DEPARTMENT OF THE INTERIOR

ALBERT B. FALL, Secretary

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, Director

# FORTY-THIRD ANNUAL REPORT

OF THE

# DIRECTOR OF THE UNITED STATES GEOLOGICAL SURVEY

TO THE

# SECRETARY OF THE INTERIOR

FOR THE FISCAL YEAR

ENDED JUNE 30

1922

WASHINGTON

GOVERNMENT PRINTING OFFICE

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**Directors of the U. S. Geological Survey**

**CLARENCE KING, 1879–1881**
**JOHN WESLEY POWELL, 1881–1894**
**CHARLES DOOLITTLE WALCOTT, 1894–1907**
**GEORGE OTIS SMITH, 1907–**

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# FORTY-THIRD ANNUAL REPORT OF THE DIRECTOR OF THE UNITED STATES GEOLOGICAL SURVEY.

GEORGE OTIS SMITH, *Director.*

## APPROPRIATIONS.

The direct appropriations for the work under the Geological Survey for the fiscal year 1922 comprised items amounting to $1,614,340. In addition $140,000, to be disbursed under the direction of the Public Printer, was appropriated for printing the reports of the Survey, and allotments of $10,000 and $7,423.96 for miscellaneous printing and binding and for miscellaneous supplies, respectively, were made from Interior Department appropriations.

## GENERAL SUMMARY.

The wide range of the Geological Survey's work is shown by the following outline of the tasks accomplished during the year. The reports of the several branches set forth the work in detail. In the fiscal year 1922 the Survey

Made geologic surveys in 32 States and Alaska.

Continued cooperative geologic work with 8 State organizations and with the Republic of Haiti, and through cooperation with governmental organizations and scientific institutions made on request special examinations relating to the geology of Hawaii, Iceland, Canada Peru, the Philippine Islands, Argentina, Colombia, Bolivia, Java, the Pacific islands, Mexico, New Zealand, and Cuba.

Made studies of ore deposits in 7 States and prepared or began to prepare 21 reports on ore deposits or mining districts.

Made field surveys and studies in 13 States with a view to determining the occurrence of oil and gas, prepared or began to prepare 32 reports on present or prospective oil and gas fields, and published maps showing oil and gas fields in Illinois, Oklahoma, Pennsylvania, and Wyoming.

Gave advice as to the adequacy of bids received for leases of oil and gas lands in the Osage Nation.

Continued the policy of undertaking intensive study of possible oil-bearing territory in advance of commercial development, carrying on such studies in the Black Hills, Colorado, and Wyoming.

Examined deposits of oil shale in 4 States.

Examined coal deposits in 3 States and prepared or began 5 reports on coal fields.

Cooperated with the Coast and Geodetic Survey and the Bureau of Soils in special investigations whose results may have very practical application.

Made comprehensive geologic, topographic, and hydrographic studies of portions of Colorado and San Juan rivers in Utah and Arizona, with the special object of determining the suitability of certain dam and reservoir sites.

Began the preparation of a geologic map of Arizona.

Completed studies of the radium-bearing carnotite ores and the tungsten deposits of the United States.

Cooperated with the Carnegie Institution in a study of earth movements in connection with earthquakes.

Cooperated with the United States Reclamation Service in geologic studies of dam and reservoir sites.

Made collections and examinations of fossils from 28 States for stratigraphic identification or correlation.

Continued the collection of statistics of mineral production and cooperated in this work with 18 States and the Bureau of the Census.

Issued special timely reports on the production of fuels.

Continued to obtain and supply information on foreign mineral reserves.

Continued the search for potash in natural salts in Texas, collecting and examining several hundred samples and finding workable percentages of potash in a number of them.

Made 1,720 quantitative analyses of rocks and minerals and over 2,200 qualitative tests of specimens submitted mainly by persons outside of the Survey.

Continued investigations of deep earth temperatures and of the porosity of oil and gas sands.

Continued studies of mineral deposits in Alaska.

Made geologic surveys covering 2,280 square miles and topographic surveys covering 505 square miles in Alaska.

Made topographic surveys in 21 States and Hawaii, partly in cooperation with other Government organizations and with 20 States and the Territory of Hawaii.

Mapped 12,057 square miles topographically and resurveyed 1,487 square miles.

Ran 3,236 miles of levels and established in connection with them 874 permanent bench marks.

Occupied 89 triangulation stations, of which 76 were permanently marked.

Ran 2,225 miles of primary traverse and set in connection therewith 483 permanent marks.

Prepared shaded relief maps of Alaska, California, Kentucky, and southwestern Arizona, also of several quadrangles and of the area adjacent to the Denver & Rio Grande Western Railroad.

Continued the compilation of the United States portion of the international map of the world, for which maps of 46 States have now been completed.

Prepared a map of China and adjacent regions for the Department of State in connection with the Conference on Limitation of Armament.

Made more than 11,000 measurements of stream flow in the United States and Hawaii, doing part of the work in cooperation with other Government organizations and with 31 States and Hawaii.

Made investigations of ground water in 10 States and Hawaii.

Analyzed 671 samples of surface and underground water.

Prepared monthly reports on the production of electricity and consumption of fuel by public-utility power plants and published maps of 14 States showing the location of power stations and transmission lines used in public service.

Continued investigations of the present and probable future use of surface and ground waters in connection with the classification of public lands.

Disposed of more than 25,000 cases referred to the Geological Survey for the preparation of reports thereon to be used in the administration of the public-land laws.

Made a net decrease of 459,341 acres in the area previously classified as coal land, a net increase of 268,359 acres in the area classified as phosphate land, and decreases of 3,914,988 acres in outstanding coal reserves, of 110,803 acres in outstanding petroleum reserves, and of 298,846 acres in outstanding phosphate reserves.

Acted on 7,638 applications for permit or lease rights under the mineral-lands leasing acts.

Defined the boundaries, in accordance with the known geologic structure, of five gas fields and one oil field in Wyoming and Montana.

Made plan and profile surveys of Colorado River in Utah and Arizona and of Klamath and Trinity rivers in California.

Made detailed studies of the possibility of developing power on rivers in Washington, Oregon, California, Idaho, Montana, Wyoming, Utah, and Colorado.

Made a net increase of 635,523 acres in power-site reserves.

Made field studies with respect to irrigability of lands under the enlarged and stock-raising homestead acts and the Nevada ground-water reclamation act in Colorado, Arizona, Utah, and Nevada.

Designated 382,320 acres in Nevada under the ground-water reclamation act.

Included 1,160 acres in California in reservoir-site withdrawals.

Made net increases of 5,744 acres in public water reserves, of 3,989,427 acres in enlarged-homestead designations, and of 4,778,633 acres in stock-raising homestead designations.

Published 159 reports, containing 9,594 pages, and reprinted 7 reports.

Engraved and printed 70 new topographic maps and engraved wholly or in part 36 new topographic maps.

Photolithographed and printed 20 new State and other maps.

Printed 969,981 copies of new and reprinted maps.

Printed under contract for other branches of the Government lithographed maps, charts, etc., in editions amounting to 2,442,227 copies.

Distributed 590,284 copies of book publications and 739,310 of map publications, of which 8,253 folios and atlases and 594,217 maps were sold.

## PUBLIC STATEMENTS BY THE DIRECTOR.

The Director has continued to show the bearing of scientific facts and conclusions upon public policy and matters of everyday interest by translating the results of the Survey's investigations into popular language for more general presentation than is possible in a Government report. The purpose of this work is to indicate the practical application of the scientific and engineering investigations carried on by the Survey. The Director has given the following addresses during the year:

Sept. 21, "The real value of oil," New York State Oil Producers' Association, Olean, N. Y.

Oct. 5, "The world distribution of minerals," General Staff College, Washington.

Oct. 19, "Some items in a prosperity program," American Mining Congress, Chicago.

Oct. 26, "Superpower," General Staff College, Washington.

Dec. 8, "A spendthrift industry," Coal Mining Institute of America, Pittsburgh, Pa.

Dec. 28, "Plain geology," American Society of Economic Geologists, Amherst, Mass.

Jan. 6, "Mineral resources in their international aspect," Conference of the Council on Foreign Relations, New York.

Jan. 23, "Work of the Interior Department," Conference of editors of business papers, Washington.

June 13, "Coal production and mine employment," Public Committee on Coal, New York.

June 26, "The broken coal year and how to mend it," National Conference of Social Work, Providence, R. I.

These addresses were printed in technical journals and proceedings of the societies. The following special articles were also prepared on request:

"Statistics the means to an end, not an end in themselves," Coal Age, July 14.

"Director Smith calls British terms 'a different experiment,'" Coal Review, Aug. 31.

"British coal problem becomes a market problem," Coal Age, Sept. 8.

"Present coal conditions in England," Black Diamond, Sept. 10.

"War problems in minerals—United States Geological Survey, 1914–1918," Engineering and Mining Journal, Dec. 3.

"Why should the consumer store coal?" Coal Review, Mar. 8.

"Wanted: More coal, fewer mines," The Nation's Business, June.

## PUBLICATIONS.

The publications of the year comprised 159 book and map publications in the regular series, 92 maps, and numerous circulars, lists of publications and maps, advance statements on mineral production, and press bulletins. The total number of pages in the book and map publications was 9,594. Seven book publications and 198 maps were reprinted.

Brief notices of the publications in the regular series and of the new maps issued during the year are given in the following pages. These titles constitute the annual record of work accomplished—that is, completed to the extent of making the results available for use.

FORTY-SECOND ANNUAL REPORT of the Director of the United States Geological Survey to the Secretary of the Interior, for the fiscal year ended June 30, 1921. 108 pages, 1 plate.

A detailed account of the work of the Geological Survey during the fiscal year 1921. The Director sets forth the economy that is being attained through higher efficiency—the greater accomplishment for the same expenditure—and the limitations that act to prevent still higher efficiency, such as inadequate office quarters, restriction on the selection of personnel, small salaries, and reduced appropriations for printing the reports of investigations. One of the special investigations made during the year was the "superpower survey." (See Prof. Paper 123, below.) The Survey has continued to supervise topographic surveys in the Dominican and Haitian republics, in which the Marine Corps cooperated by furnishing a pilot and airplane for the use of a Survey engineer in taking aerial photographs to be used in making the topographic maps. The Director has continued his efforts to translate the results of the Survey's investigations into popular language in public addresses and magazine articles, to show the bearing of scientific facts and conclusions upon public policy and everyday questions.

PROFESSIONAL PAPER 123. A superpower system for the region between Boston and Washington, by W. S. Murray and others. 261 pages, 11 plates, 61 text figures.

Report of a "special investigation of the possible economy of fuel, labor, and materials resulting from the use in the Boston-Washington industrial region of a comprehensive system for the generation and distribution of electricity to transportation lines and industries," authorized by Congress. The investigation was made by a staff of engineers under the administrative supervision of the Geological Survey. The engineering staff was assisted by constructive criticism from an advisory board consisting of men of vision and experience representing the railroads and industries. The annual net saving, if the energy required in this region in 1930 were supplied by a coordinated power system, such as is described in this report, instead of by uncoordinated systems, such as are now in use, is estimated at $429,000,000. As the total investment in generating and transmission facilities and motor equipment for the superpower system would be $1,295,000,000, the annual return on the investment would be 33 per cent. Of the 36,000 miles of railroad in this region it is estimated that 19,000 miles can be profitably electrified, at an annual return on the investment of 14.2 per cent. The coal saved annually under the superpower system would amount to 50,000,000 tons. The system contemplates interconnection of existing plants and systems and construction of new steam-electric and hydroelectric plants at the most favorable locations. Within the territory covered by this investigation—the "superpower zone"—is concentrated one-fourth of the population of the United States, and within it are operated, most of them independently, 315 electric utilities, 18 class 1 railroads, and 96,000 industrial plants. The superpower zone is the finishing shop of American industry.

PROFESSIONAL PAPER 128. Shorter contributions to general geology, 1920; David White, chief geologist. 1921. 146 pages, 22 plates, 16 text figures.

Contains seven papers by five authors, previously published separately.

PROFESSIONAL PAPER 129–B. *Orthaulax*, a Tertiary guide fossil, by C. W. Cooke. 10 pages, 4 plates.

Describes the known species of a characteristic horizon marker found in the southeastern United States, the West Indies, and Panama.

PROFESSIONAL PAPER 129–C. Graphic and mechanical computation of thickness of strata and distance to a stratum, by J. B. Mertie, jr. 16 pages, 3 plates, 8 text figures.

Gives alinement charts and simplified methods for the solution of two problems that constantly confront the geologist who is studying stratigraphy and structure.

PROFESSIONAL PAPER 129–D. Stratigraphic sections in southwestern Utah and northwestern Arizona, by J. B. Reeside, jr., and Harvey Bassler. 27 pages, 5 plates, 1 text figure.

Describes features of general interest in the stratigraphy of a region concerning which very few detailed data are available in published literature. The region is in the Colorado River drainage basin, north of the Grand Canyon.

PROFESSIONAL PAPER 129–E. The Byram calcareous marl of Mississippi and its Foraminifera, papers by C. W. Cooke and J. A. Cushman. 46 pages, 15 plates.

Mr. Cooke describes the Byram marl, a lower Oligocene formation, and gives lists of fossils that have been found in it. Mr. Cushman describes 68 species and varieties of Foraminifera, all obtained from a few cubic centimeters of material.

PROFESSIONAL PAPER 129–F. The Foraminifera of the Mint Spring calcareous marl member of the Marianna limestone, by J. A. Cushman. 32 pages, 7 plates.

Describes 84 species of Foraminifera from a lower Oligocene series of beds in Mississippi.

PROFESSIONAL PAPER 129–G. The flora of the Woodbine sand at Arthurs Bluff, Tex., by E. W. Berry. 30 pages, 5 plates, 1 text figure.

Describes 43 species from a single locality, the study of which has led to complete and decisive conclusions in regard to the age and relations of the deposits.

PROFESSIONAL PAPER 129–H. Geology of the lower Gila region, Arizona, by C. P. Ross. 17 pages, 5 plates.

Sets forth the geologic information obtained during an investigation of desert watering places and routes of travel in a part of southwestern Arizona and gives a brief summary of the diverse mineral deposits in the region.

PROFESSIONAL PAPER 129–I. The flora of the Cheyenne sandstone of Kansas, by E. W. Berry. 27 pages, 16 plates.

Gives the results of a study of several collections which, though large, comprised only 23 species. Contains a historical summary of the application of the term "Dakota."

BULLETIN 679. The microscopic determination of the nonopaque minerals, by E. S. Larsen. 294 pages, 1 plate, 14 text figures.

Out of about 1,000 known mineral species comparatively few can be identified readily in thin sections. In this bulletin the author gives tables for the systematic determination of minerals from their optical constants, describes some methods for the rapid determination of optical constants, gives the results of measurements of the optical constants of more than 500 species for which data were not previously available, and presents statistics on the optical properties of minerals.

BULLETIN 714. Mineral resources of Alaska; report on progress of investigations in 1919, by A. H. Brooks and others. 259 pages, 7 plates, 2 text figures.

The sixteenth annual bulletin on investigations in Alaska. Contains 11 papers by 7 authors, previously published separately, also a list of recent Survey publications on Alaska.

BULLETIN 715. Contributions to economic geology (short papers and preliminary reports), 1920; Part I, Metals and nonmetals except fuels; F. L. Ransome, H. S. Gale, and E. F. Burchard, geologists in charge. 230 pages, 24 plates, 40 text figures.

Contains 12 papers on potash in Spain, Alsace, and Nebraska; manganese in Wyoming, Colorado, and Arkansas; cinnabar in Idaho; iron ore and phosphate rock in Montana; silver in Nevada and New Mexico; and salt in New Mexico, Texas, Oklahoma, and Kansas.

BULLETIN 716. Contributions to economic geology (short papers and preliminary reports), 1920; Part II, Mineral fuels; David White and M. R. Campbell, geologists in charge. 248 pages, 34 plates, 14 text figures, 1 insert.

Contains eight papers on oil or gas in Socorro County, N. Mex., the Upton-Thornton, Mule Creek, and Lance Creek fields, Wyoming, and the Dallas region, Texas, and on coal in eastern Idaho, in San Juan County, N. Mex., and near Harrison, W. Va.

BULLETIN 722–A. The Alaskan mining industry in 1920, by A. H. Brooks. 74, xiii pages.

The annual report on mining in Alaska. Although the industry as a whole suffered a serious depression in 1920, the value of the mineral output was nearly $4,000,000 more than in 1919, chiefly because of the great increase in the production of copper. During 41 years of mining Alaska has produced minerals to the value of more than $461,000,000, over half of which represents the output of the last decade. Of this sum $320,000,000 is the value of the gold and $127,000,000 that of the copper.

BULLETIN 722–B. Water-power investigations in southeastern Alaska, by G. H. Canfield. 41 pages, 1 plate.

The annual report on an investigation begun by the Geological Survey in cooperation with the Forest Service in 1915. Gives records of stream flow at 20 stations.

BULLETIN 722–C. Ore deposits of the Salmon River district, Portland Canal region, Alaska, by L. G. Westgate. 24 pages, 3 text figures.

Describes the Alaskan portion of a metal-bearing district that extends across the international boundary. Assays indicate the presence in this district of high-grade silver ores.

BULLETIN 722–D. Geology of the vicinity of Tuxedni Bay, Cook Inlet, Alaska, by F. H. Moffit. 7 pages, 1 plate.

Report on an area covering about 250 square miles on the west side of Cook Inlet. Discusses the possibilities of obtaining oil in this area and concludes that the conditions, so far as known, are unfavorable.

BULLETIN 722–E. Gold lodes in the upper Kuskokwim region, Alaska, by G. C. Martin. 13 pages, 1 plate, 2 text figures.

Describes a comparatively little known region to which attention has recently been attracted by the discovery of high-grade ores there. The reported assays of the ores range from $30 to $65 to the ton.

BULLETIN 722–F. Metalliferous lodes in southern Seward Peninsula, Alaska, by S. H. Cathcart. 113 pages, 14 text figures.

Lode prospecting in Seward Peninsula began soon after placers were discovered and has been continued for 20 years, but only a few mines have ever been productive, and none are producing at present. This paper gives the results of a study that was intended to aid the prospector by ascertaining the geologic conditions under which the metalliferous lodes were formed.

BULLETIN 725–A. Deposits of chromite in California, Oregon, Washington, and Montana, by J. S. Diller, L. G. Westgate, and J. T. Pardee. 91 pages, 5 plates, 23 text figures.

BULLETIN 725–B. Chrome ores in Pennsylvania, Maryland, and North Carolina; papers by E. B. Knopf and J. V. Lewis. 59 pages, 1 plate, 3 text figures.

During the World War it was demonstrated that the United States has reserve deposits of chromium adequate to supply a war demand for several years. Now that the war is over the country is conserving its domestic supplies by employing higher-grade and cheaper ore from foreign countries. It is desirable, however, to record the facts concerning our own deposits, and these pamphlets contain several papers on chromite in the States named.

BULLETIN 725–C. Deposits of manganese ore in Montana, Utah, Oregon, and Washington, by J. T. Pardee. 110 pages, 4 plates, 11 text figures.

Another paper in the series recording the results of investigations of domestic manganese deposits during the World War.

BULLETIN 725–D. Contact-metamorphic tungsten deposits of the United States, by F. L. Hess and E. S. Larsen. 70 pages, 4 plates, 10 text figures.

Contact-metamorphic tungsten deposits have been found at 23 localities in the western United States, nearly all in California and Nevada. The first one known was discovered in 1908, but only prospecting and development work was done until 1915. The high prices paid for tungsten during the war stimulated active work at this deposit and a search for others. This bulletin describes the deposits in detail and sets forth the general geology, with a full treatment of the process of contact metamorphism.

BULLETIN 725–E. Manganese deposits near Bromide, Okla., by D. F. Hewett. 19 pages, 4 text figures.

Describes deposits to which attention was called during the period of prospective shortage of manganese ore in 1917. The deposits are small and can not yield much high-grade ore, but their geologic relations and the minerals they contain are so uncommon that a description of them is of scientific interest.

BULLETIN 725–F. Pyrite at the Haile mine, Kershaw, S. C., with a note on pyritization at the Brewer mine, near Jefferson, by F. C. Schrader.

During the World War the Geological Survey examined and estimated the ore reserves of the United States with a view to ascertaining the possibility of supplying the increased demand for sulphuric acid. One of the most interesting and promising of recent developments in this connection is the conversion of the Haile gold mine, at Kershaw, S. C., into a pyrite mine, described in detail in this paper.

BULLETIN 725–G. The Taylor Creek tin deposits, New Mexico, by J. M. Hill. 13 pages, 1 text figure.

Describes deposits which, though small and not very rich, are of interest in view of the scarcity of tin deposits in the United States.

BULLETIN 725–H. Ore deposits of Cedar Mountain, Mineral County, Nev., by Adolph Knopf. 22 pages, 5 text figures.

Describes the geology and ore deposits at two small mining camps that center around two mines, one of which produces silver-lead and the other gold.

BULLETIN 725–I. The Round Mountain district, Nevada, by H. G. Ferguson. 24 pages, 6 text figures.

The Round Mountain district has produced mainly gold and silver, but a little tungsten was mined there during the World War. This paper describes the geology and ore deposits.

BULLETIN 725–J. Ore deposits of the Sierrita Mountains, Pima County, Ariz., by F. L. Ransome. 35 pages, 4 plates, 4 text figures.

Describes deposits of copper, lead, zinc, and silver ores on both sides of the Sierrita Mountains, in southern Arizona. Copper is the chief item in the metal output, and as much as 6,680,000 pounds has been produced in a single year. The deposits are of contact-metamorphic origin.

BULLETIN 726–B. Geology of the Cement oil field, Caddo County, Okla., by Frank Reeves. Prepared in cooperation with the Office of Indian Affairs. 89 pages, 7 plates, 4 text figures.

Discusses an area covering eight townships in southwestern Oklahoma. The pronounced anticline at Cement and other folds near by suggested that the area of tilted strata bordering the mountains should contain local anticlines favorable for the accumulation of oil and gas. About half of the area studied is owned by the Indians, and as many tracts of Indian lands are leased to oil companies annually, knowledge of the true value of oil rights is especially desirable.

BULLETIN 726–C. Oil prospects in Washington County, Utah, by Harvey Bassler and J. B. Reeside, jr. 23 pages, 4 text figures.

Oil was discovered near Virgin City, Utah, in 1907, and for a short time exploration was active, but there was no market for the oil at that time and nothing more was done in this field till 1918. The authors of this paper, who made a reconnaissance examination of the field in 1919, conclude that the present field is of value for supplying local demand, and that possibly thicker oil-bearing beds may be found elsewhere in the region.

BULLETIN 726–D. Lignite in the western part of the Fort Berthold Indian Reservation south of Missouri River, N. Dak., by C. M. Bauer and F. A. Herald. 64 pages, 17 plates, 3 text figures.

In the northern Great Plains wood for fuel is practically lacking, and the lignite of the region is therefore of particular importance in the development of its commerce and industry. This paper describes the lignite deposits of an area in west-central North Dakota about 65 miles northwest of Bismarck. Analyses show that in heating value the lignite of this region at $5 a ton is equivalent to Pittsburgh bituminous coal at $11.36 a ton.

BULLETIN 726–E. Geologic structure of parts of New Mexico, by N. H. Darton. 110 pages, 21 plates, 33 text figures.

Gives the available information concerning the structural features of New Mexico as a guide to the geologist in search of new oil fields. New Mexico is not yet producing oil in notable amounts, but in many places the structural conditions are favorable to the accumulation of oil and gas if they are present in the rocks.

BULLETIN 726–F. Geologic structure and oil and gas prospects of a part of Jefferson County, Okla., by H. M. Robinson. 26 pages, 2 plates, 1 text figure.

Describes an area of about 175 square miles, in which the general structure is regarded as favorable, though the area is not very close to any commercially productive oil and gas field.

BULLETIN 726–G. The Lacasa area, Ranger district, north-central Texas, by C. S. Ross. 12 pages, 2 plates, 3 text figures.

The geologic structure of an area in Stephens County, Tex., is described and mapped, and the tracts that are considered favorable or unfavorable for oil or gas accumulation are pointed out.

BULLETIN 730–A. Peneplains of the Front Range and Rocky Mountain National Park, Colo., by W. T. Lee. 17 pages, 8 plates, 3 text figures.

The first of a new series, "Contributions to the geography of the United States," to be published annually, first in the form of separate chapters. Points out the probable correlation of some of the major surface features in the Rocky Mountain National Park with similar features in neighboring regions.

BULLETIN 730–B. Erosion and sedimentation in the Papago country, Arizona, with a sketch of the geology, by Kirk Bryan. 72 pages, 5 plates, 22 text figures.

The country inhabited by the Papago Indians, a tribe of nomadic farmers, is an area of 13,000 square miles in southwestern Arizona, between Gila River and the Mexican boundary. It is in large part a true desert, though the climatic conditions have produced large cacti, trees, and woody shrubs that give it a deceiving verdure. This paper describes the land forms in this peculiar region and discusses the processes that have been active in the production of the desert landscape. It contains a glossary of technical terms.

BULLETIN 735–A. The Candelaria silver district, Nevada, by Adolph Knopf. 22 pages, 2 text figures.

Candelaria, an old silver-mining camp in western Nevada, has produced $20,000,000, mainly about 40 years ago. The bonanza ore has long been exhausted, and the attempt now being made to revive the camp is based on the belief that there is left a considerable amount of ore of moderate grade from which a profit may be won by modern methods of mining and metallurgy. This report shows that the future prosperity of the district is not to be sought by exploring in depth but must be won from the territory lying above the deepest levels yet worked.

BULLETIN 735–B. Colemanite in Clark County, Nev., by L. F. Noble. 17 pages, 3 plates, 2 text figures.

Describes some recently discovered deposits of colemanite, a mineral that yields borax, in the Muddy Mountains. The deposits are fairly extensive, and one of them is of remarkable continuity and regularity and appears to afford unusual facilities for efficient and economical mining.

BULLETIN 735–C. Bonanza ores of the Comstock lode, Virginia City, Nev., by E. S. Bastin. 25 pages, 9 text figures.

Gives results of a microscopic study of specimens obtained at depths ranging from a few hundred to 2,900 feet. This study showed that in ores from depths greater than 500 feet, including the bulk of the bonanza ores of the lode, the silver is essentially all in primary minerals and that gold is primary in all the ores. These results offer encouragement for deep development, though ore bodies comparable in size and richness to the great bonanzas of the past are not to be expected.

BULLETIN 736–A. The structure of the Madill-Denison area, Oklahoma and Texas, with notes on oil and gas development, by O. B. Hopkins, Sidney Powers, and H. M. Robinson. 33 pages, 6 plates.

Describes the geologic structure of an area in Marshall County, Okla., and Grayson County, Tex., which includes the Madill oil field and the Enos gas field. Gives suggestions for prospecting.

WATER-SUPPLY PAPER 450. Contributions to the hydrology of the United States, 1919; N. C. Grover, chief hydraulic engineer. 1921. 86 pages, 11 plates, 5 text figures, 1 insert.

Contains papers on the geology and water resources of a part of the San Carlos Indian Reservation, Ariz., and on ground water in Lanfair Valley, Calif., and in Pahrump, Mesquite, and Ivanpah valleys, Nev.-Calif.

WATER-SUPPLY PAPER 459. Surface water supply of the United States, 1917; Part IX, Colorado River basin; N. C. Grover, chief hydraulic engineer; Robert Follansbee, C. C. Jacob, and C. E. Ellsworth, distict engineers. 192, xxxiii pages, 2 plates.

WATER-SUPPLY PAPER 460. Surface water supply of the United States, 1917; Part X, The Great Basin; N. C. Grover, chief hydraulic engineer; C. C. Jacob, H. D. McGlashan, F. F. Henshaw, G. C. Baldwin, and Robert Follansbee, district engineers. 277, xl pages, 2 plates.

WATER-SUPPLY PAPER 471. Surface water supply of the United States, 1918; Part I, North Atlantic slope drainage basins; N. C. Grover, chief hydraulic engineer; C. H. Pierce, C. C. Covert, and G. C. Stevens, district engineers. Prepared in cooperation with the States of Maine, Vermont, Massachusetts, and New York. 220 pages, 2 plates, 1 text figure.

WATER-SUPPLY PAPER 475. Surface water supply of the United States, 1918; Part V, Hudson Bay and upper Mississippi River basins; N. C. Grover, chief hydraulic engineer; W. G. Hoyt, district engineer. Prepared in cooperation with the States of Minnesota, Wisconsin, Iowa, and Illinois. 183 pages, 2 plates.

WATER-SUPPLY PAPER 476. Surface water supply of the United States, 1918; Part VI, Missouri River basin; N. C. Grover, chief hydraulic engineer; W. A. Lamb and Robert Follansbee, district engineers. Prepared in cooperation with the States of Colorado, Montana, and Wyoming. 310 pages. 2 plates.

WATER-SUPPLY PAPER 477. Surface water supply of the United States, 1918; Part VII, Lower Mississippi River basin; N. C. Grover, chief hydraulic engineer; Robert Follansbee and R. C. Rice, district engineers. 38 pages. 2 plates.

Six of the annual reports on stream gaging.

WATER-SUPPLY PAPER 487. The Arkansas River flood of June 3–5, 1921, by Robert Follansbee and E. E. Jones. 44 pages, 6 plates, 1 text figure.

Report on the severest flood that has occurred in the Arkansas River valley since its settlement. This flood was due mainly to heavy rainfall and in part to the breaking of a reservoir dam. The loss of life was heavy, and the total property losses are estimated at more than $19,000,000. This report describes the cause and effects of the flood and gives notes on previous floods in this valley.

WATER-SUPPLY PAPER 490–B. Routes to desert watering places in the Mohave Desert region, California, by D. G. Thompson. Prepared in cooperation with the Department of Engineering of the State of California. 269 pages, 18 plates, 3 text figures.

The second in the series of "desert guides" for the southwestern region of the United States. Contains five large maps showing roads and watering places, a general description of the region, suggestions for desert travel, and 232 pages of detailed road logs.

WATER-SUPPLY PAPER 500–B. Ground water for irrigation near Gage, Ellis County, Okla., by D. G. Thompson. 23 pages, 1 plate, 3 text figures.

Gives the results of a field examination to determine the possibility of obtaining water for use in irrigation from deep wells. The average annual precipitation in the Gage region is barely sufficient for farming. In 1918 a large flow of water was struck in a well being drilled for oil near Gage, and this suggested that other sources might be available, but the author concludes that the farmers can find relief from drought not so much by irrigation as by a careful study of the crops and farming methods best adapted to the climate.

WATER-SUPPLY PAPER 500–C. Some characteristics of run-off in the Rocky Mountain region, by Robert Follansbee. 17 pages, 10 text figures.

For the last nine years the Geological Survey has made a special study of the run-off of the streams that flow from the high mountain areas of Colorado and Wyoming, which furnish water for irrigating millions of acres of land, for developing electrical energy at many water-power plants, and, in their lower courses, for transportation. During this period 40 or

more gaging stations in the mountains, above practically all diversions, have been maintained for long periods, and the records thus obtained, together with studies of the topography, form the basis of this report.

MINERAL RESOURCES OF THE UNITED STATES, 1918, Part I, Metals; G. F. Loughlin, geologist in charge. 1,095 pages, 9 plates, 20 text figures, 1 insert.

The chapters of this volume were published at different dates between May 8, 1919, and August 15, 1921. The grand total value of mineral products in 1918 was about $5,541,000,000, an increase of 11 per cent over the value in 1917.

MINERAL RESOURCES OF THE UNITED STATES, 1918, Part II, Nonmetals; R. W. Stone, geologist in charge. 1,557 pages, 16 plates, 135 text figures, 3 inserts.

MINERAL RESOURCES OF THE UNITED STATES, 1919. 30 advance chapters.

MINERAL RESOURCES OF THE UNITED STATES, 1920. 59 advance chapters.

MINERAL RESOURCES OF THE UNITED STATES, 1921. 11 advance chapters.

GEOLOGIC FOLIO 213. New Athens-Okawville, Ill., by E. W. Shaw. 12 pages of folio text, 4 maps, 6 text figures.

The New Athens and Okawville quadrangles cover 468 square miles in southwestern Illinois, a short distance southeast of St. Louis, and lie in the great area of rolling country that has been called the Glaciated Plains. The area is in the eastern interior coal basin and yields bituminous coal of excellent quality. The hard rocks are of Carboniferous age and are nearly everywhere overlain by unconsolidated Quaternary drift, loess, and alluvium. This folio describes the general features of the Glaciated Plains province and gives a detailed account of the geology of the two quadrangles.

WORLD ATLAS OF COMMERCIAL GEOLOGY, Part II, Water power of the world. 37 pages, 10 maps.

The potential water power of the world is estimated at 439 million horsepower at low water, of which 62 million horsepower is in North America and 28 million in the United States. Africa is richest in undeveloped water power, with 190 million horsepower; Asia has 71 million horsepower, South America 54 million horsepower, and Europe 45 million horsepower. About 40 per cent of the developed water power of the world is in the United States, where water wheels having a capacity of 9,243,000 horsepower are installed. The leading States are New York, with 1,300,000 horsepower, and California, with 1,111,000 horsepower. In Europe France leads with 1,400,000 horsepower, Norway has 1,350,000 horsepower, Sweden 1,200,000 horsepower, and Switzerland 1,070,000 horsepower. The largest water-power development in the world is at Niagara Falls, where the plants now in operation have a capacity of 870,000 horsepower, of which 385,000 horsepower is on the United States side. The capacity on both sides is now being increased. This publication summarizes all present knowledge on the subject indicated, mentions some of the world's largest water-power developments, and gives estimates by countries and by continents of the developed and undeveloped water power.

TOPOGRAPHIC AND OTHER MAPS as indicated below. (The maps marked * were also published with a green overprint showing woodland areas.)

**Alaska.**

Kotsina-Kuskulana district: Scale, 1 inch=1 mile; contour interval, 100 feet. Latitude of center of area, 61° 39′; longitude of center of area, 143° 55′.

Map of an area at the southwest base of the Wrangell Mountains, a rough, mountainous area that has a relief of more than 6,000 feet, crossed by the valleys of Kotsina and Kuskulana rivers, both of which flow in braided channels on alluvial plains. The principal mountain summits stand at altitudes of more than 6,500 feet, and several reach 7,500 feet or more.

**California.**

Bonita Ranch: Scale, 1 inch=½ mile; contour interval, 5 feet. Latitude, 36° 52′ 30″ to 37°; longitude, 120° 7′ 30″ to 120° 15′.

Map of part of Madera County, in the Great Valley of California, a plain sloping gently westward, across which extends the valley of Fresno River, which as mapped normally carries no surface water.

* Cape San Martin: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 35° 45′ to 36°; longitude, 121° 15′ to 121° 30′.

Map of parts of Monterey and San Luis Obispo counties, showing part of the ragged coast line and the Santa Lucia Range, which rises steeply from the shore to more than 3,500 feet above the sea. Northeast of the mountains is lower country, in which Nacimiento River flows. The depths of the sea down to about 1,000 feet are indicated by contours.

Carbona: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 37° 30′ to 37° 45′; longitude, 121° 15′ to 121° 30′.

Map of parts of San Joaquin and Stanislaus counties, lying about half in San Joaquin Valley and half on the northeastern slope of the Coast Ranges, some peaks of which reach altitudes of more than 3,000 feet. There are no large perennial streams except San Joaquin River, which crosses the areas in a highly meandering course.

Charleston School: Scale, 2 inches=1 mile; contour interval, 5 and 25 feet, changing on the 400-foot contour. Latitude, 36° 52′ 30″ to 37°; longitude, 120° 45′ to 120° 52′ 30″.

Map of a part of Merced County, lying in San Joaquin Valley and the foothills of the Diablo Range. The valley portion of the area slopes gently northeastward and is crossed by two main irrigation canals. The foothills portion has a relief of about 1,000 feet.

Delta Ranch: Scale, 1 inch=½ mile; contour interval, 5 feet. Latitude, 37° to 37° 7′ 30″; longitude, 120° 37′ 30″ to 120° 45′.

Map of part of Merced County showing San Joaquin River and the broad irrigated lowland adjacent to it. The difference in elevation between the highest and lowest points in the area is less than 25 feet.

*Gonzales: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 36° 30′ to 36° 45′; longitude, 121° 15′ to 121° 30′.

Map of parts of San Benito and Monterey counties, an area occupied in large part by the Gabilan Range, many of whose peaks rise more than 3,000 feet above sea level.

Gregg: Scale, 2 inches=1 mile; contour interval, 5 feet. Latitude, 36° 52′ 30″ to 37°; longitude, 119° 52′ 30″ to 120°.

Map of a part of Madera County occupied by a gently sloping plain which is rather rough on a small scale but which has a relief of only about 100 feet. This slope appears to be formed of coalescent débris fans from the foothills of the Sierra Nevada.

*Hollister: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 36° 45′ to 37°; longitude, 121° 15′ to 121° 30′.

Map of parts of San Benito, Monterey, and Santa Clara counties, including the southern parts of San Benito and Santa Clara valleys and the mountains of the Diablo and Gabilan ranges. The absence of streams of any considerable size on the floors of the two large valleys is notable.

Howard Ranch: Scale, 1 inch=½ mile; contour interval, 5 and 25 feet. Latitude, 37° 7′ 30″ to 37° 15′; longitude, 121° to 121° 7′ 30′.

Map of parts of Merced and Stanislaus counties, near the western border of the Great Valley of California. In its eastern part the area is a plain that slopes gently eastward. In its western part there are hills that rise abruptly from the plain to elevations of nearly 1,000 feet.

*Jamesburg: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 36° 15′ to 36° 30′; longitude, 121° 30′ to 121° 45′.

Map of part of Monterey County, southeast of the city of Monterey, a mountainous region several of whose peaks in the Santa Lucia Range rise to elevations of more than 4,700 feet. The lowest points in the area stand less than 250 feet above the sea.

Kentucky Well: Scale, 1 inch=½ mile; contour interval, 5 feet. Latitude, 36° 52′ 30″ to 37°; longitude, 120° 15′ to 120° 22′ 30″.

Map of a part of Madera County that lies in the gently westward-sloping plain of central California, a region where the greatest range in elevation is only 45 feet.

Lanes Bridge: Scale, 1 inch=½ mile; contour interval, 5 and 25 feet. Latitude, 36° 52′ 30″ to 37°; longitude, 119° 45′ to 119° 52′ 30″.

Map of parts of Madera and Fresno counties, in the Great Valley of California, north of Fresno. San Joaquin River, in the southeastern part, flows in a steep-sided trench a mile or more wide that has been carved in the dissected plain. Rising abruptly above this plain is a conspicuous highland, Little Table Mountain, more than 800 feet above the sea.

Los Banos: Scale, 1 inch=½ mile; contour interval, 5 feet. Latitude, 37° to 37° 7′ 30″; longitude, 120° 45′ to 120° 52′ 30″.

Map of part of Merced County, in the broad, nearly flat floor of San Joaquin Valley. Shows a great number of canals and irrigation ditches.

Madera: Scale, 1 inch=½ mile; contour interval, 5 feet. Latitude, 36° 52′ 30″ to 37°; longitude, 120° to 120° 7′ 30″.

Map of part of Madera County, showing the city of Madera and the nearly flat plain on part of which the city has been built. Fresno River as mapped has a sandy channel without surface water.

*Nipomo: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 35° to 35° 15′; longitude, 120° 15′ to 120° 30′.

Map of parts of San Luis Obispo and Santa Barbara counties, in the Santa Lucia and San Rafael mountains, some of whose peaks stand more than 3,000 feet above the sea.

Ortigalita: Scale, 1 inch=½ mile; contour interval, 25 feet. Latitude, 36° 52′ 30″ to 37°; longitude, 120° 52′ 30″ to 121°.

Map of part of Merced County in the belt of foothills between the Diablo Range and San Joaquin Valley. The surface of the area is considerably diversified, comprising moderately rugged hilly country rising 1,100 feet above sea level, a nearly level-floored basin at 800 feet, and a little of San Joaquin Valley below 200 feet.

Oxalis: Scale, 2 inches=1 mile; contour interval, 5 feet. Latitude, 36° 52′ 30″ to 37°; longitude, 120° 30′ to 120° 37′ 30″.

Map of part of Fresno County in San Joaquin Valley. The whole area is very flat, having a relief of only 40 feet, exclusive of the shallow trench of San Joaquin River.

Piru: Scale, 1 inch=1 mile; contour interval, 100 feet. Latitude, 34° 15′ to 34° 30′; longitude, 118° 45′ to 119°.

Map of a part of Ventura County. The broad, normally dry valley bottom of Santa Clara River crosses the area and is flanked by the mountains of the Santa Barbara National Forest and by Oak Ridge.

*Quien Sabe: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 36° 45′ to 37°; longitude, 121° to 121° 15′.

Map of parts of Merced, San Benito, and Santa Clara counties, in the Diablo Range, whose highest peaks rise more than 3,500 feet above the sea. Several lowlands like Quien Sabe and Los Banos valleys occur in the midst of the highlands.

San Luis Creek: Scale, 1 inch=½ mile; contour interval, 5 and 25 feet. Latitude, 37° to 37° 7′ 30″; longitude, 121° to 121° 7′ 30″.

Map of part of Merced County, near the west border of the Great Valley of California. The northeastern part of the area is a low plain, west of which the country is hilly, and some of the higher points stand more than 1,700 feet above the sea.

Santa Rita Bridge: Scale, 1 inch=½ mile; contour interval, 5 feet. Latitude, 37° to 37° 7′ 30″; longitude, 120° 30′ to 120° 37′ 30″.

Map of parts of Merced and Madera counties, a plain traversed by San Joaquin River and its tributaries and slopes. Numerous irrigating ditches intersect the rich agricultural lands in all directions.

Triunfo Pass: Scale, 1 inch=1 mile; contour interval, 100 feet. Latitude, 34° to 34° 15′; longitude, 118° 45′ to 119°.

Map of parts of Ventura and Los Angeles counties, including the coast line, the Santa Monica Mountains, which rise to elevations of more than 2,500 feet and stand about 5 miles inland, and lowlands interspersed with other groups of hills.

Volta: Scale, 1 inch=½ mile; contour interval, 5 and 25 feet. Latitude, 37° to 37° 7′ 30″; longitude, 120° 52′ 30″ to 121°.

Map of part of Merced County showing the lowland of San Joaquin Valley and the foothills on the west. The area contains no perennial streams but is intricately traversed by canals and irrigation ditches.

### Connecticut.

[See Massachusetts, etc.]

### Delaware, District of Columbia, and Maryland.

Electric generating stations and transmission lines used in the public service in the District of Columbia and the States of Delaware and Maryland in 1919. Scale, 1 inch=8 miles.

The hydroelectric generating stations, the fuel-consuming generating stations, the stations combining these two sources of power, the substations, the switching stations, and the primary transmission lines are shown by distinctive symbols printed in red on the United States Geological Survey's base map of the area.

**Georgia.**

*Brooklet: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 32° 15′ to 32° 30′; longitude, 81° 30′ to 81° 45′.

Map of parts of Bulloch and Effingham counties, in the Atlantic Coastal Plain. The upland in the eastern part of the area is a nearly flat plain, on which there are a great number of small, irregularly distributed marshy tracts. West of this plain is a dissected upland whose highest points stand at elevations of more than 320 feet. The largest stream, Edisto River, has cut down the floor of its valley to an elevation of about 50 feet above the sea.

*Hephzibah: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 33° 15′ to 33° 30′; longitude, 82° to 82° 15′.

Map of parts of Richmond, Columbia, and Burke counties, including the western part of the city of Augusta. The region is a rolling, hilly country and has moderately broad, flat uplands, many of which stand 400 to 500 feet above the sea.

**Georgia and South Carolina.**

*Augusta: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 33° 15′ to 33° 30′; longitude, 81° 45′ to 82°.

Map of parts of Aiken County, S. C., and Richmond and Burke counties, Ga. The most prominent topographic feature is the broad, swampy flood plain through which Savannah River flows and on which, where it has been improved by levees and drainage ditches, the city of Augusta stands.

*Clarks Hill: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 33° 30′ to 33° 45′; longitude, 82° to 82° 15′.

Map of parts of Edgefield, McCormick, and Aiken counties, S. C., and Columbia, Lincoln, and Richmond counties, Ga., a much dissected, hilly region that forms part of the Piedmont province. Savannah River, which forms the boundary between the two States, flows diagonally across the area in a narrow-floored valley and is ponded by dams constructed to generate power.

**Idaho.**

*Custer: Scale, 1 inch=2 miles; contour interval, 100 feet. Latitude, 44° to 44° 30′; longitude, 114° 30′ to 115°.

Map of part of Custer County, a mountainous region, some of whose peaks rise to elevations of more than 11,000 feet. Salmon River, the largest stream in the area, flows at right angles to the general trend of the mountains, in a narrow canyon whose floor is several thousand feet below the near-by summits.

**Illinois.**

[See also Kentucky and Illinois.]

New Athens. Geologic map from Folio 213. (See p. 10.)

Oil and gas fields of the State of Illinois. Scale, 1 inch=8 miles.

Map prepared in cooperation with the Illinois Geological Survey, on the United States Geological Survey's base map of Illinois. The productive oil and gas fields, the main oil pipe lines, and the oil refineries are shown by distinctive colors and symbols.

Okawville. Geologic map from Folio 213. (See p. 10.)

**Indiana.**

Electric generating stations and transmission lines used in the public service in the State of Indiana in 1921. Scale 1 inch=8 miles.

Similar to map of Delaware, etc. (See pp. 12–13.)

**Kansas.**

State map: Scale, 1 inch=8 miles.

Base map of the State of Kansas in one color (black). It shows county and township boundaries, towns and most of even the smaller settlements, railroads, rivers, and many of the smaller streams and water features. This map forms part of the so-called "millionth map," though it is published on twice the scale adopted for that series and does not have the contours and certain other features that will be shown on the final map.

**Kentucky.**

*Brownsville: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 37° to 37° 15′; longitude, 86° 15′ to 86° 30′.

Map of parts of Edmonson, Warren, and Butler counties, including the northern part of the city of Bowling Green. The area is a much dissected, low plateau traversed by Green and Barren rivers, both rather large streams, which flow in narrow-floored valleys.

**Kentucky and Illinois.**

*Golconda: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 37° 15′ to 37° 30′; longitude, 88° 15′ to 88° 30′.

Map of parts of Hardin and Pope counties, Ill., and Crittenden and Livingston counties, Ky. A dissected low plateau traversed by Ohio River and its tributaries. The highest point in the area is about 750 feet above the sea.

**Louisiana.**

State map: Scale, 1 inch=8 miles.

Similar to base map of Kansas. (See above.)

**Louisiana and Mississippi.**

*Natchez: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 31° 30′ to 31° 45′; longitude, 91° 15′ to 91° 30′.

Map of parts of Concordia and Tensas parishes, La., and Adams and Jefferson counties, Miss. The eastern half of the area is a low dissected plateau that stands 200 to 400 feet above the sea. The western half is a part of the flood plain of the Mississippi, across which the river flows in large loops. The city of Natchez has been built on the upland at a point where the river flows directly against the bluffs.

**Maine.**

Electric generating stations and transmission lines used in the public service in the State of Maine in 1919. Scale, 1 inch=8 miles.

Similar to map of Delaware, etc. (See pp. 12–13.)

State map. Scale, 1 inch=8 miles.

Similar to base map of Kansas. (See above.)

**Maryland.**

[See Delaware, etc.; West Virginia and Maryland.]

**Maryland and West Virginia.**

[See also West Virginia and Maryland.]

*Elk Garden: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 39° 15′ to 39° 30′; longitude, 79° to 79° 15′.

Map of parts of Garrett and Allegany counties, Md., and Mineral and Grant counties, W. Va., a region traversed by narrow parallel ridges that are followed successively by the Allegheny Front and the plateau that is crossed by the North Branch of Potomac River.

* Keyser: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude 39° 15′ to 39° 30′; longitude, 78° 45′ to 79°.

Map of parts of Allegany County, Md., and Mineral and Hampshire counties, W. Va. The geologic structure of the area has given rise to parallel ridges and valleys, across which the streams cut here and there in narrow gorges.

**Massachusetts, Rhode Island, and Connecticut.**

Electric generating stations and transmission lines used in the public service in 1919. Scale, 1 inch=8 miles.

Similar to map of Delaware, etc. (See pp. 12–13.)

**Michigan.**

*Burt: Scale, 1 inch=1 mile; contour interval, 5 feet. Latitude, 43° to 43° 15′; longitude, 83° 45′ to 84°.

Map of parts of Genesee, Shiawassee, and Saginaw counties, a northward-sloping plain slightly dissected by Flint River and its tributaries, which flow in rather narrow trenches, few of them cut more than 40 feet below the near-by upland.

*Rives Junction: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 42° 15′ to 42° 30′; longitude, 84° 15′ to 84° 30′.

Map of parts of Jackson and Ingham counties, including the northern part of the city of Jackson and the lowland country to the north. Numerous morainic hills, lakes, marshes, and streams bear witness to the former occupation of the area by continental glaciers.

*Springport: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 42° 15′ to 42° 30′; longitude, 84° 30′ to 84° 45′.

Map of parts of Jackson, Eaton, Ingham, and Calhoun counties, a morainic region which is characterized by innumerable small knobs and depressions and in which the streams flow in irregular, straggling courses, in places avoiding lowlands that appear to mark former drainage courses.

*Stockbridge: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 42° 15′ to 42° 30′; longitude, 84° to 84° 15′.

Map of an area in Ingham, Jackson, Livingston, and Washtenaw counties, whose surface is formed almost wholly of glacial deposits. The surface as a whole is poorly drained, many of the hollows being occupied by ponds or small lakes, and nearly all the low-lying flat lands are swampy.

**Mississippi.**

[See also Louisiana and Mississippi.]

* Booneville: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 34° 30′ to 34° 45′; longitude, 88° 30′ to 88° 45′.

Map of parts of Prentiss, Tippah, Union, and Lee counties. Throughout the eastern part of the area the summits of the upland stand from 400 to 500 feet above sea, but in the western part the Tippah Hills rise to elevations of nearly 800 feet.

* Forest: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 32° 15′ to 32° 30′; longitude, 89° 15′ to 89° 30′.

Map of parts of Scott and Newton counties, a region of low relief, the highest points in which rise to about 600 feet above the sea.

**Missouri.**

* Sarcoxie: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 37° to 37° 15′; longitude, 94° to 94° 15′.

Map of parts of Jasper and Newton counties, just east of the Joplin lead and zinc district. The region is a dissected plain, most of whose upland surface stands between 1,100 and 1,200 feet above the sea.

* Stotts City: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 37° to 37° 15′; longitude, 93° 45′ to 94°.

Map of part of Lawrence County, a rolling plateau traversed by Spring River, whose steep-sided valley floor, one-half to three-quarters of a mile wide, is trenched below the upland.

**Nebraska.**

State map: Scale, 1 inch=8 miles.
Similar to base map of Kansas. (See p. 14.)

**New Hampshire.**

* Suncook: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 43° to 43° 15′; longitude, 71° 15′ to 71° 30′.
Map of parts of Merrimack and Rockingham counties lying just east of Concord and including the northern part of Manchester. The area is hilly and is traversed by Merrimack River. There are a number of lakes and ponds, which, together with many of the other features, have apparently been formed by glaciation.

**New Hampshire and Vermont.**

Electric generating stations and transmission lines used in the public service in the States of New Hampshire and Vermont in 1919. Scale, 1 inch=8 miles.
Similar to map of Delaware, etc. (See pp. 12–13.)

**New Jersey.**

Electric generating stations and transmission lines used in the public service in the State of New Jersey in 1920. Scale, 1 inch=8 miles.
Similar to map of Delaware, etc. (See pp. 12–13.)

**New York.**

* Cranberry Lake: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 44° to 44° 15′; Longitude, 74° 45′ to 75°.
Map of parts of St. Lawrence, Hamilton, and Herkimer counties, on the western flanks of the Adirondacks, a region of glaciated knobs and hills, some of which rise to elevations of more than 2,000 feet, and lowlands, many of which are occupied by lakes.

Electric generating stations and transmission lines used in the public service in the State of New York in 1919. Scale, 1 inch=8 miles.
Similar to map of Delaware, etc. (See pp. 12–13.)

* Nicholville: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 44° 30′ to 44° 45′; longitude, 74° 30′ to 74° 45′.
Map of parts of Franklin and St. Lawrence counties, on the northwestern flanks of the Adirondacks, a region characterized by knobby hills and irregularly distributed small lakes and marshes, which, together with other features, indicate the ancient glaciation of the area.

**Oklahoma.**

Oil and gas fields of the State of Oklahoma: Scale, 1 inch=12 miles.
Similar to map of Illinois. (See p. 13.)

State map: Scale, 1 inch=8 miles.
Similar to base map of Kansas. (See p. 14.)

**Oregon.**

* Cottage Grove: Scale, 1 inch=1 mile; contour interval, 25 feet. Latitude, 43° 45′ to 44°; longitude, 123° to 123° 15′.
Map of parts of Lane and Douglas counties. The eastern part of the quadrangle is occupied by the lowland in which the Coast Fork of Willamette River flows, but the western part is hilly, some of the hills rising to elevations of more than 1,600 feet.

* Lebanon: Scale, 1 inch=1 mile; contour interval, 25 feet. Latitude, 44° 30′ to 44° 45′; longitude, 122° 45′ to 123°. (Part of quadrangle.)
Map of part of Linn County showing mainly South Santiam River and the lowlands adjacent to it, which form part of the famous fruit and agricultural land of the Willamette Valley.

*Waldport: Scale 1 inch=1 mile; contour interval, 50 feet. Latitude, 44° 15′ to 44° 30′; longitude, 124° to 124° 15′.

Map of parts of Lincoln and Lane counties, showing a stretch of the coast and the mountains to the east, which rise rather steeply to elevations of 1,600 to 2,000 feet. The rugged, rocky coast in the southern part is succeeded in the central part of the area by a smooth sandy beach.

### Pennsylvania.

Electric generating stations and transmission lines used in the public service in the State of Pennsylvania in 1920. Scale, 1 inch=8 miles.

Similar to map of Delaware, etc. (See pp. 12–13.)

Oil and gas fields of the State of Pennsylvania: Scale, 1 inch=8 miles.

Similar to map of Illinois. (See p. 13.)

### Rhode Island.

[See Massachusetts, etc.]

### South Carolina.

[See also Georgia and South Carolina.]

*Aiken: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 33° 30′ to 33° 45′; longitude, 81° 30′ to 81° 45′.

Map of parts of Aiken and Edgefield counties, a rolling, hilly country whose highest points stand at elevations between 500 and 600 feet above the sea.

*Bowman: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 33° 15′ to 33° 30′; longitude, 80° 30′ to 80° 45′.

Map of parts of Orangeburg, Dorchester, and Calhoun counties, a region of low relief. Most of the larger valleys are flat-floored and swampy. The largest of the swamps is Four Hole Swamp, which is crossed by wagon roads at only three places in a distance of more than 18 miles.

*Orangeburg: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 33° 15′ to 33° 30′; longitude, 80° 45′ to 81°.

Map of parts of Orangeburg and Bamberg counties, a region of low relief through which Edisto River flows on a moderately wide marshy floor.

*Talatha: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 33° 15′ to 33° 30′; longitude, 81° 30′ to 81° 45′.

Map of parts of Aiken and Barnwell counties, a rolling, hilly country whose highest points stand only about 450 feet above the sea.

### South Dakota.

State map: Scale 1 inch=8 miles.

Similar to base map of Kansas. (See p. 14.)

### Texas.

*Bellaire: Scale, 1 inch=$\frac{1}{2}$ mile; contour interval, 1 foot (except in the city of Houston). Latitude, 29° 37′ 30″ to 29° 45′; longitude, 95° 22′ 30″ to 95° 30′.

Map of part of the plain of Harris County, in eastern Texas, including the southwestern part of the city of Houston.

*Houston Heights: Scale, 1 inch=$\frac{1}{2}$ mile; contour interval, 1 and 5 feet. Latitude, 29° 45′ to 29° 52′ 30″; longitude, 95° 22′ 30″ to 95° 30′.

Map of the western part of the city of Houston, in Harris County, and the nearly flat plain near that city. Buffalo Bayou traverses the southern part of the plain in a narrow, steep-sided trench.

*La Sal Vieja: Scale, 1 inch=1 mile; contour interval, 5 feet. Latitude, 26° 30′ to 26° 45′; longitude, 97° 45′ to 98°.

Map of parts of Kennedy, Willacy, and Hidalgo counties, a region of slight relief, dotted with numerous irregular depressions, many of which contain lakes.

*Marathon: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 30° to 30° 15′; longitude, 103° to 103° 15′.

Map of part of Brewster County, a region of irregularly distributed, rather narrow ridges separated by lowlands filled with desert wash.

*Monument Springs: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 30° to 30° 15′; longitude, 103° 15′ to 103° 30′.

Map of part of Brewster County, a region characterized by the northward-trending Del Norte Mountains and lower ranges to the east, which trend northeastward. Between the ranges are lowlands filled with desert wash.

*Park Place: Scale, 1 inch=½ mile; contour interval, 1 and 5 feet. Latitude, 29° 37′ 30″ to 29° 45′; longitude, 95° 15′ to 95° 22′ 30″.

Map of the southern part of the city of Houston, in Harris County, and the nearly flat plain near that city. In the northeastern part of the area is the Houston ship canal, which connects the city with Galveston Bay.

*Settegast: Scale, 1 inch=½ mile; contour interval, 1 and 5 feet. Latitude, 29° 45′ to 29° 52′ 30″; longitude, 95° 15′ to 95° 22′ 30″.

Map of the central and northeastern parts of the city of Houston, in Harris County, and the nearly flat plain close to that city.

*Tarida Ranch: Scale, 1 inch=1 mile; contour interval, 5 feet. Latitude, 26° 30′ to 26° 45′; longitude, 97° 30′ to 97° 45′.

Map of parts of Willacy and Cameron counties, only a short distance west of the Gulf. Few points in the area stand more than 35 feet above sea level. Numerous depressions, many of which are occupied by lakes and ponds, and many small mounds occur irregularly throughout the area.

### United States.

Producing coal districts of the United States. Wall map, 48 by 75 inches, in two sheets. Scale 1 inch=40 miles, approximately.

The map shows by a red overprint the outline of the areas in which coal is being produced and the names of the districts under which the areas are grouped.

### Vermont.

[See also New Hampshire and Vermont.]

* Montpelier: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 44° 15′ to 44° 30′; longitude, 72° 30′ to 72° 45′.

Map of parts of Lamoille and Washington counties, a hilly region traversed by the Worcester Mountains, some of whose peaks rise more than 3,700 feet above sea level. Winooski River, the largest stream in the area, flows across the general trend of the hills, and the lower part of its valley is a succession of gorges.

### Virginia.

[See also West Virginia and Virginia.]

* Big Stone Gap: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 36° 45′ to 37°; longitude, 82° 45′ to 83°. (Part of quadrangle.)

Map of parts of Wise and Lee counties. In the southern part of the region there are a number of nearly parallel ranges, which are succeeded to the north and west by higher hills that rise more than 4,000 feet above the sea. The larger streams flow in most places nearly parallel to the hills but at several places cut across them in narrow gaps, the most notable of which is Big Stone Gap.

Electric generating stations and transmission lines used in the public service in the State of Virginia in 1921. Scale, 1 inch=8 miles.

Similar to map of Delaware, etc. (See pp. 12–13.)

* Wise: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 36° 45′ to 37°; longitude, 82° 30′ to 82° 45′.

Map of parts of Wise and Scott counties, a dissected mountainous region, some of whose peaks rise more than 4,000 feet above the sea but whose lowest points are less than 1,300 feet high.

### Washington.

* Walla Walla: Scale, 1 inch=2 miles; contour interval, 50 feet. Latitude, 46° to 46° 30′; longitude, 118° to 118° 30′.

Map of parts of Walla Walla and Columbia counties, a region in whose southeastern part are the Blue Mountains, about 4,500 feet above sea level. Northwest of the mountains is a plateau whose upland stands about 2,000 feet above sea level but which has been minutely dissected.

**West Virginia.**

[See also Maryland and West Virginia.]

* Moorefield: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 39° to 39° 15′; longitude, 78° 45′ to 79°.

Map of parts of Hampshire and Hardy counties, a region crossed by rather massive mountains, some of whose summits stand more than 3,000 feet above the sea. A large part of the area is drained by the South Branch of Potomac River and its tributaries.

* Onego: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude 38° 45′ to 39°; longitude, 79° 15′ to 79° 30′.

Map of parts of Pendleton, Randolph, Tucker, and Grant counties. The southeastern part of the area is characterized by linear ridges and valleys underlain by folded rocks. The northwestern part, however, is an extensive plateau, which is underlain by nearly flat-lying rocks and forms part of the Appalachian Plateau province.

**West Virginia and Maryland.**

[See also Maryland and West Virginia.]

* Davis: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 39° to 39° 15′; longitude, 79° 15′ to 79° 30′.

Map of parts of Grant and Tucker counties, W. Va., and Garrett County, Md., a region of striking topographic forms, in the eastern part of which are the steep, rugged slopes of the Allegheny Front. Westward these slopes give place to more open, rolling plateau topography.

**West Virginia and Virginia.**

* Petersburg: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 38° 45′ to 39°; longitude, 79° to 79° 15′.

Map of parts of Hardy, Grant, and Pendleton counties, W. Va., and Rockingham County, Va., a region of nearly parallel mountain ranges separated from one another by the South Branch of Potomac River and its tributaries.

**Wisconsin.**

Kendall: Scale 1 inch=1 mile; contour interval, 20 feet. Latitude, 43° 45′ to 44°; longitude, 90° 15′ to 90° 30′.

Map of parts of Monroe and Juneau counties, a dissected plateau country at elevations of 900 to 1,400 feet above the sea.

**Wyoming.**

Oil and gas fields of the State of Wyoming: Scale, 1 inch=8 miles.

Similar to map of Illinois. (See p. 13.)

Saddleback Hills: Scale, 1 inch=1 mile; contour interval, 25 feet. Latitude, 41° 45′ to 42°; longitude, 106° 15′ to 106° 30′.

Map of part of Carbon County, practically all of which stands at an elevation of more than 6,500 feet, and the highest points at more than 7,800 feet. The Saddleback Hills are formed by two sharp ridges that converge and unite toward the north and mark a structure produced by the folding of the rocks of which they are made.

## GEOLOGIC BRANCH.

The geologic branch, under the supervision of David White, chief geologist, consists of three divisions:

1. The division of geology (Sidney Paige, geologist in charge) conducts areal geologic surveys and special scientific and economic investigations and researches. It is engaged in preparing the geologic map of the United States and in studying the geology of mineral deposits; and through field examinations it cooperates in the classification of the mineral lands of the public domain.

2. The division of mineral resources (G. F. Loughlin, geologist in charge) keeps the public informed as to the state of the mineral industries and the rate of production of mineral commodities in the United States. This division also

compiles and prepares for publication information concerning foreign mineral deposits—their geology, quality, reserves, state of development, output, and trade distribution. Branch offices of this division are maintained at San Francisco, Salt Lake City, and Denver.

3. The division of chemical and physical research (George Steiger, chief chemist, acting in charge) makes the chemical analyses that are essential to the work of the geologic branch and conducts physical and chemical researches bearing on geologic problems.

The division of Alaskan mineral resources (Alfred H. Brooks, geologist in charge) was on April 1 made an independent branch, and the account of its work will be found on pages 38–41.

## DIVISION OF GEOLOGY.

### ORGANIZATION AND PERSONNEL.

At the beginning of the year the scientific force of the division of geology consisted of 86 geologists, 12 associate geologists, 15 assistant geologists, 13 geologic aids, 2 junior geologists, and 1 mineral geographic aid. During the year 4 geologists, 1 assistant geologist, and 2 geologic aids resigned and 1 assistant geologist died, making a total of 8 separations. One geologist and one assistant geologist were appointed during the year. As the result of these changes and of promotions, the total at the end of the year was 123, including 86 geologists, 9 associate geologists, 13 assistant geologists, 11 geologic aids, 2 junior geologists, 1 mineral geographic aid, and 1 junior topographer (title changed from geologic aid).

The division is organized in the ten sections named below, and it also exercises administrative supervision of the section of geologic map editing, a part of the publication branch.

Areal geology: Sidney Paige, geologist in charge.
Geology of metalliferous deposits: F. L. Ransome, geologist in charge.
Geology of nonmetalliferous deposits: G. R. Mansfield, geologist in charge.
Coastal Plain investigations: L. W. Stephenson, geologist in charge. Includes the subsection of investigations of sedimentation, T. W. Vaughan, geologist in charge.
Glacial geology: W. C. Alden, geologist in charge.
Paleontology and stratigraphy: T. W. Stanton, geologist in charge.
Geology of coal fields: M. R. Campbell, geologist in charge.
Geology of oil and gas fields: K. C. Heald, geologist in charge.
Geology of iron and steel metals: E. F. Burchard, geologist in charge.
Petrology: E. S. Larsen, jr., geologist in charge.

### FINANCIAL STATEMENT.

The total funds available for the geologic work of the Survey in the United States for the fiscal year 1920–21 were as follows:

| | |
|---|---|
| Geologic surveys | $352,000 |
| Repayments | 7,433 |
| Classification of lands | 38,750 |
| Scientific assistants | 17,700 |
| Search for potash deposits (part of appropriation for chemical and physical researches) | 7,250 |
| | 423,133 |

The authorized expenditures, classified by subjects, were approximately as follows:

| | |
|---|---|
| Economic geology of metalliferous deposits | $57,150 |
| Economic geology of nonmetalliferous deposits | 13,075 |
| Economic geology of fuels (oil, gas, coal) | 123,540 |
| Scientific researches not directly connected with economic geology (paleontology, glaciation, Coastal Plain formations, etc.) | 117,122 |
| Supervision, administration, salaries of clerical, technical, and skilled-labor forces, purchase and repair of instruments, office supplies, etc | 112,246 |
| | 423,133 |

Of the amounts available for geologic work, $100,000 was used directly for field expenses, including the search for potash. About 80 per cent of this amount was expended west of the one hundredth meridian, and about 20 per cent east of it.

### COOPERATION.

A brief outline of the scope of the Survey's activities in both formal and informal cooperation, which are largely continuous from year to year, will be found on page 45 of the Forty-first Annual Report. The principal cooperative projects of the current year are noted in the account of the work by States.

### SPECIAL FEATURES.

For those concerned with the application of geology to practical affairs it is worth noting that in four oil fields—Mexia, Tex.; Burbank, Okla.; Bellevue, La.; and the Sweet Grass Hills, Mont.—geologic mapping by the United States Geological Survey had proved the existence of oil-bearing structural features prior to the extensive development that has since taken place. The policy of undertaking the intensive study of possible oil-bearing territory in advance of commercial development will be continued in so far as funds are available. During the year a party began the study of the region about the northern rim of the Black Hills with a view to appraising its broad possibilities as a petroleum producer. Detailed studies of correlation are being made in northern Colorado and southern Wyoming with a view to clearing up a number of debated questions regarding the age and stratigraphic position of important oil sands. This work, which consists in the accurate measurement of sections sufficiently near together that little opportunity for error can creep in, has already thrown much light on the geologic history of the region. Year by year such work is more certainly recognized as of first importance to those concerned with subsurface geology and its direct application to the exploration for oil. The prompt issue of press bulletins presenting the results of recent field work, accompanied by simple maps showing newly discovered structural features favorable for oil, has proved very useful to the public. The chief geologist has given some attention to the occurrence, nature, and origin of oil shale, but it is hoped that in the future many puzzling problems for the chemist and the biologist may receive increasing attention. Systematic investigations of oil shale by the Survey, although interrupted for some years, will be resumed, it is hoped, at an early date.

With the cordial cooperation of the Coast and Geodetic Survey, studies are being carried on to discover the possibility of correlating gravity determinations (by pendulum observations) with geologic structure and major units of rock masses. The spirit of broad inquiry and desire on the part of the Coast Survey to offer every assistance in this work is gratifying. The results of these investigations, which may have very practical application, will be published in due course.

Laboratory studies undertaken by the subsection of sedimentation have been materially advanced through the cordial cooperation of the Bureau of Soils, particularly through the work of Milton Whitney, chief of that bureau, whose study of colloids in soils is of direct application in the interpretation of sedimentary processes.

During the year the water-resources branch of the Survey made comprehensive studies of portions of Colorado and San Juan rivers in Utah and Arizona with a view to determining the suitability of various dam and reservoir sites. Geologists accompanied all the parties engaged in this work, and it was thereby made possible to gain abundant geologic information concerning an extensive region that had been previously little known and is particularly difficult of access. This is the first time that surveys of scientific exploration have been carried the length of San Juan River. Geologic studies were also made by river from Green River, Utah, to Lees Ferry, Ariz., including that portion of the canyon known as the Cataract Canyon. Observations over so extensive an area have added materially to the knowledge of the stratigraphy and structure of this region, and with respect to the occurrence of oil they are of immediate practical value.

It has long been recognized as desirable to attempt more reconnaissance explorations of the vast areas in the West that are practically unknown, and, so far as funds will permit, it is hoped to perform some of this semiexploratory work each year. One project of this sort to be carried out at the present time is a detailed reconnaissance of the Tonopah quadrangle, Nevada, an area of 4,000 square miles. A similar project is the preparation of a geologic map of Arizona in cooperation with the State Bureau of Mines, now in progress.

An extensive field investigation of the radium-bearing carnotite ores of the United States has been practically completed, as well as a similar study of the tungsten deposits of the United States. Reports on both of these subjects are now in preparation.

Studies of the complexly folded and metamorphosed pre-Cambrian and Paleozoic rocks of the Maryland and Pennsylvania Piedmont areas have settled a number of puzzling stratigraphic and structural questions of long standing. Several field conferences have been held, in which the State geologists of Maryland and Pennsylvania joined, and it may be said that the present state of knowledge of this terrane marks a distinct advance in American geology.

The division has cooperated with the geophysical committee, organized on the Pacific coast under the auspices of the Carnegie Institution, in a study of earth movements in connection with earthquakes. In connection with this study considerable detailed mapping has been done along the San Andreas fault, also considerable reconnaissance surveying.

Discoveries made in the course of boring for oil in Texas point to the probable presence of layers of potash-bearing salts in commercial quantities. Because of lack of funds on the part of the Bureau of Economic Geology and Technology of Texas cooperative arrangements for this work were terminated in November, but it is planned to continue the work on an even more comprehensive scale.

At the request of the United States Reclamation Service a number of geologists have cooperated with the engineers of that service in geologic studies of dam and reservoir sites. This highly practical application of geology is particularly satisfying to those to whom usefulness and public service are synonymous.

Geologic surveys under the general direction of the United States Geological Survey have been carried out by the Haitian Government, and a report on the geology of the Republic is in progress. Similar work for the Dominican Republic ceased in 1919. A geologic reconnaissance report on the Dominican Republic was issued by the Dominican Government during the year.

Additions have been made by Survey geologists to the status of areal geologic mapping and the correlation of the post-Cretaceous geologic formations in the Pacific region in two symposia published in the Proceedings of the First Pan-Pacific Scientific Conference.

As a result of the work done by Survey geologists on the paleontology and correlation of the Tertiary formations of eastern Mexico the major divisions of the Tertiary section have been discriminated and biologically characterized, so that the Mexican formations can now be correlated with Tertiary formations of the southern United States, the West Indies, and eastern Central America.

Definite progress has been made in the investigation of the calcium carbonate deposits of the Floridian and Bahaman regions. A fairly full statement of these researches is given in the report of the Committee on Sedimentation of the National Research Council.

## WORK OF THE DIVISION, BY STATES.

[Brief notices of the publications issued during the year are given on pp. 4–10.]

### ALABAMA.

*Field work.*—Charles Butts carried on stratigraphic studies in Alabama, including the examination of several geologic sections near Triana. Mr. Butts also examined proposed additions to the Appalachian National Forest. E. F. Burchard studied brown ores and cement rock.

*Office work.*—A report on southern Alabama and western Florida was begun by C. W. Cooke, who also compiled a geologic map for a relief model of Alabama and Florida. Collections of Tertiary fossils made in Alabama were examined by Julia A. Gardner and Mr. Cooke. The Bessemer-Vandiver and Columbiana-Montevallo folios were completed by Charles Butts. R. D. Mesler prepared collections of fossils for examination. E. O. Ulrich studied fossils from the Chester formation.

### ARIZONA.

*Field work.*—N. H. Darton continued geologic studies in cooperation with the Arizona Bureau of Mines, the results to be used in the preparation of a map of the State. Sidney Paige studied the geology of Green and Colorado rivers between Green River, Utah, and Lees Ferry, Ariz., accompanied in Arizona by H. D. Miser. C. P. Ross studied the geology and ore deposits of the Christmas quadrangle.

*Office work.*—G. H. Girty and J. B. Reeside, jr., examined fossils collected by Mr. Darton. Mr. Girty continued studies of the Triassic faunas of the State, and a paper on stratigraphic sections in southwestern Utah and north-

western Arizona was completed by Mr. Reeside. A report on the rock formations in the Colorado Plateau of southeastern Utah and northern Arizona, by H. D. Miser, C. R. Longwell, R. C. Moore, Kirk Bryan, and Sidney Paige, was continued. W. H. Dall worked on fossils collected by N. H. Darton. F. L. Ransome completed a reconnaissance report on the Pima and Papago mining districts, revised a paper on the Sierrita Mountains, and continued the preparation of a report on the Oatman mining district. L. F. Noble continued the preparation of a report on nitrate in the Mohave Desert and the valley of Colorado River, which includes a few deposits in Arizona. T. W. Stanton reported on collections of Triassic faunas. Edward Sampson prepared a paper on the origin of serpentine in the limestone type of asbestos deposit.

*Publications.*—Issued: Prof. Papers 129–D, 129–H; Bulletins 725–J, 730–B; press notice, "Mining districts near Tucson, Ariz." In press: "A section of the Paleozoic formations of the Grand Canyon at the Bass trail," by L. F. Noble (Prof. Paper 131–B); "Silver ores near Wickenburg, Ariz.," by E. S. Bastin (Bulletin 735–E).

ARKANSAS.

*Field work.*—E. F. Burchard examined Poteau Mountain, Ark., and prepared a report on the lands on this mountain for the Forest Service. Geologic work was done in the vicinity of St. Joe and Duff by R. D. Mesler. W. W. Rubey, assisted by L. G. Mosburg and H. W. Hoots, collected drill records and made studies for a report on the El Dorado oil field. K. C. Heald visited this field and inspected the work.

*Office work.*—W. W. Rubey continued the preparation of a report on the El Dorado oil field and, with James Gilluly and K. C. Heald, prepared press notices on this field. A folio covering the De Queen and Caddo Gap quadrangles was completed by H. D. Miser. Mr. Miser and C. S. Ross prepared papers on peridotite dikes in Scott County and diamond-bearing peridotite in Pike County. Cretaceous fossils from Arkansas were studied by L. W. Stephenson, R. D. Mesler studied the Normanskill and associated faunas, and G. H. Girty studied the Boone fauna.

*Publications.*—Issued: Press notices. "El Dorado oil field in Arkansas not on an anticline," "Wildcat wells in south-central Arkansas stop short of deep oil sands," "Oil from the Nacatoch sand, El Dorado, Ark." In press: "Manganese deposits of the Batesville district, Ark.," by H. D. Miser (Bulletin 734).

CALIFORNIA.

*Field work.*—J. S. Diller carried on further studies in the Lassen Peak volcanic area, Calif. W. S. W. Kew completed his studies of the oil geology of the Santa Monica, Redondo, and San Pedro quadrangles and carried on triangulation in the San Pedro Hills, preparatory to geologic mapping for a report on the oil geology of Los Angeles County. The Elk Hills were visited in September by K. C. Heald and Mr. Kew, who inspected the area covered by Naval Reserve No. 1 and planned for detailed mapping. F. L. Hess examined deposits of tungsten in the vicinity of San Francisco and Randsburg. L. F. Noble examined the San Andreas rift. F. E. Matthes carried on physiographic studies of the Sierra Nevada, from the Yosemite region eastward to the east border of the Mount Lyell quadrangle. J. M. Hill studied the copper deposits of Plumas County.

*Office work.*—J. S. Diller completed his report on the Lassen Peak volcanic district, revised the text of the Riddle folio, and prepared a brief paper on the geology and physiography of the Klamath River basin. E. S. Larsen prepared a paper for outside publication on merwinite, a new mineral from the vicinity of Riverside. F. E. Matthes has completed a geologic report on the Yosemite National Park and is preparing a report on the Green River and Table Mountain region of the Sierra Nevada. J. M. Hill prepared a paper covering the mining industry of California and Oregon. A report on the Los Angeles-Ventura district, prepared during the fiscal year 1921–22, was revised by W. S. W. Kew. W. H. Dall reported on Eocene fossils from Catalina Island and southern California and on Pleistocene fossils from Indian Wells Valley.

*Publications.*—Issued: Bulletins 721, 725–A. In press: "Nitrate deposits in the Amargosa region, southeastern California," by L. F. Noble, G. R. Mansfield, and others (Bulletin 724).

COLORADO.

*Field work.*—J. D. Sears, assisted by C. P. Ross, carried on geologic work in the Axial and Monument Butte quadrangles, Colo., and Mr. Sears, assisted by W. H. Bradley, K. K. Landes, and James Gilluly, did geologic work in Moffat County. Mr. Sears also visited the Rangely oil field for the land-classification board. H. D. Miser was engaged in geologic studies along San Juan River in this State, in cooperation with a party of hydraulic engineers. T. W. Stanton made stratigraphic studies near Morrison and Colorado Springs.

*Office work.*—E. S. Larsen completed a report on the geology and ore deposits of the Creede district and continued work on a report covering the geology of the San Cristobal quadrangle. C. P. Ross, E. S. Larsen, and C. W. Cross continued the preparation of a report on the igneous geology of the San Juan region. Kirtley Mather, assisted by W. W. Atwood, continued the preparation of a paper on the physiography and Quaternary geology of the San Juan Mountains. F. H. Knowlton began a study of the fossil plants of the Animas formation and completed a paper on the Green River flora. J. B. Reeside, jr., continued the preparation of a report on the Cretaceous and Tertiary formations of the west side of the San Juan Basin of Colorado and New Mexico. Mr. Reeside also examined fossils collected by W. T. Lee. M. R. Campbell prepared a report on the classification data of the Yampa coal field, also a report on the Twentymile Park district J. D. Sears prepared a report on the structure and oil possibilities of parts of Moffat County. W. T. Lee prepared a paper on stratigraphic problems in northern Colorado and southern Wyoming. Cretaceous plants from Colorado were reported on by F. H. Knowlton for Messrs. Lee and Reeside. G. H. Girty reported on fossils from this State. W. T. Lee prepared a report that included discussions of the stratigraphy of the Dakota group east of the Rocky Mountain front and treated briefly the significance of these stratigraphic descriptions in connection with possible oil development.

*Publications.*—Issued: Bulletin 730–A; press notice, "The Yampa coal field, in northwestern Colorado." In press: "The Laramie flora of the Denver Basin," by F. H. Knowlton (Prof. Paper 130); "Guidebook of the western United States—Part E, The Denver & Rio Grande Western Route," by M. R. Campbell (Bullet n 707); "The geology and ore deposits of the Creede district, Colo," by W. H. Emmons and E. S. Larsen (Bulletin 718); "Silver enrichment in the San Juan Mountains, Colo.," by E. S. Bastin (Bulletin 735–D).

DISTRICT OF COLUMBIA.

*Field work.*—C. K. Wentworth studied the origin and nature of the Coastal Plain terraces in the District of Columbia and collected samples of gravel. C. W. Cooke gave some attention to the geology and ground waters at several places.

FLORIDA.

*Office work.*—C. W. Cooke began a report on the geology of western Florida and southern Alabama and continued the preparation of a geologic map and profile for a relief model of part of Alabama and Florida. T. W. Vaughan and Julia A. Gardner examined fossils from Florida. Miss Gardner worked on her report on the Alum Bluff Mollusca. Mr. Vaughan studied calcium carbonate bottom samples collected from this State. W. H. Dall reported on fossils from St. Petersburg.

GEORGIA.

*Field work.*—C. W. Cooke made geologic studies in connection with the revision of a geologic map of Georgia in cooperation with the State.

*Office work.*—J. A. Gardner examined collections of fossils from Georgia. C. W. Cooke prepared a paper on prehuman history, describing the geologic history of the region around Macon, for the Mexican Geographic Magazine.

IDAHO.

*Field work.*—Edward Sampson and J. L. Gillson studied the geology and mines in the Pend Oreille region in cooperation with the State of Idaho. Mr. Sampson visited the asbestos deposits near Henry Lake. J. T. Pardee studied the Pleistocene features of Clark Fork valley in northern Idaho.

*Office work.*—A report by the Idaho Bureau of Mines and Geology on "Oil prospects in southeastern Idaho" was critically reviewed by K. C. Heald. A report on oil and gas prospects of southwestern Idaho is now in preparation by J. P. Buwalda. G. R. Mansfield classified phosphate lands in the Lanes Creek, Freedom, Crow Creek, Slug Creek, Montpelier, Cranes Flat, and Henry quadrangles, Idaho and Wyoming, continued the preparation of a report on the geology and mineral resources of southeastern Idaho, and completed a paper on the climate of southeastern Idaho. Edwin Kirk reported on fossils for Edward Sampson, who is preparing a report on the geology of the Pend Oreille region. G. H. Girty and F. H. Knowlton examined collections of Triassic and Tertiary fossils from the State, and Mr. Girty worked on a short paper entitled "The Triassic of Idaho."

*Publication.*—In press: "Geology and ore deposits of Shoshone County, Idaho," by J. B. Umpleby and E. L. Jones, jr. (Bulletin 732).

ILLINOIS.

*Field work.*—The Waterloo-Columbia field, Ill., was visited by W. W. Rubey, who studied its bearing on the possibilities of finding oil in Missouri.

*Publication.*—Issued: Geologic Folio 213.

INDIANA.

*Field work.*—Charles Butts, in cooperation with A. C. Mallott, of Indiana University, investigated stratigraphic problems relating to the Chester group.

KANSAS.

*Office work.*—The age of the Stapleton oil sand of the Eldorado field, Kans., was discussed by A. E. Fath in a paper published in the Bulletin of the American Association of Petroleum Geologists.

*Publication.*—Issued: Prof. Paper 129–I.

KENTUCKY.

*Field work.*—David White examined deposits of oil shale at a number of localities in Kentucky.

*Office work.*—Further work was done by Charles Butts on the Equality-Shawneetown folio. E. O. Ulrich made investigations of the Chester material from this State. Mr. Ulrich and the State geologist of Maryland held conferences regarding Kentucky stratigraphy. The oil and gas field map of Kentucky was compiled by L. B. Pusey, under the direction of G. B. Richardson, and submitted for publication.

*Publication.*—A paper on the Mississippian formations of eastern Kentucky, by Charles Butts, was issued by the State Geological Survey.

LOUISIANA.

*Office work.*—T. W. Stanton reported on Comanche fossils from a deep well in Caddo Parish, La., and T. W. Vaughan reported on collections from this State. Julia A. Gardner made determinations of well samples from Louisiana. W. H. Dall made a report on Pleistocene material.

MARYLAND.

*Field work.*—C. K. Wentworth continued his studies of the Coastal Plain terraces in Maryland. Anna I. Jonas carried on geologic mapping in Carroll County. Asbestos and talc deposits near Conowingo were examined by Edward Sampson. E. O. Ulrich and R. D. Mesler made paleontologic studies of the Clinton formation at Cumberland.

*Office work.*—A report on the crystalline rocks of Baltimore County, Md., was finished and transmitted to the State geologist of Maryland by Eleanora Bliss Knopf and A. I. Jonas.

*Publication.*—Issued: Bulletin 725–B.

MASSACHUSETTS.

*Field work.*—Laurence LaForge completed his studies in Boston, Mass., and vicinity, the results of which are to be incorporated in the Boston folio. L. M. Prindle completed his investigations in the Hoosick, Bennington, Berlin, and Greylock quadrangles.

*Office work.*—Preparation of the Boston folio was continued by Laurence LaForge. L. M. Prindle continued office work on the folio covering the Hoosick, Bennington, Berlin, and Greylock quadrangles. A report on the Quaternary geology of eight quadrangles in central Massachusetts was revised by W. C. Alden.

MICHIGAN.

*Field work.*—The surface geology of the Stockbridge and Rives Junction quadrangles, Mich., was mapped by Frank Leverett, in cooperation with the State Survey.

*Office work.*—The 100-foot contours and surface geology of the map of the southern peninsula of Michigan which appears in Monograph 53 were revised by Frank Leverett, who also made copies of the maps showing the Quaternary geology of the Schoolcraft, Springport, Rives Junction, Stockbridge, Flint, Holly, and Durand quadrangles for the use of the Michigan Geological Survey. A small amount of time was devoted by Mr. Leverett to the manuscript of a report on the region around Camp Custer. A paper on eakleite from Isle Royale was prepared by E. S. Larsen for outside publication.

MINNESOTA.

*Office work.*—The Pleistocene geology of Minnesota was studied by Frank Leverett, and a report on the subject was in course of preparation during the year. He also prepared a scientific paper on certain glacial features of the State for the meeting of the Geological Society of America.

MISSISSIPPI.

*Publications.*—Issued: Prof. Paper 129–E; press notice, "Possible indications of oil in Mississippi."

MISSOURI.

*Field work.*—Stratigraphic and structural conditions in Missouri bearing upon the possibilities of undiscovered oil fields were studied by W. W. Rubey during August and September. Frank Leverett studied the relations of the older glacial drifts of northwestern Missouri.

*Office work.*—An estimate of the petroleum reserves of Missouri was made by W. W. Rubey during October and submitted to the joint committee of the Geological Survey and the American Association of Petroleum Geologists. A complete set of cuttings from a well in Vernon County was prepared for study and examined in a preliminary way by Mr. Rubey in February. Paleontologic studies were made by G. H. Girty and E. O. Ulrich.

MONTANA.

*Field work.*—Detailed structure mapping of the Crow Indian Reservation, with particular attention to anticlinal structure that appeared favorable for oil and gas, was done by W. T. Thom, jr., assisted by Gail F. Moulton, and further field work was done by Mr. Thom, assisted by W. W. Rubey. The Glendive (Cedar Creek) anticline was mapped by Mr. Moulton, N. W. Bass, and M. N. Bramlette. Mr. Thom outlined the work for this party and stayed with them for the first week. Reconnaissance mapping in northern Fergus County was carried on by Frank Reeves, assisted by James Gilluly, L. C. Fenstermacher, J. B. Eby, and M. N. Bramlette. A number of domes south of the Little Rocky Mountains that might be favorable for oil accumulation were mapped by A. J. Collier and S. H. Cathcart in the course of their work in the Fort Belknap Indian Reservation. Mr. Collier, assisted by W. W. Boyer, examined the Sweet Grass arch. Work in the northern Big Horn Basin was begun by R. S. Knappen, assisted by Gail F. Moulton.

*Office work.*—Two press bulletins describing structural conditions and oil development in the Soap Creek field in the Crow Indian Reservation and a paper discussing the oil prospects of a number of anticlinal folds in the reservation were prepared by W. T. Thom, jr. Progress was made on a report covering the area in Fergus County mapped during the fiscal years 1920–21 and 1921–22, but no report was submitted, with the exception of data for the use of the land-classification board. A report by Mr. Thom on the

geology and oil and gas prospects of eastern Montana was completed and issued as a press bulletin. Mr. Thom and C. E. Dobbin spent some time working on a map showing geologic structure in the Dakota sandstone in eastern Montana. A report on the oil prospects of the Cedar Creek anticline was prepared by Mr. Thom and Gail F. Moulton and issued as a press bulletin. A report on the structural features favorable for oil in Garfield County was prepared by Messrs. Thom and Dobbin and issued as a press bulletin. Incidentally data for land classification in eastern and southern Garfield County were submitted to the land-classification board. The mapping of the geologic structure of the southwestern part of the Lake Basin field was revised by Mr. Thom, and a press bulletin calling attention to favorable features and prospects for oil and gas was issued. A report describing the geologic structure and possible economic significance of laccolithic domes south of the Little Rocky Mountains was prepared by A. J. Collier. Mr. Collier prepared land-classification data covering oil possibilities in the Fort Belknap Indian Reservation for the land-classification board. Edwin Kirk reported on fossils collected by Mr. Collier. G. H. Girty reported on fossils from the State. J. T. Pardee prepared a report on the glacial geology and origin of gold-bearing gravels of the Pioneer district and completed a report on ground water in the vicinity of Townsend. W. C. Alden continued the preparation of a report on the Cenozoic history of Montana, in which he describes the Tertiary and Pleistocene bench gravels east of the Rocky Mountains. T. W. Stanton studied the invertebrate fossils from the Lance formation.

*Publications.*—Issued: Bulletins 725–A, 725–C; press notices, "The Ingomar dome, Mont.," "The Soap Creek oil field, Crow Indian Reservation, Mont.," "Recent drilling in the Soap Creek oil field, Crow Indian Reservation, Mont.," "Oil and gas may be found in the Eagle sandstone in the Lake Basin field, Mont.," "Geology of northern Fergus County, Mont.," "Oil and gas prospects in Garfield County, Mont.," "Oil and gas prospects in the Cedar Creek anticline and vicinity, in Montana, North Dakota, and South Dakota." In press: "Oil and gas prospects in and near the Crow Indian Reservation, Mont.," by W. T. Thom, jr. (Bulletin 736–B); "Possibility of finding oil in laccolithic domes south of the Little Rocky Mountains, Mont.," by A. J. Collier and S. H. Cathcart (Bulletin 736–F).

### NEBRASKA.

*Field work.*—Reported gas seepages near Grand Island, Nebr., were examined by K. C. Heald. T. W. Stanton made stratigraphic studies near Crawford and collected Cretaceous and invertebrate fossils. Frank Leverett studied the relations of the older glacial drift in Nebraska.

### NEVADA.

*Field work.*—Reported occurrences of oil near Fallon, Nev., were examined by D. F. Hewett, who also investigated underground water resources near Searchlight and, with C. H. Behre, examined carnotite deposits near Jean. G. R. Mansfield and L. F. Noble visited the Callville borax deposits. H. G. Ferguson and party began the mapping of the Tonopah quadrangle. G. H. Girty continued studies of Triassic faunas of the State. F. L. Hess studied the deposits of vanadium ore near Goodsprings.

*Office work.*—Adolph Knopf continued the preparation of a report on the Rochester district and completed a report on the Candelaria district. The report on the Jarbidge district was revised by F. C. Schrader. Fossils from various parts of the State were examined by W. H. Dall, Edwin Kirk, and T. W. Stanton. D. F. Hewett completed a geologic map of the Goodsprings quadrangle and continued the preparation of a report on the manganese resources of the State. A report on the Manhattan mining district was completed by H. G. Ferguson. L. F. Noble completed a report on the colemanite deposits in Clark County.

*Publications.*—Issued: Bulletins 725–H, 725–I, 735–A, 735–B, 735–C; press notices, "The Comstock lode probably still far from exhausted," "Colemanite in the Muddy Mountains, Nev."

### NEW HAMPSHIRE.

*Field work.*—Arthur Keith continued studies of the stratigraphy of central New Hampshire.

NEW JERSEY.

*Office work.*—G. R. Mansfield revised and completed a bulletin on the New Jersey greensands.

*Publication.*—In press: "Potash in the greensands of New Jersey," by G. R. Mansfield (Bulletin 727).

NEW MEXICO.

*Office work.*—J. B. Reeside, jr., made progress on a report on the Cretaceous and Tertiary formations of the west side of the San Juan Basin of Colorado and New Mexico. J. D. Sears prepared a report on the Gallup-Zuni area. W. T. Lee continued the preparation of a folio on the Raton, Brilliant, and Koehler quadrangles. H. G. Ferguson began a detailed report on the Mogollon mining district. F. H. Knowlton studied the fossil plants of the Animas formation.

*Publications.*—Issued: Bulletins 725–G, 726–E. In press: "Copper deposits of the Tyrone district, N. Mex.," by Sidney Paige (Prof. Paper 122).

NEW YORK.

*Field work.*—Studies in the Hoosick and Bennington quadrangles, lying partly in New York, were completed by L. M. Prindle. Charles Butts spent a short time in a study of Niagara Gorge and Eighteenmile Creek. He also examined the Portage formation at Mount Morris and collected samples of black shale for oil tests. T. W. Vaughan made field examinations in Essex County and studied the geology and physiography of the Hudson Valley and Lake Champlain region in connection with the correlation of Pleistocene formations along the Atlantic coast. Samples of carbonaceous Devonian shale at several points in the western part of the State were collected by David White. E. S. Larsen studied the occurrence of the mineral serendibite in Warren County.

NORTH CAROLINA.

*Field work.*—W. S. Bayley studied the magnetites of North Carolina and the limonites of Cherokee County in cooperation with the State Geological Survey. E. F. Burchard examined iron-ore deposits in Ashe and Cherokee counties, conferring with W. S. Bayley and J. H. Pratt in the field. M. R. Campbell, assisted by K. K. Kimball, made geologic studies of the Deep River coal field. Julia A. Gardner studied fossil faunas of the Miocene and Pliocene of Virginia and North Carolina in connection with a report on Miocene and Pliocene gastropods and pelecypods. G. R. Mansfield investigated the lights seen in the vicinity of Brown Mountain.

*Office work.*—W. S. Bayley prepared a paper on the brown iron ores of western North Carolina in cooperation with the State Geological Survey. Arthur Keith completed the Kings Mountain-Gaffney folio.

*Publications.*—Issued: Bulletin 725–B; press notices, "Origin of the lights at Brown Mountain, N. C.," "Small field of high-grade coal in North Carolina." In press: "General features of the brown hematite ores of western North Carolina," by W. S. Bayley (Bulletin 735–F).

NORTH DAKOTA.

*Field work.*—The mapping of the Baker-Glendive anticline of Montana extended into southwestern North Dakota.

*Office work.*—A report on the Baker-Glendive anticline was prepared by W. T. Thom, jr., and Gail F. Moulton.

*Publications.*—Issued: Bulletin 726–D; press notices, "Oil and gas prospects in the Cedar Creek anticline and vicinity, in Montana, North Dakota, and South Dakota," "New report on the lignite of North Dakota."

OHIO.

*Field work.*—E. O. Ulrich made paleontologic studies in Adams County, Ohio. David White collected samples of carbonaceous shales.

*Office work.*—G. H. Girty studied fossils collected from this State.

*Publication.*—In press: "Economic geology of the Summerfield and Woodsfield quadrangles, Ohio," by D. D. Condit (Bulletin 720).

OKLAHOMA.

*Field work.*—The oil and gas resources of eastern Grant County, Okla., were studied by R. S. Knappen, assisted by H. W. Hoots. The Burbank field was examined by K. C. Heald, assisted by Clarence Byler. Mr. Heald attended three sales of leases in the Osage Nation and gave advice as to the adequacy of bids received. Physiographic studies were made in Oklahoma by N. M. Fenneman.

*Office work.*—A press bulletin describing anticlinal structure in Grant County was prepared by R. S. Knappen. Progress was made on a bulletin discussing the oil geology of the county. A report on the structure and oil resources in Tps. 26 and 27 N., R. 12 E., Osage County, was completed and submitted for publication by P. V. Roundy and K. C. Heald. A report on the oil geology of the Bristow quadrangle was completed by A. E. Fath. A progress report on the subsurface conditions in the Pershing field, Osage County, was completed by W. W. Rubey. P. V. Roundy studied samples of drill cuttings from Oklahoma, particularly from fields in Stephens County. N. M. Fenneman prepared a paper on physiographic studies within the State. G. H. Girty studied the Boone fauna. T. W. Stanton made studies of the Comanche fossils from this State. C. E. Siebenthal studied the geology and zinc mines of the Wyandotte quadrangle.

*Publications.*—Issued: Bulletins 725–E, 726–B, 726–F, 736–A; press notices, "Undiscovered oil pools in southern Oklahoma," "Possibilities of oil in Grant County, Okla." In press: "Structure and oil and gas resources of the Osage Reservation, Okla.—Tps. 26 and 27 N., R. 12 E.," by P. V. Roundy, K. C. Heald, and G. B. Richardson (Bulletin 686–Z); "Physiographic provinces and sections in western Oklahoma and adjacent parts of Texas," by N. M. Fenneman (Bulletin 730–D).

OREGON.

*Office work.*—F. H. Knowlton and T. W. Stanton reported on fossils from the Wallowa Mountains, Oreg. J. M. Hill prepared a preliminary review on the mining industry in California and Oregon. J. S. Diller has in preparation a paper on the engulfment of Mount Mazama to form a great pit for Crater Lake.

*Publication.*—Issued: Bulletins 725–A, 725–C.

PENNSYLVANIA.

*Field work.*—K. K. Kimball, assisted by L. P. Foley and R. P. Paxson, continued work in the New Kensington quadrangle, Pa. General geologic work in the McCalls Ferry and Quarryville quadrangles was done by E. B. Knopf and A. I. Jonas. In cooperation with the Pennsylvania Bureau of Topographic and Geological Survey Miss Jonas studied the geology of Lancaster and York counties. Areal and structural mapping of the New Kensington quadrangle was continued by G. B. Richardson and assistants. David White collected samples of carbonaceous shale. G. W. Stose, in cooperation with Florence Bascom, made detailed geologic studies of the Honeybrook quadrangle. Mr. Stose carried on reconnaissance mapping in the Hanover quadrangle.

*Office work.*—Work on a report on the New Kensington quadrangle was done by K. K. Kimball. A map showing the oil fields of Pennsylvania was compiled by L. B. Pusey under the direction of G. B. Richardson. E. O. Ulrich reported on specimens from the Freedomville dolomite and on certain fossiliferous pebbles for C. K. Wentworth. G. H. Girty made paleontologic studies of Triassic material from the State. The Bellefonte folio was partly revised by Charles Butts.

*Publication.*—Issued: Bulletin 725–B.

SOUTH CAROLINA.

*Field work.*—C. W. Cooke spent some time in the field in connection with the preparation of a paper on the geology and underground waters of the Coastal Plain of South Carolina. This work was done in cooperation with the State.

*Office work.*—Arthur Keith completed the Kings Mountain-Gaffney folio.

*Publications.*—Issued: Bulletin 725–F; press notice, "Pyrite at the Haile mine, Kershaw, S. C."

SOUTH DAKOTA.

*Office work.*—T. W. Stanton and F. H. Knowlton examined Cretaceous fossils from South Dakota. Sidney Paige made some progress on a report on the Homestake mine.

*Publication.*—Issued: Press notice, "Oil and gas prospects in the Cedar Creek anticline and vicinity, in Montana, North Dakota, and South Dakota."

TENNESSEE.

*Field work.*—Oil shales in Tennessee were examined by David White. R. D. Mesler did some field work near Sweetwater, Loudon, and Knoxville. E. F. Burchard made a study of the iron ores of Tennessee in cooperation with the State; he also studied the marble deposits in Lincoln County. W. H. Emmons made further studies in connection with the report on the Ducktown district. G. R. Mansfield visited some bauxite deposits in the State.

*Office work.*—G. H. Girty continued the study of the faunas of the Fort Payne formation of the Waynesboro quadrangle. W. S. Bayley continued the preparation of his report on the magnetic ores of east Tennessee, in cooperation with the State. T. W. Stanton assembled and revised the manuscript on the Coon Creek fauna, by Bruce Wade. Conferences relating to stratigraphic correlation were carried on between E. O. Ulrich and the State geologist. Mr. Ulrich also made studies of paleontologic material from the State. R. D. Mesler continued work on the faunas of the Athens shale and the Whitesburg limestone. G. W. Stose revised a manuscript of a report on the manganese deposits of eastern Tennessee, to be published by the State Survey. A brief report on the Tennessee marble areas mapped during the season of 1920–21 was prepared by K. K. Kimball.

*Publication.*—In press: "Manganese deposits of east Tennessee," by G. W. Stose and F. C. Schrader (Bulletin 737).

TEXAS.

*Field work.*—N. M. Fenneman made physiographic studies in Texas. D. D. Christner continued the inspection of wells in progress of drilling and gathered samples of salt brines in connection with potash studies. Later in the year this work was taken over by H. W. Hoots. J. A. Gardner continued to study the Eocene of Texas. L. W. Stephenson continued field work in connection with a report on the Cretaceous stratigraphy of Texas between San Antonio and the Rio Grande. A. C. Trowbridge made field studies in connection with the Tertiary geology of southern Texas.

*Office work.*—M. I. Goldman examined samples of cap rock from salt domes and prepared a short paper on such domes. A report by C. E. Dobbin on the Wiles area, in Stephens County, was submitted for publication. A report on the Ranger oil field was revised by Frank Reeves. L. B. Pusey prepared the oil and gas map of Texas, under the supervision of G. B. Richardson and K. C. Heald. A manuscript by Sidney Powers and O. B. Hopkins, on the Brooks, Steen, and Grand Saline salt domes, in Smith and Van Zandt counties, was transmitted for publication. A preliminary report on the Rio Grande region of Texas was submitted by A. C. Trowbridge. A report on the flora of the Woodbine sandstone at Arthurs Bluff was completed by E. W. Berry. T. W. Stanton reported on Comanche invertebrates from this State. L. W. Stephenson prepared a press notice on the geologic features near Del Rio, in Val Verde and Kinney counties. M. R. Campbell revised a paper by Alexander Deussen on the Coastal Plain of Texas.

*Publications.*—Issued: Prof. Paper 129–G; Bulletins 726–G, 736–A; press notices, "Risks great in oil fields of north-central Texas." "Anticlinal fold near Del Rio, Tex.," "Stock promotion and potash in west Texas," "Extension of possible potash area in western Texas," "Potash in new area of Texas." In press: "Geology of the Coastal Plain region of Texas," by Alexander Deussen (Prof. Paper 126); "Physiographic provinces and sections in western Oklahoma and adjacent parts of Texas," by N. M. Fenneman (Bulletin 730–D); "Geology of the Wiles area, Ranger district, Tex.," by C. E. Dobbin (Bulletin 736–C); "Geology of the Ranger oil field, Tex.," by Frank Reeves (Bul-

letin 736–E); "The Brooks, Steen, and Grand Saline salt domes, Smith and Van Zandt counties, Tex.," by Sidney Powers and O. B. Hopkins (Bulletin 736–G).

UTAH.

*Field work.*—Work in Kane and Garfield counties, Utah, with particular reference to oil and gas possibilities, was carried on by R. C. Moore, assisted by P. C. Benedict and A. C. Tester. Mr. Moore also studied the oil value of lands in southern Wayne County and examined the coal territory in the Paunsagunt Plateau, for the land-classification board. The asphalt deposit at Rozel Point, at the north end of Great Salt Lake, was visited by K. C. Heald. E. M. Spieker, assisted by W. B. Upton, jr., and W. W. Boyer, made geologic studies with reference to coal in Carbon County. F. C. Calkins carried on detailed geologic mapping in an area north and south of Big Cottonwood Creek. C. R. Longwell and Kirk Bryan continued geologic studies of Colorado River in connection with power-site investigations. J. D. Sears studied the coal lands near Vernal for the land-classification board. M. R. Campbell spent a short time in the Castlegate coal field. H. D. Miser studied the geology along the lower course of San Juan River and along Colorado River in Glen Canyon, Utah and Arizona. Sidney Paige made geologic studies along Colorado River between Green River, Utah, and Lees Ferry, Ariz., in connection with power-site surveys.

*Office work.*—R. C. Moore prepared a report on Kane and Garfield counties and submitted a short paper discussing oil prospects in the Circle Cliffs anticline, for issue as a press bulletin. A report on the coal and oil values of lands in southern Wayne County was submitted to the land-classification board by Mr. Moore. Work on a report on oil shale in the Rocky Mountain region, by Dean E. Winchester, was completed by K. C. Heald. H. D. Miser prepared a press bulletin on the stratigraphy of southern Utah. F. L. Hess wrote a report on the radium deposits of Temple Mountain and Salt Lake City and a paper on the molybdenum deposits at Ouray. G. H. Girty prepared a paper as the result of the study of collections of fossils from this State. A paper on the Rainbow Bridge is in preparation by H. D. Miser, K. W. Trimble, and Sidney Paige.

*Publications.*—Issued: Prof. Paper 129–D; Bulletins 725–C, 726–C; press notices, "Coal resources of the Wasatch Plateau, Utah," "Possible oil in southern Utah," "Geologic work in southeastern Utah." In press: "Guidebook of the western United States, Part E—The Denver & Rio Grande Western Route," by M. R. Campbell (Bulletin 707).

VERMONT.

*Field work.*—A. C. Swinnerton continued detailed studies of the Castleton quadrangle, Vt., under the direction of Arthur Keith. Mr. Keith studied the stratigraphy and structure of northwestern Vermont. L. M. Prindle continued studies of the Hoosick and Bennington quadrangles.

*Office work.*—Arthur Keith prepared a paper on the Cambrian succession of northwestern Vermont.

VIRGINIA.

*Field work.*—G. W. Stose and Charles Butts made stratigraphic studies in the Big Stone Gap area. C. K. Wentworth studied the terrace gravels of Virginia. M. R. Campbell and C. E. Dobbin examined certain proposed forest reserves in this State. Mr. Campbell also made geologic studies in the vicinity of Orkney Springs. Arthur Keith prepared a report on the proposed Whitetop National Forest for the Forest Service. W. C. Mansfield collected fossils and made stratigraphic studies in the vicinity of Yorktown, Suffolk, and Smithfield.

*Office work.*—Work on a coal report on Wise County was continued by J. B. Eby. Stratigraphic and paleontologic investigations were made by E. O. Ulrich and G. W. Stose. Mr. Ulrich studied collections of fossils obtained near Salem. M. R. Campbell revised a paper on the Lee County coal field. R. D. Mesler continued paleontologic work on the Athens fauna and the Whitesburg limestone. J. A. Gardner continued paleontologic studies for a report on the Pliocene and Miocene of Virginia and North Carolina.

*Publications.*—Issued: Press notices, "Possible coal mining in a new field on lower Guest River, Va.," "The Endless Caverns at New Market, Va."

WASHINGTON.

*Field work.*—J. T. Pardee made a study of the Pleistocene geology in the neighborhood of the Spokane River valley, in eastern Washington. F. C. Calkins investigated supposed oil seeps at Spokane for the Department of Justice.

*Office work.*—W. H. Dall reported on Pleistocene fossils from Puget Sound and identified certain Tertiary and Eocene fossils from the Olympic Peninsula.

*Publications.*—Issued: Bulletins 725–A, 725–C.

WEST VIRGINIA.

*Office work.*—G. H. Girty prepared a paper on the upper Mississippian fauna of West Virginia.

WISCONSIN.

*Office work.*—E. O. Ulrich studied some of the Cambrian formations of Wisconsin.

WYOMING.

*Field work.*—The oil-bearing strata of Wyoming were examined by W. T. Lee and J. B. Reeside, jr., assisted by H. S. Cave, Quentin D. Singewald, and R. Lee Collins. A sketch map of the Bolton Creek district was prepared by M. G. Gulley. The Beaver Valley anticline, in Weston County, was examined by M. N. Bramlette. The Teapot dome, in Natrona County, was visited by K. C. Heald to study its geology and probable productivity. Oil fields in eastern Wyoming were visited by C. D. Avery. Data for revision and completion of the geologic map of Wyoming were collected in Denver, Casper, and Laramie by J. D. Sears. M. R. Campbell spent some time in the examination of the Rock River coal field. C. R. Longwell and assistants began the study of the Black Hills rim, in northern Wyoming, with relation to the occurrence of structure favorable for oil.

*Office work.*—D. F. Hewett continued the preparation of a report on the geology and mineral resources of the Meeteetse and Grass Creek quadrangles. T. W. Stanton examined fossils from the Cretaceous of this State. F. H. Knowlton continued preparation of a report on the Green River flora. G. R. Mansfield prepared classification data of phosphate lands for the land-classification board. G. H. Girty examined collections of fossils from this State. J. B. Reeside, jr., revised a report on the fauna of the Dakota formation. A report on the Lost Soldier-Ferris district was prepared by A. E. Fath and Gail F. Moulton. An article on the age of the domes and anticlines in this district, prepared by Mr. Fath, was published in the Journal of Geology. The oil and gas map of Wyoming was compiled by L. B. Pusey under the supervision of G. B. Richardson and K. C. Heald. A report describing the Beaver Valley anticline, in Weston County, was prepared by M. N. Bramlette and transmitted to the land-classification board. An oral report on the Teapot dome was made to the Secretary of the Interior, and a memorandum furnishing bases for conclusions was transmitted to the Director of the Survey. A report on the Osage oil field, Weston County, was completed by A. J. Collier. Data for use in preparing a structure contour map of northeastern Wyoming were collected by W. T. Thom, jr. James Gilluly drew a structure contour map of the Kirby Creek district, Hot Springs County, under the direction of K. C. Heald. The structure map of the Rock Creek oil field, by E. T. Hancock, was revised by Mr. Gilluly under the supervision of Mr. Heald. A statement regarding the stratigraphy, structure, and oil possibilities of Hanna Basin, based upon field work by C. F. Bowen, was prepared by Mr. Heald for issue as a press bulletin. A paper on the oil-bearing strata of Wyoming was transmitted for publication in "Contributions to economic geology." A second paper discussing stratigraphy of a separate group was nearly completed.

*Publications.*—Issued: Press notice, "Coal and oil resources of the Hanna Basin, Carbon County, Wyo." In press: "The Osage oil field, Weston County, Wyo.," by A. J. Collier (Bulletin 736–C).

HAITI.

A report on a reconnaissance of the geology, mineral resources, and water resources of the Republic of Haiti is in preparation by W. P. Woodring, J. S.

Brown, and W. S. Burbank. The field work was done in compliance with a request from the civil authorities of the Republic and was begun September 21, 1920.

OTHER COUNTRIES.

Through cooperation with governmental and scientific institutions a number of members of the geologic staff, especially the paleontologists, have been called on for special examinations or determinations relating to the faunas and geology of Hawaii, Iceland, Canada, Peru, the Philippine Islands, Argentina, Colombia, Bolivia, Java, the Pacific islands, Mexico, New Zealand, and Cuba.

GENERAL PUBLICATIONS.

In addition to the publications listed above under the individual States the following publications of more general scope were prepared in the division of geology:

Issued: Prof. Papers 128, 129–B, 129–C, 129–F; Bulletins 679, 715, 716, 725–D; press notice, "The oil supply of the United States."

In press: "Coal fields of the United States—general introduction" (revised), by M. R. Campbell (Prof. Paper 100–A); "Shorter contributions to general geology, 1921" (Prof. Paper 129); "Additions to the flora of the Wilcox group," by E. W. Berry (Prof. Paper 131–A); "High-grade clays of the eastern United States," by H. Ries, W. S. Bayley, and others (Bulletin 708); "Contributions to economic geology, 1921," Parts I and II (Bulletins 725 and 726); "The occurrence and uses of peat in the United States," by E. K. Soper and C. C. Osbon (Bulletin 728); "Oil shale of the Rocky Mountain region," by D. E. Winchester (Bulletin 729); "The shapes of pebbles," papers by C. K. Wentworth (Bulletin 730–C); "The commercial granites of New England," by T. N. Dale (Bulletin 738); "Mica deposits of the United States," by D. B. Sterrett (Bulletin 740).

DIVISION OF MINERAL RESOURCES.

The organization of the division of mineral resources was described in the last annual report. During the year the division was depleted by nine resignations and two deaths. R. W. Stone, chief of the nonmetals section and administrative assistant, resigned January 1, and his place was not filled until April 1, when F. J. Katz returned from a 2½ years' furlough to the Bureau of the Census. During May and June Mr. Katz acted in charge of the division, relieving Mr. Loughlin, who resumed his geologic work.

An outstanding feature of the work of the division during the year was a reduction of the force without appreciable decrease in the service rendered. This reduction, already planned to take effect as soon as delayed work was caught up, was hastened by unexpected resignations. The work on mineral fuels, however, was so far behind that the funds released by resignations were necessarily used in part to engage temporary help to complete this work. It is confidently expected that the annual reports on fuels for 1921 will be completed quite as promptly as those for the years preceding the war.

The experience in completing these reports emphasizes the desirability of engaging temporary clerks from January to June to expedite the routine work that has hitherto delayed the completion of the longer reports. It is hoped that this plan can be followed every year, and that there will still remain more funds than formerly for conducting field work, which has necessarily been neglected during the last few years. Even with the present reduced force the total appropriation is inadequate for the work that should be done by the division.

The failure to obtain properly qualified specialists to give at least a part of their time to the work of this division still leaves 11 subjects to be cared for without adequate supervision. The annual reports on these subjects have been again prepared by the more experienced statistical clerks, who deserve much credit for their work; but the standard of these reports, including the collection of general information relating to these subjects, can not be maintained indefinitely without the supervision of specialists. During the war, when the number of specialists employed was largest, a great deal of information was made available. Since then much of the work on nonmetals other than fuels has been "drifting on its momentum." Owing to the general business depression that has prevailed the shortage of specialists has not been seriously felt until recently; but during the last few months resumption of activity by mineral producers and consumers has brought an increasing number of inquiries for technical information, and if the division is to maintain the quality of its work, specialists who can devote a part of their time to the division of mineral resources and part to the division of geology must be obtained.

The work on fuels continued to excite the most public interest, and special timely reports were issued as each situation arose. Reports on consumers' stocks of coal were prepared in cooperation with the Bureau of the Census. The work on other nonmetals and metals continued as usual, but without any very striking features, owing to the depressed state of most of the mineral industries.

On January 1 cooperation with the Bureau of the Census was resumed in the collection of statistics on such subjects as that bureau had to cover in its biennial census of manufactures. The present arrangement is a great improvement over previous arrangements and has caused very little delay or inconvenience to either bureau. It is so evident, however, that the two bureaus have different objectives in view that it is doubtful if the attempt to avoid duplication in the canvass of producers reduces the amount of labor. The two bureaus assist each other gladly whenever possible, but any attempt of one bureau to collect statistics in which only the other bureau is interested is necessarily cumbersome.

Cordial cooperation with the State geological surveys continued, and the number of cooperating States increased from 17 to 18.

In January, for the first time since the three western offices were established in 1905, the statisticians in charge of them assembled in Washington for a conference on the work of the division. The conference was very successful and helpful to all concerned and brought the western and home offices in much closer touch than ever before. The scope of work in the western offices continues to grow in all branches of the mineral industry, and much service has been rendered by these offices in collecting data for the weekly and monthly reports on fuels. The demands on these offices during the year have again emphasized the need of a resident geologist at each office, but circumstances have prevented the assignment of geologists to the offices in Denver and Salt Lake City.

The section of foreign mineral reserves continued to supply timely information, especially on oil, and added to its files of information on foreign geology and mineral statistics. Owing to the shortage of specialists, practically no headway was made with the part of the

World Atlas that is to show the mineral reserves of Europe and Latin America.

Progress in completion of the annual chapters for Mineral Resources of the United States has been very encouraging. The final installments of the long-delayed volume for 1919 were sent to the printer in March and May, and by the end of June 32 chapters of the volume for 1921 had been transmitted. Those still incomplete involve the handling of a large number of producers' reports and can not be completed earlier, unless all producers return their statements much earlier in the year and the clerical force is temporarily enlarged to expedite the office work. The preliminary summary of mineral production in 1921 was transmitted on April 1 and was published on September 14, 1922, whereas the corresponding summary for 1920 was published on July 7, 1921. Extra payment for expediting the printing of the summary for 1921 was not permitted, and this accounts for the difference in dates of publication.

All the reports for 1921 have been much curtailed, primarily to keep within the reduced printing fund, and also because the scope of most of the reports has become so stabilized that much of the discussion of statistical tables is no longer necessary. The number of copies printed for free distribution has also been reduced.

## DIVISION OF CHEMICAL AND PHYSICAL RESEARCH.

The work of the division of chemical and physical research comprised researches relating to geologic processes, complete and partial analyses of rocks, minerals, and ores, and the identification and study of minerals. George Steiger, chief chemist, supervised the work in chemistry and acted in charge of the division, and C. E. Van Orstrand directed the work in physics.

The available funds were $3,000 for one chemist and a lump-sum appropriation of $40,000 for laboratory expenses and salaries of chemists, physicists, and helpers. Of the lump sum, $6,860 was allotted for field expenses in the search for potash. The personnel of the division consisted of 7 chemists, 2 physicists, 2 laboratory aids, 1 clerk, 1 laboratory assistant, and 1 laborer. The privileges of the laboratory were temporarily extended to Miss Taisia Stadnichenko, who has been engaged in some studies of oil shale with David White.

### WORK IN CHEMISTRY.

During the year 1,720 quantitative analyses were made, mainly for use in geologic investigations, and in addition 2,206 specimens were qualitatively tested, most of them for persons not officially connected with the Survey. A large number of minerals were also identified.

Laboratory experiments on the effect of nitric acid on certain granites were concluded by George Steiger, and the data were prepared for publication. A long series of analyses of waters of Chesapeake Bay was made by E. P. Henderson, and the results are being prepared for publication by R. C. Wells. Another long series of analyses of ocean-bottom samples was made by J. G. Fairchild, and the results will be used in a geologic investigation by T. W. Vaughan. Each of these series of analyses is the most complete ever made in its particular class.

The carbon dioxide content of sea water at Tortugas, Fla.; the alkalinity of Searles Lake brine; the water of Borax Lake; and experiments on the accurate determination of silica were some of the studies occupying the time of Mr. Wells, who prepared papers on each except the first. Mr. Wells also wrote the chapter on sodium compounds, 1920, for Mineral Resources and prepared a report on physical and chemical investigations of sediments for the division of geology of the National Research Council. Toward the end of the year he started an elaborate study of the formation of the Lake Superior copper ores.

Two new minerals were analyzed and their physical properties determined, the names gillespite and sincosite were given to them, and articles describing them by W. T. Schaller were published in the Journal of the Washington Academy of Sciences.

Uranium and vanadium minerals were studied in detail, and analytical methods for the determination of vanadium and selenium were tested by Mr. Schaller, who also studied the rare minerals mordenite, vegasite, autunite, carnotite, melanovanadite, hydroboracite, ludlamite, serendibite, and tschermigite, checking their predetermined optical properties and, for some of them, determining properties which had not heretofore been described.

An interesting study of organic compounds as they exist in oil shale before being changed by heat was conducted in collaboration with Mr. White and Miss Stadnichenko by E. T. Erickson, who prepared an article on the detection of small quantities of petroleum that was published in the Engineering and Mining Journal. The first reported occurrence of tschermigite in this country was described by Mr. Erickson. Associated with the tschermigite was a small quantity of a new variety of jarosite containing ammonia.

An article containing some original ideas on the evolution of matter, by F. W. Clarke, was published in the Journal of the Washington Academy of Sciences. Mr. Clarke completed a manuscript on the composition of river and lake waters of the United States and partly prepared a more complete paper on the evolution of matter.

An elaborate report on the composition of the earth's crust, by Mr. Clarke and Henry S. Washington, of the Carnegie Geophysical Laboratory, was transmitted for publication as a professional paper.

The search for potash in natural salts continued to yield promising results. The field work is described in the report of the division of geology. Several hundred samples of salts were collected by the Survey's field representatives in western Texas and were assayed by R. K. Bailey. Potash was found in varying quantities in samples from 15 different wells distributed over an area of several hundred square miles. Some of the samples contained more than 11 per cent of potash, and in a number of these wells one or more zones of salts containing workable percentages of potash were encountered. The wells were being drilled for oil, not for potash, and the samples were not taken in a way to show the thickness of the layers of potash-rich salt. A number of core-drilled wells are in prospect within this area, and more definite information is expected in the near future. A new field test for polyhalite, the principal potash

mineral occurring in the salts so far obtained, was devised by Mr. Steiger and published, together with other tests and a method for assay, in a special press notice. An article on the potash salts of western Texas, by Mr. Steiger, was published in Chemical and Metallurgical Engineering.

### WORK IN PHYSICS.

Work in the physical laboratory included theoretical and experimental investigations in both field and laboratory by C. E. Van Orstrand on the general subject of deep earth temperatures. Observations of temperatures in deep wells were made in North Dakota, Oregon, Washington, California, Colorado, and Illinois. Mr. Van Orstrand also continued the reduction of the temperature data for the entire globe, which is nearly completed, and the development of apparatus for making temperature tests in deep wells by means of mercury thermometers, which has been carried to such a point that a geothermal survey can be conducted with reasonable efficiency and a high degree of accuracy. Some temperature curves for a cooling sphere were evaluated for incorporation in the volume on the probability integral. A short paper by Mr. Van Orstrand and M. A. Shoultes on the values of the sine and cosine to 33 places of decimals for various values of the argument expressed in seconds is ready for publication.

The pore space in 142 samples of oil sand and the diameter of grains of 10 samples were determined by A. F. Melcher and J. G. Douglas. Apparatus for determinations of permeability and absorption in oil and gas sands has been completed, and some preliminary tests have been made. Attention was given to a microscopic examination of oil sands for the purpose of obtaining information in regard to shape of pores, location of cement, and other significant features. A field study of the oil sand in the Burbank field, Osage County, Okla., was made by Mr. Melcher, who also wrote for the Bulletin of the American Association of Petroleum Geologists a note on the permeability and absorption of sands for oil, water, and gas with reference to their normal and possible yield.

Mr. Shoultes assisted in all the experimental work of the laboratory and in addition made tests on the diffusion of solids, interpolated values of exponential and trigonometric functions, and reduced observations of deep earth temperatures.

### ALASKAN MINERAL RESOURCES BRANCH.

The personnel of the Alaskan force included, on June 30, 1921, 1 geologist in charge, 4 geologists, 2 topographic engineers, 1 draftsman, and 3 clerks on annual salaries, 2 geologists on monthly salaries, and 1 geologist and 1 topographic engineer on per diem salaries; and on June 30, 1922, 1 geologist in charge, 4 geologists, 2 topographic engineers, 1 draftsman, and 3 clerks on annual salaries, 1 geologist on monthly salary, and 3 geologists on per diem salaries.

The funds available, including an appropriation of $75,000, an unexpended balance of $13,800, and an allotment of $12,000 from the appropriation for classification of public lands, were expended as follows:

*Approximate distribution of funds for investigations in Alaska, field season 1921.*

| | 1920–21 | 1921–22 |
|---|---|---|
| Administration, Alaska branch | | $5,700 |
| General investigation, mineral resources | | 4,520 |
| Southeastern Alaska | $1,900 | 7,700 |
| Cook Inlet | 9,000 | 11,170 |
| Alaska Railroad | | 2,350 |
| Alaska Peninsula | 8,930 | 9,210 |
| Yukon Basin | 3,340 | 7,300 |
| Map compilation | | 4,660 |
| Collection of mineral statistics | | 1,800 |
| Miscellaneous expenses, including clerical salaries, etc | 2,630 | 6,660 |
| Office of Director | | 8,500 |
| To be allotted to field work, 1922 | | 5,430 |
| | 25,800 | 75,000 |

*Approximate allotments of Alaskan funds to different kinds of surveys and investigations, field season 1921.*

| | 1920–21 | 1921–22 |
|---|---|---|
| Administration, Alaska branch | | $5,700 |
| Special geologic and mineral resources investigation | $500 | 11,900 |
| Reconnaissance geologic surveys | 8,820 | 13,950 |
| Detailed geologic surveys | 4,200 | 7,200 |
| Reconnaissance topographic surveys | 4,850 | 4,100 |
| Detailed topographic surveys | 4,800 | 5,100 |
| Map compilation | | 4,660 |
| Collection of mineral statistics | | 1,800 |
| Miscellaneous expenses, including clerical salaries, etc | 2,630 | 6,660 |
| Office of Director | | 8,500 |
| To be allotted to field work, 1922 | | 5,430 |
| | 25,800 | 75,000 |

*Allotments of Alaskan funds for salaries and field expenses, field season 1921.*

| | 1920–21 | 1921–22 |
|---|---|---|
| Scientific salaries | $500 | $30,490 |
| Field expenses | 22,670 | 21,340 |
| Miscellaneous expenses, including clerical salaries, etc | 2,630 | 9,240 |
| Office of Director | | 8,500 |
| To be allotted to field work, 1922 | | 5,430 |
| | 25,800 | 75,000 |

The following table shows the progress of investigations in Alaska and the annual grants of funds since systematic surveys were begun, in 1898. A varying amount is spent each year on special investigations that yield results which can not be expressed in terms of area. Since 1918 the reduction of the annual appropriation and the increased cost of all field work has not permitted extensive geologic and topographic surveys.

*Progress of surveys in Alaska, 1898–1921.*

| Year. | Appropriation. | Areas covered by geologic surveys. | | | Areas covered by topographic surveys.[a] | | | | Investigations of water resources. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Exploratory (scale 1:625,000 or 1:1,000,000). | Reconnaissance (scale 1:250,000). | Detailed (scale 1:62,500). | Exploratory (scale 1:625,000 or 1:1,000,000). | Reconnaissance (scale 1:250,000; 200-foot contours). | Detailed (scale 1:62,500; 25, 50, or 100 foot contours). | Lines of levels. | Bench marks set. | Gaging stations maintained part of year. | Stream-volume measurements. |
| | | *Sq. m.* | *Sq. m.* | *Sq. m.* | *Sq. m.* | *Sq. m.* | *Sq. m.* | *Miles.* | | | |
| 1898 | $46,189 | 9,500 | ..... | ..... | 12,840 | 2,070 | ..... | ..... | ..... | ..... | ..... |
| 1899 | 25,000 | 6,000 | ..... | ..... | 8,690 | ..... | ..... | ..... | ..... | ..... | ..... |
| 1900 | 60,000 | 3,300 | 6,700 | ..... | 630 | 11,150 | ..... | ..... | ..... | ..... | ..... |
| 1901 | 60,000 | 6,200 | 5,800 | ..... | 10,200 | 5,450 | ..... | ..... | ..... | ..... | ..... |
| 1902 | 60,000 | 6,950 | 10,050 | ..... | 8,330 | 11,970 | 96 | ..... | ..... | ..... | ..... |
| 1903 | 60,000 | 5,000 | 8,000 | 96 | ..... | 15,000 | ..... | ..... | ..... | ..... | ..... |
| 1904 | 60,000 | 4,050 | 3,500 | ..... | 800 | 6,480 | 480 | 86 | 19 | ..... | ..... |
| 1905 | 80,000 | 4,000 | 4,100 | 536 | ..... | 4,880 | 787 | 202 | 28 | ..... | ..... |
| 1906 | 80,000 | 5,000 | 4,000 | 421 | ..... | 13,500 | 40 | ..... | ..... | 14 | 286 |
| 1907 | 80,000 | 2,600 | 1,400 | 442 | ..... | 6,120 | 501 | 95 | 16 | 48 | 457 |
| 1908 | 80,000 | 2,000 | 2,850 | 604 | ..... | 3,980 | 427 | 76 | 9 | 53 | 556 |
| 1909 | 90,000 | 6,100 | 5,500 | 450 | 6,190 | 5,170 | 444 | ..... | ..... | 81 | 703 |
| 1910 | 90,000 | ..... | 8,635 | 321 | ..... | 13,815 | 36 | ..... | ..... | 69 | 429 |
| 1911 | 100,000 | 8,000 | 10,550 | 496 | ..... | 14,460 | 246 | ..... | ..... | 68 | 309 |
| 1912 | 90,000 | ..... | 2,000 | 525 | ..... | ..... | 298 | ..... | ..... | 69 | 381 |
| 1913 | 100,000 | 3,500 | 2,950 | 180 | 3,400 | 2,535 | 287 | ..... | ..... | ..... | ..... |
| 1914 | 100,000 | 1,000 | 7,700 | 325 | 600 | 10,300 | 10 | ..... | ..... | ..... | ..... |
| 1915 | 100,000 | ..... | 10,700 | 200 | ..... | 10,400 | 12 | 3 | 2 | 9 | ..... |
| 1916 | 100,000 | ..... | 5,100 | 636 | ..... | 9,700 | 67 | ..... | ..... | 20 | ..... |
| 1917 | 100,000 | ..... | 1,750 | 275 | ..... | 1,050 | ..... | ..... | ..... | 19 | ..... |
| 1918 | 77,000 | ..... | 3,500 | ..... | ..... | 1,200 | ..... | ..... | ..... | ..... | ..... |
| 1919 | 75,000 | ..... | 2,700 | ..... | ..... | 2,300 | ..... | ..... | ..... | 19 | ..... |
| 1920 | 75,000 | ..... | 1,480 | ..... | ..... | 770 | ..... | ..... | ..... | 19 | ..... |
| 1921 | [b]87,000 | ..... | 2,130 | 150 | ..... | 300 | 205 | ..... | ..... | ..... | ..... |
| | 1,875,189 | 73,200 | 111,095 | 5,657 | 51,680 | 152,600 | 3,936 | 462 | 74 | ..... | ..... |
| Percentage of total area of Alaska | ..... | 12.48 | 18.95 | 0.96 | 8.81 | 26.02 | 0.67 | ..... | ..... | ..... | ..... |

[a] The Coast and Geodetic Survey, International Boundary Commission, and General Land Office have also made topographic surveys in Alaska. The areas covered by these surveys are, of course, not included in these totals.

[b] $12,000 for classification of public lands.

By order of the Director, dated April 1, 1922, the division of Alaskan mineral resources was made the Alaskan mineral resources branch.

Alfred H. Brooks, chief Alaskan geologist, was engaged in office work until August 3 and was absent in Alaska until October 10. He visited Anchorage, Juneau, and the Kantishna and Willow Creek districts. His office time was divided between geologic studies, the annual progress report and press bulletin, field plans, the preparation and delivery of lectures, proof reading, statistics, critical reading and revision of manuscripts, attending scientific meetings, the preparation of an article on the scientist in the Federal service, and administrative and routine matters.

R. H. Sargent made a trip to southeastern Alaska in September, 1921, to investigate areas and methods of topographic surveys. In the office he was occupied chiefly in the administration of Alaska topographic surveys and map compilation.

A. F. Buddington was engaged in geologic mapping and investigation of mineral resources of the Wrangell district.

H. M. Eakin, geologist, was employed under contract to complete the report on the geology and mineral resources of Juneau and vicinity.

A detailed geologic and topographic survey of the Iniskin oil field, on Cook Inlet, was made under the direction of F. H. Moffit. A. A. Baker assisted in the geologic work, and the topographic surveys were made by C. P. McKinley, assisted by Gerald Fitz Gerald.

Richard K. Lynt was detailed to make reconnaissance topographic surveys in the Cold Bay district. About half of his office time has been devoted to map compilation.

S. R. Capps, assisted by W. R. Smith, was employed in geologic reconnaissance surveys in the Cold Bay district. Mr. Capps also continued the preparation of a report on the geology and mineral resources of the region tributary to the Alaska Railroad. On April 16, 1922, he was furloughed for one year to engage in foreign commercial oil work.

The geologic mapping and study of the mineral resources of the Fairbanks quadrangle was continued by J. B. Mertie, jr. His office work also included the completion of the long-delayed report on the Ruby-Kuskokwim region.

George C. Martin was engaged in studying the geology and mineral resources of the lower Yukon and Koyukuk region. Most of his office time has been devoted to geologic studies of the Alaska Mesozoic formations.

C. Arthur Hollick was employed four and one-half months in continuing his studies on the Alaska Tertiary fossil plants.

James McCormick was employed for about five months in the revision of the "Geographic dictionary of Alaska." John H. Renshawe devoted about one month to the completion of the relief map of Alaska. John B. Torbert has been engaged in Alaska cartographic work throughout the year.

Lack of funds prevented the continuation of stream gaging in southeastern Alaska.

Miss Lucy M. Graves, chief clerk, has continued to carry much of the burden of the administration of the Alaska branch and has acted as chief during the absence of the chief Alaskan geologist and of the senior geologist, G. C. Martin. The details of collecting the statistics of the mineral production of Alaska have been in the hands of T. R. Burch.

The field parties for the season of 1922 are distributed as follows:

A. H. Brooks is making general investigations in the coastal regions of Alaska, including some of the Aleutian Islands.

A. F. Buddington is continuing a geologic reconnaissance survey and study of the mineral resources of the Wrangell district.

J. B. Mertie, jr., is extending the geologic reconnaissance surveys and investigations of the mineral resources of a portion of the Yukon-Tanana region.

F. H. Moffit is continuing geologic surveys and a study of the mineral resources of the Chitina region.

R. H. Sargent, assisted by R. K. Lynt, is continuing topographic reconnaissance surveys in the Cold Bay oil field. A. A. Baker and W. R. Smith are attached to this party as geologists.

P. S. Smith is investigating the geology and mineral resources of a part of the region tributary to the Alaska Railroad.

## TOPOGRAPHIC BRANCH.

### ORGANIZATION.

The organization of the topographic branch during the year was as follows:

Chief topographic engineer, C. H. Birdseye.
Atlantic division, topographic engineer in charge, Frank Sutton.
Central division, topographic engineer in charge, W. H. Herron.
Rocky Mountain division,[1] topographic engineer in charge, T. G. Gerdine.
Pacific division,[1] topographic engineer in charge, G. R. Davis.
Division of West Indian surveys, topographic engineer in charge, Glenn S. Smith. (In the absence of Mr. Birdseye, Mr. Smith acted as chief topographic engineer.)
Computing section, topographic engineer in charge, E. M. Douglas.
Section of inspection and editing, topographic engineer in charge, W. M. Beaman.
Section of cartography, draftsman in charge, A. F. Hassan.
Map information office, topographic engineer in charge, J. H. Wheat.
Section of relief maps, geographer in charge, J. H. Renshawe.
Section of photographic mapping, topographic engineer in charge, T. P. Pendleton.[2]

### PERSONNEL.

During the fiscal year one assistant topographic engineer, who had held a commission in the Engineer Officers' Reserve Corps, was reinstated. The technical force was increased by the appointment of 8 junior topographers and the reinstatement and transfer of 2 topographic engineers. The force was reduced by 1 death, 1 retirement, 11 resignations, and 9 transfers. With these changes the corps now includes 1 chief topographic engineer, 4 topographic engineers in charge of divisions, 4 geographers, 75 topographic engineers, 2 topographers, 29 assistant topographic engineers, 35 junior topographers, 1 map editor, 2 map revisers, and 8 draftsmen, a total of 161. During the year 10 topographic engineers, 8 assistant topographic engineers, and 34 junior topographers were on furlough. One topographic engineer in charge of a division and 4 members of the permanent force were on furlough during the year for work in Porto Rico. In addition, 30 technical field assistants were employed during the whole or a part of the year. The clerical force comprises 10 clerks of various grades.

### PUBLICATIONS.

The published work of the topographic branch for the fiscal year consists of 70 new standard topographic maps and 6 new State maps; 4 new State maps are in press. Advance photolithographic editions were printed for 66 new topographic maps now in process of engraving and final publication; and 32 photolithographs were printed of new topographic maps, for which publication has not yet been otherwise provided. A map of Camp A. A. Humphreys and vicinity, Virginia, was printed for the War Department.

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[1] On the death of G. R. Davis, T. G. Gerdine was appointed topographic engineer in charge of the Pacific division and Glenn S. Smith was appointed topographic engineer in charge of the Rocky Mountain division. At this time the State of Washington was added to the Pacific division and the State of Mississippi to the Rocky Mountain division.

[2] T. P. Pendleton was on leave without pay from Apr. 16 to the end of the fiscal year, and during that time J. H. Wheat was in charge of the section.

Seven additional advance chapters of Bulletin 709, giving the results of triangulation and primary traverse for 1916–1918, prepared for publication in 1920, are still in press. Sufficient manuscript is now on hand, awaiting funds for publication, for 30 or more bulletins on spirit leveling, primary traverse, and triangulation, covering work for several years, in more than 35 States.

New features introduced during the year were (1) the classification of roads as to through and secondary routes and the representation of this classification on the topographic maps by a red overprint, (2) the preparation of plan and profile drawings of the special river surveys for reproduction and sale as three-color photolithographs.

APPROPRIATIONS.

The Federal appropriations for topographic surveys for the fiscal year 1922 were as follows:

| | |
|---|---|
| Topographic surveys | $330,000.00 |
| Salaries, scientific assistants | 9,200.00 |
| Special funds for military mapping (contributed by War Department) | 14,321.72 |
| | 353,521.72 |

Practically all of these appropriations were expended during the fiscal year.

COOPERATION.

Cooperation has been maintained in 20 States and 1 Territory, which contributed the following amounts:

| | | | |
|---|---|---|---|
| California | $13,001.85 | South Dakota | $1,960.79 |
| Hawaii | 24,259.11 | Tennessee | 6,049.51 |
| Idaho | 2,712.25 | Texas | 9,459.46 |
| Illinois | 39,756.63 | Utah | 118.22 |
| Iowa | 1,239.20 | Vermont | 2,990.47 |
| Kentucky | 9,726.81 | Virginia | 7,071.01 |
| Maine | 5,676.45 | Washington | 8,421.67 |
| Mississippi | 4,377.98 | West Virginia | 19,860.21 |
| Missouri | 15,556.39 | Wisconsin | 11,840.22 |
| New York | 15,000.00 | | |
| Oregon | 5,553.81 | | 223,416.44 |
| Pennsylvania | 18,784.40 | | |

In addition, repay work was executed as follows: For the land-classification board, work on base maps needed in the classification of lands and power sites, entailing the expenditure of $27,080.76, and in this connection the Southern California Edison Co. cooperated with the Geological Survey on surveys of Colorado River in Utah and Arizona, expending $36,479.39 for work supervised by the Geological Survey; work for the Reclamation Service cost $15,804.45, the larger part of which was made available to the Reclamation Service by the Klamath-Shasta Valley Irrigation District, and in this connection the State of California expended $6,324.59; work for the National Park Service cost $4,269.47; base-map work for the Bureau of Education, $124.85; base-map work for the Bureau of Public Roads, $9,817.66; base-map work for the Forest Service, $976.57; field surveys for the Navy Department, $328.39; base-map work for the State Department, $1,423.67; and work for the War Department on the special military map of Camp A. A. Humphreys,

Va., $716.71. The total amount available from these sources was $103,346.51.

The total amount expended from all sources for the work of the topographic branch was $680,284.67.

## SUMMARY OF RESULTS.

The condition of topographic surveys to June 30, 1922, distinguished as to scale and date, is shown on Plate I.

As shown in the following table, the new area mapped was 11,402 square miles, making the total area surveyed to date in continental United States, exclusive of Alaska, 1,218,912 square miles, or 40.2 per cent of the entire country. In addition, 1,487 square miles of resurvey was completed, making the total area of surveys during the year 12,889 square miles. River surveys amounting to 455 linear miles were also made.

In connection with these surveys, 3,035 linear miles of primary levels were run, making 290,781 miles of primary and precise levels run since the authorization of this work by Congress in 1896. In the course of this work 811 permanent bench marks were established.

Triangulation stations to the number of 73 were occupied and 64 were permanently marked.

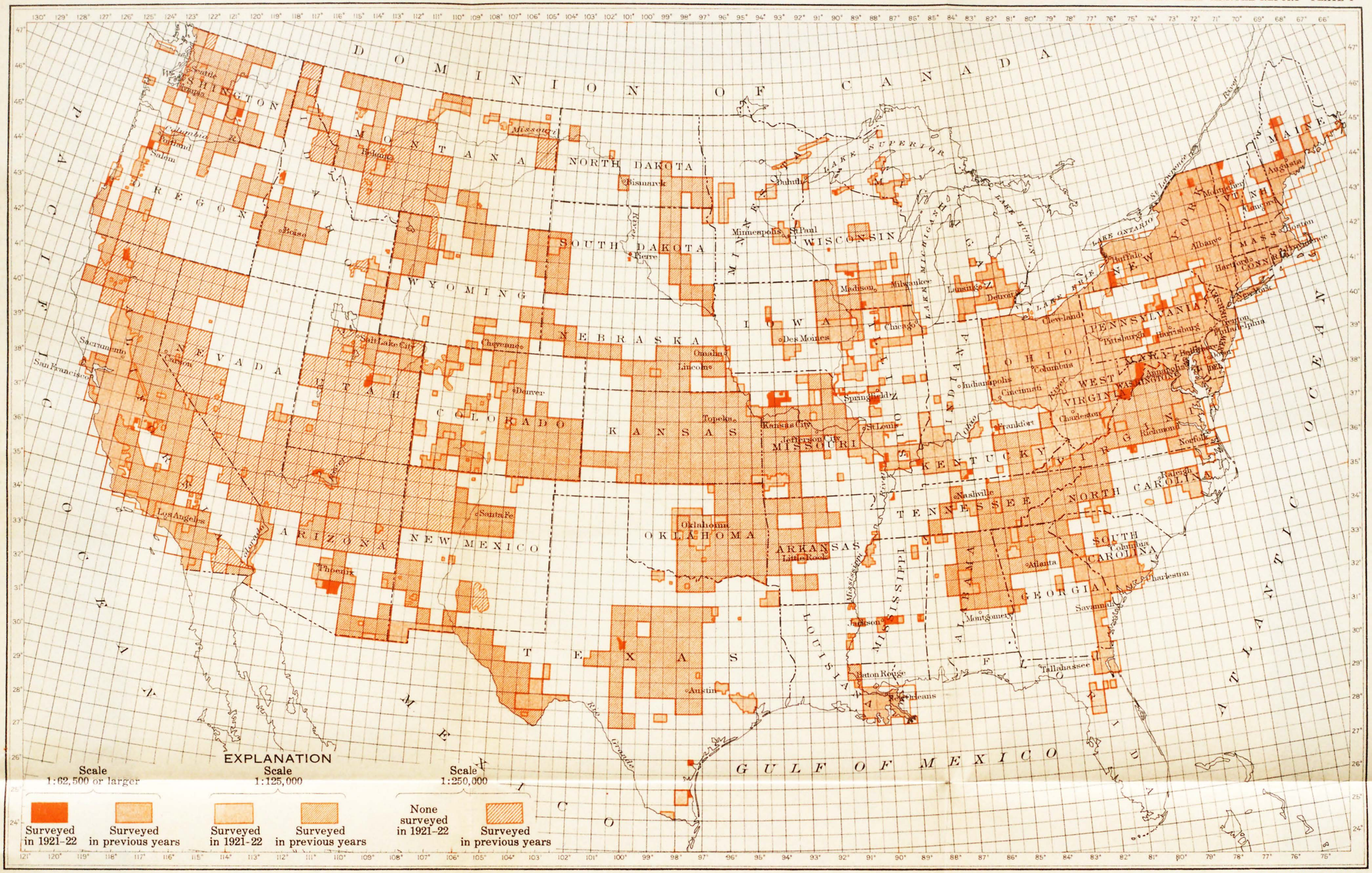
Primary traverse lines aggregating 2,225 miles were run, in connection with which 483 permanent marks were set.

In addition, 655 square miles of topographic mapping was completed in Hawaii, 201 miles of primary levels were run, 63 permanent bench marks established, and 16 triangulation stations were occupied and 12 marked.

*Present condition of topographic surveys of the United States and new area surveyed July 1, 1921, to June 30, 1922.*[a]

| State. | New area mapped July 1, 1921, to June 30, 1922. | Total area mapped to June 30, 1922. | Percentage of total area of State mapped to June 30, 1922. |
|---|---|---|---|
| | *Sq. miles.* | *Sq. miles.* | |
| Alabama | | 19,192 | 37.0 |
| Arizona | 843 | 55,429 | 48.7 |
| Arkansas | | 21,494 | 40.3 |
| California | 861 | 120,062 | 76.1 |
| Colorado | | 51,134 | 49.3 |
| Connecticut | | 4,965 | 100.0 |
| Delaware | | 2,370 | 100.0 |
| District of Columbia | | 70 | 100.0 |
| Florida | | 4,716 | 8.0 |
| Georgia | | 24,835 | 41.9 |
| Idaho | 82 | 28,572 | 33.8 |
| Illinois | 1,998 | 20,414 | 36.0 |
| Indiana | | 3,609 | 10.0 |
| Iowa | 116 | 12,386 | 22.0 |
| Kansas | | 64,159 | 78.0 |
| Kentucky | 419 | 19,197 | 47.2 |
| Louisiana | | 8,366 | 17.2 |
| Maine | 365 | 10,844 | 32.8 |
| Maryland | | 12,327 | 100.0 |
| Massachusetts | | 8,266 | 100.0 |

[a] This table differs from those in previous annual reports in that it has been revised to eliminate areas in Montana, Utah, Arizona, New Mexico, Nevada, and California covered by reconnaissance surveys made by the Powell, Wheeler, Hayden, King, and Northern Transcontinental surveys. Of the areas included in the table fully 50 per cent were covered by maps that are now in need of thorough revision.




# AREAS COVERED BY TOPOGRAPHIC SURVEYS MADE BY UNITED STATES GEOLOGICAL SURVEY PRIOR TO JULY 1, 1922

## AND THE SCALE EMPLOYED FOR EACH AREA

Scale $\frac{1}{14000000}$

100 0 100 200 300 400 500 Miles

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

*Present condition of topographic surveys, etc.*—Continued.

| State. | New area mapped July 1, 1921, to June 30, 1922. | Total area mapped to June 30, 1922. | Percentage of total area of State mapped to June 30, 1922. |
|---|---|---|---|
| | *Sq. miles.* | *Sq. miles.* | |
| Michigan | ..... | 11,153 | 19.2 |
| Minnesota | ..... | 7,354 | 8.7 |
| Mississippi | 622 | 3,762 | 8.0 |
| Missouri | 1,220 | 38,614 | 55.6 |
| Montana | ..... | 41,590 | 28.5 |
| Nebraska | ..... | 27,117 | 35.0 |
| Nevada | ..... | 41,141 | 37.5 |
| New Hampshire | ..... | 4,235 | 45.3 |
| New Jersey | ..... | 8,224 | 100.0 |
| New Mexico | ..... | 40,412 | 32.9 |
| New York | 733 | 46,734 | 94.9 |
| North Carolina | ..... | 18,876 | 36.0 |
| North Dakota | ..... | 10,017 | 14.1 |
| Ohio | ..... | 41,040 | 100.0 |
| Oklahoma | ..... | 39,908 | 57.0 |
| Oregon | 316 | 25,904 | 26.7 |
| Pennsylvania | 1,031 | 28,927 | 64.1 |
| Rhode Island | ..... | 1,248 | 100.0 |
| South Carolina | ..... | 13,675 | 44.1 |
| South Dakota | 77 | 19,109 | 24.6 |
| Tennessee | 137 | 21,420 | 50.9 |
| Texas | 449 | 77,313 | 29.0 |
| Utah | 659 | 16,302 | 19.2 |
| Vermont | 361 | 5,290 | 55.3 |
| Virginia | 214 | 36,272 | 85.0 |
| Washington | 414 | 32,004 | 46.2 |
| West Virginia | ..... | 24,170 | 100.0 |
| Wisconsin | 485 | 14,606 | 26.0 |
| Wyoming | ..... | 30,088 | 30.7 |
| Total continental United States (exclusive of Alaska) | 11,402 | 1,218,912 | 40.2 |
| Hawaii | 655 | 2,416 | 37.4 |

*Topographic surveys from July 1, 1921, to June 30, 1922.*

| State. | Contour interval. | For publication on scale of— | | | | Total area surveyed. | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 : 24,000 | 1 : 31,680 | 1 : 62,500 | 1 : 125,000 | New. | Resurvey. | Total. |
| | *Feet.* | *Sq. miles.* | *Sq. miles.* | *Sq. miles.* | *Sq. miles.* | *Sq. miles.* | *Sq. miles.* | *Sq. miles.* |
| Arizona | 25, 50 | ..... | 60 | 779 | ..... | 839 | ..... | 839 |
| California | 5, 25 | 298 | 563 | ..... | ..... | 861 | ..... | 861 |
| Idaho | 50 | ..... | ..... | 82 | ..... | 82 | ..... | 82 |
| Illinois | 10, 20 | ..... | ..... | 1,998 | ..... | 1,998 | ..... | 1,998 |
| Iowa | 10 | ..... | ..... | 116 | ..... | 116 | ..... | 116 |
| Kentucky | 20 | ..... | ..... | 419 | ..... | 419 | ..... | 419 |
| Maine | 20 | ..... | ..... | 365 | ..... | 365 | ..... | 365 |
| Mississippi | 20 | ..... | ..... | 622 | ..... | 622 | ..... | 622 |
| Missouri | 20 | ..... | ..... | 1,220 | ..... | 1,220 | ..... | 1,220 |
| New York | 20 | ..... | ..... | 733 | ..... | 733 | ..... | 733 |
| Oregon | 25, 50 | ..... | ..... | 316 | ..... | 316 | ..... | 316 |
| Pennsylvania | 20 | ..... | ..... | 1,031 | ..... | 1,031 | ..... | 1,031 |
| South Dakota | 20 | ..... | ..... | 77 | ..... | 77 | ..... | 77 |
| Tennessee | 20 | ..... | ..... | 137 | ..... | 137 | ..... | 137 |
| Texas | 5 | 3 | 356 | 90 | ..... | 449 | ..... | 449 |
| Utah | 5, 20, 50 | ..... | 663 | ..... | ..... | 663 | ..... | 663 |
| Vermont | 20 | ..... | ..... | 361 | ..... | 361 | ..... | 361 |
| Virginia | 20 | ..... | ..... | 214 | ..... | 214 | ..... | 214 |
| Washington | 25, 100 | ..... | ..... | 222 | 192 | 414 | ..... | 414 |
| West Virginia | 50 | ..... | ..... | 1,487 | ..... | ..... | 1,487 | 1,487 |
| Wisconsin | 10, 20 | 36 | ..... | 449 | ..... | 485 | ..... | 485 |
| | | 337 | 1,642 | 10,718 | 192 | 11,402 | 1,487 | 12,889 |
| Hawaii | 10, 50 | ..... | 655 | ..... | ..... | 655 | ..... | 655 |

*Topographic surveys from July 1, 1921, to June 30, 1922*—Continued.

| State. | Levels. | | Primary traverse. | | Triangulation. | |
|---|---|---|---|---|---|---|
| | Distance run. | Permanent bench marks. | Distance run. | Permanent marks. | Stations occupied. | Stations marked. |
| | *Miles.* | | *Miles.* | | | |
| Arizona | 41 | 13 | | | | |
| California | 109 | 25 | 30 | 7 | 38 | 31 |
| Idaho | 51 | 14 | | | 19 | 23 |
| Illinois | 764 | 195 | 741 | 178 | | |
| Kentucky | 66 | 20 | 3 | | | |
| Maine | 8 | 2 | | | | |
| Mississippi | 18 | | | | | |
| Missouri | 428 | 110 | 251 | 56 | | |
| New York | 85 | 25 | 113 | 10 | | |
| Pennsylvania | 332 | 81 | 155 | 1 | | |
| South Dakota | 79 | 17 | | | | |
| Tennessee | 93 | 33 | 166 | 20 | | |
| Texas | 72 | 31 | 99 | 34 | | |
| Vermont | 84 | 19 | | | | |
| Virginia | 34 | 9 | 140 | 42 | | |
| Washington | 32 | | | | | |
| West Virginia | 498 | 143 | | | 16 | 10 |
| Wisconsin | 241 | 74 | 527 | 135 | | |
| | 3,035 | 811 | 2,225 | 483 | 73 | 64 |
| Hawaii | 201 | 63 | | | 16 | 12 |

GENERAL OFFICE WORK.

Computations for vertical and horizontal control were made, and the results were copied and cataloged by the computing section. The section of relief maps prepared shaded relief maps of Alaska, California, Kentucky, and southwestern Arizona, as well as relief maps of the following quadrangles: Seven Devils, Idaho; Howard, Lockhaven, and Williamsport, Pa.; Monument Springs, Tex.; and Washington, D. C., and vicinity. In addition, relief maps were prepared of the area adjacent to the Denver & Rio Grande Western Railroad for illustrations to accompany the Guidebook of the Western United States, Part E. The section of photographic mapping was engaged in miscellaneous work in connection with the utilization of Air Service photographs in topographic mapping. The map information office was engaged in indexing and cataloging the map data available in the several Federal departments and in furnishing miscellaneous map information to the public.

SECTION OF INSPECTION AND EDITING OF TOPOGRAPHIC MAPS.

The section of inspection and editing of topographic maps continued to supervise the office preparation of all field topographic maps and to inspect and edit them before reproduction; it also edited a large number of maps submitted by other Survey branches and Government bureaus.

The number of Survey topographic maps in progress in the topographic branch (exclusive of those being engraved and printed) ranged from 103 in August to 151 in April; the monthly average was 133. An average of 15 employees were engaged in this section for the year.

James McCormick employed one-third of his time as the Survey representative on the United States Geographic Board and on similar special investigations and nearly one-half of the year on a revision of the Geographic Dictionary of Alaska.

The work of the section is described further under "Publication branch" (p. 74).

### SECTION OF CARTOGRAPHY.

The compilation of the base of the United States portion of the international map of the world was continued during the year, with the cooperation of the Bureau of Public Roads. The Maine, Kansas, and Colorado portions of this map, in course of compilation the previous year, were completed, and the Texas portion of this map, also partly compiled the previous year, was 98 per cent completed. Preliminary maps based on the State maps of the General Land Office were also compiled for Louisiana, Oklahoma, Utah, Nevada, and New Mexico. The map of North Carolina was partly revised, and the eastern two-thirds of the map of Montana was completely revised. Maps of this series have been prepared for 46 States.

Other map projects included the preparation of a map of China and adjacent regions for the Department of State in connection with the Conference on Limitation of Armament; a map of Benton County, Tenn., in cooperation with that State; compilation of road data in cooperation with the State of Illinois; road maps of New York, Indiana, and Missouri for the Bureau of Public Roads; and several maps for the Brazilian exhibit of the Federal Board for Vocational Education.

### ATLANTIC DIVISION.

#### FIELD WORK.

*Summary.*—During the season topographic mapping was carried on in Maine, Mississippi, New York, Pennsylvania, Tennessee, Vermont, Virginia, and West Virginia. This work comprised the completion of the survey of 17 quadrangles and 1 special area and the resurvey of 5 quadrangles, in addition to which 12 quadrangles were partly surveyed and 8 were partly resurveyed. Triangulation and primary traverse were carried on by nine parties in New York, Pennsylvania, Tennessee, Virginia, and West Virginia.

*Maine.*—In cooperation with the Maine State Water Power Commission the survey of the Brassua Lake and Farmington quadrangles was completed and that of the Long Pond quadrangle was begun, the total area mapped being 365 square miles, for publication on the sale of 1:62,500, with a contour interval of 20 feet. For the control of the Long Pond quadrangle 8 miles of primary levels were run and 2 permanent bench marks established.

*Mississippi.*—In cooperation with the Mississippi Geological Survey the survey of the Meridian, Morton, and Tupelo quadrangles was completed, and that of the Pelahatchee quadrangle was begun, the total area mapped being 622 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Morton and Pelahatchee quadrangles 18 miles of primary levels were run.

*New York.*—In cooperation with the State engineer of New York, the survey of the Cattaraugus, Livingston Manor, Santa Clara, and Stark quadrangles was completed, and that of the Red House quadrangle was begun, the total area mapped being 733 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Cattaraugus, Red House, and Santa Clara quadrangles 85 miles of primary levels were run and 25 permanent bench marks were established. For the control of the Cattaraugus and Red House quadrangles 113 miles of primary traverse were run and 10 permanent marks set.

At the request of the Bureau of Yards and Docks, Navy Department, a proposed hospital site for the Veterans' Bureau, near Liberty, N. Y., was surveyed. The cost of the work, amounting to $328.39, was paid by the Navy Department.

*Pennsylvania.*—In cooperation with the Pennsylvania State Bureau of Topographic and Geological Survey, the survey of the Howard, Lock Haven, Pocono, Shippensburg, Tyrone, and Williamsport quadrangles was completed and that of the Mauch Chunk, Mount Union, and Milton quadrangles was begun, the total area mapped being 1,031 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For control for new work 332 miles of primary levels were run, 81 permanent bench marks established, 155 miles of primary traverse were run, and 1 permanent mark set.

*Tennessee.*—In cooperation with the Tennessee State geologist, the survey of the Lillydale and Reelfoot Lake quadrangles was begun, the total area mapped being 137 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For control for new work 93 miles of primary levels were run, 33 permanent bench marks established, 166 miles of primary traverse run, and 20 permanent marks set.

*Vermont.*—In cooperation with the Vermont State geologist, the survey of the Bolton quadrangle was completed and that of the Franklin Pond, Montgomery, and Northfield quadrangles was begun, the total area mapped being 361 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Franklin Pond and Montgomery quadrangles, 84 miles of primary levels were run and 19 permanent bench marks established.

*Virginia.*—In cooperation with the State geologist of Virginia, the survey of the Chatham quadrangle was completed, and that of the Callands quadrangle was begun, the total area mapped being 214 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Callands quadrangle and for new work 34 miles of primary levels were run, 9 permanent bench marks established, 140 miles of primary traverse run, and 42 permanent marks set.

*West Virginia.*—In cooperation with the State geologist of West Virginia, the resurvey of the Circleville, Hanging Rock, Richwood, and White Sulphur Springs quadrangles was completed and that of the Horton quadrangle was begun, the total area mapped being 658 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. For control for new work, 361 miles of primary levels were run and 105 permanent bench marks were established. For the control of the Circleville and Durbin quadrangles 5 triangulation stations were occupied, 4 of which were marked. E. I. Ireland, topographic engineer, was in immediate charge of the field work.

*West Virginia-Virginia.*—In cooperation with the State geologist of West Virginia, the resurvey of the Wardensville quadrangle and the West Virginia portion of the Capon Bridge, Fort Seybert, Edinburg, McDowell, Middletown, and Orkney Springs quadrangles was completed, and that of the Winterburn quadrangle was begun, the total area mapped being 829 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. The area mapped was all in West Virginia. For control for new work 137 miles of primary levels were run, 38 permanent bench marks established, and 11 triangulation stations occupied, 6 of which were marked.

### OFFICE WORK.

The drafting of 23 sheets was completed and that of 10 sheets begun. Primary-level circuits were adjusted for 56 quadrangles. Geographic positions were computed for 44 quadrangles.

## CENTRAL DIVISION.

### FIELD WORK.

*Summary.*—During the season topographic mapping was carried on in Illinois, Iowa, Kentucky, Missouri, and Wisconsin. This work comprised the completion of the survey of 10 quadrangles and 9 special areas, in addition to which 11 quadrangles and 3 special areas were partly surveyed. Primary traverse was carried on by six parties in Illinois, Kentucky, Missouri, and Wisconsin.

*Illinois.*—In cooperation with the Illinois Department of Registration and Education, the survey of the Alto Pass, Buda, and Monmouth quadrangles was completed and that of the Liberty, Oregon, and Quincy quadrangles was begun, the total area mapped being 666 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For control for new work, 764 miles of primary levels were run, 195 permanent bench marks established, 741 miles of primary traverse run, and 178 permanent marks set.

In addition, the survey of a number of areas along certain proposed trunk-line highway routes was begun. These surveys of fractional areas have been designated as numbered projects. The survey of projects Nos. 1, 1A, 1B, 3, and 9 was completed, and that of Nos. 2 and 13 was begun, the total area mapped being 1,034 square miles, for publication on the scale of 1:62,500, with a contour interval of 10 feet. This work was done in such a manner as to be available for future incorporation in regular topographic maps.

The survey of the Virden special area was completed, the total area mapped being 298 square miles, for publication on the scale of 1:62,500, with a contour interval of 10 feet.

*Iowa.*—In cooperation with the Iowa State Geological Survey, the survey of the Lehigh quadrangle was completed, the total area mapped being 116 square miles, for publication on the scale of 1:62,500, with a contour interval of 10 feet.

*Kentucky.*—In cooperation with the Kentucky Geological Survey, the survey of the Bowling Green quadrangle was completed and that of the Frankfort and Mammoth Cave quadrangles was begun, the total area mapped being 285 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Frankfort and Mammoth Cave quadrangles 66 miles of primary levels were run and 20 permanent bench marks were established.

*Kentucky-Illinois.*—In cooperation with the State of Kentucky, the survey of the Cave in Rock quadrangle was completed, the total area mapped being 134 square miles (all in Kentucky), for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Leitchfield quadrangle 3 miles of primary traverse were run.

*Missouri.*—In cooperation with the Missouri State geologist, the survey of the Braymer and Chillicothe quadrangles was completed and that of the Cape Girardeau, Chula, Dawn, Hale, Polo, and Winston quadrangles was begun, the total area mapped being 1,182 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For control for new work 424 miles of primary levels were run, 110 permanent bench marks established, 251 miles of primary traverse run, and 56 permanent marks set.

*Missouri-Illinois.*—In cooperation with the State of Missouri, the survey of the Jonesboro quadrangle was completed, the total area mapped being 38 square miles (all in Missouri), for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of this area 4 miles of primary levels were run.

*Wisconsin.*—In cooperation with the State geologist of Wisconsin, the survey of the South Wayne quadrangle was completed, the total area mapped being 180 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For control for new work 154 miles of primary levels were run, 51 permanent bench marks established, 511 miles of primary traverse run, and 131 permanent marks set.

In addition, the survey of the Gogebic range area was completed, the area mapped being 36 square miles, for publication on the scale of 1:24,000, with a contour interval of 10 feet.

The survey of highway projects Nos. $A_1$ and $A_2$ was also completed and that of highway project No. $A_3$ was begun, the total area mapped being 269 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of these projects 87 miles of primary levels were run, 23 permanent bench marks established, 16 miles of primary traverse run, and 4 permanent marks set.

### OFFICE WORK.

The drafting of 18 sheets was completed and that of 22 sheets was begun. Primary-level circuits were adjusted for 58 quadrangles. Geographic positions were computed for 80 quadrangles.

## ROCKY MOUNTAIN DIVISION.

### FIELD WORK.

*Summary.*—During the season topographic mapping was carried on in Arizona, Idaho, South Dakota, Texas, Utah, and Washington. This work comprised the completion of the survey of five quadrangles and one special area and the partial survey of 21 quadrangles. In addition, a profile survey was made of portions of two rivers. Triangulation and primary traverse were carried on by three parties in Idaho and Texas.

*Arizona.*—In cooperation with the National Park Service for work in the Grand Canyon the survey of the Supai quadrangle was continued, the total area mapped being 142 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet.

In addition, the survey of the Casa Grande Valley was continued, the total area mapped being 637 square miles, for publication on the scale of 1:62,500, with a contour interval of 25 feet. In connection with this project the survey of two quadrangles was completed and that of three quadrangles was begun. For the control of this area 41 miles of primary levels were run and 13 permanent bench marks were established. This work was done for the land-classification board, the topographic branch furnishing the services of experienced topographic engineers and the necessary instruments.

*Arizona-Utah.*—In cooperation with the Southern California Edison Co. the Geological Survey made special surveys and investigations in Arizona and Utah to ascertain the feasibility of storage and diversion of the waters of Colorado River. This was known as the Glen Canyon investigation. Surveys were carried from the mouth of Green River down Colorado River to Lees Ferry, Ariz., and in conjunction therewith surveys were carried from Bluff, Utah, down San Juan River to its mouth for the purpose of determining the capacity and extent of the reservoir, with a dam site located on Colorado River in the vicinity of Lees Ferry. In this work 485 square miles of topographic mapping (60 square miles in Arizona and 425 square miles in Utah) and 349 miles of river traverse were completed, for publication on the scale of 1:31,680, with contour intervals of 5 and 20 feet. In connection with this investigation a dam-site survey covering 7 square miles was completed in the vicinity of Lees Ferry on the scale of 1:4,800. For the control of this project about 425 miles of precise levels were run by the United States Coast and Geodetic Survey between Green River, Utah, and Flagstaff, Ariz. About 130 miles of these levels, between Halls Crossing and Lees Ferry, follow Colorado River.

*Idaho.*—In cooperation with the Forest Service triangulation was extended over the Idaho National Forest, 19 stations being occupied, 34 located, and 23 marked; 51 miles of primary levels were run and 14 permanent bench marks established. In connection with this work a reconnaissance photographic map covering 1,200 square miles in the Idaho National Forest was completed.

*Idaho-Oregon.*—In cooperation with the State Bureau of Mines and Geology of Idaho and the State Bureau of Mines and Geology of Oregon the survey of the He Devil quadrangle was begun, the total area mapped being 128 square miles (82 square miles in Idaho and 46 square miles in Oregon), for publication on the scale of 1:62,500, with a contour interval of 50 feet.

*South Dakota.*—In cooperation with the State geologist of South Dakota, the survey of the Pierre quadrangle was begun, the total area mapped being 77 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of this area 79 miles of primary levels were run and 17 permanent bench marks were established.

*Texas.*—In cooperation with the Texas Bureau of Economic Geology and Technology, the survey of the Corpus Christi quadrangle was begun, the total area mapped being 90 square miles, for publication on the scale of 1:62,500, with a contour interval of 5 feet. In connection with this work 25 miles of primary levels were run, 19 permanent bench marks established, 99 miles of primary traverse run, and 34 permanent marks set.

In cooperation with the State Board of Water Engineers, the survey of the Bronte-Ballinger irrigation project, consisting of the Bronte, Spur Creek, Hatchel, Quarry Creek, Miles, Mays School, Maverick, Marie, Baker Flat, Rowena, and Lowake quadrangles, was completed, the total area mapped being 355 square miles, for publication on the scale of 1:31,680, with a contour interval of 5 feet. In connection with this project the survey of a dam site covering

1 square mile on the scale of 1:1,200 was made, also the survey of a reservoir site on the scale of 1:24,000 was completed, 3 square miles being mapped. For the control of this area 47 miles of primary levels were run and 12 permanent bench marks established.

In addition, 210 linear miles of road traverse in Henderson County, covering 132 square miles, were executed for the Bureau of Soils to serve as data for base maps on which to plot the soil classification. This work was done in such a manner as to be available for future incorporation in regular topographic maps.

*Utah.*—The survey of the Castle Dale, Hiawatha, and Monument Peak quadrangles, Utah, was begun, the total area mapped being 238 square miles, for publication on the scale of 1:31,680, with a contour interval of 50 feet. This work was done for the land-classification board, the topographic branch furnishing the services of an experienced topographic engineer and the necessary instruments.

*Washington.*—In cooperation with the Washington State Department of Conservation and Development, the survey of the Corfu and Sultan quadrangles was completed and that of the Othello No. 3 was begun, the total area mapped being 414 square miles, for publication on the scales of 1:62,500 and 1:125,000, with contour intervals of 25 and 100 feet. For the control of the Corfu quadrangle 32 miles of primary levels were run.

### OFFICE WORK.

The drafting of 4 sheets was completed and that of 9 sheets begun. Primary-level circuits were adjusted for 13 quadrangles. Geographic positions were computed for 14 quadrangles.

## PACIFIC DIVISION.

### FIELD WORK.

*Summary.*—During the season topographic mapping was carried on in California, Hawaii, and Oregon. This work included the completion of the survey of 36 quadrangles and the partial survey of 3 quadrangles and 1 special area. In addition a profile survey of one river was completed. Triangulation and primary traverse were carried on by two parties in California and Hawaii.

*California.*—In cooperation with the California Department of Public Works, for work in San Joaquin Valley, the survey of the Aukland, Clovis, Fresno, Herndon, Malaga, Mendota, Monocline Ridge, No. 21, No. 25, No. 26, No. 27, Reedley special, Squaw Valley, and Wahtoke quadrangles was completed, the total area mapped being 563 square miles, for publication on the scale of 1:31,680, with a contour interval of 5 feet. For the control of the Riverdale quadrangle, 30 miles of primary traverse were run and 7 permanent marks set.

In cooperation with the United States Reclamation Service, the Klamath-Shasta Valley irrigation district, and the Department of Public Works of California, the survey of a portion of Shasta Valley was begun on a scale of 2,000 feet to the inch, with a contour interval of 5 feet, for preliminary study and planning the general outline of an irrigation system, it being understood that, if the project is found feasible, a resurvey on a larger scale will be necessary. In connection with this project, 298 square miles of topographic mapping was completed. For the control of this area, 109 miles of primary levels were run. 25 permanent bench marks established, and 38 triangulation stations occupied, 31 of which were marked.

In addition, 106 linear miles of river traverse along Klamath River were completed for the land-classification board, the topographic branch furnishing the services of an experienced topographic engineer and the necessary instruments.

*Hawaii.*—In cooperation with the governor of Hawaii, the survey of the Honakahau NW. ¼, Honakahau SW. ¼, Honuapo NW. ¼, Honuapo SW. ¼, Kahului NW. ¼, Kalae NW. ¼, Kaunakakai NE. ¼, Kaunakakai NW. ¼, Kaunakakai SE. ¼, Kaunakakai SW. ¼, Kilauea NE. ¼, Kilauea NW. ¼, Papohaku NE. ¼, Papohaku SE. ¼, Pukoo NE. ¼, Pukoo SE. ¼, Pukoo SW. ¼, Pukoo NW. ¼, Puna NW. ¼, and Puna SW. ¼ quadrangles was completed and that of the Puna NE. ¼ and Puna SE. ¼ quadrangles was begun, the total area mapped being 655 square miles, for publication on the scale of 1:31,680, with contour intervals of 10 and 50 feet. For control for new work 201 miles of primary levels were run, 63

permanent bench marks established, and 16 triangulation stations occupied, 12 of which were marked. A. O. Burkland, topographic engineer, was in immediate charge of the field work.

*Oregon.*—In cooperation with the War Department, the survey of the Reedsport quadrangle, Oreg., was completed, and that of the Earl quadrangle was continued, the total area mapped being 58 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet.

In cooperation with the State engineer, the survey of the Mount Angel quadrangle was completed, the total area mapped being 212 square miles, for publication on the scale of 1:62,500, with a contour interval of 25 feet.

#### OFFICE WORK.

The drafting of 44 sheets was completed and that of 5 begun. Primary-level circuits were adjusted for 13 quadrangles. Geographic positions were computed for 15 quadrangles.

## WATER-RESOURCES BRANCH.

### ORGANIZATION.

The work of the water-resources branch was conducted under the supervision of N. C. Grover, chief hydraulic engineer, and is organized in five divisions:

Division of surface water, John C. Hoyt, hydraulic engineer, in charge.
Division of ground water, O. E. Meinzer, geologist, in charge.
Division of quality of water, W. D. Collins, chemist, in charge.
Division of power resources, A. H. Horton, hydraulic engineer, in charge.
Division of enlarged and stock-raising homesteads, H. C. Cloudman, classifier, in charge.

### PERSONNEL.

During the year the technical force was reduced 13 and was increased 14—a net increase of 1. At the end of the year the force consisted of 1 chief hydraulic engineer, 35 hydraulic engineers, 6 engineers, 26 assistant engineers, 23 junior engineers, 4 geologists, 1 assistant geologist, 1 chemist, 3 associate chemists, 10 classifiers, and 1 expert mechanician, a total of 111. Of this number 1 assistant engineer is on leave without pay, and 4 hydraulic engineers, 3 assistant engineers, 2 junior engineers, and 1 expert mechanician are employed occasionally. In addition, 12 members of the advisory board of the superpower survey hold appointments for occasional service in the study of problems relating to interconnection of power systems, especially those crossing State boundaries.

In the clerical force there were 4 separations and 2 accessions, and at the end of the year the force numbered 34. Of this number 5 are employed occasionally.

### ALLOTMENTS.

The appropriation for gaging streams was $180,000. In addition $95,500 of the appropriation for classification of lands was expended for field work by the water-resources branch. Of the total appropriations, 79 per cent was allotted for work in public-land States. The cooperative funds made available by State allotments, amounting to $217,010, have been increased in some States and decreased in others, making necessary corresponding adjustments of this work.

*Allotments of appropriation for gaging streams, 1921–22.*

| | |
|---|---|
| Administration, general | $17,658.02 |
| Branch administration | 10,300.00 |
| Computations | 17,000.00 |
| Inspection | 1,400.00 |
| | 46,358.02 |
| Surface water: | |
| Connecticut | 500.00 |
| Maine | 1,000.00 |
| New Hampshire | 1,500.00 |
| Vermont | 1,000.00 |
| Massachusetts | 2,500.00 |
| New York | 5,500.00 |
| New Jersey | 1,500.00 |
| Middle Atlantic States | 3,000.00 |
| South Atlantic States | 5,000.00 |
| Tennessee and Kentucky | 3,000.00 |
| Ohio | 3,000.00 |
| Texas | 5,000.00 |
| Wisconsin | 3,500.00 |
| Minnesota | 300.00 |
| Iowa | 2,000.00 |
| Illinois | 1,500.00 |
| Surface water—Continued. | |
| Missouri | $4,000.00 |
| Kansas | 3,500.00 |
| Colorado, Wyoming, and New Mexico | 7,500.00 |
| Montana | 5,000.00 |
| North Dakota | 300.00 |
| Utah | 5,000.00 |
| Nevada | 3,000.00 |
| Idaho | 5,000.00 |
| Oregon | 5,000.00 |
| Washington | 5,000.00 |
| California | 5,500.00 |
| Arizona | 3,500.00 |
| Hawaii | 4,500.00 |
| | 96,600.00 |
| Ground water | 10,000.00 |
| Quality of water | 14,000.00 |
| Power resources | 10,000.00 |
| General supplies | 700.00 |
| Contingent | 2,341.98 |
| | 180,000.00 |

COOPERATION.

*States.*—The following amounts were expended by States from cooperative allotments. In addition, several State agencies cooperated by furnishing office quarters and occasional service in field and office.

| | | |
|---|---|---|
| Alabama | | $110 |
| Arizona: | | |
| State water commissioner— | | |
| Stream-gaging fund | $3,000 | |
| General fund | 1,160 | |
| | | 4,160 |
| California: | | |
| State engineer | 12,185 | |
| Division of water rights | 9,730 | |
| City and county of San Francisco | 2,645 | |
| Los Angeles County | 3,325 | |
| San Bernardino, Riverside, and Orange counties | 2,995 | |
| | | 30,880 |
| Colorado | | 800 |
| Georgia | | 270 |
| Hawaii: | | |
| Commissioner of public lands | 28,520 | |
| City and county of Honolulu | 310 | |
| | | 28,830 |
| Idaho: | | |
| Outside of Snake River basin | 17,255 | |
| Snake River basin | 1,933 | |
| | | 19,190 |
| Illinois | | 3,820 |
| Iowa: | | |
| State Highway Commission | 2,300 | |
| State Geological Survey | 725 | |
| | | 3,025 |
| Kansas | | 3,885 |

| | | |
|---|---|---|
| Kentucky | | $650 |
| Maine | | 4,330 |
| Massachusetts | | 3,200 |
| Minnesota | | 810 |
| Missouri | | 9.810 |
| Montana | | 8,150 |
| Nevada | | 3,115 |
| New Hampshire | | 1,450 |
| New Jersey: | | |
| State Department of Conservation and Development | $11,225 | |
| City of Morristown | 65 | |
| Borough of Pompton Lakes | 260 | |
| | | 11,550 |
| New York: | | |
| State engineer | 13,245 | |
| City of Rochester | 85 | |
| | | 13,330 |
| North Carol'na | | 4,140 |
| North Dakota | | 565 |
| Ohio | | 6,000 |
| Oregon | | 11,530 |
| Tennessee | | 3,090 |
| Texas | | 14,635 |
| Utah | | 4,435 |
| Vermont | | 1,130 |
| Washington: | | |
| Department of Conservation and Development | 6,335 | |
| City of Seattle | 580 | |
| City of Tacoma | 100 | |
| Intercounty River Improvement Commission | 55 | |
| | | 7,070 |
| West Virginia | | 425 |
| Wisconsin | | 6,045 |
| Wyoming | | 6,580 |
| | | 217,010 |

The work done under cooperative agreements with the States has been restricted to studies of stream flow, except in Arizona, California, Connecticut, Idaho, and North Dakota.

*Reclamation Service.*—The measurement of streams that are to furnish water to reclamation projects under construction has been continued in cooperation with the United States Reclamation Service. The field work is done by Survey engineers who are employed in the locality, and the cost is repaid by the Reclamation Service through transfer of funds.

*Office of Indian Affairs.*—In accordance with authorization by the Office of Indian Affairs, stream gaging was continued on the Crow, Fort Hall, Yakima, Colville, Klamath, Gila River, Shoshone, Western Shoshone, Walker River, and Uinta Indian reservations.

*National Park Service.*—Streams in the Yosemite, Yellowstone, and Glacier national parks were measured during the year at stations maintained in cooperation with the National Park Service.

*Forest Service.*—A study of stream flow in the Angeles National Forest, in southern California, was continued in cooperation with the Forest Service. Stream gaging in the Arapaho and Uncompahgre national forests was done by the Forest Service, which was reimbursed by the Geological Survey.

*City of San Francisco.*—In connection with the proposed storage of the water of Tuolumne River in Hetch Hetchy Valley as a water sup-

ply for the city of San Francisco, measurement of that stream was continued in cooperation with the city government.

*Colorado River Commission.*—Cooperation was extended to the Colorado River Commission by furnishing data in regard to stream flow and by starting a comprehensive system of gaging on the Colorado and its tributaries.

*Federal Power Commission.*—Projects of the Federal Power Commission in Oregon, California, Idaho, Colorado, and Arizona were examined. The operations of one California licensee of the commission are supervised by the Geological Survey, as well as the operations of one Arizona and one Oregon permittee of the commission. All stream gaging by permittees of the commission is done in cooperation with the Geological Survey. Such cooperative stream gaging is in progress in Virginia, North Carolina, South Carolina, Florida, Alabama, Louisiana, Arkansas, Washington, Idaho, Utah, Oregon, Arizona, California, Montana, Wisconsin, Colorado, and Iowa.

## PUBLICATIONS.

The publications of the year prepared by the water-resources branch comprised 8 reports and 3 separate chapters. Titles and brief summaries of these publications are given on pages 9–10. At the end of the year 22 other reports were in press and 10 manuscripts were awaiting editorial work.

## DIVISION OF SURFACE WATER.

### ORGANIZATION.

The work of the division of surface water consists primarily of the measurement of the flow of rivers, but it includes also special investigations of conditions affecting stream flow and the utilization of the streams. In carrying on the work the United States is divided into 19 districts, including Hawaii. The district offices and engineers in charge are as follows:

New England: C. H. Pierce, customhouse, Boston, Mass.
New York: C. C. Covert, Journal Building, Albany, N. Y.
New Jersey: O. W. Hartwell, State House, Trenton, N. J.
Middle Atlantic and Ohio River: A. H. Horton, Washington, D. C.
South Atlantic and eastern Gulf: W. E. Hall, 33–35 Broadway, Asheville, N. C.
Tennessee: W. R. King, Municipal Building, Chattanooga, Tenn.
Upper Mississippi River: S. B. Soulé, Capitol Building, Madison, Wis.; suboffices, Kimball Building, Chicago, Ill., and Ames, Iowa.
Missouri-Kansas: E. L. Williams, Rolla, Mo.; suboffice, Federal Building, Topeka, Kans.
Upper Missouri River: W. A. Lamb, Montana National Bank Building, Helena, Mont.
Rocky Mountain: Robert Follansbee, Post Office Building, Denver, Colo.
Great Basin: A. B. Purton, Federal Building, Salt Lake City, Utah.
Idaho: C. G. Paulsen, Idaho Building, Boise, Idaho.
Snake River basin: G. C. Baldwin, Federal Building, Idaho Falls, Idaho.
Washington: G. L. Parker, Federal Building, Tacoma, Wash.
Oregon: F. F. Henshaw, Post Office Building, Portland, Oreg.
California: H. D. McGlashan, customhouse, San Francisco, Calif.; suboffice, Federal Building, Los Angeles, Calif.
Arizona: R. C. Rice, care of University of Arizona, Tucson, Ariz.
Texas: C. E. Ellsworth, Capitol Building, Austin, Tex.
Hawaii: E. D. Burchard, Capitol Building, Honolulu, Hawaii.

## CHARACTER AND METHODS OF WORK.

Field investigations necessary to the work are made from the district offices, where the results are sufficiently analyzed to insure accuracy and completeness. At selected places, known as gaging stations, the volume of water carried by the streams is measured and records of stage and other data are collected from which the daily flow of the streams is computed. Data collected from the district offices are transmitted to Washington, where they are reviewed in the computing section and prepared for publication. By this review the records obtained in different parts of the country are brought to a uniform standard, and standardization is further effected through annual conferences of the engineers.

At the end of the year 1,540 gaging stations were being maintained, including 77 in Hawaii; 258 stations were discontinued and 444 new stations established during the year. Records for about 165 additional stations were received, ready for publication, from a number of Government bureaus and private persons, and a number of Government and State organizations and individuals also cooperated in the maintenance of the regular gaging stations.

*Gaging stations and cooperating parties for the year ended June 30, 1922.*

| State. | Geological Survey alone. | Reclamation Service. | Forest Service. | Indian Office. | Army engineers. | Weather Bureau. | Other Federal bureaus. | State cooperation. | Municipal cooperation. | Private persons. | Counted more than once. | Maintained at end of year. | Established during year. | Discontinued during year. | Regular gagings during year. | Miscellaneous gagings during year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alabama | .... | .... | .... | .... | 1 | 1 | .... | 2 | 2 | 5 | 1 | 10 | 9 | 3 | 29 | 5 |
| Arizona | .... | 1 | .... | .... | .... | .... | .... | 22 | ..... | 1 | 5 | 22 | 1 | 13 | 567 | 52 |
| Arkansas | .... | .... | .... | .... | .... | .... | .... | ..... | ..... | 2 | ..... | 2 | 2 | ..... | 2 | ..... |
| California | .... | .... | 23 | 1 | .... | 1 | 6 | 193 | 44 | 65 | 140 | 193 | 43 | 3 | 2,789 | 643 |
| Colorado | 5 | 1 | 8 | .... | .... | 1 | .... | 19 | 1 | 3 | 3 | 35 | 1 | 5 | 133 | ..... |
| Connecticut | 1 | .... | .... | .... | .... | .... | .... | ..... | ..... | 2 | ..... | 3 | ..... | 3 | 4 | ..... |
| Florida | .... | .... | .... | .... | .... | .... | .... | ..... | ..... | 2 | ..... | 2 | 3 | 1 | 3 | ..... |
| Georgia | .... | .... | .... | .... | 2 | 2 | .... | 4 | ..... | 9 | 3 | 14 | .... | 1 | 8 | 4 |
| Idaho | .... | 4 | 8 | 14 | .... | 2 | .... | 93 | 1 | 187 | 73 | 236 | 124 | 124 | 1,578 | 268 |
| Illinois | .... | .... | .... | .... | 1 | 3 | 7 | 27 | 1 | 1 | 13 | 27 | 3 | 5 | 96 | 6 |
| Indiana | .... | .... | .... | .... | .... | .... | .... | ..... | ..... | 2 | ..... | 2 | 1 | ..... | 1 | ..... |
| Iowa | .... | .... | .... | .... | .... | 5 | .... | 20 | ..... | 7 | 4 | 28 | 1 | ..... | 103 | 2 |
| Kansas | .... | .... | .... | .... | .... | 2 | .... | 30 | 1 | 9 | 12 | 30 | 14 | 1 | 120 | 4 |
| Kentucky | .... | .... | .... | .... | .... | 1 | .... | 4 | ..... | ..... | ..... | 5 | ..... | ..... | 7 | 3 |
| Louisiana | .... | .... | .... | .... | .... | .... | .... | ..... | ..... | 1 | ..... | 1 | 1 | ..... | ..... | ..... |
| Maine | .... | .... | .... | .... | .... | .... | .... | 16 | ..... | 4 | 4 | 16 | ..... | 1 | 70 | ..... |
| Maryland | 3 | .... | .... | .... | .... | .... | .... | ..... | ..... | ..... | ..... | 3 | ..... | ..... | 8 | ..... |
| Massachusetts | .... | .... | .... | .... | .... | .... | .... | 17 | ..... | ..... | ..... | 17 | ..... | ..... | 92 | 1 |
| Michigan | .... | .... | .... | .... | .... | .... | .... | ..... | ..... | 1 | ..... | 1 | 1 | 1 | 1 | ..... |
| Minnesota | .... | .... | .... | .... | 2 | 2 | .... | 6 | ..... | ..... | ..... | 10 | ..... | ..... | 38 | ..... |
| Missouri | .... | .... | .... | .... | .... | 2 | .... | 43 | ..... | 7 | 7 | 45 | 40 | ..... | 269 | 14 |
| Montana | 8 | 32 | 2 | 11 | .... | .... | .... | 70 | ..... | 1 | ..... | 124 | 23 | 24 | 438 | 63 |
| Nevada | .... | .... | .... | 3 | .... | .... | .... | 29 | ..... | 12 | 15 | 29 | 7 | 2 | 165 | 27 |
| New Hampshire | .... | .... | .... | .... | .... | .... | .... | 10 | ..... | 6 | 6 | 10 | 1 | 4 | 78 | ..... |
| New Jersey | .... | .... | .... | .... | .... | .... | .... | 26 | 3 | 6 | 9 | 26 | 26 | 1 | 229 | 43 |
| New Mexico | .... | 1 | .... | .... | .... | .... | .... | ..... | ..... | ..... | ..... | 1 | 1 | ..... | 1 | ..... |
| New York | .... | .... | .... | .... | 1 | 2 | .... | 54 | 1 | 16 | 20 | 54 | 6 | 7 | 233 | 14 |
| North Carolina | .... | .... | .... | .... | 14 | 1 | .... | 4 | ..... | 6 | ..... | 25 | 24 | 20 | 158 | 6 |
| North Dakota | .... | .... | .... | .... | .... | .... | .... | 8 | ..... | ..... | ..... | 8 | 3 | ..... | 17 | ..... |
| Ohio | .... | .... | .... | .... | 2 | 7 | .... | 21 | 10 | 4 | 2 | 42 | 40 | ..... | 217 | 24 |
| Oregon | .... | 2 | 1 | 9 | .... | 3 | .... | 92 | 29 | 24 | 68 | 92 | 18 | ..... | 485 | 20 |
| South Carolina | .... | .... | .... | .... | .... | .... | .... | ..... | ..... | 2 | ..... | 2 | 2 | ..... | 7 | ..... |
| Tennessee | .... | .... | .... | .... | 26 | 11 | .... | 35 | ..... | 9 | 46 | 35 | ..... | 1 | 140 | 4 |
| Texas | .... | .... | .... | .... | .... | 3 | .... | 50 | 6 | 8 | 17 | 50 | 13 | 3 | 365 | 67 |
| Utah | .... | 1 | .... | 4 | .... | .... | .... | 54 | 1 | 22 | 28 | 54 | 5 | 9 | 219 | 58 |
| Vermont | .... | .... | .... | .... | .... | .... | .... | 11 | ..... | 6 | 6 | 11 | 2 | 3 | 41 | 11 |
| Virginia | 3 | .... | .... | .... | 7 | 1 | .... | ..... | ..... | 4 | 1 | 14 | 1 | ..... | 43 | 1 |
| Washington | 2 | .... | 3 | 10 | .... | .... | 2 | 64 | 22 | 28 | 63 | 68 | 2 | 11 | 439 | 14 |
| West Virginia | .... | .... | .... | .... | 6 | .... | .... | 11 | ..... | 5 | 6 | 16 | 2 | ..... | 55 | 2 |
| Wisconisn | .... | .... | .... | .... | 3 | .... | .... | 43 | ..... | 9 | 12 | 43 | 1 | 2 | 161 | ..... |
| Wyoming | .... | 7 | 1 | 6 | .... | 1 | 2 | 42 | ..... | 10 | 12 | 57 | 2 | 2 | 217 | 5 |
| Hawaii | .... | .... | .... | .... | .... | .... | .... | 77 | 3 | 29 | 32 | 77 | 21 | 8 | 343 | 53 |
| | 22 | 49 | 46 | 58 | 65 | 51 | 17 | 1,197 | 125 | 515 | 605 | 1,540 | 444 | 258 | 9,969 | 1,414 |

### PUBLICATIONS.

For convenience and uniformity in publications the United States has been divided into 12 primary drainage basins, and the results of stream measurements are published annually in a series of progress reports that correspond to these 12 divisions; the records for the twelfth division are published in three papers. In addition to the progress reports, special reports on hydraulic subjects have been completed for publication during the year.

## DIVISION OF GROUND WATER.

### GENERAL FEATURES.

The division of ground water investigates the waters that lie below the surface—their occurrence, quantity, quality, and head; their recovery through wells and springs; and their utilization for domestic, industrial, irrigation, and public supplies and at watering places for live stock and desert travelers. Each year surveys are made of selected areas where the problems of water supply are most urgent, and the results are generally published in water-supply papers that include maps showing the ground-water conditions. The investigations relating to quality of water are made in cooperation with the division of quality of water; the surveys in the Atlantic Coastal Plain and in the West Indies are made by the geologic branch. Reports on parts of Mississippi, South Carolina, and Texas are not yet completed or are awaiting publication.

Projects involving large expenditures for drilling wells to develop water supplies are considered each year by the United States Government, especially by the War and Navy departments. The ground-water division is called upon to furnish information and advice on a large number of these projects.

Important features of the year's work were (1) cooperation with the State of Idaho in a systematic survey of the artesian and other ground-water resources of that State, especially to develop irrigation supplies; (2) cooperation with the States of North Dakota and South Dakota and with the North Dakota Well Drillers' Association in their efforts to adopt effective legal and mechanical methods to conserve the artesian-water supply by preventing excessive waste from approximately 15,000 flowing wells in these States; and (3) cooperation with the United States Public Health Service in its experiments at Fort Caswell, N. C., to determine the extent to which *Bacillus coli* and the germs of typhoid fever are transported by ground water. Norah E. Dowell was assigned to the Fort Caswell laboratory during the month of May.

A comprehensive work on ground water in the United States, with a discussion of principles, is being prepared by O. E. Meinzer. Part I, which relates to the occurrence of ground water, was completed in the fiscal year 1921, and Part II, which relates to the origin, discharge, and quantity of ground water, is in preparation. Short papers were prepared by Mr. Meinzer on Pleistocene lakes, by Kirk Bryan on the origin of the water of the Arkansas Hot Springs, and by D. G. Thompson on the hydrology of playas.

Cooperation with the committee on physiography was continued through Mr. Meinzer, who serves on that committee. Several manu-

scripts for geologic folios were examined with respect to their treatment of the subject of ground water.

### WORK BY STATES.

*Arizona.*—Progress was made on a report on the geology and water resources of San Pedro Valley, Ariz., by Kirk Bryan, of the Geological Survey, and G. E. P. Smith, of the Arizona Agricultural Experiment Station. A brief report on the water supply of the Santa Rita range reserve was made by Mr. Bryan to the United States Forest Service.

*Arkansas.*—A brief report as to methods for increasing the supply of hot water in the Hot Springs National Park was made by Mr. Bryan for the National Park Service.

*California.*—Much progress was made by Mr. Thompson on a comprehensive paper on the geography, geology, and hydrology of the Mohave Desert region, Calif. A special report on the Mohave Valley by Mr. Thompson was filed in the office of the United States Geological Survey in Los Angeles, where it is accessible to the public. A report regarding a water supply on San Miguel Island was made by Mr. Thompson to the United States Public Health Service. A report on ground water in the Napa quadrangle was prepared by Miss Dowell, on the basis of field work previously done by W. O. Clark, to be published in a geologic folio. An investigation as to means for increasing the water supply for the Mariposa Grove of Yosemite National Park was made in June by Mr. Bryan for the National Park Service. Water levels were measured in selected wells in southern California, as in previous years, under the direction of F. C. Ebert.

The large amount of ground-water work in California is made possible through financial cooperation of the State Department of Engineering.

*Connecticut.*—Reports on the New Haven area, Conn., and on the relation of sea water to ground water, with special reference to the Connecticut coast, were completed by J. S. Brown. Additional field work was done in the Pomperaug Valley by Miss Dowell, and a report on the quantitative study of the water in that valley has been nearly completed. All work in Connecticut is done in cooperation with the State Geological and Natural History Survey.

*District of Columbia.*—A brief report regarding a ground-water supply for the Government Printing Office was prepared by Mr. Thompson, and an examination of the sanitary conditions at the wells that supply St. Elizabeths Hospital was made by Mr. Meinzer in cooperation with the Public Health Service.

*Hawaii.*—An investigation of ground water in the Kau district, Hawaii, was nearly completed by Mr. Clark prior to his resignation, December 31, 1921, but the report has not yet been submitted.

*Idaho.*—An intensive investigation of the water resources of the Mud Lake basin, Idaho, begun in April, 1921, was carried on during the year by L. L. Bryan, who did the engineering work, and H. T. Stearns, who did the geologic work. A preliminary report, including an inventory of the water supply for the year ending March 31, 1922, was completed, and on June 30 it was being mimeographed. Field work for the final report is still in progress. Financial cooperation was received from the Idaho Department of Reclamation, the United States General Land Office, and the Idaho Bureau of Mines and Geology. The work was under the technical supervision of the ground-water division and the Boise district of the division of surface water.

A systematic investigation of the artesian and other ground-water resources of Idaho, in cooperation with the State Bureau of Mines and Geology, was begun in May, 1921, and was continued through this fiscal year. Mr. Meinzer made a general reconnaissance of large parts of the State east of Twin Falls. He prepared a brief report on Pahsimeroi Valley, which is to be published by the State, and a paper entitled "Ground water for irrigation in Idaho," which he presented to the Idaho Irrigation Congress. A survey of the Goose Creek artesian basin was made by A. M. Piper. A brief preliminary report on artesian conditions in the vicinity of Grand View was made by Mr. Stearns.

*Maryland.*—A brief report on prospects for developing a ground-water supply in the vicinity of Silver Hill, Md., was made by Mr. Thompson to the Secretary of the Interior.

*Montana.*—Surveys of ground water in Yellowstone, Treasure, and Big Horn counties, Mont., were made by G. M. Hall, and a survey of ground water in the Townsend area, with special reference to artesian prospects, was made

by J. T. Pardee. A mimeographed preliminary report on the Townsend area was issued as a press notice.

*Nevada.*—A brief investigation of the prospects of developing irrigation supplies from wells in the vicinity of Searchlight, Nev., was made by D. F. Hewett, of the geologic branch.

*North Dakota.*—Progress was made by H. E. Simpson, State water geologist, on a comprehensive report on ground water in North Dakota. This work is being done in cooperation with the State Geological Survey. In January Mr. Meinzer conferred with Professor Simpson and others at an interstate conference on the conservation of the artesian-water supply.

*Virginia.*—A brief report on a water supply for Manassas, Va., was made by Mr. Thompson.

### DIVISION OF QUALITY OF WATER.

The division of quality of water makes analyses of surface and ground waters and interprets such analyses to determine the suitability of the waters, as far as mineral content is concerned, for domestic and industrial uses and for irrigation. During the year 671 samples of water were analyzed. These included 118 samples from Yellowstone, Big Horn, and Treasure counties, Mont., that were analyzed by C. S. Howard, who has written a discussion of the quality of ground water in Yellowstone County. Mr. Howard also wrote a discussion of quality of water for the report by Alexander Deussen on ground water in the Coastal Plain of Texas southwest of Brazos River. The 196 analyses of ground waters in North Dakota were nearly all made by H. B. Riffenburg, who has begun to write the discussion of quality of water for the report by Professor Simpson on the ground waters of North Dakota. Analyses of 90 samples from public water supplies were made by Margaret D. Foster for use in a report on the industrial utility of public water supplies. Miss Foster also studied the details of several of the analytical methods in use in the laboratory. Some of the results of this work are included in a mimeographed report on field examination of water by W. D. Collins. Analyses were made for Miss Dowell's Fort Caswell study (58), Mr. Thompson's study of soils in the Mohave Desert (40), Mr. Brown's Haitian reconnaissance (20), and a study of the availability of Pecos River water for irrigation in Texas (20). Sections on quality of water in four ground-water reports and two geologic folios were reviewed. The report on production of mineral waters in 1920 was prepared by Mr. Collins.

### DIVISION OF POWER RESOURCES.

The work of the division of power resources during the year comprised the preparation of monthly reports of the production of electricity and consumption of fuel by public-utility power plants, of State maps showing the location of the power stations and transmission lines used in public service, and of a report on developed and potential water power of the United States.

The monthly reports of power production are based on reports submitted by public-utility companies showing their monthly output of electricity and the fuel consumed in generating it, if fuel is used. About 2,350 companies operating 3,500 power plants, each having a monthly output of 10,000 kilowatt-hours or more, are requested to submit reports of their production of electricity and consumption of fuel. The reports received represent about 90 per cent

of the total generating capacity of these plants. Each report is now published within 30 days after the end of the last month included in it. The following tables show the power and fuel statistics for the calendar years 1919, 1920, and 1921:

*Electricity produced at public-utility power plants in the United States, 1919–1921.*

| Year. | Total. | | Water power. | | | Fuel power. | | |
|---|---|---|---|---|---|---|---|---|
| | Kilowatt-hours. | Change from previous year (per cent). | Kilowatt-hours. | Per cent of total. | Change from previous year (per cent). | Kilowatt-hours. | Per cent of total. | Change from previous year (per cent). |
| 1919 | 38,921,000,000 | ..... | 14,606,000,000 | 37.5 | ..... | 24,315,000,000 | 62.5 | ..... |
| 1920 | 43,555,000,000 | +11.9 | 16,150,000,000 | 37.1 | +10.6 | 27,405,000,000 | 62.9 | +12.7 |
| 1921 | 40,976,000,000 | −5.9 | 14,971,000,000 | 36.5 | −7.3 | 26,005,000,000 | 63.5 | −5.1 |

*Fuel consumed in the production of power at public-utility plants in the United States, 1919–1921.*

| Year. | Coal. | | Fuel oil. | | Gas. | |
|---|---|---|---|---|---|---|
| | Short tons. | Change from previous year (per cent). | Barrels. | Change from previous year (per cent). | M cubic feet. | Change from previous year (per cent). |
| 1919 | 35,100,000 | ..... | 11,050,000 | ..... | 21,406,000 | ..... |
| 1920 | 37,124,000 | +5.8 | 13,123,000 | +18.8 | 24,702,000 | +15.4 |
| 1921 | 31,585,000 | −14.9 | 12,045,000 | −8.2 | 23,722,000 | −4.0 |

Maps showing the location of the power stations and transmission lines used in public service and the names of the public-utility companies and their plants were published for Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Maryland, Delaware, District of Columbia, Virginia, and Indiana.

The report on the developed and potential water power of the United States was published in February as a press notice. It contains tables that show for each State the total installed capacity of water wheels in plants of 100 horsepower or more and the maximum and minimum potential water power. The table of developed water power shows that near the end of 1921 there were in the United States 3,120 water-power plants of 100 horsepower or more, with a total installed capacity of 7,926,958 horsepower. Of this total 78 per cent is in public-utility plants and 22 per cent in manufacturing plants. The five leading States and the amount of developed water power in horsepower in each are as follows: New York, 1,291,857; California, 1,149,099; Washington, 454,356; Maine, 449,614; and Montana, 344,420.

## DIVISION OF ENLARGED AND STOCK-RAISING HOMESTEADS.

The work of the enlarged and stock-raising homestead division is divided into two distinct classes—the examination of public lands for

designation under the enlarged and stock-raising homestead laws and the examination of streams and neighboring lands as a basis for the classification of public lands with respect to their value for water power or irrigation.

In the season of 1921 the examination of lands applied for under enlarged and stock-raising homestead laws was started as early as possible without incurring loss of time because of bad weather and was therefore in full progress at the beginning of July. It was continued generally until November. Twenty classifiers of various grades, including five assigned from the land-classification board, were engaged in field work during the whole or part of the season.

Field examination under the stock-raising homestead law was confined generally to lands for which applications had already been made and was begun in land districts where no work was done last year or the work was not finished. At the beginning of the year about 3,000 applications requiring field examination of the lands involved were on hand. In addition to individual examination of the lands included in most of these applications, reconnaissance examinations were made, for the designation of block areas, in all the States in which work was done except California. The lands in the following States included in applications pending at the beginning of the year were examined:

Arizona: All districts.
California: All districts.
Colorado: Del Norte, Denver, Durango, Glenwood Springs, Montrose, and Pueblo.
Idaho: Blackfoot, Boise, Hailey, Lewiston.
Montana: Bozeman, Glasgow, Great Falls, Havre, and Lewistown districts and most of the Billings, Helena, Kalispell, Miles City, and Missoula districts.
Nebraska: All of western part.
Nevada: All districts.
New Mexico: All districts.
North Dakota: All districts.
Oregon: La Grande district and most of the Burns, The Dalles, and Vale districts.
South Dakota: All districts.
Utah: All districts.
Washington: All districts.
Wyoming: Practically all districts.

Field examination of entries under the enlarged-homestead act was confined during the summer of 1921 mostly to Colorado, Wyoming, New Mexico, Arizona, California, and Oregon. Lands included in a few entries in other States were examined in connection with the examination of stock-raising homesteads.

During the field season of 1922 the force engaged in the examination of lands subject to entry under the stock-raising homestead law has been assigned also to the examination of lands applied for under the enlarged-homestead laws. Field work was begun early in June and at the end of the month was in progress in California, Colorado, Idaho, Montana, North Dakota, Oregon, Utah, and Wyoming.

The reconnaissance investigation of the surface and ground-water resources of Nevada that was begun in the spring of 1921 for the purpose of classifying lands under the ground-water reclamation act was continued during the summer of that year, and in June, 1922, a brief additional reconnaissance was made to supplement the data previously obtained.

For the purpose of classifying lands with relation to their value in connection with the development of water power, surveys were made of water-power possibilities on Salmon River from Salmon, Idaho, to the mouth of the river and of Big Horn River through Big Horn Canyon, Wyo.; and the surveys begun last year along Siuslaw River and tributaries, Oreg., and on Snake River from Milner to Weiser, Idaho, were completed.

A reconnaissance examination of power-site withdrawals along Arkansas River and headwater tributaries west of Pueblo, Colo., including profile surveys of streams, was in progress in the summer of 1921 and is being continued this year for the purpose of obtaining sufficient data to prepare a general report on the utilization of that portion of the Arkansas River basin.

Examinations were made in the Bear River basin, Utah and Idaho, and in the Green, Sevier, and Weber River basins, Utah, in order to determine where water-power development exists in trespass and whether all lands that should be reserved for power purposes are included in power-site reserves.

In California examinations were made of power and irrigation possibilities in the Feather and Kaweah River basins, and a reconnaissance of the power-site value of lands in the Eel and Mad River basins is now in progress.

In order to designate dam sites for detailed survey and to obtain information necessary for preparing a report on the water-power resources of Colorado River between the mouth of Green River and Lees Ferry, Ariz., an engineer was detailed to a topographic party making a survey of that stretch of the river. Another engineer was assigned to locate dam sites on Klamath and Trinity rivers, Calif., for detailed survey by a topographic party.

A report on Klamath River in Oregon and California and its utilization, based on an examination made last year, has been completed in manuscript form and will be published as a water-supply paper.

The manuscript of a report on the water resources of Uinta Basin, Utah, and their utilization was prepared from information already at hand combined with the results of a little field work. This report will be published as a water-supply paper.

Some revision has been given to reports on the water powers of the Great Salt Lake basin, Utah, and on the water powers of New Mexico.

## LAND-CLASSIFICATION BOARD.

### ORGANIZATION AND PERSONNEL.

The work of the land-classification board consists of classification based on mineral character and classification based on water supply, and the corresponding units of organization are the division of mineral classification and the division of hydrographic classification The latter division includes three more or less distinct sections, each dealing with a type of classification work in which water supply is an essential element. At the end of the fiscal year the organization and the technical personnel were as follows:

Chief, W. C. Mendenhall, geologist.
Chief engineer and assistant chief, Herman Stabler.
Secretary, Elsie Patterson.

Division of mineral classification: J. D. Northrop, geologist; C. D. Avery, mining engineer; G. W. Holland and N. W. Bass, classifiers; W. W. Boyer, associate geologist.

Division of hydrographic classification: Power section: B. E. Jones and W. G. Hoyt, hydraulic engineers; N. J. Tubbs, engineer; E. E. Jones, classifier; Warren Oakey, assistant engineer. Irrigation section: J. F. Deeds, hydraulic engineer; C. E. Nordeen, topographic engineer; W. N. White, classifier. Grazing section: J. G. Mathers, engineer; A. E. Aldous, W. L. Hopper, and R. O. Helland, classifiers.

In addition two engineers, R. W. Davenport and D. J. Guy, have been detailed from the board for duty with the Federal Power Commission.

During the year there were 2 additions to the force and 10 separations. At its end the total number of persons on the regular staff, including the clerical force and employees detailed to the Federal Power Commission, was 53. In addition to this regular force 14 classifiers on the rolls of the water-resources branch joined the staff of the land-classification board during the office season in connection with the stock-raising homestead classifications.

## SCOPE AND CHARACTER OF THE WORK.

The land-classification board was organized to perform the duties relating to "the classification of public lands" with which the Geological Survey is charged by the law of March 3, 1879 (20 Stat. 394). Since its organization the board has prepared and recommended withdrawals of lands known or believed to be valuable for coal, planned their examination, classified and appraised them, and initiated their restoration to the public domain for disposal in accordance with their classification. It has recommended the creation of oil, phosphate, and potash reserves pending the enactment by Congress of appropriate laws for the disposition of the minerals involved. It has classified large areas of oil-shale lands and has selected the lands to be set aside as oil and oil-shale reserves for the Navy and drafted orders for their withdrawal. It has formally classified as to all minerals all or parts of several Indian reservations and as to metalliferous minerals extensive areas of land within the Northern Pacific Railroad grant, the board planning the examination, the Indian Office furnishing the funds, and the geologic branch executing the field work. It has initiated withdrawals of lands valuable for the development of water power in order to prevent possible serious interference with their use for that purpose and bears an important part in facilitating the utilization of the withdrawn lands for water-power development. It prepares and recommends designations required prior to allowance of applications for entry of lands under the enlarged and stock-raising homestead acts.

Under the mineral leasing act of February 25, 1920 (41 Stat. 437), the classified mineral lands and the mineral reserves previously created on recommendation of the board are subject to lease, and the board is required to define the "known geologic structure" of producing oil or gas fields, to determine what is leasing and what is prospecting ground, to recommend the creation of leasing units, to suggest appropriate requirements as to royalty, minimum annual production, and minimum investment, and generally to make the

classifications and to give advice on the geologic and economic problems that must be solved to render the leasing act effective.

The tasks that arise in connection with the work above outlined are performed on the basis of records accumulated during 43 years of activity by the Survey in mapping the topography and investigating the mineral and water resources of the public domain. If existing records are deficient and can not be supplemented satisfactorily from other scientific sources, the board prepares plans for field investigation and makes an allotment from its funds to such other branch of the Survey as is best equipped to obtain the needed information. In a sense the land-classification board is a repository of essential data relating to the natural resources of the public domain and a clearing house for information of many types required in the administration of the laws enacted by Congress and the policies adopted by the Executive for the conservation and utilization of those resources.

The greater part of the information disseminated by the board is utilized through the General Land Office and the office of the Secretary of the Interior, where such facts as to the character of lands are needed as a basis for the administration of certain laws and the development of certain policies. Much of the land-classification work is done under a plan of procedure arranged with the General Land Office, which involves the submission of technical reports on numerous types of cases before that office and the department for disposal. Other bureaus and offices of the Interior Department, as well as other departments of the Government, are also supplied with information pertaining to the character of the public domain.

## FUNDS.

The sundry civil act of March 4, 1921, appropriated $300,000 for the classification of lands by the Geological Survey in the fiscal year ended June 30, 1922. Expenditures from this appropriation by the several branches of the Survey for general administration, for the office work of the land-classification board, and for field work currently needed as a prerequisite thereto, were substantially as follows:

| | |
|---|---|
| Administrative branch | $25,800 |
| Alaska branch | 2,000 |
| Geologic branch | 38,800 |
| Land-classification board | 110,400 |
| Topographic branch | 25,500 |
| Water-resources branch | 95,500 |
| | 298,000 |

The remainder of the appropriation ($2,000) was withheld from use in much needed work on request of the Bureau of the Budget as a part of its economy program.

## CORRESPONDENCE.

During the year 20,719 letters and petitions were received by the land-classification board, about 28 per cent less than in the preceding year. In addition, 5,475 copies of miscellaneous correspondence were sent to the board for its information and filing; this correspondence

was made up largely of letters from the General Land Office to its local officers and of reports on the character of lands by its inspectors and examiners, copies of decisions rendered by the Department of the Interior, and copies of withdrawals and restorations recommended by the Reclamation Service. Within the same period 17,704 letters were prepared by the board, or 2½ per cent less than in the preceding year. These figures show an average of 68 incoming letters and of 58 outgoing letters for each working day of the year.

### SUMMARY OF CASES.

The information supplied by the board is furnished either in reports submitted in response to specific requests for data or in the form of broad areal classifications made under the laws relating to the public domain and its natural resources. The following table gives a summary of the cases before the board for action during the year and indicates that reports were rendered on more than 25,000 specific requests. The number of cases disposed of, however, is of small significance in the light of the fact that some require only a few minutes' consideration, whereas others require exhaustive study and research extending over several days or weeks, and some necessitate field investigations.

*General summary of cases.*

| Class of cases. | Record for fiscal year 1921-22. | | | | | | Record since receipt of first case. | |
|---|---|---|---|---|---|---|---|---|
| | Pending July 1, 1921. | Received during fiscal year. | Total. | Acted on during fiscal year. | Pending June 30, 1922. | Gain or loss during fiscal year. | Received. | Acted on. |
| General Land Office requests | 2,864 | 1,518 | 4,382 | 3,500 | 882 | +1,982 | ..... | ..... |
| Applications for classification as to mineral: | | | | | | | | |
| Coal | 28 | 21 | 49 | 23 | 26 | +2 | 724 | 698 |
| Oil | 156 | 1,021 | 1,177 | 1,045 | 132 | +24 | 1,578 | 1,446 |
| Phosphate | 1 | ..... | 1 | ..... | 1 | ..... | 28 | 27 |
| Applications for mineral permits | 934 | 7,318 | 8,252 | 7,539 | 713 | +221 | 15,891 | 15,178 |
| Applications for mineral leases | 30 | 114 | 144 | 97 | 47 | −17 | 243 | 196 |
| Applications for patent, potassium | ..... | 2 | 2 | 2 | ..... | ..... | 14 | 14 |
| Federal Power Commission cases: | | | | | | | | |
| Preliminary permits | 26 | 8 | 34 | 32 | 2 | +24 | 35 | 33 |
| Licenses | 3 | 5 | 8 | 7 | 1 | +2 | 8 | 7 |
| Determinations under sec. 24 | 25 | 12 | 37 | 35 | 2 | +23 | 37 | 35 |
| Applications for reclassifications as to water resources | 12 | 9 | 21 | 14 | 7 | +5 | 617 | 610 |
| Applications for rights of way | 16 | 160 | 176 | 167 | 9 | +7 | 5,096 | 5,087 |
| Irrigation project reports | 16 | 18 | 34 | 25 | 9 | +7 | 856 | 847 |
| Applications under enlarged-homestead acts | 966 | 1,020 | 1,986 | 1,263 | 723 | +243 | 53,537 | 52,814 |
| Applications under stock-raising homestead act | 8,443 | 6,754 | 15,197 | 11,296 | 3,901 | +4,542 | 100,079 | 96,178 |
| Applications under ground-water reclamation act | 111 | 144 | 255 | 213 | 42 | +69 | 588 | 546 |
| Indian Office requests for information | 18 | 10 | 28 | 23 | 5 | +13 | 9,475 | 9,470 |
| Cases in national forests | ..... | 11 | 11 | 9 | 2 | −2 | 274 | 272 |
| | 13,649 | 18,145 | 31,794 | 25,290 | 6,504 | +7,145 | ..... | ..... |

### DIVISION OF MINERAL CLASSIFICATION.

The activities of the division of mineral classification are directed along three primary lines of effort involving, first, the withdrawal, classification, and restoration of public lands known or believed to possess mineral value; second, the solution of geologic problems

arising in the administration of the act providing for leasing of mineral lands; and, third, the preparation of reports concerning the mineral character of specific lands for the information and guidance of other Government bureaus charged with the administration of the public land and Indian land laws.

Despite the preoccupation of the division with urgent problems pertaining to the second phase of its activities, substantial progress was made during the year along the broader lines of mineral-land classification.

The approval of the potash-land leasing act in October, 1917, and of the general mineral-lands leasing act in February, 1920, removed in effect the necessity for further withdrawals of lands known or believed to contain deposits of coal, oil, gas, phosphate, oil shale, sodium, or potash, but it did not obviate the necessity for the classification and restoration to the public domain of some 50,000,000 acres then embraced in outstanding mineral-land withdrawals. To this unfinished task the mineral division is devoting as much energy as the limitations imposed by small personnel, inadequate geologic information, and pressure of more urgent tasks will permit. The results accomplished in the fiscal year include a net reduction of 459,341 acres in the total area previously classified as coal land, a net increase of 268,359 acres in the area previously classified as phosphate land and decreases of 3,914,988 acres, or 10 per cent, in the area of outstanding coal withdrawals, of 110,803 acres, or about 2 per cent, in the area of outstanding petroleum reserves, and of 298,846 acres, or 11 per cent, in the area of outstanding phosphate reserves. No change was effected during the year in the areas previously classified as oil land, withdrawn or classified as oil-shale land, included in potash reserves, or withdrawn on account of concealed deposits of metalliferous minerals.

The gross areas already classified as valuable for mineral and those remaining withdrawn at the end of the fiscal year for certain minerals under the act of June 25, 1910, are shown in the following table:

*Summary of outstanding mineral withdrawals and classifications, June 30, 1922, in acres.*

| State. | Coal. | | Oil. | |
|---|---|---|---|---|
| | Withdrawn. | Classified as coal land. | Withdrawn. | Classified as oil land. |
| Alaska | | 56,993 | | |
| Arizona | 141,945 | | 230,400 | |
| Arkansas | | 61,160 | | |
| California | 17,643 | 8,720 | 1,178,392 | |
| Colorado | 4,277,957 | 3,170,645 | 222,977 | |
| Florida | | | | |
| Idaho | 4,761 | 4,603 | | |
| Louisiana | | | 466,990 | |
| Montana | 10,612,683 | 6,585,071 | 1,350,937 | 42,097 |
| Nevada | 83,833 | | | |
| New Mexico | 5,369,349 | 582,684 | | |
| North Dakota | 5,954,364 | 11,178,286 | 84,894 | |
| Oregon | 4,361 | 18,887 | | |
| South Dakota | | 250,093 | | |
| Utah | 5,179,100 | 1,101,587 | 1,962,787 | |
| Washington | 691,852 | 141,444 | | |
| Wyoming | 2,437,283 | 6,736,313 | 1,089,176 | |
| | 34,775,131 | 29,896,486 | 6,586,553 | 42,097 |

*Summary of outstanding mineral withdrawals and classifications, June 30, 1922, in acres*—Continued.

| State. | Oil shale. | | Phosphate. | | Potash (withdrawn). |
|---|---|---|---|---|---|
| | Withdrawn. | Classified as oil-shale land. | Withdrawn. | Classified as phosphate land. | |
| California | | | | | 90,518 |
| Colorado | 41,560 | 952,239 | | | |
| Florida | | | 119,563 | | |
| Idaho | | | 720,534 | 267,722 | |
| Montana | | | 287,883 | | |
| Nevada | 123 | | | | 39,422 |
| Utah | 86,584 | 2,705,035 | 302,465 | | |
| Wyoming | | 460,103 | 995,049 | 25,293 | |
| | 128,267 | 4,117,377 | 2,425,494 | 293,015 | 129,940 |

The contributions of the mineral division to the administration of the mineral-lands leasing acts are fundamental and important. They involve, with respect to coal, the determination whether a prospecting permit or a lease should be issued and, if a lease is required, the establishment of a leasing unit consistent in area and content of coal with the mining operation to be undertaken and the recommendation of appropriate stipulations in the matters of royalty, minimum investment, and minimum annual production. With respect to oil and gas they require the definition of "the known geologic structure" of producing oil or gas fields as the primary distinction between leasing and prospecting areas, the determination of the structural relations of lands embraced in prospecting-permit applications, and the classification of all tracts included in such applications which are at the same time involved in unperfected entries under the nonmineral-land laws. Similar types of essential service involving decisions based on geologic evidence are rendered in the administration of the potash-land leasing act and the sections of the general mineral-lands leasing act pertaining to phosphate, oil shale, and sodium.

The following table summarizes the year's activities of the division to the extent that they involve the consideration of specific applications for permit or lease rights under the leasing acts:

*Applications under the mineral leasing acts, fiscal year 1921–22.*

| Mineral. | Permits. | | | Leases. | | | Patents. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Received. | Acted on. | Pending. | Received. | Acted on. | Pending. | Received. | Acted on. | Pending. |
| Oil and gas | 6,647 | 7,051 | 462 | | | | | | |
| Coal | 515 | 345 | 234 | 106 | 91 | 43 | | | |
| Phosphate | | | | 4 | 3 | 1 | | | |
| Sodium | 8 | 10 | 2 | | 1 | | | | |
| Potassium | 148 | 133 | 15 | 3 | 2 | 1 | 2 | 2 | |
| Oil shale | | | | 1 | | 2 | | | |

The broader phases of the division's activities under the leasing acts were restricted during the year almost entirely to its designa-

tions of the boundaries of the "known geologic structure" of producing oil and gas fields—that is, the designation of the lands that are subject to lease only, as distinguished from those on which prospecting permits may be granted. The results, which involve an exhaustive study of each area considered, include definitions of the Gas City and Baker gas fields, in Montana, and the Hidden Dome and Little Grass Creek gas fields and Bolton Creek oil field, in Wyoming, together with a revised definition of the Mahoney Dome gas field, in Wyoming. At the end of the year 38 fields, having a total area of 343,082 acres, had been defined.

In the matter of reports rendered in response to requests of the General Land Office and the Office of Indian Affairs for information concerning the mineral possibilities of specific lands, gratifying progress resulted from a special effort made during the year to dispose of the excess of pending cases accumulated during the period in which the efforts of the division were necessarily centered on its functions under the leasing acts. The general summary of cases (p. 65) shows a net gain of 1,982 such cases involving reports to the General Land Office and of 13 cases involving reports to the Office of Indian Affairs. The anticipated effect of this effort is the attainment of current status in this phase of divisional activity early in the ensuing fiscal year.

In all the types of activity pursued by the division the requisite of definite information on which to base decisions and recommendations of appropriate action has necessitated the planning and financing of considerable field work, both reconnaissance and detailed, undertaken by the geologic and topographic branches.

## DIVISION OF HYDROGRAPHIC CLASSIFICATION.

### POWER SECTION.

The work of the power section consists primarily in obtaining and making available for administration under the public-land laws information as to the water-power resources of the public lands. Reports are made on specific problems as they arise, such problems ordinarily involving conflict between projects for power development and applications under the land laws. The endeavor is made to reach solutions by which the possibilities for developing power may be preserved with a minimum of interference with agricultural, transportation, or other interests. In connection with these specific problems and also in a broad way constant review is being made of power reserves in order that all land having material value for the development of power, and only such land, shall be held reserved for that purpose. The extent of this task is indicated by the fact that over 4,000,000 acres of land is included in power reserves whose use will be required for the development of about 15,000,000 continuous horsepower.

In order that its information may be substantially complete, the section designates areas not thoroughly surveyed for examination

by the field branches of the Survey. Important items of field work to obtain data for power classification in progress at the request of the land-classification board and financed by allotments from its funds during the year included plan and profile surveys of Colorado River between Green and Paria rivers, Utah and Arizona, and of Klamath and Trinity rivers, California; and detailed studies and reports on the possibilities of developing power in the Klamath River basin, Oregon and California; Kaweah River, California; Siuslaw River, Oregon; Snake River, Idaho, Oregon, and Washington; Salmon River, Idaho; Bear River, Idaho and Utah; the Uinta Basin, Utah; Arkansas River, Colorado; and Big Horn River, Montana and Wyoming. All such information as it becomes available is carefully indexed and incorporated in an inventory of water resources maintained by the land-classification board, which, when complete, will enable the section to give competent advice on short notice as to the manner in which each tract of public land having value for power can best be used in connection with the development of water power and as to the relation of such use to other possible uses of the tract.

The work of the section, in so far as it is readily subject to statistical record, is briefly summarized in the table of power-site reserves, the table of outstanding water resources and agricultural withdrawals and classifications, and the general summary of cases. Certain features of the operations under power permits and grants issued prior to the passage of the Federal water-power act, as disclosed by reports made on request of the section, are summarized in the following paragraph.

Pursuant to the instructions of the Secretary, dated August 24, 1916 (45 L. D. 326), permittees under the act of February 15, 1901 (31 Stat. 790), and grantees under the act of March 4, 1911 (36 Stat. 1253), to whom rights have been granted by the Secretary of the Interior since January 1, 1913, were called upon for detailed reports of the operations or developments of their power systems during the calendar year 1921. An examination of these reports shows that the total installation of the 59 reporting companies is 1,260,000 kilowatts, of which 1,010,000 kilowatts is installed at hydroelectric plants. The total energy generated amounted to 3,725,000,000 kilowatt-hours, of which 3,400,000,000 kilowatt-hours was generated by water power. A total of 52,430,000 kilowatt-hours was purchased from companies which have no portion of their plants under permit or grant from the Interior Department. Of the amount purchased 42,970,000 kilowatt-hours was generated by water power. The operating expenses for the companies generating 100,000,000 kilowatt-hours or more a year (90 per cent of which was generated by water power), including taxes and depreciation, averaged 8.7 mills per kilowatt-hour sold. The gross income from electrical operations of the same companies was 16 mills per kilowatt-hour of energy sold.

*Power output of permittees and grantees, 1916–1921.*

| Year. | Number reporting. | Kilowatt-hours. | Increase or decrease. | |
|---|---|---|---|---|
| | | | Kilowatt-hours. | Per cent. |
| 1916 | 26 | 1,200,000,000 | ..... | ..... |
| 1917 | 32 | 2,000,000,000 | +800,000,000 | +67 |
| 1918 | 51 | 3,200,000,000 | +1,200,000,000 | +60 |
| 1919 | 57 | 3,100,000,000 | −100,000,000 | −3 |
| 1920 | 56 | 4,200,000,000 | +1,100,000,000 | +35 |
| 1921 | 59 | 3,725,000,000 | −475,000,000 | −11 |

*Power-site reserves, in acres.*

[Includes all areas reserved or classified as valuable for power purposes and withheld subject to disposal only under the Federal water-power act of June 10, 1920 (41 Stat. 1063). Designations, classifications, and other types of reserves are included in the total areas without distinction.]

| State. | Reserved prior to July 1, 1921. | Eliminated prior to July 1, 1921. | Reserves outstanding prior to July 1, 1921. | Reserved during fiscal year. | Eliminated during fiscal year. | Reserves outstanding June 30, 1922. |
|---|---|---|---|---|---|---|
| Alabama | 422 | ..... | 422 | 327 | ..... | 749 |
| Alaska | 131,587 | 520 | 131,067 | 20,178 | ..... | 151,245 |
| Arizona | 944,369 | 105,194 | 839,175 | 158,870 | ..... | 998,045 |
| Arkansas | 26,081 | ..... | 26,081 | 2,388 | ..... | 28,469 |
| California | 603,536 | 17,994 | 585,542 | 213,809 | 258 | 799,093 |
| Colorado | 305,365 | 32,615 | 272,750 | 18,387 | 15,631 | 275,506 |
| Florida | 486 | ..... | 486 | ..... | ..... | 486 |
| Idaho | 396,067 | 132,657 | 263,410 | 3,536 | 32,694 | 234,252 |
| Michigan | 1,240 | ..... | 1,240 | ..... | ..... | 1,240 |
| Minnesota | 12,841 | 532 | 12,309 | ..... | ..... | 12,309 |
| Montana | 241,619 | 67,500 | 174,119 | 9,200 | 10,626 | 172,693 |
| Nebraska | 761 | ..... | 761 | ..... | ..... | 761 |
| Nevada | 27,875 | 280 | 27,595 | 244,721 | ..... | 272,316 |
| New Mexico | 214,422 | 6,239 | 208,183 | 759 | 298 | 208,644 |
| Oregon | 503,351 | 47,795 | 455,556 | 3,495 | 17,488 | 441,563 |
| South Dakota | 12 | ..... | 12 | ..... | ..... | 12 |
| Utah | 586,394 | 112,939 | 473,455 | 2,278 | 4,373 | 471,360 |
| Washington | 157,546 | 35,296 | 122,250 | 18,544 | 545 | 140,249 |
| Wisconsin | 1,096 | ..... | 1,096 | ..... | 226 | 870 |
| Wyoming | 195,753 | 67,546 | 128,207 | 21,170 | ..... | 149,377 |
| | 4,350,823 | 627,107 | 3,723,716 | 717,662 | 82,139 | 4,359,239 |

*Summary of outstanding water resources and agricultural withdrawals and classifications, June 30, 1922, in acres.*

| State. | Power reserves. | | | | |
|---|---|---|---|---|---|
| | Withdrawals. | Classifications. | Designations.[a] | Miscellaneous. | Total. |
| Alabama | 120 | 190 | ..... | 439 | 749 |
| Alaska | 93,415 | 1,183 | ..... | 56,647 | 151,245 |
| Arizona | 302,208 | 151 | 528,245 | 167,441 | 998,045 |
| Arkansas | 22,354 | 1,590 | ..... | 4,525 | 28,469 |
| California | 297,105 | 24,605 | ..... | 477,383 | 799,093 |
| Colorado | 252,510 | 3,652 | ..... | 19,344 | 275,506 |
| Florida | ..... | ..... | ..... | 486 | 486 |
| Idaho | 231,555 | 389 | ..... | 2,308 | 234,252 |
| Michigan | 1,240 | ..... | ..... | ..... | 1,240 |
| Minnesota | 12,309 | ..... | ..... | ..... | 12,309 |
| Montana | 148,197 | 5,218 | ..... | 19,278 | 172,693 |
| Nebraska | 761 | ..... | ..... | ..... | 761 |
| Nevada | 27,543 | ..... | ..... | 244,773 | 272,316 |
| New Mexico | 65,483 | ..... | 143,161 | ..... | 208,644 |
| Oregon | 415,180 | 1,242 | 15,891 | 9,250 | 441,563 |
| South Dakota | ..... | ..... | ..... | 12 | 12 |
| Utah | 450,770 | 1,792 | ..... | 18,798 | 471,360 |
| Washington | 114,170 | 5,182 | ..... | 20,897 | 140,249 |
| Wisconsin | ..... | ..... | ..... | 870 | 870 |
| Wyoming | 88,691 | 20,351 | ..... | 40,335 | 149,377 |
| | 2,523,611 | 65,545 | 687,297 | 1,082,786 | 4,359,239 |

[a] Designated and not otherwise withdrawn.

*Summary of outstanding water resources, etc.*—Continued.

| State. | Reservoir withdrawals. | Public water withdrawals. | Stock-raising homestead designations. | Enlarged-homestead designations.[b] | Ground-water reclamation designations. |
|---|---|---|---|---|---|
| Arizona | 23,040 | 13,951 | 12,867,276 | 25,607,205 | ..... |
| Arkansas | ..... | ..... | 1,120 | ..... | ..... |
| California | 1,160 | 67,788 | 7,381,667 | 12,744,281 | ..... |
| Colorado | 1,728 | 1,820 | 7,080,227 | 32,577,537 | ..... |
| Idaho | ..... | 12,120 | 4,873,575 | 12,970,976 | ..... |
| Kansas | ..... | ..... | 101,434 | 637,734 | ..... |
| Michigan | ..... | ..... | 2,831 | ..... | ..... |
| Montana | 9,080 | 7,199 | 14,239,552 | 52,857,424 | ..... |
| Nebraska | ..... | ..... | 136,135 | ..... | ..... |
| Nevada | ..... | 10,431 | 415,509 | 46,450,478 | 1,109,000 |
| New Mexico | ..... | 6,281 | 30,506,500 | 42,808,207 | ..... |
| North Dakota | 1,569 | ..... | 329,832 | 12,259,022 | ..... |
| Oklahoma | ..... | ..... | 61,151 | ..... | ..... |
| Oregon | 10,619 | 13,201 | 5,899,111 | 20,179,812 | ..... |
| South Dakota | ..... | 240 | 6,393,257 | 15,973,095 | ..... |
| Utah | 80 | 34,526 | 990,528 | 10,479,289 | ..... |
| Washington | 35,943 | 920 | 591,289 | 6,330,033 | ..... |
| Wyoming | 1,714 | 82,185 | 18,867,903 | 28,643,472 | ..... |
| | 84,933 | 250,662 | 110,738,897 | 320,518,565 | 1,109,000 |

[b] Includes 559,554 acres in Idaho and 1,562,614 acres in Utah designated under nonresidence provisions of the acts.

### IRRIGATION SECTION.

The primary work of the irrigation section is classification of lands with respect to irrigability under the enlarged and stock-raising homestead and Nevada ground-water reclamation acts. In the main, the thousands of applications received are disposed of on the basis of office information recorded in the inventory of water resources and other convenient aids to ready reference. Broad areal classification has been made as far as practicable, and in consequence the number of incoming cases has been reduced to a minimum. Cases that can not be handled otherwise are listed for field examination and report by the water-resources branch. Additional broad field studies in critical areas are planned for execution by the field branches when required and financed by allotments from the funds of the board. During the year such studies were made in the Arkansas River valley, Colorado, the Casa Grande Valley, Arizona, and the Uinta Basin, Utah, and an extended survey of irrigation possibilities was made in Nevada.

The section also makes reports on the sufficiency of water supply and general feasibility of irrigation projects that require some form of Federal approval in connection with the administration of the public-land laws, and it initiates the withdrawal of lands for reservoir sites.

The tables relating to enlarged and stock-raising homestead designations and the general summary of cases show briefly the results of many features of the work of the section. During the year an area of 382,320 acres in Nevada was designated under the ground-water reclamation act, and 1,160 acres in California was included in reservoir-site withdrawals.

### GRAZING SECTION.

The stock-raising homestead law requires that prior to entry under its terms the land shall be classified as nontimbered, nonirrigable, valuable chiefly for grazing and raising forage crops, and of such character that 640 acres is reasonably required for the support of a family. The grazing section of the board determines what lands shall be so classified, except as to irrigability, which is determined

by the irrigation section. The nature of the classification is so complex that in many extensive areas detailed information concerning the particular tract applied for is essential to proper classification. Field examination of individual tracts by the water-resources branch is therefore planned by the grazing section and financed by allotments from the board's funds. Broad areal classification, after general reconnaissance, is applied wherever practicable, thus reducing the number of detailed field investigations to a minimum.

After struggling since 1917 to overcome the handicap of an almost total lack of specific information and to report on the many thousands of applications filed soon after the passage of the act, the grazing section has finally made its work essentially current.

Reservation and restoration of tracts valuable for watering stock is also a duty of this section. During the year additions to public water reserves embraced 285 acres in Arizona, 8,192 acres in California, 240 acres in Idaho, 1,103 acres in Nevada, 80 acres in New Mexico, 1,317 acres in Oregon, 2,570 acres in Utah, and 40 acres in Wyoming, and the cancellations of such reserves included 585 acres in California, 240 acres in Montana, 45 acres in Nevada, 200 acres in New Mexico, 900 acres in Oregon, 3,871 acres in Utah, and 2,242 acres in Wyoming. The areas remaining reserved as public watering places in the several States at the end of the year are shown in the table of outstanding water resources and agricultural withdrawals and classifications, which also shows the outstanding designations under the stock-raising homestead act.

The general summary of cases and the summary of stock-raising homestead designations show in detail other features of the progress of the work of this section.

*Summary of enlarged-homestead designations, in acres.*

[Areas classified as arid and nonirrigable, residence by entrymen required (act of Feb. 19, 1909 (35 Stat. 639), applicable to Arizona, Colorado, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming; act of June 17, 1910 (36 Stat. 531), applicable to Idaho; act of June 13, 1912 (37 Stat. 132), applicable to California, North Dakota; act of Mar. 3, 1915 (38 Stat. 953), applicable to Kansas; act of Mar. 4, 1915 (38 Stat. 1163), applicable to South Dakota). Areas classified as arid, nonirrigable, and lacking domestic water supply, residence by entrymen not required (act of Feb. 19, 1909 (35 Stat. 639), applicable to Utah; act of June 17, 1910 (36 Stat. 531), applicable to Idaho).]

| State. | Designations prior to July 1, 1921. | Cancellations prior to July 1, 1921. | Designations outstanding prior to July 1, 1921. | Designations during fiscal year. | Cancellations during fiscal year. | Designations outstanding June 30, 1922. |
|---|---|---|---|---|---|---|
| Arizona | 30,704,092 | 5,409,474 | 25,294,618 | 312,587 | ..... | 25,607,205 |
| California | 11,806,396 | 226,480 | 11,579,916 | 1,176,205 | 11,840 | 12,744,281 |
| Colorado | 32,157,584 | 184,320 | 31,973,264 | 604,913 | 640 | 32,577,537 |
| Idaho: | | | | | | |
| Total | 13,256,029 | 444,125 | 12,811,904 | 168,352 | [a] 9,280 | 12,970,976 |
| Nonresidence | 552,787 | 4,233 | 548,554 | 11,000 | ..... | 559,554 |
| Kansas | 605,734 | ..... | 605,734 | 32,000 | ..... | 637,734 |
| Montana | 52,619,721 | 244,282 | 52,375,439 | 481,985 | ..... | 52,857,424 |
| Nevada | 49,948,295 | 3,564,797 | 46,383,498 | 66,980 | ..... | 46,450,478 |
| New Mexico | 42,980,781 | 227,732 | 42,753,049 | 55,158 | ..... | 42,808,207 |
| North Dakota | 12,231,960 | 3,848 | 12,228,112 | 30,910 | ..... | 12,259,022 |
| Oregon | 21,054,769 | 984,494 | 20,070,275 | 109,745 | 208 | 20,179,812 |
| South Dakota | 16,260,175 | 348,170 | 15,912,005 | 61,090 | ..... | 15,973,095 |
| Utah: | | | | | | |
| Total | 10,583,974 | 350,415 | 10,233,559 | 265,290 | [b] 19,560 | 10,479,289 |
| Nonresidence | 1,565,174 | 12,320 | 1,552,854 | 19,280 | 9,520 | 1,562,614 |
| Washington | 6,501,725 | 251,842 | 6,249,883 | 80,150 | ..... | 6,330,033 |
| Wyoming | 28,214,138 | 156,256 | 28,057,882 | 585,590 | ..... | 28,643,472 |
| | 328,925,373 | 12,396,235 | 316,529,138 | 4,030,955 | 41,528 | 320,518,565 |

[a] 9,280 acres previously designated under secs. 1–5, now designated under sec. 6.
[b] 9,400 acres previously designated under secs. 1–5, now designated under sec. 6.

*Summary of stock-raising homestead designations, in acres.*

[Areas classified as nonirrigable, nontimbered, chiefly valuable for grazing and raising forage crops, and of such character that 640 acres is reasonably required for the support of a family. Act of December 29, 1916 (39 Stat. 862).]

| State. | Designations prior to July 1, 1921. | Cancellations prior to July 1, 1921. | Designations outstanding prior to July 1, 1921. | Designations during fiscal year. | Cancellations during fiscal year. | Designations outstanding June 30, 1922. |
|---|---|---|---|---|---|---|
| Arizona | 13,609,930 | 832,040 | 12,777,890 | 89,386 | ..... | 12,867,276 |
| Arkansas | 240 | ..... | 240 | 880 | ..... | 1,120 |
| California | 7,354,132 | ..... | 7,354,132 | 27,535 | ..... | 7,381,667 |
| Colorado | 6,115,441 | 8,240 | 6,107,201 | 973,666 | 640 | 7,080,227 |
| Idaho | 4,451,804 | 574 | 4,451,230 | 422,745 | 400 | 4,873,575 |
| Kansas | 93,114 | ..... | 93,114 | 8,320 | ..... | 101,434 |
| Michigan | 911 | ..... | 911 | 1,920 | ..... | 2,831 |
| Montana | 13,735,267 | 16,000 | 13,719,267 | 520,285 | ..... | 14,239,552 |
| Nebraska | 124,778 | ..... | 124,778 | 11,357 | ..... | 136,135 |
| Nevada | 199,849 | ..... | 199,849 | 218,460 | 2,800 | 415,509 |
| New Mexico | 29,896,683 | ..... | 29,896,683 | 610,417 | 600 | 30,506,500 |
| North Dakota | 310,254 | ..... | 310,254 | 19,578 | ..... | 329,832 |
| Oklahoma | 49,871 | ..... | 49,781 | 11,280 | ..... | 61,151 |
| Oregon | 5,405,301 | 840 | 5,404,461 | 494,858 | 208 | 5,899,111 |
| South Dakota | 6,267,477 | 320 | 6,267,157 | 126,170 | 70 | 6,393,257 |
| Utah | 717,060 | 240 | 716,820 | 273,708 | ..... | 990,528 |
| Washington | 360,220 | ..... | 360,220 | 232,203 | 1,134 | 591,289 |
| Wyoming | 18,129,266 | 3,080 | 18,126,186 | 741,717 | ..... | 18,867,903 |
| | 106,821,598 | 861,334 | 105,960,264 | 4,784,485 | 5,852 | 110,738,897 |

## PUBLICATION BRANCH.

### DIVISION OF BOOK PUBLICATION.

#### SECTION OF TEXTS.

During the year 22,697 pages of manuscript were edited and prepared for printing, and proof sheets comprising 2,121 galley proofs and 11,487 page proofs were read and corrected. Indexes were prepared for 19 publications, covering 4,600 pages. Copy and proof or stencils for 1,958 pages of multigraph and mimeograph matter were read. The publications of the year are listed and abstracted on pages 4–10.

At the end of the fiscal year six persons were employed in this section. The water-resources branch has continued to render special assistance in preparing copy and reading proof.

#### SECTION OF ILLUSTRATIONS.

The number of illustrations prepared was 2,565, including 215 miscellaneous maps, 574 sections and diagrams, 402 photographs, and 1,374 paleontologic drawings; 302 miscellaneous jobs were also done by the section. The illustrations transmitted to accompany manuscripts numbered 1,716, to be reproduced by chromolithography, photolithography, halftone, zinc etching, and cuts already engraved. The number of proofs received and examined was 1,663. At the end of the year material for illustrating 44 reports was on hand. During the year the force has been reduced by one death and one resignation; one of the vacancies was filled by transfer from another section of the Survey, and the force now includes 11 persons.

## DIVISION OF MAP EDITING.

### SECTION OF GEOLOGIC MAPS.

The geologic maps and other illustrations for 42 reports, 7 folios of the Geologic Atlas of the United States, and Part II of the World Atlas of Commercial Geology were examined and edited during the year. Part II of the World Atlas, comprising 10 maps printed in colors, with accompanying text, was completed and published. One geologic folio (No. 213, New Athens-Okawville, Ill.) was completed and published. Three folios (Raton-Brilliant-Koehler, N. Mex.-Colo., Hot Springs, Ark., and Ray, Ariz.) were well advanced and the maps printed. The maps of the Central Black Hills (S. Dak.) and Carlyle-Centralia (Ill.) folios were in color proof, approved for printing. The Riddle (Oreg.) folio was prepared and made ready for engraving.

### SECTION OF INSPECTION AND EDITING OF TOPOGRAPHIC MAPS.

During the year 62 topographic maps were edited and transmitted for engraving, 227 published topographic maps were edited for reprint, and 294 maps were edited as illustrations for Survey reports, a total of 583 maps edited. The proofs read in first, second, and combined proof for new topographic maps numbered 95, and plate proof was read for corrections to 166 reprinted topographic maps. Proofs were corrected for 98 maps reproduced by photolithography. At the end of the year 69 new topographic maps were in process of engraving and printing. Index maps for 16 State circulars were revised and proofs corrected. A new edition of the topographic and geologic index map of the United States was prepared and printed on a scale of 1:2,500,000. (See also "Topographic branch," pp. 46–47.)

## DIVISION OF DISTRIBUTION.

A total of 457 publications, comprising 157 new books and pamphlets, 1 new geologic folio, Part II of the World Atlas of Commercial Geology, 7 reprinted books and pamphlets, 2 new geologic maps, 90 new or revised topographic maps, 198 reprinted topographic maps, and 1 list of publications, were received by the division of distribution during the year. A number of special pamphlets and forms prepared for administrative use were also delivered and distributed. The total units of all publications received numbered 479,117 books and pamphlets, 4,258 geologic folios, 5,010 copies of Part II of the World Atlas, 132 geologic maps, and 969,981 topographic and other maps, a grand total of 1,458,498.

The division distributed 590,284 books, 8,734 folios, 3,099 copies of the World Atlas (1,103 of Part I and 1,996 of Part II), and 727,477 maps, a total of 1,329,594, of which 6,346 folios, 1,907 copies of the World Atlas (788 of Part I and 1,119 of Part II), and 594,217 maps were sold. The sum received and deposited in the Treasury as the result of sales of publications was $42,078.99, including $38,838.84 for topographic and geologic maps, $872.75 for geologic folios, and $2,367.40 for copies of the World Atlas. The division received and answered 97,607 letters.

## DIVISION OF ENGRAVING AND PRINTING.

### TOPOGRAPHIC MAPS AND GEOLOGIC FOLIOS.

During the fiscal year 70 new topographic maps were engraved and printed. In addition to these, 22 new topographic maps were engraved, but the printing was not completed by June 30. A strip to complete the map of Lawrence County, Mo., was also engraved, but no prints were required. Engraving on 14 more new topographic maps was nearly completed. Twenty new maps were photolithographed and printed, making a total of 90 new maps printed and delivered.

Corrections were engraved on the plates of 222 maps. Reprint editions of 181 topographic maps showing corrections and of 17 corrected State and other photolithographed maps were also printed and delivered.

Of new and reprinted maps 288 different editions, amounting to 969,981 copies, were delivered to the map room.

One new geologic folio was published, the edition amounting to 4,258 copies. Extra geologic maps of this folio to the number of 132 copies were also delivered.

### OTHER GOVERNMENT MAP PRINTING.

A large amount of work was also done for the Government Printing Office, various branches of the War Department, Federal Board for Vocational Education, Veterans' Bureau, Department of State, Treasury Department, Department of Labor, Navy Department, Department of Justice, International Boundary Commission, Department of the Interior, Reclamation Service, General Land Office, Bureau of Mines, Office of Indian Affairs, National Park Service, Bureau of Standards, Forest Service, Federal Power Commission, Interstate Commerce Commission, Alaskan Engineering Commission, United States Tariff Commission, Weather Bureau, Bureau of Soils, Bureau of Public Roads, Bureau of Markets and Crop Estimates, and States Relations Service. This work for other branches of the Government included many reprint editions and amounted to about $106,000, for which the appropriation for engraving and printing geologic maps was reimbursed by transfer of credit on the books of the United States Treasury.

Work was also done for private firms, State organizations, and colleges, and the money received in payment for the work, $350.67, was turned into the Treasury of the United States to be credited to miscellaneous receipts. Transfer impressions to the number of 491 were made during the year, including 230 furnished to contracting printers on requisition of the Government Printing Office, 161 furnished to private firms and institutions, and 100 furnished under cooperative agreements without charge to various State geological surveys.

During the year Part II of the World Atlas of Commercial Geology and the large irrigation and relief map of California were completed, as well as a large amount of miscellaneous work relating to the map publications of the Geological Survey.

Of contract and miscellaneous printing of all kinds, 2,442,227 copies were printed. Including topographic maps and geologic folios, a grand total of 3,416,598 copies were printed and delivered.

### PHOTOGRAPHIC LABORATORY.

The output of the photographic laboratory consisted of 12,819 negatives (1,289 wet, 2,361 dry, 319 paper, 4,734 field negatives developed, and 4,116 photolithographic), 907 lantern slides, 90,629 prints (67,219 maps and diagrams, 16,561 photographs for illustrations, and 6,849 rectigraphs), 3,664 zinc plates, 158 zinc etchings, 46 celluloid prints, 263 lantern slides colored, and 993 prints mounted.

## ADMINISTRATIVE BRANCH.

### EXECUTIVE DIVISION.

The work of the executive division was of the same general character as during the fiscal year 1921.

*Mails, files, and records.*—During the year 148,015 pieces of mail, of which 2,508 were registered, were opened and referred; 5,000 letters and cards were received in connection with revisions of mailing lists. In addition 174,800 letters were received direct by the other divisions, making a total of 327,815, a decrease of 6 per cent compared with 1921. Of the letters opened in this division, 21,955 contained $41,889.38 remitted for Survey publications, a decrease of 10 per cent in number of letters and of $2,330.02 in amount compared with 1921. The number of ordinary letters mailed through the division was 108,065, of registered letters and packages 21,436, and of form letters and cards, etc. (addressograph section) 600,000. In addition 299,200 pieces of mail were sent out direct from other divisions. The total number of outgoing pieces of mail for the Geological Survey was 1,028,701.

*Freight and express.*—During the year 2,000 pieces of freight and express were handled, 954 outgoing and 1,046 incoming.

*Personnel.*—The roll of Secretary's appointees numbered 877 at the end of the fiscal year, 122 less than at the end of 1921. The total number of changes in the personnel was 506, which included 74 appointments and 196 separations (4 deaths).

During the calendar year 18,170 days of annual leave and 4,965 days of sick leave were granted, being 68 per cent of the amount of the annual leave which could have been taken and 18½ per cent of the amount of sick leave which it would have been possible to grant to an average of 893 employees; 12,366 days of leave without pay and furlough were also granted.

The personnel work and the recording, referring, reviewing, filing, and mailing of correspondence required the service of 17 clerks. On June 30, 1922, this number was reduced to 13.

### DIVISION OF SCIENTIFIC AND TECHNICAL EQUIPMENT.

The requisitions on the division of scientific and technical equipment during the year numbered 1,286, of which 1,254 were completed. Registration of instruments was checked and errors corrected. The principal correction was in aneroid barometers, which were found to be very irregular and showed improper handling. An exhibition of the barometer was arranged, and an effort was made to educate all users in the proper care of this delicate instrument. An apparatus for determining the flow of oil, salt water, and fresh water through oil and sand was devised. A system for the setting of platinum

cross wires was perfected and is now being used for the Geological Survey and Reclamation Service at a material saving. Previously only one shop in the country did work of this sort, and naturally its charges were high. A noncorrosive and nonmagnetic bomb to withstand a pressure of 3,000 pounds was made. Improvements on deep-well apparatus and many other devices were accomplished at much less cost than would have been possible in an outside shop.

### LIBRARY.

In the library the receipts numbered 1,598 books, 14,572 periodicals and pamphlets, and 653 maps; 1,401 books were bound. The record of readers and visitors is 13,369, and the loans for outside use 7,736 books and 426 maps. Continued calls are received from libraries in other parts of the country for the loan of publications known to be available only in this library, such as scarce foreign governmental reports on geology, foreign technical and scientific periodicals, and foreign maps. New cards to the number of 7,396 were added to the catalog, and 576 catalog entries were prepared and submitted to the Library of Congress for printing. Over 3,000 letters were written, largely concerning the exchange of publications; this correspondence involved the translation of hundreds of letters in foreign languages. Foreign articles and letters to the number of 265 were translated for other divisions of the Survey. The bibliography of North American geology for 1919 and 1920 was prepared and submitted for publication. The small staff of the library did its best to make this great, highly special, and almost priceless collection of books and maps fill the full measure of service which it should render to students and specialists.

### DIVISION OF ACCOUNTS.

Condensed statements covering the expenditures from Federal funds during the year are given on pages 78–79. The amounts contributed by States for cooperative work are set forth on pages 43, 53–54.

*Amounts appropriated for and expended by the United States Geological Survey pertaining to the fiscal year ended June 30, 1922.*[a]

| Appropriation. | Amount of appropriation. | Transferred to the general reserve as a saving. | Funds available. | | | | | Expenditures. | | | Balance. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Net amount available for expenditures. | Repayments on account of work performed. | | | Total. | Disbursements. | Outstanding liabilities. | Total. | |
| | | | | For other Government establishments. | | For other Geological Survey units. | | | | | |
| | | | | Made. | To be made. | | | | | | |
| Salaries, office of Director | $22,160.00 | $1,283.33 | $20,876.67 | | | | $20,876.67 | $20,876.67 | | $20,876.67 | |
| Salaries, scientific assistants | 29,900.00 | | 29,900.00 | | | | 29,900.00 | 29,900.00 | | 29,900.00 | |
| Gaging streams, etc | 180,000.00 | 2,700.00 | 177,300.00 | $21,051.82 | $5,951.36 | $5,099.19 | 209,402.37 | 206,642.82 | $2,470.80 | 209,113.62 | $288.75 |
| Chemical and physical researches | 40,000.00 | 600.00 | 39,400.00 | | | 79.10 | 39,479.10 | 38,821.77 | 584.84 | 39,406.61 | 72.49 |
| Preparation of illustrations | 18,280.00 | | 18,280.00 | | 180.00 | | 18,460.00 | 18,448.93 | | 18,448.93 | 11.07 |
| Mineral resources of the United States | 125,000.00 | 1,800.00 | 123,200.00 | | | 111.92 | 123,311.92 | 121,993.55 | 1,160.35 | 123,153.90 | 158.02 |
| Geologic maps of the United States | 140,000.00 | 15,000.00 | 125,000.00 | 84,024.50 | 10,862.86 | 14,540.96 | 234,428.32 | 216,372.16 | 12,749.48 | 229,121.64 | 5,306.68 |
| Books for the library | 2,000.00 | | 2,000.00 | | | | 2,000.00 | 1,755.71 | 244.29 | 2,000.00 | |
| Topographic surveys | 330,000.00 | 4,800.00 | 325,200.00 | 37,436.34 | 12,387.53 | 15,116.05 | 390,139.92 | 386,507.64 | 2,636.59 | 389,144.23 | 995.69 |
| Geologic surveys | 352,000.00 | 5,100.00 | 346,900.00 | 6,627.35 | 811.32 | 761.02 | 355,099.69 | 340,188.37 | 12,990.24 | 353,178.61 | 1,921.08 |
| Mineral resources of Alaska | 75,000.00 | | 75,000.00 | | | | 75,000.00 | 70,143.09 | 4,675.34 | 74,818.43 | 181.57 |
| Classification of lands | 300,000.00 | 2,000.00 | 298,000.00 | 2,562.27 | 260.00 | 1,398.73 | 302,221.00 | 298,694.30 | 2,897.85 | 301,592.15 | 628.85 |
| | 1,614,340.00 | 33,283.33 | 1,581,056.67 | 151,702.28 | 30,453.07 | 37,106.97 | [b] 1,800,318.99 | [b] 1,750,345.01 | 40,409.78 | [b] 1,790,754.79 | 9,564.20 |

[a] In addition to these appropriations, $140,000 for Survey publications was contained in the appropriation for printing and binding but not disbursed by Survey officials. There was also an allotment of $10,000 for miscellaneous printing and binding from the Interior Department appropriation for that purpose, and an allotment of $7,423.96 for miscellaneous supplies from the appropriation for contingent expenses of the Interior Department.

[b] Included in this amount is $37,106.97 covering work performed by Survey units for other Survey units, necessarily reported in combining totals but otherwise a duplication.

*Classification of expenditures by the United States Geological Survey pertaining to the fiscal year ended June 30, 1922.*

| Appropriation. | Total. | Salaries and wages. | Transportation of persons and things. | Provisions; subsistence and support of persons. | Forage; subsistence and support of animals. | Printing, engraving, lithographing, etc. | Special and miscellaneous service. | Materials; miscellaneous supplies, etc. | Stationery, drafting, etc., supplies. | Equipment (including live stock). | Maintenance, operation, and repair of passenger-carrying vehicles. | Hire of motor-propelled and horse-drawn passenger-carrying vehicles. | Purchase of motor-propelled passenger-carrying vehicles. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Salaries, office of Director | $20,876.67 | $20,876.67 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Salaries, scientific assistants | 29,900.00 | 29,900.00 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Gaging streams, etc | 209,113.62 | 160,983.72 | $13,183.72 | $6,671.67 | $9.20 | $2,136.42 | $6,137.77 | $2,559.21 | $1,177.34 | $13,548.10 | $307.46 | $486.76 | $1,912.25 |
| Chemical and physical researches | 39,406.61 | 29,970.78 | 491.40 | 2,294.93 | ..... | 54.63 | 2,369.73 | 1,109.64 | 123.96 | 2,007.31 | 840.48 | 143.75 | ..... |
| Preparation of illustrations | 18,448.93 | 18,078.06 | ..... | ..... | ..... | 242.68 | 74.75 | 14.44 | 39.00 | ..... | ..... | ..... | ..... |
| Mineral resources of the United States | 123,153.90 | 113,060.54 | 3,076.87 | 2,006.07 | .75 | 1,118.36 | 2,975.45 | 12.96 | 296.22 | 606.68 | ..... | ..... | ..... |
| Geologic maps of the United States | 229,121.64 | 169,811.06 | 510.97 | 233.91 | ..... | 81.52 | 5,344.78 | 7,920.91 | 36,005.68 | 9,156.41 | ..... | 56.40 | ..... |
| Books for the library | 2,000.00 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 2,000.00 | ..... | ..... | ..... |
| Topographic surveys | 389,144.23 | 288,798.00 | 21,252.64 | 45,057.43 | 4,246.42 | 6,786.50 | 7,190.61 | 1,015.26 | 760.98 | 8,226.14 | 4,857.82 | 952.43 | ..... |
| Geologic surveys | 353,178.61 | 280,266.62 | 14,977.54 | 16,835.64 | 808.92 | 4,906.06 | 11,675.36 | 1,445.13 | 1,087.36 | 17,163.96 | 928.42 | 959.60 | 2,124.00 |
| Mineral resources of Alaska | 74,818.43 | 52,530.70 | 10,321.97 | 2,769.33 | 365.11 | 1,070.42 | 6,765.27 | 219.20 | 263.04 | 513.39 | ..... | ..... | ..... |
| Classification of lands | 301,592.15 | 230,159.54 | 14,801.88 | 24,579.06 | 1,754.23 | 4,480.74 | 4,754.36 | 890.05 | 1,016.22 | 18,677.19 | 222.14 | 256.74 | ..... |
| | 1,790,754.79 | 1,394,435.69 | 78,616.99 | 100,448.04 | 7,184.63 | 20,877.33 | 47,288.08 | 15,186.80 | 40,769.80 | 71,899.18 | 7,156.32 | 2,855.68 | 4,036.25 |

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