
	....	5,114,154
1916. Generated	....	6,888,899
Purchased	....	3,370,024
	....	10,258,923
1917. Generated	....	3,495,407
Purchased	....	8,184,605
	....	11,680,012
1918. Generated	....	4,178,843
Purchased	....	11,526.660
	....	15,705,503
1919. Generated	....	1,222,365
Purchased	....	24,806,064
	....	26,028,429
1920. Generated	....	2,047,740
Purchased	....	29,891,630
	....	31,939,370
Dec. 31, 1920:		
Number of substations	....	1
Capacity of substation in kilovolt-amperes.	....	11,000
Miles of high-tension transmission line.	....	....
Miles of primary distribution line.	....	77.97
Miles of secondary distribution line.	....	51.19

m Sold in 1915 to Consolidated Electric Co.

TABLE 314.—*Physical and operating data of distributing utilities reporting to California Railroad Commission, Dec. 31, 1913–1920.*

	Amador Electric Light & Power Co.[a]	Bay Point Light & Power Co.	Bell Electric Co.	Bishop Light & Power Co.	Boulder Creek Light & Water Co.
Purchased 1913 kilowatt-hours	705,160	260,000	....	346,270	....
1914 do	725,698	300,000	....	355,850	....
1915 do	739,980	300,000	599,087	353,871	....
1916 do	852.760	327,320	583,520	360,460	....
1917 do	803,000	250,800	595,840	393,740	....
1918 do	666,000	636,240	539,580	(*b*)	[c] 16,080
1919 do	723,000	693,360	604,640	....	28,480
1920 do	756,662	792,240	707,530	....	70,213
Dec. 31, 1920:					
Number of substations	3	1	....	(1917) 1	....
Capacity of substations in kilowatts	675	[d] 300	....	102	....
Miles of high-tension transmission line	12	7	....	....	....
Miles of primary distribution line	19	7	32	8.55	8½
Miles of secondary distribution line	9	8	32	3.00	

[a] Steam plant, 250-kilowatt capacity; no output.
[b] Sold Mar. 1, 1918, to Southern Sierras Power Co.
[c] May to December, inclusive. No current purchased in prior years; hydroelectric output of 35-kilowatt plant not reported.
[d] 300 kilovolt-amperes.

TABLE 314.—*Physical and operating data of distributing utilities reporting to California Railroad Commission, Dec. 31, 1913–1920*—Continued.

	Butte County Power, Light & Water Co.[e]	California Telephone & Light Co.	Calistoga Electric Co.	Consolidated Utilities Co.
Purchased 1913 ... kilowatt-hours		995,030	54,100	$29,641.20
1914 ... do		1,520,583	95,240	(*f*)
1915 ... do		1,638,378	132,860	
1916 ... do		1,881,270	177,810	
1917 ... do		2,119,956	191,280	
1918 ... do		2,625,003	Sold.	
1919 ... do	2,754,340	139,120		
1920 ... do	4,058,793	(*g*)		
Dec. 31, 1920:				
Number of substations		6		(1912) 1
Capacity of substations in kilowatts		2,090		100
Miles of high tension transmission line		1		
Miles of primary distribution line		871.29	(1917) 20	6
Miles of secondary distribution line			(1917) 11	10

	Corona Gas & Electric Light Co.	Del Mar Water Light & Power Co.[h]	Del Monte Light & Power Co.	Durham Light & Power Co.	Glendora Light & Power Co.	Half Moon Bay Light & Power Co.
Purchased 1913 ... kilowatt-hours	527,400				114,000	
1914 ... do	428,226	216,400			(*i*)	841,209
1915 ... do	452,400	227,400				730,080
1916 ... do	482,241	139.078				(*i*)
1917 ... do	492,192	153,364		118,680		
1918 ... do	(*j*)	(*k*)		121,200		
1919 ... do			118,493	(*l*)		
1920 ... do			243,981			
Dec. 31, 1918:						
Number of substations				1		
Miles of primary distribution line			(1920) 12.94	17		
Miles of secondary distribution line			(1920) 1.50	3½		

	H. G. Lacey Co.	Mendocino Electric Light & Power Co.	Middle Yuba Hydroelectric Power Co.	Mount Konocti Light & Power Co.	Mountain Light & Water Co. (formerly Ben Lomond Water Works).
Purchased 1913 ... kilowatt-hours	3,430,240	$4,141.41	656,987	189,196	
1914 ... do	3,701,360	3,691.09	1,384,920	297,961	
1915 ... do	3,808,150	3,778.89	1,470,720	320,697	
1916 ... do	2,318,400	3,813.94	1,804,320	341,699	3,080
1917 ... do	2,352,001	4,096.06	1,909,920	382,293	3,600
1918 ... do	[m]3,305,000	3,927.32	1,240,944	372,919	19,200
1919 ... do		4,404.80	1,074,240	400,156	22,227
1920 ... do		4,444.00	14,750,400	(*n*)	(*o*)
Dec. 31, 1920:					
Number of substations	1		1	1	
Capacity of substations in kilowatts	700		1,200	[d]3 0	
Miles of high-tension transmission line		16	10.5		3
Miles of primary distribution line	58.6	16	12	68	
Miles of secondary distribution line	35.5	10	0.75	15	

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[d] 300 kilovolt-amperes.

[e] No record of amount of power purchased from Diamond Match Co. Flat rate of $100 per month is paid for all used. Sold February, 1916.

[f] Sold to Pacific Light & Power Co.

[g] Sold to Mount Shasta Power Corporation May, 1920.

[h] Del Mar steam plant of 120 kilowatts used only in case of emergency, and output not reported.

[i] Sold in 1916 to Great Western Light & Power Co.

[j] Sold Mar. 31, 1918, to Southern Sierras Power Co.

[k] Sold to San Diego Consolidated Gas & Electric Co. May 1, 1918.

[l] Sold to Pacific Gas & Electric Co. July 16, 1919.

[m] Sold to Mount Whitney Power & Electric Co. Dec. 21, 1918.

[n] Sold to California Telephone & Light Co. Nov., 1919.

[o] Consolidated with Santa Cruz County Utility Co. May 1, 1920.

TABLE 314.—*Physical and operating data of distributing utilities reporting to California Railroad Commission, Dec. 31, 1913–1920*—Continued.

	Novato Utilities Co.[p]	Pinole Electric Light & Power Co.	Rialto Light, Power & Water Co.	Surprise Valley Electric Light & Power Co.	Tuolumne County Electric Power & Light Co.	Tuolumne Transmission Co.
Purchased 1913.....kilowatt-hours..	81,360	([q])	([q])	67,550	$5,437.72	835,550
1914...............do....	54,660	....	102,070	74,880	5,488.04	1,195,950
1915...............do....	....	....	109,640	78,060	....	709,900
1916...............do....	53,120	....	119,470	78,922	....	433,150
1917...............do....	58,254	....	141,210	78,086	467,659	([r])
1918...............do....	62,360	....	([p])	59,368	410,126	....
1919...............do....	79,600	290,768	....	59,890	414,340	....
1920...............do....	92,920	286,200	....	61,439	504,318	....
Dec. 31, 1920:						
Number of substations..........	1	2	(1917) 1	1	....	....
Capacity of substations in kilowatts..........	150	....	(1917) 75	75	....	....
Miles of high-tension transmission line..........	....	....	....	17.5	....	(1917) 26
Miles of primary distribution line	28½	37,139 ft.	(1917) 4.63	2.25	....	....
Miles of secondary distribution line..........	11	44,076 ft.	(1917) 3.8	3.50	....	....

	United Light, Fuel & Power Co.	Vacaville Water & Power Co.[s]	Vallejo Electric Light & Power Co.	West Sacramento Electric Co.
Purchased 1913..........kilowatt-hours..	233,441	$7,527.30	1,692,200	....
1914..........do....	278,068	7,573.71	1,798,400	1,250,266
1915..........do....	314,640	7,907.59	1,861,600	[t] 863,080
1916..........do....	340,329	7,504.81	1,864,800	....
1917..........do....	367,378	7,685.80	2,134,400	....
1918..........do....	412,674	7,928.66	2,341,800	....
1919..........do....	436,937	7,519.44	2,638,400	....
1920..........do....	560,329	9,707.03	3,242,400	....
Dec. 31, 1920:				
Number of substations..........	1	1	....	....
Capacity of substations in kilowatts..........	....	200	[d] 1,1 5	....
Miles of high-tension transmission line..........	1.67	....	....	(1915) 5
Miles of primary distribution line..........	9.17	2,300	134	22.75
Miles of secondary distribution line..........	30.7	110	70.5	3

[d] 300 kilovolt-amperes.
[p] Reorganization of Novato Light & Power Co. in 1917.
[q] No record.
[r] Operated by Sierra & San Francisco Power Co.
[s] Reorganization of Vacaville Water & Light Co. in 1919. Purchased energy reported at cost.
[t] Nine months only.

NOTE.—The companies named below operated but made no reports to the Railroad Commission:
Consolidated Securities Co. (now Maclay Rancho Co.).
Ca laonia Electric plant (S. H. McKinley lease of McKinley Bros.).
Crescent City Light, Water & Power Co. (destroyed by fire in 1913).
Downey Light, Power & Water Co.
Escondido Utilities Co. (No. 1 steam, 150 kilowatts).
Exchequer Mining & Power Co.
Invincible Mines (Cons.) (not a public utility).

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