U. S. DEPARTMENT OF THE INTERIOR

ANNUAL REPORT OF THE DIRECTOR OF THE GEOLOGICAL SURVEY

TO THE SECRETARY OF THE INTERIOR
FOR FISCAL YEAR ENDED JUNE 30, 1928

U. S. DEPARTMENT OF THE INTERIOR

FORTY-NINTH ANNUAL REPORT

OF THE

DIRECTOR OF THE GEOLOGICAL SURVEY

TO THE

SECRETARY OF THE INTERIOR

1928

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Directors of the Geological Survey

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

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ANNUAL REPORT

OF THE

DIRECTOR OF THE GEOLOGICAL SURVEY

DEPARTMENT OF THE INTERIOR,
GEOLOGICAL SURVEY,
October 15, 1928.

SIR: The appropriations made directly for the work of the Geological Survey for the fiscal year 1928 included 10 items, amounting to $1,807,880. In addition $109,000 was appropriated for printing the reports of the Geological Survey, and $11,000 for miscellaneous printing and binding, and an allotment of $15,763.95 for miscellaneous supplies was made from appropriations for the Interior Department.

A detailed statement of the amounts appropriated and expended is given at the end of this report. The balance on August 30, including a budget reserve of $850, was $28,301.48.

The total amount of funds made available for disbursement by the Geological Survey, together with State funds directly disbursed for work administered by the Federal officials, was $2,909,170.

MEETING THE DEMAND

The function of consulting geologist or hydraulic engineer to the public is one that exposes the Geological Survey to a decidedly increasing demand that is gratifying, even though embarrassing. The growing interest in the great public projects of completing the topographic map of the country and of making an inventory of its water resources is demonstrated by the larger amount of cooperative funds contributed by the States to the mapping and investigative program of the Federal Geological Survey. This year such contributions, coming from 38 States and Hawaii, exceeded three-quarters of a million dollars.

Another item expressing the augmented extent and scope of work administered by the Geological Survey includes the funds transferred to it from other Federal agencies for technical services rendered. This item exceeded one-third of a million dollars in the fiscal year 1928, showing an increase of 10 per cent over the preceding year. The volume of work to be requested by other Federal agencies is always difficult to forecast, but these recent years indicate the general need of the type of investigations for which a corps of trained specialists is available.

Another index of increasing demand is afforded by the number of visitors to the principal local offices of the Geological Survey in the

West. These offices at Denver, Salt Lake City, San Francisco, and Los Angeles make a special effort to answer all inquiries for geologic and engineering information, whether included in published reports or not, and this year they served 8,464 callers, an increase of nearly 10 per cent over the preceding year. General correspondence between the public and the Washington office increased 5 per cent, as did also the distribution of publications on specific request. As in other recent years, the number of both books and maps distributed has exceeded the number printed in the same period, proving that there is no accumulation of dead stock on the shelves. Especially notable was the increase of nearly 15 per cent in the sales of maps. In the distribution of its publications the Geological Survey is a going concern.

A less tangible measure of appreciation of the country's need of surveys and investigations of the type in which the Geological Survey is engaged is afforded by the general demand for an increase in such work. In recent months the chambers of commerce and mining and development associations in the West and the engineering societies of the whole country have called attention to the increasing need of Federal investigations in aid of mining and other development, characterizing the Geological Survey's half century of service in aiding " in finding, developing, and conserving the natural resources of our country " as a fundamental and indispensable contribution to the mining industry.

The fact that too often escapes notice is that the present high-pressure industrial development throughout the country involves an ever greater demand for raw materials as well as for the basic engineering information required in the great constructive undertakings by private enterprise and by the Government itself.

It is difficult to appreciate the full scope of developmental activity that calls for the investigative work by the Government scientific bureaus. Where the topographic map once served a single purpose it is now utilized in a dozen ways; similarly, exact information regarding water resources, both surface and underground, is demanded by State and municipal officials and by the promoters of industrial and agricultural projects. The need of geologic investigation is possibly even greater, in view of the present magnitude of the output of the mines and oil wells of the country. In its growth in volume of output the mining industry stands by itself, but in the process of furnishing the needed raw materials to other industries in rapidly increasing quantities mines and wells become more rapidly exhausted and new deposits must be found. Thus arises the demand for more and better geology, as voiced in the many expressions of public opinion from the mining centers of the country. The United States Geological Survey is being called to take the lead in an intensive study directed to the finding of ore in order to forestall any serious decline in the needed supply of the metals and other essential minerals, with the consequent slowing down of all industry. The premise commonly mentioned in these requests for increased activity is the recognized pioneer work by the geologists and engineers in the earlier decades of developmental progress in the Western States.

THE YEAR'S OPERATIONS

The director continued his service as chairman of the advisory committee of the Federal Oil Conservation Board and as chairman of the Naval Oil Reserve Commission. In connection with his administration of the general work of the Geological Survey he made addresses and informal talks and contributed articles to the press, all with the purpose of helping to bring before the public the results of the work of his associates. A list of these addresses and articles follows:

Need of Facts, Western Society of Engineers, Chicago, December 12.
Charles D. Walcott and the United States Geological Survey, National Museum auditorium, Washington, January 24.
Canada—Its Natural Wealth, Canadian Institute of Mining and Metallurgy, Quebec, March 9.
Engineer-Citizens, Lehigh Valley Mineral Industry Conference, Easton, Pa., April 26.
Your Future, commencement address at Colorado School of Mines, Golden, May 18.
America in High, commencement address at Colby College, Waterville, Me., June 18.
Coal—the Premier Source of Energy, Coal Age, July.
Charles D. Walcott, American Journal of Science, July.
Work of United States Geological Survey as Related to the Mining Industry, Mining Congress Journal, February.
One Step in Production Control, Mining and Metallurgy, May.
Federal Cooperation with the States, United States Daily, June 28.

In recognition of the Geological Survey's long service to the mining industry, the director was elected president of the American Institute of Mining and Metallurgical Engineers in February, and between that time and July he attended meetings of mining men in eight States.

The branch chiefs also represented the Geological Survey at technical or other meetings and spoke on various subjects, a few of which are listed below:

Geology and Mining, by W. C. Mendenhall, American Mining Congress, December 3.
Outfitting Alaska Expeditions, by Philip S. Smith, Harvard Club, April 14.
The Alaskan Branch of the Geological Survey, by Philip S. Smith, American Mining Congress, December 3.
Topographic Mapping in Connection with Flood Control, by C. H. Birdseye, Arkansas and Red River Flood Control Convention, Oklahoma City, Okla., December 1.
Topographic Mapping of the United States, by C. H. Birdseye, Western Society of Engineers, Chicago, December 12.
Colorado River, by C. H. Birdseye, student section, American Society of Civil Engineers, George Washington University, Washington, January 6.
Story of Topography, by C. H. Birdseye, Society of Engineers, Atlanta, Ga., February 6.
Run-off Characteristics of the Mississippi River Discharge Basin, by N. C. Grover, American Society of Civil Engineers, Columbus, Ohio, October, 1927.
River Flow Observations and Their Significance, by N. C. Grover, Southern Appalachian Power Conference, Chattanooga, Tenn., October, 1927.
The Recording of River Discharge, by N. C. Grover, Military Engineer, April–May, 1928, p. 120.
A Nation's Water Power, by Herman Stabler, Economic Geography, volume 3, No. 4, October, 1927.

A brief summary of the work done by the Geological Survey during the fiscal year is given in the following paragraphs:

GEOLOGIC WORK

Geologic work was done in 43 States, Alaska, and the District of Columbia. In this work 16 of the States cooperated. The cooperative work takes a variety of forms but consists mainly of the study of specific problems on a cost-sharing basis. Among the results of such work are contributions to proposed geologic maps of Arkansas, Florida, Pennsylvania, Texas, and Virginia. Considerable geologic work was also done in cooperation with other Government organizations and with nongovernmental scientific associations. Cooperative investigations bearing on oil and gas resources were made in 1 State, on metalliferous deposits in 5 States, on potash in 2 States, on coal in 3 States, and on general geologic problems in 17 States. The investigations in search of potash, carried on in cooperation with the Bureau of Mines, centered largely in Texas, where three sites for core drilling were selected and the drilling at five other sites was completed. The cores were studied and selected portions analyzed, and preliminary reports on the economic results were prepared. Volcanologic studies were carried on in California, Alaska, and Hawaii. Numerous paleontologic determinations were made. Investigations of ore deposits, coal, oil shale, and other minerals and studies in glacial geology, stratigraphy, and structure were continued. In the chemical laboratory 5,627 samples of potash salts were examined and 71 specimens submitted in connection with specific problems were subjected to special examinations and tests; 2,055 specimens were identified for private persons. Further work was done on problems connected with petroleum recovery.

EXPLORATIONS IN ALASKA

The principal explorations conducted by the Geological Survey in Alaska in the field season of 1927 were made in the Copper River region, the northeastern part of the Yukon Basin, and the Mount Spurr region of the Alaska Range. The work in the Yukon Basin resulted in 3,700 square miles of geologic mapping and 4,900 square miles of topographic mapping of previously unmapped country, also a geologic resurvey with greater precision of 300 square miles. The Mount Spurr expedition accomplished the topographic mapping of 2,265 square miles and the geologic mapping of 2,000 square miles of new country. The compilation of the aerial photographs of southeastern Alaska taken by the Navy Department at the request of the Geological Survey was continued, and a drainage map of a tract of about 2,000 square miles in this region was completed.

Six field projects were in progress at the end of the fiscal year 1928, including reconnaissance and detailed topographic mapping in southeastern Alaska, geologic reconnaissance in the Copper River, upper Tanana, and Yukon regions, and geologic and topographic reconnaissance in the Alaska Range. Some of the work in southeastern Alaska is being done for the Forest Service, which is bearing the cost. Airplanes were used to cooperate in transporting part of the supplies and equipment used by the party surveying in the Alaska Range. The supervision of operations under leases issued by the Government for extracting coal and oil on public lands was continued during the year, a small staff being maintained at two local offices in Alaska for this purpose.

TOPOGRAPHIC MAPPING

The topographic work was done in cooperation with 26 States, and the area mapped amounted to 17,721 square miles in 34 States, the District of Columbia, and Hawaii. Of this total 13,777 square miles represents new surveys, 2,407 square miles resurveys, and 1,537 square miles revisions. The total area mapped to June 30, 1928, is 1,314,316 square miles. Nine States and the District of Columbia are now entirely mapped, and the percentages in the other States range from 8 to 88.4. Of the total continental United States, exclusive of Alaska, 43.2 per cent has been mapped. River surveys amounting to 14 linear miles and 101 square miles were also made. In connection with the topographic work 6,272 miles of spirit levels and 4,046 miles of transit traverse were run and 157 triangulation stations were occupied. Cooperation was continued with the Air Corps, United States Army, whereby aerial photographs were furnished for use in topographic mapping. A shaded relief and highway map of New Hampshire and a contour map of Virginia were compiled in cooperation with the respective States.

INVESTIGATIONS OF WATER RESOURCES

The work on water resources is done largely in cooperation with other Federal bureaus, with State, county, and municipal agencies, and with permittees and licensees of the Federal Power Commission. The amount expended by State, county, and municipal agencies for such work during the year, in part directly and in part through the Geological Survey, was $338,819. This sum covered work in 31 States and Hawaii. Including the cooperative work, the study of surface waters, which consists primarily of the measurement of the flow of streams, was carried on in 42 States and Hawaii, in which at the end of the year 1,830 gaging stations were being maintained. The work on ground-water resources has been planned to meet the more and more exacting public demand for precise information with increasing need for the water. Investigations relating to ground water and reservoir sites were made in 15 States. Research into the principles of hydrology has been continued in order to provide a more secure basis for ground-water investigations. A hydrologic laboratory and three experiment stations have been maintained, 30 automatic water-stage recorders have been installed over observation wells, and thousands of measurements of water levels in wells have been made. Cooperation was continued with well drillers' associations with a view to developing higher standards and better results in water-well drilling. The work on quality of water involved the examination of 801 samples. The investigations of power resources included the preparation of monthly and annual reports on the production of electricity and consumption of fuel by public-utility power plants. A report on the developed and potential water power of the United States was published.

WORK IN CLASSIFYING AND LEASING PUBLIC LAND

The work of classifying public and Indian lands with respect to mineral content and of supervising mineral operations on such lands was carried on in 21 States and Alaska. The number of cases involving land classification acted on during the year was 19,956, and the results accomplished include net decreases of 720 acres in the area of outstanding coal withdrawals, of 3,960 acres in outstanding petroleum withdrawals, and of 13,276 acres in outstanding phosphate reserves. At the end of the year the total area classified as mineral in character amounted to 36,488,995 acres in 14 States and Alaska and the outstanding mineral withdrawals to 44,951,277 acres in 14 States. Definition of the "known geologic structure" of producing oil and gas fields was continued, and at the end of the year the net area so defined was 517,745 acres in seven States. Investigations to obtain information for classifying public land with respect to its value for the development of water power were made in four States. There was a net increase of 143,754 acres in the area included in power reserves, making a total of 6,233,762 acres in 20 States and Alaska, on which about 15,000,000 continuous horsepower can be developed. The net increase in enlarged-homestead designations was 476,900 acres, making a total outstanding of 325,159,793 acres in 14 States, and the net increase in stock-raising homestead designations was 1,023,934 acres, making a total outstanding of 119,124,604 acres in 18 States. There was a net increase of 37,814 acres in public water reserves, and the total outstanding is now 403,391 acres in 12 States. The supervisory work on public lands subject to the mineral leasing laws was increased between 10 and 12 per cent by the receipt of 85 leases, 4,588 permits, and 8 licenses, covering 7,910,582.60 acres. The production of petroleum on such lands during the year was 23,370,549.38 barrels, on which the oil, gas, and gasoline royalty value was $3,735,451.41. The production of coal on such lands was 3,000,248.38 tons, of phosphate rock 23,459.95 tons, and of sodium 16,127.99 tons, on which the royalty rentals and bonuses amounted to $387,307.10. Supervision over oil and gas operations on naval petroleum reserves was continued, and the petroleum produced amounted to 9,839,859.19 barrels, on which the oil, gas, and gasoline royalty value was $2,232,375.39. Inspectional, regulatory, and advisory service was rendered in connection with the leasing of mineral deposits on Indian lands in eight States, with a royalty value of over $7,000,000, nearly all in Oklahoma.

PUBLICATIONS

The publications of the year consisted of 53 books and pamphlets of the regular series (including 5 reprints), 150 new or revised maps, 165 reprinted maps, and numerous circulars, lists of publications, etc. The total number of pages in the new book publications was 5,639. In addition to the publica-

tions in the regular series, 94 brief reports were issued in mimeographed form as memoranda for the press. The manuscript edited and prepared for printing amounted to 23,193 pages; 2,686 galley proofs and 11,260 page proofs were read and corrected. Indexes were prepared for 24 publications, covering 5,670 pages. The drawings prepared for publications numbered 2,605, and the proofs of illustrations examined 1,423. Maps for 2 folios were wholly or partly prepared for engraving, and maps and illustrations for 47 other reports were edited. The new topographic maps edited and transmitted for engraving numbered 86, and 706 other maps were edited. Map proofs numbering 755 were read. Of new and reprinted maps and folios 748,860 copies were printed. The publications distributed numbered 1,006,888, of which 5,111 folios and 699,365 maps were sold for $48,762.35.

GEOLOGIC BRANCH

W. C. MENDENHALL, Chief Geologist

ORGANIZATION

The work of the geologic branch has been administered during the year through 10 units, representing topical or geographic groupings of activities. These units are as follows:

Paleontology and stratigraphy, T. W. Stanton, geologist in charge.
Geology of metalliferous deposits, G. F. Loughlin, geologist in charge.
Areal geology and geology of nonmetalliferous deposits, G. R. Mansfield, geologist in charge.
Geology of iron and steel metals, E. F. Burchard, geologist in charge.
Glacial geology, W. C. Alden, geologist in charge.
Coastal Plain investigations, L. W. Stephenson, geologist in charge.
Geology of fuels, H. D. Miser, geologist in charge.
Volcanology, T. A. Jaggar, jr., volcanologist in charge.
Petrology, C. S. Ross, geologist in charge.
Chemistry and physics, George Steiger, chemist in charge.

The sections of areal geology and nonmetalliferous deposits were combined on July 15, 1927, under G. R. Mansfield. H. D. Miser succeeded W. T. Thom, jr., as geologist in charge of the section of geology of fuels.

The professional force was reduced by two deaths, one transfer, and two resignations. With these changes it now includes 98 geologists of different grades, 8 chemists, 2 physicists, 1 laboratory aide, and 1 topographic engineer. Six draftsmen (2 temporary) and 6 preparators of fossils (1 temporary—1 temporary preparator of fossils having died during the year) constitute the subprofessional force. In the clerical force there were 4 accessions (3 appointed for field offices) and 3 separations (1 from field office), 1 by retirement and 2 by resignation, leaving a total of 31 clerks of various grades, 5 of whom are temporary.

ALLOTMENTS AND EXPENDITURES

The funds available for the work of the geologic branch for the fiscal year were as follows:

Geologic surveys	$328,200
Classification of lands	31,000
Volcanologic surveys	20,000
Investigating potash deposits	9,750
Repayments from other Federal departments	617
Repayments from State, city, and other cooperating organizations	22,798
	412,365

The expenditures from these funds may be classified approximately as follows:

Geologic investigations (economic and scientific)	$304,915
Supervision, administration, services of clerical, technical, and skilled-labor forces, etc	82,000
Hawaiian volcanology	19,450
Budget reserve and unexpended balances	6,000
	412,365

GOVERNMENT GEOLOGIC WORK AND ITS USES

Geology is one of the fundamental physical sciences. It deals with the origin of the earth, with its extinct life, with the growth of its mountain chains, its continents, and its oceans, and with its composition, including substances in and on the earth—soils, metals, building materials, fertilizers, coal, oil, and water—upon which man so largely depends. All of our important educational institutions teach geology, for it is both a practical and a cultural science. It is a part of every balanced curriculum, because it is basic in man's understanding of his relations to things about him.

The chief foundation of the textbooks on the geology of the United States and the largest single source of material for the teacher of geology in this country is either directly or indirectly the 1,500 or more volumes issued by the United States Geological Survey. These volumes present the results of original studies. Each contributes to our knowledge of the earth which we inhabit. New reports and maps are sought constantly for educational purposes, and old reports are in continual use. From the institutions of learning throughout the country, therefore, come steady demands for more material. With the increased costs and the decreased appropriations of late years and the consequently lessened output of such teaching material, there have come complaints and criticisms. Geologic folios and other geologic reports are badly needed. Few are available. The stream of educational material in this field is being dried up at its source. This situation needs prompt correction by adequate support of Government research in geology for the benefit of the educational institutions of the country.

There are, indeed, few industries in the United States that are not dependent upon materials with which the science of geology is concerned. Mining, of course, deals directly with ores and minerals. Coal, oil, iron, copper, lead, zinc, aluminum, gold and silver, quicksilver—all come from the crust of the earth. Building materials (granite, marble, concrete, brick, pottery), the fertilizers (potash, phosphates, and nitrates), many of the substances used in paints and varnishes, jewels and precious stones—all have the same source. And nearly all industries depend upon these mineral substances. There could not be a railroad or a train to run over it, nor an automobile, a steamship, a telegraph or telephone line, a radio or an airplane, or even a modern building, without the use of geologic materials, the ores of the earth.

The uses of all these materials are increasing as man closes in on the waste spaces of the world and lives more intensively in the settled places. Some of them are to be had in abundance, some are limited in quantity and are definitely exhaustible or are being ex-

hausted. The search for them becomes constantly more intense, and all of man's resourcefulness, all of the energy, and all of the science of which he is master are needed to find new supplies to satisfy modern needs. The trends of colonization and settlement, the issues of peace and war, have been vitally affected by the presence or absence of these mineral resources, and civilizations have waned as the supplies have diminished.

The average citizen knows little of the complicated chain of linked and correlated human endeavor that lies back of the satisfaction of his simplest needs. He buys 5 gallons of gasoline. Ten years before, perhaps, a group of geologists explored western Texas or northern Montana or central Wyoming. After examining many hundreds of square miles, favorable geologic conditions were found, and an area was recommended for drilling. Eventually it was drilled, oil was discovered, pipe lines and refineries were built, and distribution was effected. Thus the citizen was enabled to drive another hundred miles without a thought as to how it all happened. But back of it was the essential but forgotten geologic work.

All of this is going on to-day so that man's needs may continue to be satisfied ten or a hundred years hence. The men who must win the ores or the mineral substances know the burden that is on them to do their share in maintaining modern civilization. The rest of us do not. But those who have the vision, those who do know, want geologic work done—not less but more. They want the help that geologic maps, geologic research, geologic understanding can give in finding the mineral bases of modern life. Giving this aid constitutes the economic use of geology. The Government is properly expected to do its share in this work for all of its citizens. It is looked to, not to apply geologic principles to specific problems, such as to digging coal or mining copper—that is the field of the practicing geologist and the mining engineer—but to establish the principles ready for application, to supply the general maps, to determine the rock succession, the broad relations and habits of ores, and the laws of their occurrence, and thus to guide exploration from hopeless into hopeful areas.

There can be no applied science unless there is science to apply. The application of science, geologic or other, depends upon the maintenance of research, for it is pure research that discovers new facts and new natural laws that can be put to use. Every active scientific organization, therefore, is continuously engaged in research whose direct applicability to human use may not be manifest at the moment. Thus the Geological Survey staff is constantly engaged in geologic research—always in connection with its individual projects, for each study, however practical its purpose, involves research, but often in fields not ordinarily called practical. Paleontology—the study of fossils, in itself a purely scientific study—has been found to have such direct practical applications that purely commercial institutions, like oil companies, now have staffs of paleontologists, but the value of their work depends upon broader studies than they are usually able to make, and the Geological Survey should be supplying them, much more adequately than it is, with reference material.

Even the study of earth temperatures, entered upon as an abstract science, is developing interesting possibilities in oil-field work. Simi-

larly studies in the alteration of ore bodies and in their distribution, zonal or other, lead to conclusions that are most definitely applicable and are applied in mining. Great mining companies base decisions involving the expenditure of millions upon the results of such scientific studies. The Government has been and should continue to be the leader in this work; otherwise it will not be adequately or systematically done, and the cost of its neglect to the people and the industries of the country is beyond reckoning.

Work covering broad fields of research or areas not confined to States was conducted by many of the geologists and paleontologists, and the results of some of these studies have been submitted for publication by the Geological Survey or through unofficial channels. In the following list the first two papers were submitted for publication in the Shorter Contributions to General Geology, and the remainder for outside publication:

Exogyra olisiponensis Sharpe and *Exogyra costata*, by J. B. Reeside, jr.

Additions to the flora of the Green River formation, by Roland W. Brown.

Glacial epoch in North America, by Frank Leverett. For volume on North America in Geologie der Erde.

The Lower Cretaceous or Comanche series, by T. W. Stanton. American Journal of Science.

An *Acanthoceras rhotomagense* fauna in the Cretaceous of the Western Interior, by J. B. Reeside, jr. Journal of the Washington Academy of Sciences.

Two new unionid pelecypods from the Upper Triassic, by J. B. Reeside, jr. Journal of the Washington Academy of Sciences.

Triassic-Jurassic "Red Beds" of the Rocky Mountain region, by J. B. Reeside, jr. Journal of Geology.

Pycinodema nom. nov. pro *Pycnodema* Kirk non Schrammen, by Edwin Kirk. Proceedings of the United States National Museum.

The crinoid genus *Vasocrinus* Lyon, by Edwin Kirk. Proceedings of the United States National Museum.

Cryphiocrinus, a new genus of free-swimming crinoids, by Edwin Kirk. American Journal of Science.

Bathmopterus, a new gastropod genus from the Silurian of Alaska, by Edwin Kirk. Proceedings of the United States National Museum.

On the generic name *Orbiculoidea* D'Orbigny and its application, by G. H. Girty. Journal of the Washington Academy of Sciences.

Stones of *Celtis* in the Tertiary of the western United States, by E. W. Berry.

Distribution in tropical America of *Turritella ocoyana*, by W. P. Woodring. Proceedings of Cordilleran section of the Geological Society of America.

Ecology of the mollusks of the Bowden formation, Jamaica, by W. P. Woodring. Proceedings of Cordilleran section of the Geological Society of America.

Variations in Appalachian stratigraphy, by Charles Butts. Address as retiring president of the Geological Society of Washington; published in the bulletin of the society.

Some results of recent work in the southern Taconic area, by E. B. Knopf. American Journal of Science.

Structural symmetry in North America, by Arthur Keith. Presidential address at the Cleveland meeting of the Geological Society of America; published in the bulletin of the society.

Structure contour maps of the Pittsburgh-Huntington Basin, by G. B. Richardson. Bulletin of the Geological Society of America.

Our petroleum supply, by C. E. Dobbin. Presented at joint meeting of the Washington Society of Mechanical Engineers and the Washington Society of Engineers; published in the Journal of the American Society of Mechanical Engineers.

The economic geology of coal in North America, by C. E. Dobbin. For volume on North America in Geologie der Erde.

The carbon ratio theory in the light of Hilt's law, by Frank Reeves. Bulletin of the American Association of Petroleum Geologists.

Major marine transgressions and regressions and structural features of the Gulf Coastal Plain, by L. W. Stephenson. American Journal of Science.

Correlation of the Upper Cretaceous or Gulf series of the Gulf Coastal Plain, by L. W. Stephenson. American Journal of Science.

Structural features of the Atlantic and Gulf Coastal Plain, by L. W. Stephenson. Bulletin of the Geological Society of America.

Cenozoic formations of the Coastal Plain east of the Mississippi River, by C. W. Cooke. For volume on North America in Geologie der Erde.

Correlation of the Cenozoic deposits of the eastern Gulf States, by C. W. Cooke. Presented at the meeting of the American Association for the Advancement of Science.

Sedimentary analcite, by C. S. Ross. American Mineralogist.

Titaniferous biotite, by C. S. Ross. American Mineralogist.

Anauxite, by C. S. Ross and W. F. Foshag. American Mineralogist.

Clay minerals and their methods of study, by C. S. Ross. Proceedings of the International Soil Congress.

Altered volcanic materials of the Paleozoic and their recognition, by C. S. Ross. Bulletin of the American Association of Petroleum Geologists.

The origin of the albitite bodies, by E. S. Larsen. Presented at the meeting of the Geological Society of America in Cleveland; published in the bulletin of the society.

Usefulness of petrology in the selection of limestone, by G. F. Loughlin. Rock Products.

Bibliography of building stone and resistance of natural stone to fire, by G. F. Loughlin. Presented at Atlantic City meeting of the American Society of Testing Materials.

Usefulness of petrology in quarrying and use of stone, by G. F. Loughlin. Presented at the meeting of the American Institute of Mining and Metallurgical Engineers.

American potash, by G. R. Mansfield. Technical Engineering News.

Geographic terminology, by M. R. Campbell. Annals of Association of American Geographers.

Correction for well logs, by W. B. Lang. Bulletin of the American Association of Petroleum Geologists.

The fracturing of incompetent beds, by T. S. Lovering. Journal of Geology.

Physico-chemical factors controlling magmatic differentiation and vein formation, by C. S. Ross. Economic Geology.

Dolomitization and ore deposition, by D. F. Hewett. Economic Geology.

The effect of gravitational compaction on the structure of sedimentary rocks, by W. W. Rubey. Bulletin of the American Association of Petroleum Geologists.

Gullies of the Great Plains formed by subsidence, by W. W. Rubey.

The compressibility of sand-mica mixtures [discussion], by W. W. Rubey. Proceedings of the American Society of Civil Engineers.

Some factors in rock metamorphism, by David White. Proceedings of the National Academy of Sciences.

A spiral graph of geologic time, by David White. Journal of the Washington Academy of Sciences.

A recent collection of late Pliocene invertebrates from the headwaters of the Amazon, by J. A. Gardner. Journal of the Washington Academy of Sciences.

Incompleted projects comprise studies of the copper deposits of the southern Appalachian region, by C. S. Ross and M. N. Short, a summary of which was issued as Press Memorandum 23711; a report on Appalachian oil-field studies, by G. B. Richardson; a review of the metal production of Europe, by D. F. Hewett; a report on gold reserves for the International Geological Congress, by G. F. Loughlin; studies of the Cambrian faunas of the upper Mississippi Valley, by E. O. Ulrich in cooperation with the Milwaukee Public Museum; studies of the Cretaceous formations of the Western Interior province, by J. B. Reeside, jr.; studies of the genus *Lingulidiscina*, the Devono-Carboniferous faunas, the occurrence of *Archimedes* in the Pennsylvanian, and the genus *Myalina*, and revision of the paper on the genus *Astartella*, by G. H. Girty; study of the genus *Bairdia* and of conodont genera and species and papers on *Kirkbya* and *Parapar-*

chites, by P. V. Roundy; studies of the Eocene Foraminifera of the Coastal Plain, by J. A. Cushman; report on *Virgiana* in the Silurian of western North America, by Edwin Kirk; and research on microchemical methods of ore identification and on certain rare nickel ores, by M. N. Short.

ALABAMA

Investigations of iron-ore deposits in Colbert and Franklin Counties and at Florence, Lauderdale County, and Giles, Madison County, were conducted by E. F. Burchard in connection with a report on iron-ore reserves and production of the Tennessee River Basin in Alabama, Georgia, Kentucky, Tennessee, and Virginia, which was made and transmitted to the district engineer, Corps of Engineers, Florence, Ala. Mr. Burchard prepared a discussion of a paper on Occurrence and Age of Certain Brown Iron Ore Deposits in Alabama and adjacent States for Economic Geology. A report on the Bessemer and Vandiver quadrangles, Alabama, by Charles Butts, was issued as Geologic Folio 221.

ARIZONA

Examinations of the Supai formation of the Grand Canyon, Ariz., in a successful search for fossil evidence on which to determine the geologic age of the formation was made by David White. Paleontologic material was also procured from the Redwall and Cambrian formations and from the Unkar series. The field and travel expenses of this work were covered by the cooperation of the Carnegie Institution with a committee of the National Academy of Sciences in the investigation of the geologic history of the Grand Canyon section. Mr. White also made a partly successful search for fossil remains in the pre-Cambrian Mescal limestone, which was examined in several areas of central and northern Arizona, and continued office studies of the Permian fossil plants from the Hermit shale in the Grand Canyon. The following articles by Mr. White were published: The Flora of the Hermit Shale in the Grand Canyon, Arizona (Nat. Acad. Sci. Proc., vol. 13, No. 8, August, 1927); and Study of the Fossil Floras in the Grand Canyon, Arizona (Carnegie Inst. Yearbook No. 26, 1926–27, pp. 366–369). The Grand Canyon of the Colorado River, a text describing the geologic features, with a brief summary of the history, discovery, and exploration of the Grand Canyon, to be printed on the back of the revised topographic map of the Bright Angel quadrangle, was prepared by F. E. Matthes, who also wrote an article on Breaking a Trail Through Bright Angel Canyon, for Nature Notes, published by the National Park Service. Continued work on the construction of a relief model of the Grand Canyon, which is being done in cooperation with the National Park Service, American Museum Association, a National Academy committee, and the National Research Council, was supervised by Mr. Matthes. N. H. Darton prepared a paper on tectonics in Arizona and New Mexico for the meeting of the Geological Society of America in Cleveland. In connection with studies in southern San Juan County, Utah, A. A. Baker, H. E. Gregory, and J. B. Reeside, jr., made a reconnaissance of the geology of portions of northeastern Arizona.

ARKANSAS

In informal cooperation with the Arkansas Geological Survey unpublished material has been contributed by the Federal Survey toward the compilation of a revised geologic map of Arkansas, which will be published by the State organization. A proposed addition to the Ouachita National Forest lying in Garland, Montgomery, and Hot Springs Counties, in west-central Arkansas, was the subject of a report by H. D. Miser to the Forest Service in connection with the preservation of the navigation of the streams in whose drainage basins the tract lies. A paper on the age relations of Carboniferous rocks of the Ouachita Mountains, Arkansas and Oklahoma, by H. D. Miser and C. W. Honess, was published as Bulletin 44 of the Oklahoma Geological Survey. The lead and zinc deposits of northern Arkansas are being studied by E. T. McKnight, in cooperation with the Arkansas Geological Survey. The faunas of the basal Fayetteville shale and the Morrow formation are the subject of papers in preparation by G. H. Girty. E. O. Ulrich studied the Paleozoic stratigraphy of Arkansas, accompanied by the State geologists of Arkansas and Missouri.

CALIFORNIA

A field study of the geology of the eastern part of the Santa Monica Mountains, Calif., was completed by H. W. Hoots, and a report on this study was submitted. A paper entitled "The Santa Monica Mountains, a Major Anticlinal Uplift Adjoining Los Angeles Basin," was presented by Mr. Hoots at a meeting of the American Association of Petroleum Geologists held in San Francisco in March. The results of his study of portions of Humboldt County were issued in the form of a press notice, Oil and Gas Exploration in Southwest Humboldt County. Further field work in the Elk Hills oil field was done by W. P. Woodring, and office work on the report was continued by Mr. Woodring and P. V. Roundy. Field study of the Plumas County copper deposits was begun by Adolph Knopf. In connection with his resurvey of the Mother Lode district Mr. Knopf studied new developments at many of the mines and completed the manuscript for a professional paper on the geology and ore deposits of the district. Office work on a report on the Allegheny district was continued by H. G. Ferguson, and work on a report on the geology of the Ivanpah quadrangle, which lies partly in Nevada, was continued by D. F. Hewett. A chapter on rocks of the Yosemite Valley was prepared by F. E. Matthes for the forthcoming professional paper on the valley, and the chapter on bedrock geology is being revised by F. C. Calkins. A paper on evidence of three glaciations of the Yosemite region was prepared by Mr. Matthes for the Geological Society of America. As a part of his study of the physiography of the upper San Joaquin Basin Mr. Matthes made a field reconnaissance in the upper drainage basin of the San Joaquin River. The report on the San Joaquin Basin is well advanced. A paper on late Tertiary thrust faults of the Mohave Desert by D. F. Hewett was submitted for publication in the Proceedings of the National Academy of Sciences. A paper on two Tertiary epochs of thrust faulting in the Mohave Desert was presented by Mr. Hewett at the annual meeting of the Geological Society of America. A report on nitrate deposits in southeastern California, with notes on deposits in southeastern Arizona and southwestern New Mexico, was completed by L. F. Noble. The San Andreas rift is being studied by Mr. Noble. The fault scarp near Bakersfield is described by G. K. Gilbert in Professional Paper 153. The Lassen Volcano Observatory, one of the stations maintained for studies of volcanology, has been conducted by R. H. Finch. A paper on the observatory was presented by Mr. Finch at a meeting of the Seismological Society of America at San Francisco in March. Mr. Finch made an investigation to determine the cause of the destructive mud flows of Mud Creek on Mount Shasta in 1924 and 1926. T. W. Stanton reported on Jurassic fossils from the Monte de Oro formation near Oroville.

COLORADO

Cooperative work by the Colorado Metal Mining Fund and the United States Geological Survey, in a study of the mining geology of the State, was continued under the general direction of G. F. Loughlin and B. S. Butler. The work consisted of a resurvey of old districts that needed checking in the light of new developments, detailed studies of districts which had not been previously mapped by the Geological Survey, and a general inspection of the metalliferous regions of the State. At Cripple Creek a study of the deeper mine workings was made by Mr. Loughlin, assisted for a short time by T. S. Lovering, and the preliminary results of this study were published as Technical Publication 13 of the American Institute of Mining and Metallurgical Engineers, entitled "Ore at Deep Levels in the Cripple Creek District." A restudy of the Creede district was made by E. S. Larsen, who will prepare a supplementary report. Work in the Ouray-Telluride area was started by W. S. Burbank and in the Breckenridge district by Mr. Lovering. New work included detailed studies in the Bonanza district, by Mr. Burbank; in the mineralized portion of the Montezuma quadrangle, by Mr. Lovering, who also made a reconnaissance of adjacent parts of the Fraser quadrangle and other bordering areas; and in the Alma district, by Mr. Butler and J. T. Singewald. A paper on the geology of the Moffat tunnel was presented at the meeting of the American Institute of Mining and Metallurgical Engineers by Mr. Lovering, who also gave a paper on the Williams thrust fault at the meeting of the Geological Society of America. Mr. Butler inspected the metalliferous region of the State to determine what kinds of study are needed and to select different places for future study. M. N. Short continued his studies of the ores from the several districts, and J. B. Reeside, jr.,

and Edwin Kirk studied and reported on Cretaceous and Ordovician invertebrates for Messrs. Lovering and Burbank. A report on the geology and ore deposits of the Leadville mining district, by S. F. Emmons, J. D. Irving, and G. F. Loughlin, was issued as Professional Paper 148. Studies of oil shales from the Green River formation of Colorado, Utah, and Wyoming were continued by W. H. Bradley, and three papers embodying the results of these studies have been completed for Geological Survey publication—one on the origin and microfossils of these shales, one on the varves and climate of the Green River epoch, and one on the occurrence and origin of analcite and meerschaum beds in the Green River formation. Mr. Bradley sent to Science a paper on zeolite beds in the Green River formation. Additional field work in the Book Cliffs coal fields was done by C. E. Erdmann, and progress was made on the report. Fresh-water shells from the Mesaverde of the eastern Book Cliffs were studied by Mr. Reeside. A paper describing ammonites from the Greenhorn limestone of Colorado is in preparation by Mr. Reeside, who also completed a paper on five new species of Cretaceous mollusks from Colorado and Utah for publication in the Journal of the Washington Academy of Sciences. Progress was made by M. R. Campbell on his report on the coal resources, structure, and stratigraphy of the eastern Yampa coal field. Data on the invertebrate fossils and stratigraphy were prepared by Mr. Reeside. Revision of the report by E. T. Hancock and J. B. Eby on the geology and coal resources of the Meeker quadrangle, Moffat and Rio Blanco Counties, was completed. Fluorspar deposits in Boulder County were examined by E. F. Burchard. A report on the correlation of geologic formations between east-central Colorado, central Wyoming, and southern Montana, by W. T. Lee, and one on the cephalopods of the Eagle sandstone and related formations in the Western Interior of the United States, by J. B. Reeside, jr., were issued as Professional Papers 149 and 151, respectively. A report on the geology and oil and gas prospects of northeastern Colorado, by K. F. Mather, James Gilluly, and R. G. Lusk, was issued as Bulletin 796–B.

DISTRICT OF COLUMBIA

Arthur Keith examined excavations in Washington in connection with his studies of the geology of the District of Columbia.

FLORIDA

The revised report and geologic map of Florida, which was prepared in cooperation with the Florida Geological Survey, was completed by C. W. Cooke with the assistance of W. C. Mansfield in the collection and determination of fossils. The report will be issued by the Florida Geological Survey. The mollusks of the Choctawhatchee marl, from the northwestern part of the State, are receiving monographic treatment by W. C. Mansfield. This is a cooperative project, and the report will be issued by the Florida Geological Survey. A paper entitled "Stratigraphy and Age of the Pleistocene Deposits in Florida from Which Human Bones Have Been Reported" was prepared by C. W. Cooke for publication in the Journal of the Washington Academy of Sciences. Part V of the report on the molluscan fauna of the Alum Bluff group of Florida, covering Tellinacea, Solenacea, Mactracea, Myacea, and Molluscoidea, by Julia Gardner, was published as Professional Paper 142–E.

GEORGIA

Iron ores of the Georgia portion of the Tennessee River Basin were examined by E. F. Burchard for a report to the Corps of Engineers, War Department. The State geologist consulted regarding the structure of the Tate marble belt with Arthur Keith, who reviewed maps and sections for the report by W. S. Bayley on this region.

HAWAII

From the headquarters of the section of volcanology, T. A. Jaggar, jr., in charge, at Volcano House, Hawaii, observations of the volcanic phenomena in the island group were continued, and in cooperation with the Hawaiian Volcano Research Association four seismograph stations were maintained on the island of Hawaii, and the publication of the Volcano Letter, a weekly leaflet

about the activities of the Hawaiian volcanoes, and the monthly Bulletin, containing the scientific results obtained at the station, was continued. Cooperation was maintained with the Coast and Geodetic Survey in running precise-level lines to the top of Mauna Loa, establishing a new tide-gage station at Hilo, and making gravity measurements at Hilo, Kilauea, and Mauna Loa. Mr. Jaggar gave a lecture on volcano research of the Geological Survey at a meeting of the Geophysical Union on April 27.

IDAHO

As a part of a comprehensive study of the ore deposits of south-central Idaho, C. P. Ross made investigations in the Casto quadrangle, completed a report thereon, and began field mapping of the Bayhorse quadrangle. The Thunder Mountain district of Idaho County is the subject of a special report by Mr. Ross which is about completed. Mr. Ross also prepared a paper on Mesozoic and Tertiary granitic rocks in Idaho for publication in the Journal of Geology. A report describing the geology, geography, and mineral resources of a portion of southeastern Idaho, by G. R. Mansfield, with descriptions of Carboniferous and Triassic fossils, by G. H. Girty, has been issued as Professional Paper 152. Mr. Mansfield has extended these investigations to cover the Paradise Valley, Ammon, and Portneuf quadrangles. The report on the Portneuf quadrangle has been completed and will be issued as Bulletin 803. Reports on the Paradise Valley and Ammon quadrangles are under way. Papers summarizing some of these investigations were presented by Mr. Mansfield at the annual meetings of the American Association for the Advancement of Science and the Geological Society of America, and a paper on the Idaho phosphate field was presented by Mr. Mansfield at the February meeting of the American Institute of Mining and Metallurgical Engineers in New York. A preliminary report on the Pend Oreille district, prepared by Edward Sampson in cooperation with the Idaho Bureau of Mines and Geology, has been transmitted to that bureau for publication. A paper on stages in the contact metamorphism in the Pend Oreille district was presented by J. L. Gillson before the Mineralogical Society of America at Cleveland. A paper on lake beds in Idaho as building stones has been submitted for publication by C. H. Behre. Fossil collections sent in by the Idaho Bureau of Mines and Geology were studied and reported on by the paleontologists of the United States Geological Survey as a part of the informal cooperation which exists between the two organizations—Lower Cretaceous invertebrates by T. W. Stanton, Devonian invertebrates by Edwin Kirk, fossil plants by E. W. Berry, Carboniferous fossils by G. H. Girty and P. V. Roundy, and fresh-water mollusks collected near Payette by W. C. Mansfield. W. C. Alden carried on reconnaissance mapping in Fremont County in connection with his general studies of the glacial geology and physiography of the northwestern part of the United States. A report on a Pleistocene manganese deposit in Bannock County, by D. F. Hewett, was issued as Bulletin 795–H.

ILLINOIS

Progress was made toward the completion of a geologic folio on the Equality and Shawneetown quadrangles, which lie partly in Illinois and partly in Kentucky. The investigation has been made by Charles Butts in cooperation with the Illinois Geological Survey. Outcrop material from Illinois was studied by P. V. Roundy in connection with his general studies in micropaleontology. M. R. Campbell conferred with the Illinois State geologist and his associates regarding the character, classification, and use of Illinois coals in connection with his general study of the classification of coal. W. C. Alden, in company with M. M. Leighton, State geologist, made a brief field study of the glacial and interglacial deposits in the State. A paper on some issues in Chester stratigraphy in western Kentucky and southern Illinois by Charles Butts was sent to the Journal of Geology. Work on the genesis of ores is mentioned under Missouri.

INDIANA

Study of a new crinoid genus from the Devonian of Indiana was begun by Edwin Kirk. Carboniferous invertebrates and gastropods from the Spergen limestone were studied by P. V. Roundy. The manuscript of a report on the grading of Indiana limestone, by G. F. Loughlin, has been completed.

IOWA

M. R. Campbell conferred with the Iowa State geologist and his associates regarding the character, classification, and use of Iowa coal, in connection with his general study of the classification of coal.

KANSAS

A cooperative report on the geology of Cowley County, Kans., with special reference to the occurrence of oil and gas, was completed by N. W. Bass and transmitted to the Kansas Geological Survey for publication. T. W. Stanton reported on Comanche ammonites; G. H. Girty and P. V. Roundy studied the Carboniferous invertebrates, and Mr. Roundy examined Carboniferous microfossils in connection with his general studies of micropaleontology.

KENTUCKY

Progress was made by Charles Butts toward the completion of a geologic folio on the Equality and Shawneetown quadrangles, which lie partly in Kentucky. A report on iron-ore reserves of the Tennessee River Basin was made by E. F. Burchard to the Corps of Engineers, War Department. A paper on some issues in Chester stratigraphy in western Kentucky and southern Illinois was prepared by Mr. Butts for publication in the Journal of Geology.

LOUISIANA

The formations of the Claiborne group in Louisiana and Texas were correlated by Julia Gardner. Reports on Comanche fossils from drill cores of deep wells in Louisiana were made by T. W. Stanton. Carboniferous invertebrates from Louisiana were studied by P. V. Roundy.

MAINE

Preparation of a geologic folio describing the Portland and Casco Bay quadrangles, Maine, was continued by Laurence LaForge. Arthur Keith made geologic examinations in the field and conducted office investigations to determine the cause of recent earthquakes which have been felt in Maine. He prepared a paper on the earthquake at Milo, Me., for presentation at the meeting of the Seismological Society at Charlottesville, Va., in May, 1928.

MARYLAND

In connection with his cooperative glacial studies in Pennsylvania Frank Leverett examined the gravel deposits of Susquehanna River of Illinoian age, in Maryland. He was accompanied by C. W. Cooke and Mrs. E. B. Knopf in a correlation of the terraces near the mouth of the Susquehanna. G. W. Stose began field work in the South Mountain region of the Emmitsburg and Ijamsville quadrangles, the results of which will probably be published as a folio. The Frederick County report which A. I. Jonas is preparing for the Maryland Geological Survey, in informal cooperation with the United States Geological Survey, will contain contributions by Mr. Stose on the South Mountain region. E. W. Berry made a contribution to a short paper on the coal fields of Maryland which the Bureau of Mines requested the Geological Survey to prepare for inclusion in a report of that bureau. Notes on Pleistocene faunas from Maryland and Virginia, by W. C. Mansfield, were included in Professional Paper 150–F, published during the year.

MASSACHUSETTS

Further field studies in the Taconic area, including the Greylock and Berlin quadrangles, Massachusetts, were made by L. M. Prindle, and progress was made toward the completion of the report covering this area.

MICHIGAN

Studies of the Carboniferous invertebrate fauna of the Marshall sandstone were continued by G. H. Girty. In continuation of his studies of the Paleozoic of Michigan, E. O. Ulrich made a field examination of the section to the east and west of Escanaba and of a section on or near the south shore of Lake Superior, in informal cooperation with the Michigan Geological Survey. Proof of the professional paper on the copper deposits of Michigan, by B. S. Butler and W. S. Burbank, has been reviewed.

MINNESOTA

The manuscript of a report on the Quaternary geology of Minnesota and parts of adjacent States was completed by Frank Leverett, assisted by F. W. Sardeson. This report has been prepared in cooperation with the Minnesota Geological Survey and will be issued as a professional paper of the United States Geological Survey.

MISSOURI

For the studies of the genesis of zinc ores in the Central States which C. E. Siebenthal and R. C. Wells are making, Mr. Siebenthal collected specimens from southeastern Missouri and southern Illinois.

MONTANA

Investigations of the metalliferous deposits in the vicinity of Helena, Mont., were continued by J. T. Pardee, and a preliminary report on the gold deposits at York, Lewis and Clark County, was issued as Press Memorandum 22323. At the request of the Post Office Department, Mr. Pardee examined deposits of the Vermiculite & Asbestos Co., Libby, Mont., and prepared a report concerning them. A paper entitled "Deposits of Vermiculite and Other Minerals in the Rainy Creek District Near Libby, Mont.," by Mr. Pardee and E. S. Larsen, jr., has been submitted for publication in Contributions to Economic Geology, and a paper on the stocks of the alkaline rocks in Rainy Creek near Libby, by the same authors, for publication in the Journal of Geology. Mr. Pardee continued work on a report on late Tertiary faults in southwestern Montana and prepared a report on the geology of a dam site in Hungry Horse Canyon, on the South Fork of Flathead River, for the Columbia Basin Irrigation League. Physiographic and glacial studies in western Montana and office work on the report on the geology and physiography of that region were continued by W. C. Alden. Studies of coal fields of southern and east-central Montana were carried on by two parties, one under the direction of A. J. Collier, assisted by C. E. Erdmann, who continued mapping the coal fields of McCone County, and another under the supervision of N. W. Bass, who mapped the Ashland coal field of Powder River County and adjacent parts of Rosebud and Custer Counties. In the office Mr. Collier made some progress on his report on the geology of the Little Rocky Mountains and Fort Belknap Indian Reservation. The report on the Bearpaw Mountains was revised by Frank Reeves, who also has in hand a report on the geology of the Big Snowy Mountains. A report on the geology and mineral resources of parts of Carbon, Big Horn, Yellowstone, and Stillwater Counties, by R. S. Knappen and G. F. Moulton, was completed. J. B. Reeside, jr., identified Jurassic fossils for Frank Reeves and studied and reported on Lance invertebrates for A. J. Collier. Cretaceous invertebrates were reported on by T. W. Stanton, and Carboniferous invertebrates were studied by G. H. Girty. Reports on the correlation of geologic formations between east-central Colorado, central Wyoming, and southern Montana, by W. T. Lee, and on the cephalopods of the Eagle sandstone and related formations in the Western Interior of the United States, by J. B. Reeside, jr., were issued as Professional Papers 149 and 151, respectively. A report on the phosphate rock in the Three Forks-Yellowstone Park region, Montana, by D. D. Condit, E. H. Finch, and J. T. Pardee, was issued as Bulletin 795–C.

NEVADA

The final report on the Pioche district, Nevada, which includes the Highland, Bristol Range, and Panaca quadrangles, was completed by L. G. Westgate and Adolph Knopf, Mr. Westgate describing the general geology of the area and

Mr. Knopf the geology of the ore deposits and the mines. Edwin Kirk discussed Ordovician, Silurian, and Devonian invertebrates for this report. A bulletin on the geology and ore deposits of the Goodsprings quadrangle has been completed by D. F. Hewett. A report on the areal and economic geology of the Hawthorne and Tonopah quadrangles is in preparation by H. G. Ferguson, and a report on the mining districts in the Carson Sink region by F. C. Schrader is nearing completion. A study of the Lowry Peak quadrangle was begun by Mr. Ferguson, who examined some of the mines in the Eureka district and with Messrs. Girty, Kirk, and Longwell studied the stratigraphy of the region. Notes on the stratigraphy and structure of the northwestern portion of the Spring Mountains and a paper on a late Paleozoic positive area in Nevada were submitted by T. B. Nolan for publication in the American Journal of Science. Geologic field studies in the Las Vegas quadrangle were continued by C. R. Longwell, and general geologic studies in the Frenchman Flat Basin, Las Vegas and Furnace Creek quadrangles, and the Opal Mountain Basin, Camp Mohave quadrangle, by C. E. Erdmann. Ordovician, Silurian, and Devonian fossils were determined by Mr. Kirk for Messrs. Longwell and Erdmann. A "Tectonic Study of Some Basin Ranges in Nevada" was submitted by Mr. Longwell for outside publication. Mr. Hewett prepared a summary of the stratigraphy and structure of the Great Basin area for publication in the volume on North American geology to be included in "Geologie der Erde." Reports on the quicksilver deposits of the Pilot Mountains, by W. F. Foshag, and the Gilbert district, by H. G. Ferguson, were issued as Bulletins 795–E and 795–F, and a description of the Chalk Mountain, Quartz Mountain, Gold Basin, and King mining districts was issued as a press memorandum.

NEW HAMPSHIRE

In connection with his studies of the causes of recent earthquakes in the northeastern United States, Arthur Keith made some field investigations in New Hampshire and collected data from various sources.

NEW JERSEY

A paper on the results of field study in 1927 of the glacial and associated deposits of Pennsylvania and New Jersey was presented by Frank Leverett at the meeting of the Geological Society of America in Cleveland December 28–31. Field work to determine the age of the Rancocas and Manasquan formations of New Jersey was done by L. W. Stephenson and C. W. Cooke, and a paper entitled "The Eocene Age of the Supposed Late Upper Cretaceous Fauna of New Jersey," setting forth the results of this work, was prepared by them for publication in Science.

NEW MEXICO

The investigations in search of potash were continued in New Mexico, and a temporary building was erected on the post-office grounds at Roswell to store the well cores and to serve as a laboratory. The core of well 3, in Eddy County, the drilling of which was completed by the Bureau of Mines, was sampled and studied by W. B. Lang and J. W. Vanderwilt, and selected portions were sent to Washington for analysis. Samples of a core from a private potash test in Eddy County and many samples of well cuttings from Eddy, Lea, and adjacent counties have been studied. Three press notices entitled "Government Strikes Potash in New Mexico," "Potash Found in 26 More Wells in Texas and New Mexico," and "Potash Exploration—Third Government Test Strikes Substantial Bodies of Potash" were prepared by G. R. Mansfield. For a study of the ore deposits of Socorro County being made by the New Mexico Bureau of Mines and Mineral Resources the United States Geological Survey will supply data on the Magdalena mining district, compiled by G. F. Loughlin, and bring up to date a report begun some years ago on the Santa Rita mining district by A. C. Spencer. Upper Cretaceous invertebrates from the Santa Rita district were identified by T. W. Stanton. Mr. Spencer made a brief visit to a tin-bearing district in Sierra County. N. H. Darton began the preparation of a chapter on New Mexico for inclusion in the volume on the geology of North America for publication in "Geologie der Erde." The preparation of a report on Lake Valley invertebrates was continued by G. H. Girty. Field work in the San Juan Basin of northwestern New Mexico was begun by C. H. Dane and J. B. Reeside, jr., who carried on stratigraphic studies and detailed plane-table

mapping of the coal-bearing and associated formations, primarily for the purpose of land classification. A brief stratigraphic reconnaissance of northwestern New Mexico was made by A. A. Baker, with H. E. Gregory and J. B. Reeside, jr., in connection with Mr. Baker's work in southern Utah. Mapping of the Santa Clara quadrangle was begun by E. S. Larsen, with C. S. Ross, in connection with the report on the igneous geology of the Jemez Mountains. A report on the cephalopods of the Eagle sandstone and related formations in the Western Interior of the United States, by J. B. Reeside, jr., was published as Professional Paper 151, and a report on the geology and ore deposits of the Mogollon mining district, by H. G. Ferguson, as Bulletin 787. Investigations of tectonics are mentioned under Arizona.

NEW YORK

In connection with studies of the southern Taconic area Mrs. E. B. Knopf made a special investigation of the structural relations of the pre-Cambrian and Paleozoic rocks in the Poughkeepsie and Clove quadrangles, New York, and continued work on a report on these investigations. Study of the geology of the Hoosick and Berlin quadrangles was continued by L. M. Prindle in his investigation of the Taconic region of New York, Vermont, and Massachusetts. Granite intrusions in the vicinity of Lake Placid, in the Adirondacks, were examined by James Gilluly.

NORTH CAROLINA

A paper on seven new species and five new subspecies of mollusks from the Miocene of Virginia and North Carolina, with a brief outline of the divisions of the Chesapeake, was prepared by W. C. Mansfield for publication in the Proceedings of the United States National Museum. Mr. Mansfield made additional field investigations in connection with his studies of the upper Miocene of the Carolinas. An article on the origin of nickel silicates at Webster, N. C., was written by C. S. Ross, E. V. Shannon, and F. A. Gonyer for Economic Geology. Notes on Pliocene and Pleistocene faunas from North Carolina, by W. C. Mansfield, were included in Professional Paper 150–F, issued during the year.

NORTH DAKOTA

Cuttings from the Glenfield well, eastern North Dakota, were studied by J. B. Reeside, jr. The report on the geology and lignite resources of the Marmarth field, southwestern North Dakota, by C. J. Hares, is in press and will be issued as Bulletin 775. Studies of stratigraphy of the Fox Hills and Lance formations are mentioned under South Dakota.

OHIO

The manuscript of the Cleveland geologic folio, describing in detail the geology and mineral resources of the Cleveland, Berea, and Euclid quadrangles, has been completed. Work on a paper on the Waverly fauna was continued by G. H. Girty. Data on mild earth tremors in Ohio and other Eastern States are being gathered by Arthur Keith in libraries and newspapers. Carboniferous microfossils from Ohio were examined by P. V. Roundy.

OKLAHOMA

Office work on a report covering the richest portion of the zinc-lead ore district of the Joplin region of Missouri, Kansas, and Oklahoma was continued by C. E. Siebenthal. A paper on the age relations of the Carboniferous rocks of the Ouachita Mountains, by H. D. Miser and C. W. Honess, was completed by Mr. Miser and transmitted to the Oklahoma Geological Survey, which published it as Bulletin 44. Papers on fossiliferous boulders in the Ouachita "Caney" shale and the age of the shale containing them, and on the Paleozoic section of the Arbuckle and Wichita uplifts, by E. O. Ulrich, have been submitted to the Oklahoma Geological Survey for publication. Descriptions of the faunas of the Moorefield shale and the Morrow and Glenn formations were continued by G. H. Girty, who also worked on a paper on an uncommon Penn-

sylvanian fauna from Oklahoma. Microfossils from the Caney and Moorefield shales were studied by P. V. Roundy. Mr. Roundy attended sales of Osage leases at Pawhuska December 12 and March 28 and 29, to advise the Office of Indian Affairs concerning the adequacy of bids. T. W. Stanton reported on Comanche ammonites from Oklahoma.

OREGON

The manuscript for a revised report on the Wallowa Mountains, Oreg., was completed by C. P. Ross. A paper on zeolites from Ritter Hot Springs, Grant County, was completed by D. F. Hewett, E. V. Shannon, and F. A. Gonyer for publication in the American Journal of Science. The structure of the Klamath Lake region is described by G. K. Gilbert in Professional Paper 153.

PENNSYLVANIA

Cooperative studies of glacial geology in Pennsylvania were continued by Frank Leverett. Two reports covering this investigation will be submitted to the Pennsylvania Geological Survey for publication—one on the pre-Wisconsin drifts of the Susquehanna drainage basin, which is about completed, and another on pre-Wisconsin drifts of the Lehigh, Delaware, and Raritan drainage basins. Other cooperative projects that are under way include reports on the Lancaster quadrangle and on the York, Middletown, Hanover, and New Cumberland quadrangles by G. W. Stose and A. I. Jonas, Miss Jonas working for the Pennsylvania Survey. Mr. Stose contributed material and time to the revision of the Pennsylvania geologic map, which is being compiled by the State survey. Progress was made on reports on the New Kensington, Butler, and Zelienople quadrangles by G. B. Richardson; on the Quakertown-Doylestown geologic folio by Mr. Stose and Florence Bascom; and on a report on the Tyrone quadrangle by Charles Butts. A paper on the Martinsburg shale and lava flow in Pennsylvania by Miss Jonas, one on the structure of the Pittsburgh-Huntington Basin by Mr. Richardson, and one on the high-level gravel on Susquehanna River by Mr. Stose were presented at the annual meeting of the Geological Society of America. G. H. Girty continued his studies of the Pottsville and other Carboniferous faunas of Pennsylvania. Devonian and Ordovician invertebrates were studied by E. O. Ulrich for the Pennsylvania survey. A description of the Pocono fauna of the Broad Top coal field by Mr. Girty was published as Professional Paper 150–E.

SOUTH CAROLINA

In connection with studies of the upper Miocene of the Carolinas, W. C. Mansfield made trips to South Carolina to examine these deposits in the field and collect material for office study.

SOUTH DAKOTA

A paper on the contact of the Fox Hills and Lance formations in the northern Great Plains, by C. E. Dobbin and J. B. Reeside, jr., was revised by the authors. E. W. Berry studied the flora of the Newcastle sandstone in the Black Hills. A report on the cephalopods of the Eagle sandstone and related formations in the Western Interior of the United States, by Mr. Reeside, was issued as Professional Paper 151.

TENNESSEE

Additional data were gathered by E. F. Burchard to bring up to date his report on brown iron ores of the western Highland Rim, a cooperative project with the Tennessee Geological Survey, and the revised manuscript was transmitted to the State for publication. Mr. Burchard prepared a report on iron-ore reserves of the Tennessee River Basin for the Corps of Engineers, War Department, and his report on the brown iron ores of west-middle Tennessee was issued as Bulletin 795–D. R. D. Mesler prepared Ozarkian and Canadian invertebrates collected by Charles Butts, and P. V. Roundy studied Carboniferous invertebrates. A trip to Jefferson City and Mascot to examine zinc mines with special reference to dolomitization was made by E. T. McKnight.

TEXAS

The potash investigations for the year were largely centered in Texas. Drilling of 5 wells, 1 in Ector County, 2 in Crockett County, and 2 in Upton County, was completed by the Bureau of Mines. Four of these wells were logged, studied, and sampled, and samples were sent to the Washington office for analysis. W. B. Lang and J. W. Vanderwilt, of the field force, and E. P. Henderson, of the Washington office, participated in this work. An important part of the work in Texas consisted in the selection of three drilling sites in Reagan, Glascock, and Crane Counties, which were recommended to the Bureau of Mines as a basis for its drilling program for the year. Two press notices entitled "First Government Potash Test Encouraging" and "Potash Struck by Four Government Tests in Texas" were prepared by G. R. Mansfield. Field mapping of the Upper Cretaceous formations of Texas was extended by L. W. Stephenson, who also continued office studies in connection with his report on the Upper Cretaceous formations of Texas. A paper entitled "Notes on the Taylor and Navarro Formations of Northeastern Texas," by L. W. Stephenson and C. H. Dane, was sent to the American Association of Petroleum Geologists for publication. Field and office studies of the stratigraphy and paleontology of the Eocene and later Tertiary formations of Texas were continued by Julia Gardner, who also continued studies of the Midway formations of the State in cooperation with the Texas Bureau of Economic Geology. Miss Gardner completed a short paper covering the Tertiary formations of the western Gulf region for publication in the volume on North America in Geologie der Erde and prepared a paper on Tertiary formations in Texas for the meeting of the American Association for the Advancement of Science. She had in preparation a paper setting forth general results of the reconnaissance made along the Wilcox-Claiborne contact in eastern Texas, of which W. C. Spooner and A. F. Crider are joint authors. Nitrate deposits at San Saba and in Brewster and Presidio Counties and prospects near Candelaria were examined by G. R. Mansfield. A reconnaissance of the part of western Texas along the Rio Grande and at points in Brewster County was made by T. W. Stanton in connection with his studies of the stratigraphy of the Cretaceous of Texas. Mr. Stanton also continued the study of the Comanche stratigraphy of Texas and cooperated with N. H. Darton, who is mapping the geology of central and western Texas, in reporting on Comanche collections. Outcrop material from the State and Carboniferous invertebrates and Cretaceous ostracodes for comparative generic references were studied by P. V. Roundy, and a collection of ammonites from the Eagle Ford formation of Texas by J. B. Reeside, jr. Studies of the salt-dome cap rock were continued by M. I. Goldman. The work of gathering and compiling data for the revised geologic map of Texas has been continued by Messrs. Stanton and Darton for the western and central parts of the State and by L. W. Stephenson and Miss Gardner for the Coastal Plain area.

UTAH

Field studies of the stratigraphy and structure of portions of southeastern Utah primarily to determine the oil possibilities of the region were continued. An area between the Green and Colorado Rivers in Grand County in the vicinity of Thompsons, a northward extension of the area mapped by E. T. McKnight in 1926, was mapped by a party in charge of Mr. McKnight and C. H. Dane, assisted by C. E. Erdmann and J. W. Vanderwilt for a portion of the time. Reports on these investigations are in progress. An area east of the Colorado in northern San Juan County, known as the Moab district, was mapped by A. A. Baker's party, working southward from the area mapped by him in 1926. A report on this work is in preparation. A preliminary report on these investigations in southeastern Utah, by C. E. Dobbin and J. B. Reeside, jr., was issued as Press Notice 16318, Geology and Oil in Southeastern Utah. A party in charge of Mr. Baker began areal and structural geologic mapping of an area in southwestern San Juan County, lying between the San Juan River on the north, the Najavo Indian Reservation on the east, the Colorado River to the west, and the Arizona boundary to the south. J. B. Reeside, jr., who is studying the Mesozoic stratigraphy of Utah, collaborated with Mr. Baker in field studies in this part of the State. Studies of oil shale by W. H. Bradley are mentioned under Colorado. D. J. Fisher continued the preparation of a report

on the Book Cliffs coal field. A paper by Messrs. Dobbin and Reeside on problems of the Chugwater-Sundance contact was submitted for publication by the American Association of Petroleum Geologists. A report on the geology and ore deposits of the Gold Hill quadrangle is in preparation by T. B. Nolan, who presented a paper on stratigraphy and structure of the quadrangle at the meeting of the Geological Society of America. A paper describing the areal geology, ore deposits, and stratigraphy of the Stockton and Fairfield quadrangles is in preparation by James Gilluly. Mr. Gilluly presented a paper on Basin Range faults in the Oquirrh Range at the annual meeting of the Geological Society of America. The general geology of the Cottonwood-American Fork district is being described by F. C. Calkins, the report on the ore deposits of this district having been completed by B. S. Butler. D. F. Hewett's work on the Great Basin area is mentioned under Nevada. A paper on the Upper Cretaceous section in the Colob Plateau, southwestern Utah, by G. B. Richardson, was sent to the Journal of the Washington Academy of Sciences. P. V. Roundy studied Carboniferous invertebrates. The structure of the Wasatch, Fish Springs, and House Ranges is described by G. K. Gilbert in Professional Paper 153, which was issued a few days after the end of the year. The following reports were issued during the year: A Section of the Kaibab Limestone in Kaibab Gulch, Utah, by L. F. Noble (Professional Paper 150–C); Sedimentary Rocks of the San Rafael Swell and Some Adjacent Areas in Eastern Utah, by James Gilluly and J. B. Reeside, jr. (Professional Paper 150–D); The Cephalopods of the Eagle Sandstone and Related Formations in the Western Interior of the United States, by J. B. Reeside, jr. (Professional Paper 151); Economic Geology of the Castlegate, Wellington, and Sunnyside Quadrangles, Carbon County, Utah, by F. R. Clark (Bulletin 793); Geology and Coal Resources of the Salina Canyon District, Sevier County, Utah, by E. M. Spieker and A. A. Baker (Bulletin 796–C); and Potash in Great Salt Lake Desert, Utah (Press Notice 16251).

VERMONT

Studies of a part of the Taconic area of southwestern Vermont, included in the Bennington quadrangle, were continued by L. M. Prindle. Stratigraphic and structural studies in northwestern Vermont were made by Arthur Keith.

VIRGINIA

Geologic studies in different parts of Virginia were made in cooperation with the Virginia Geological Survey, the most important one being investigations for the revision of a geologic map of Virginia, which will be issued by the State. Charles Butts continued mapping the Appalachian Valley portion, A. I. Jonas the Piedmont area, and W. C. Mansfield the Coastal Plain area. Contributions were also made by G. W. Stose, E. O. Ulrich, and M. I. Goldman. A cooperative study of the geology of the warm springs in the Shenandoah Valley and in the mountain valleys in Alleghany, Bath, and Highland Counties was made by Frank Reeves. Charles Butts accompanied Mr. Reeves for a study of the stratigraphy of this region. Iron-ore deposits at Rectortown, Covington, Clifton Forge, Barbours Creek, Bastian, and Rocky Gap were examined by E. F. Burchard, who conferred with owners of these deposits and with Virginia State officials. A report on the Great Gossan lead is in preparation by C. S. Ross. A manuscript on the geology and sand and gravel resources of the Coastal Plain of Virginia, by C. K. Wentworth, has been transmitted to the State for publication. Field and office work in connection with the preparation of a paper on new species of mollusks from the Miocene of Virginia was continued by W. C. Mansfield, and a paper entitled "Seven New Species and Five New Subspecies of Mollusks from the Miocene of Virginia and North Carolina, with a Brief Outline of the Divisions of the Chesapeake," will be published in the Proceedings of the United States National Museum. Deposits of manganese ore near Woodstock were examined by E. F. Burchard, D. F. Hewett, H. D. Miser, and M. I. Goldman to note new developments. Investigations of iron ores for the War Department are mentioned under Alabama. A paper on the Helderberg group of Virginia and West Virginia was submitted by F. M. Swartz for publication. Notes on Pleistocene faunas from Maryland and Virginia, by W. C. Mansfield, were included in Professional Paper 150–F.

WASHINGTON

Reservoir sites near Washtucna and Kahlotus, Wash., were examined by J. T. Pardee for the Columbia Basin Irrigation League. E. W. Berry continued work on a paper on the Puget flora left unfinished by the late F. H. Knowlton, and also on a paper on the Latah flora, much of the material for which was collected by Mr. Knowlton.

WEST VIRGINIA

The study of the Devonian and basal Mississippian rocks of Randolph County and portions of Pocahontas County, W. Va., for the purpose of gathering materials for use in the preparation of a report on the floras of the Devonian and lower Mississippian of this part of the State, was carried on by David White in cooperation with the West Virginia Geological Survey. In the office he studied the Devonian and lower Mississippian floras of West Virginia, including materials from other parts of the northern Appalachian trough. G. H. Girty studied Pottsville faunas of West Virginia. A paper on the Helderberg group of Virginia and West Virginia was submitted by F. M. Swartz for publication.

WISCONSIN

E. O. Ulrich devoted some time to the description of species of *Dikelocephalus* in connection with the preparation of a paper on the Upper Cambrian faunas of Wisconsin for publication by the Public Museum of Milwaukee. Manuscript for a geologic folio on the Sparta and Tomah quadrangles, by F. T. Thwaites, W. H. Twenhofel, and Lawrence Martin, has been completed by the authors and is being reviewed.

WYOMING

Parts of Lincoln County, W. Va., and Yellowstone Park were studied by W. C. Alden in the course of his physiographic and glacial investigations. A paper on the Gros Ventre landslide and flood was prepared by Mr. Alden for publication in the Transactions of the American Institute of Mining and Metallurgical Engineers, and one on the glaciation of Yellowstone National Park and its environs for publication in the Ranger-Naturalist Manual for 1928. At the request of N. C. Grover, chief of the water-resources branch, Mr. Alden also prepared notes on proposed dam sites west of the Wind River Mountains. The preparation of reports on the stratigraphy, structure, and oil and gas possibilities of the Black Hills rim was continued by W. W. Rubey, who completed a paper on lithologic studies of fine-grained Upper Cretaceous sedimentary rocks from the Black Hills region. Invertebrate fossils from the western Black Hills were identified by J. B. Reeside, jr. Field studies of oil-shale deposits in the Green River Basin were continued by W. H. Bradley. Other work on oil shale is mentioned under Colorado. A paper entitled "Problems of the Chugwater-Sundance Contact" was written by C. E. Dobbin and Mr. Reeside for publication in the Bulletin of the American Association of Petroleum Geologists. Mr. Reeside collaborated with R. R. Woolley, of the water-resources branch, in drawing geologic cross sections of dam sites on Green River, Colo., Utah, and Wyo., for a paper which Mr. Woolley is preparing. A paper on the contact of the Fox Hills and Lance formations in the northern Great Plains, by Messrs. Dobbin and Reeside, is being revised by the authors. T. W. Stanton reported on Lance and Fort Union invertebrates. Fossil plants from the Frontier formation of Wyoming were studied by E. W. Berry. A report on the iron-ore deposits in the Seminoe Mountains is in preparation by T. S. Lovering. The following reports were issued during the year: Correlation of Geologic Formations Between East-Central Colorado, Central Wyoming, and Southern Montana, by W. T. Lee (Professional Paper 149); Cephalopods from the Lower Part of the Cody Shale of Oregon Basin, Wyo., by J. B. Reeside, jr. (Professional Paper 150–A); The Cephalopods of the Eagle Sandstone and Related Formations in the Western Interior of the United States, by J. B. Reeside, jr. (Professional Paper 151); The Gillette Coal Field, Northeastern Wyoming, by C. E. Dobbin and V. H. Barnett, with a chapter on the Minturn district and the northwestern part of the Gillette field, by W. T. Thom, jr. (Bulletin 796–A); and Geology and Oil and Gas Possibilities of the Bell Springs District, Carbon County, Wyo., by C. E. Dobbin, H. W. Hoots, and C. H. Dane (Bulletin 796–D).

WORK IN CHEMISTRY

In connection with geologic or mineralogic studies 32 partial and 60 complete analyses, each of the latter consisting of 10 to 18 separate determinations, were made and 5,627 samples of potash salts were examined. Special examinations and tests were made of 71 specimens submitted in connection with specific problems. Specimens to the number of 2,055 sent by 1,077 persons not connected with the Geological Survey were identified. A number of these specimens proved to be of value to the scientific and economic work of the Geological Survey.

The study of analytical methods for lead, thorium, and uranium, with particular reference to the determination of the geologic age of radioactive minerals, was continued by R. C. Wells, in cooperation with the committee of the National Research Council on the measurement of geologic time by atomic disintegration. M. F. Connor cooperated as guest chemist of the Geological Survey laboratory. Mr. Wells also studied concentrates from granites and kolm from Sweden, whose age was definitely determined and which can be correlated with the Upper Cambrian by means of fossils. Mr. Wells did some further experimental work on the solubility of calcium carbonate in salt solutions, the conditions under which the mineral kernite forms, and the occurrence of selenium in sulphide ores and commercial sulphuric acid.

An intensive study of the properties and genetic relationships of potash and associated minerals from the Texas-New Mexico field was made by W. T. Schaller, who is now preparing a report on the mineralogy of these deposits. Mr. Schaller also studied in the field, supplemented by laboratory investigations, the borate minerals of the Kramer district of California, of which three proved to be new in science.

After extended laboratory experiments George Steiger prepared for publication a paper on the disintegration of Indiana limestone. For the committee on sedimentation of the National Research Council, Mr. Steiger prepared a bibliography on chemical work done during the year having a bearing on the subject of sedimentation.

A dehydration study of certain clays, showing changes in their optical properties as the water was driven out by heat or by the lowering of the vapor tension of the desiccating air, with the object of determining their chemical construction, was made by J. G. Fairchild in cooperation with C. S. Ross.

A study of the changes in optical properties of triplite due to the variation in chemical composition was made by E. P. Henderson.

Progress in the search for soluble potash salts was so satisfactory during the year that it can now be stated with reasonable assurance that there are in the salt fields of eastern New Mexico and western Texas deposits of these salts which compare favorably with and possibly when developed and their exact extent is known will even surpass the German and French deposits both in extent of the beds and in their potash content. Water has been an endless source of trouble and expense in the foreign mines, but no water has yet been encountered in the New Mexico-Texas salt formation, and the rich beds in general lie nearer to the surface here than abroad. These condi-

tions will give our domestic deposits a decided advantage when mining operations are begun.

During the year 4,743 cuttings taken from 55 wells drilled for oil and 884 samples from 13 core wells drilled in the search for potash were examined for their potash content. The cuttings came from wells drilled in the following counties:

Texas:
- Crane
- Midland
- Glasscock
- Upton
- Crockett
- Ector
- Pecos
- Reagan
- Garza
- Winkler
- Loving

Texas—Continued.
- Andrews
- Ward

New Mexico:
- Guadalupe
- Lea
- Eddy
- De Baca
- Quay
- Chaves

Kansas:
- Pratt

The area in which the most intensive core drilling was done lies in Eddy County, N. Mex. The American Potash Co. of New Mexico drilled its first core well about 20 miles northeast of Carlsbad, and the core was examined by the Geological Survey in 1927. This company's property is mainly on territory covered by the potash leasing act. During the fiscal year the Geological Survey has examined five additional cores from wells drilled within a radius of 6 miles from the original well. These cores appear to indicate several beds of sylvinite (potassium chloride and sodium chloride) and two or three beds of polyhalite (calcium-potassium-magnesium sulphate) ranging in thickness from 2 to 7 feet and carrying from 10 to 20 per cent of potash (K_2O). The cores from seven wells drilled under the appropriation made by Congress for investigating potash deposits were also examined. Three of these wells are in New Mexico—20 miles north, 10 miles northwest, and 12 miles south of the original American Potash Co.'s well. No beds of sylvinite were encountered in these wells, but numerous beds of polyhalite were found ranging in thickness from a few inches to 10 feet and having a potash content of 10 to 18 per cent. The Government drilled four wells in Texas, in southwestern Ector County, northwestern Crockett County, and southwestern and western Upton County. The salts encountered in these wells are very similar to those from the New Mexico wells, the only potash salt being polyhalite. In general the strata are not quite so thick nor so rich as those in the New Mexico wells, but they were closer to the surface. A core received from the Gypsy Oil Co.'s well, between the American Potash Co.'s development and one of the Government wells, was examined and found to show salts similar in character to those of the American Potash Co.'s core, the potash being contained as sylvinite and polyhalite.

The following papers were completed during the year:

Wells, R. C., The element "mosandrum" of J. Lawrence Smith: Washington Acad. Sci. Jour.
—— Physico-chemical geology [book review]: Am. Chem. Soc. Jour.
—— Eminent chemists of our time [book review]: Ind. and Eng. Chemistry.
—— Note on the J. Lawrence Smith method for the analysis of samarskite: Am. Chem. Soc. Jour.
—— Examination of sulphuric acid for selenium: Washington Acad. Sci. Jour.
—— Evaporation from large bodies of water and some figures for Chesapeake Bay [to appear in Washington Acad. Soc. Jour.].

Schaller, W. T. Hydroboracite from California: Festschrift Victor Goldschmidt.
—— Probable identity of camsellite with szaibelyite: Am. Mineralogist.
—— Occurrence of kernite and associated borates; Potash minerals from Texas-New Mexico field; Base exchange of artificial autunites [read at Cleveland meeting of Mineralogical Society of America].
Loughlin, G. F., and Steiger, George, Indiana oolitic limestone [to be published as a Geological Survey bulletin].
Larsen, E. S., and Steiger, George, Dehydration and optical studies of alunogen, nontronite, and griffithite: Am. Jour. Sci.
Henderson, E. P., Uvarovite from California; Correlation of chemical composition and optical properties of triplite [read at Cleveland meeting of Mineralogical Society of America].
Erickson, E. T., Qualitative tests for boron, bromine, and iodine in well cuttings and core samples of the saline fields of Texas and New Mexico [mimeographed in Geological Survey].

WORK IN PHYSICS

C. E. Van Orstrand continued in charge of the physical laboratory. He made a field trip which began March 26 and continued until the end of the fiscal year, for the purpose of taking temperature tests in deep wells near the iron mines at Birmingham, Ala., and also in the oil fields of Texas, Oklahoma, and California. A considerable portion of the time spent in the oil fields was devoted to cooperation with three research associates of the American Petroleum Institute who have adopted the apparatus developed by Mr. Van Orstrand for the purpose of making temperature tests in deep wells and who are also carrying out an extended program of research relative to the variation of temperature with structure which Mr. Van Orstrand found in some of the oil fields of California and Wyoming. The remainder of his time was devoted to administrative duties and the preparation of papers.

The testing, research, and field work of P. G. Nutting on petroleum, silica, and water have continued, covering adsorption and surface reactions with especial reference to petroleum recovery, the migration of fluids through sand and other porous bodies, the formation and accumulation of petroleum and asphalt, the association of water with minerals, the filtration of oils, bonded mixtures of fluids and solids, the deformation of granular solids, the flotation of ores, and many other problems of similar nature. Many of the results obtained have been given to the public through scientific and technical publications, and all have been available to the Geological Survey's staff.

The following papers were completed during the year:

Van Orstrand, C. E., A machine for measuring the depths of deep wells: Washington Acad. Sci. Jour.
—— On the nature of isogeothermal surfaces: Am. Jour. Sci.
—— Measuring the depths of deep wells: Oil and Gas Jour.
—— The world's deepest wells and the temperatures found in some of them: Oil and Gas Jour.
Nutting, P. G., Weights and temperature: Science.
—— The deformation of granular solids: Washington Acad. Sci. Jour.
—— Association of water with serpentine: Washington Acad. Sci. Jour.
—— Geodynamical principles [summary for geologists; not published].
—— Computing dam seepage: Econ. Geology.
—— Nature and action of the petroleum filtering earths; Washington Acad. Sci. Jour.; Oil and Gas Jour.
—— Petroleum and the filtering earths: Washington Acad. Sci. Jour.
—— Petroleum recovery by the soda process: Oil and Gas Jour.

ALASKAN BRANCH

PHILIP S. SMITH, Chief Alaskan Geologist

FUNDS

The funds used by the Geological Survey in its Alaska work are provided in two items in the general act making appropriations for the Interior Department. One of these items reads, "for continuation of the investigation of the mineral resources of Alaska, * * *." In the act for the fiscal year 1927 the amount was $50,000; for 1928, $60,000; for 1929, $64,500. Each of these appropriations was available immediately on the passage of the act in which it was contained. The other item is an allotment made from the appropriation "for the enforcement of the provisions of the acts of October 20, 1914, October 2, 1917, February 25, 1920, and March 4, 1921, and other acts relating to the mining and recovery of minerals on Indian and public lands and naval petroleum reserves, * * *." Allotments under this item are available only during the fiscal year specified. In the fiscal year 1927 the allotment for this kind of work in Alaska was $19,500; in 1928, $14,500. The two types of work indicated will be described for convenience as the mineral-resources work and the leasing work.

MINERAL-RESOURCES WORK

PRINCIPAL RESULTS OF THE YEAR

The principal products of the Alaskan work of the Geological Survey are the reports and maps that are based on original surveys or investigations. During the year eight Alaskan reports have been issued, as follows:

Mineral industry of Alaska in 1925, by F. H. Moffit. (Bulletin 792–A.)
Administrative report, 1925–26, by F. H. Moffit. (Bulletin 792–A.)
Geology of the Knik-Matanuska district, by K. K. Landes. (Bulletin 792–B.)
The Toklat-Tonzona region, by S. R. Capps. (Bulletin 792–C.)
Geologic investigations in northern Alaska (1925), by Philip S. Smith. (Bulletin 792–C.)
Mineral resources of Alaska, 1925, by F. H. Moffit and others. (Bulletin 792.)
Mineral industry of Alaska in 1926, by Philip S. Smith. (Bulletin 797–A.)
Administrative report, 1926–27, by Philip S. Smith. (Bulletin 797–A.)

Fifteen reports that have been completed by their authors and approved for editing or printing are now in various stages of publication. These reports are as follows:

The Upper Cretaceous floras of Alaska, by Arthur Hollick, with a description of the Upper Cretaceous plant-bearing beds, by G. C. Martin.
The Skwentna region, by S. R. Capps. (Bulletin 797–B.)
The Sheenjek River district, by J. B. Mertie, jr. (Bulletin 797–C.)
Surveys in northwestern Alaska in 1926, by Philip S. Smith. (Bulletin 797–D.)
Aerial photographic surveys in southeastern Alaska, by R. H. Sargent and F. H. Moffit. (Bulletin 797–E.)
The Aniakchak district, by R. S. Knappen. (Bulletin 797–F.)
Geology and mineral deposits of southeastern Alaska, by A. F. Buddington and Theodore Chapin. (Bulletin 800.)
Geology of Hyder and vicinity, southeastern Alaska, by A. F. Buddington. (Bulletin 807.)
Geography and geology of northwestern Alaska, by Philip S. Smith and J. B. Mertie, jr.
The mineral industry of Alaska in 1927, by Philip S. Smith. (Bulletin 810–A.)

Administrative report, 1927–28, by Philip S. Smith. (Bulletin 810–A.)
Notes on the upper Nizina River, by F. H. Moffit.
The Mount Spurr region, by S. R. Capps.
The Chandalar-Sheenjek district, by J. B. Mertie, jr.
Geology of the Eagle-Circle district, by J. B. Mertie, jr.

Six other reports have been in course of preparation by their authors as time permitted, but no definite statement as to the time of publication can yet be made.

Practically every one of the foregoing reports is accompanied by maps, the base of which has been made principally from surveys conducted by the topographers of the Alaskan branch. Among these maps the following were completed during the year by members of the branch under the general direction of R. H. Sargent or were issued in a preliminary photolithographic edition or as sale publications:

Topographic map of northwestern Alaska, a map compiled from all available sources but mainly from surveys by the Geological Survey and including many new topographic data, derived principally from recent plane-table surveys by Gerald FitzGerald; scale, 1:500,000. Not to be issued separately from the report on northwestern Alaska by Smith and Mertie.

Topographic map of Aniakchak district, by R. H. Sargent; scale, 1:250,000. Issued in a free preliminary photolithographic edition and to be included in Bulletin 797.

Topographic map of East Fork of Chandalar-Sheenjek region, by Gerald FitzGerald and J. O. Kilmartin; surveyed on scale of 1:250,000 but compiled on scale of 1:500,000. Not to be issued separately from the report on the Chandalar-Sheenjek region by Mertie.

Drainage map of part of the Hyder-Ketchikan region, southeastern Alaska, compiled mainly from aerial photographs made by the Navy Department, at the request of the Geological Survey, especially for this work. Compilation made under direction of R. H. Sargent; scale, 1:250,000. To be included in Bulletin 797.

Preliminary topographic map of part of the Mount Spurr region, Alaska, by R. H. Sargent; scale, 1:250,000. To be included in Bulletin 810. This map will probably later be combined with other surveys and issued separately as a compiled map in a free photolithographic edition.

In addition to these more detailed maps the base map of Alaska on the scale of 1:5,000,000 was revised and brought up to date and was issued in a sale edition and as an index map to show the progress of topographic mapping in the Territory, carrying on the back a list of selected publications of the Geological Survey that describe the mineral deposits of Alaska and the features of its major geographic divisions.

In addition to these official reports several articles were prepared by the scientific and technical members or former members of the branch for publication in outside journals, and a number of public lectures were given regarding the general work of the branch or on some of its special features. Most of these articles were prepared unofficially but represent excellent by-products of the regular work and serve to reach special audiences not readily reached by the official publications. Among the articles of this sort may be mentioned the following:

Some post-Tertiary changes in Alaska of possible climatic significance, by Philip S. Smith: National Research Council Bull. 61, pp. 35–39, 1927.

The Alaskan branch of the Geological Survey, by Philip S. Smith: Min. Cong. Jour., vol. 14, pp. 165–166, 1928.

Aerial surveys in southeastern Alaska, by R. H. Sargent: Military Engineer, vol. 20, pp. 189–195, 1928.

Types of mineralization of southeastern Alaska, by A. F. Buddington: Econ. Geology, vol. 22, pp. 158–179, 1927.

Mineral deposits of the Hyder district, by W. B. Jewell: Econ. Geology, vol. 22, pp. 494–517, 1927.

The Mount Spurr region, Alaska, by S. R. Capps, report delivered at meeting of Geological Society of America, Cleveland, December, 1927.

PROJECTS IN PROGRESS DURING SEASON OF 1927

The following tables indicates the areas covered by the different types of survey in Alaska. No report is made for the field season of 1928, because that work is still in progress and its extent can not be predicted, as the parties are all out in the field beyond reach of communication. The absence of this information is relatively immaterial for practical purposes because for the field season of 1927 all of the area surveyed during that season is counted, even though part of the work was done during the fiscal year that ended June 30, 1927. Therefore the areas surveyed in the fiscal year 1927 on projects that fall within the field season of 1927 may be considered to offset the areas surveyed in the fiscal year 1928 that fall within the field season of 1928 but have been disregarded in the tabulation.

Areas surveyed by Geological Survey in Alaska, 1898–1927, in square miles

Field season	Geologic surveys			Topographic surveys		
	Exploratory (scale 1:500,000, 1:625,000, or 1:1,000,000)	Reconnaissance (scale 1:250,000)	Detailed (scale 1:62,500 or larger)	Exploratory (scale 1:500,000, 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)
1898–1926	75,150	163,255	4,277	55,630	197,400	4,066
1927		6,350			7,465	
	75,150	169,605	4,277	55,630	204,865	4,066
Correction		−300			−300	
	75,150	169,305	4,277	55,630	204,565	4,066
Percentage surveyed of total area of Alaska	42.4			45.1		

In this table only the net areas surveyed are listed in the appropriate columns and there is no duplication of areas under "Geologic surveys" or under "Topographic surveys," though, of course, most of the areas that have been surveyed geologically have also been surveyed topographically. In other words, none of the area that is reported in the column of reconnaissance geologic surveys is also reported in the columns for geologic exploratory or detailed surveys. It is by no means unusual that in the course of later surveys it becomes desirable to revise the mapping or to resurvey on a large scale an area that had already been surveyed on a smaller scale. In order that this should not result in duplication, it is necessary to deduct the proper amount from the area previously reported. This deduction is shown as a "correction" in the foregoing table, 300 square miles covered by previously reported reconnaissance topographic and geologic surveying having been resurveyed in 1927 with greater precision.

The necessity for resurveying in more detail some areas is easily understood. For many areas in Alaska exploratory mapping is all that may be warranted at first. As development progresses more specific information may be required and a more detailed survey made, and in an intensely developed mining camp only a most detailed map would furnish the desired information. To spend money on making detailed surveys everywhere would be a waste of time and funds far more reprehensible than to resurvey different tracts here and there as conditions call for better maps. Even in some areas where it is anticipated that more detailed maps may eventually be required it has seemed best to make rapid and relatively inexpensive exploratory surveys to supply the most urgent demands for immediate information and then follow with the necessarily slower and costlier surveys. This was practically the course followed when the first stampede to Nome was in progress, for within two or three months after the return of the Federal geologist from this camp an exploratory map of the environs of Nome was published by the Geological Survey. This was succeeded the next year by reconnaissance field surveys of much of the region within a hundred miles of Nome. Only a few years later detailed mapping was undertaken of the tracts adjacent to the richest mining camps.

At present the scale adopted for most of the Alaskan work is 1:250,000, in which about 4 miles on the ground is represented by an inch on the map, with a contour interval of 200 feet. That scale is adequate for general purposes, and by its use surveys can be performed expeditiously and very cheaply. It is obvious, however, that such a scale is entirely inadequate for furnishing the more specific data required in many problems. Therefore, though the preceding table shows that about 42 per cent of the total area of Alaska has been surveyed geologically, only about 30 per cent has been surveyed on a standard that can be regarded as of reconnaissance grade. Unquestionably a greater number of detailed surveys should be made, but when it is realized that at the rate at which the work is now being done it will still be about 50 years before all the parts of the Territory that appear to show promise of containing deposits of minerals that may be of commercial value are surveyed even on a reconnaissance scale it is evident that detailed surveys are practically out of the question unless more funds are made available.

The surveys tabulated above were made in the Nizina district of the Copper River region; the district around Sheenjek River and the East Fork of the Chandalar, in the northeastern part of the Yukon Basin in Alaska; and the vicinity of Mount Spurr, in the Alaska Range.

The work in the Copper River region was in charge of F. H. Moffit, who, with a small camp equipment and one camp hand, made general reconnaissance geologic studies to obtain additional data on the occurrence of the copper deposits of that region. Much new geologic information was collected, and several areas that had been given but passing attention during the earlier surveys were more critically examined. The mining camps in the Nizina and Chitina Valleys were also visited, and late information regarding recent developments of the mineral resources of the whole district was collected.

The work in the East Fork of the Chandalar and Sheenjek district was a combined geologic and topographic reconnaissance survey in charge of J. B. Mertie, jr., geologist, with Gerald FitzGerald, topographer, and two camp assistants. In order to utilize most effectively the short open season the topographer left Washington in February and went by ordinary means of transportation to Fairbanks, where a dog team was purchased and a camp

assistant hired. This advance party then traveled by dog team to Fort Yukon, where necessary supplies and equipment needed for the rest of the season were bought. From Fort Yukon this party, early in April, struck across country for Christian River and Arctic Village, on the East Fork of Chandalar River, having hired natives to help freight in some of the supplies. Surveys were started, and while sledding on the snow was still possible caches of supplies were distributed at selected points, so that they would be available during the summer. With the break-up of the ice on the rivers, so that travel by regular lines of transportation could be resumed, the geologist went to Fort Yukon, where, with a small load of supplies in a canoe, he and one camp hand started up Chandalar River. Travel upstream was extremely slow because of the high water in the river and the speed of the current, but eventually junction with the advance party was made and the work carried on by the combined unit. During the subsequent work travel was entirely on foot, and the only means of transporting supplies was on the backs of the men or their dogs. With the approach of cold weather the party descended East Fork of Chandalar River in skin boats until they reached the point where the geologist's canoe had been left in the spring, and then the return to Fort Yukon was made as rapidly as stops necessary to make the desired surveys permitted. The result of this work was about 3,700 square miles of geologic reconnaissance mapping and 4,900 square miles of topographic reconnaissance mapping of hitherto unmapped country and the topographic and geologic resurvey of 300 square miles of country that had been mapped with less precision in an earlier year.

The field project in the vicinity of Mount Spurr was conducted by a combined geologic and topographic party in charge of S. R. Capps, geologist, with R. H. Sargent, topographer, and four camp assistants. These surveys were essentially a continuation of those made north of Mount Spurr in 1926. Through the courtesy of the Alaska Railroad the party, with all its equipment, was landed at Trading Bay, on the west side of Cook Inlet, about the middle of June and thence proceeded westward, mapping the country as it advanced. The coastal part of the region is exceedingly difficult to traverse because of the swampy lowlands, the large streams, and the tangle of trees and brush. In the mountainous part of the region the slopes are steep, the large streams are unfordable and flow with great velocity, and glaciers protruding from the valleys block the main routes, so that passage is impossible or made only after laborious effort. Many interesting geologic and geographic facts came out of the surveys of this party besides the definite reconnaissance topographic mapping of 2,265 square miles of hitherto unmapped country and the reconnaissance geologic survey of 2,000 square miles. Among these items may be mentioned the discovery of a large river, numerous lakes, glaciers, mountains, and an active volcano. Unfortunately, the observations made by this party do not indicate that the region offers much promise of containing mineral deposits that are of present economic value.

The only other field work in progress was a general reconnaissance of several of the placer-mining camps in Seward Peninsula and of a few of the camps along the western stretches of the Yukon and in the vicinity of the Alaska Railroad. This work, which was done by Philip S. Smith, does not lend itself to expression in terms of area and was undertaken mainly to provide information regarding recent mining developments and to permit the laying out of plans for future work, so as best to fit the needs of the industry.

An important piece of work that was started in the winter of 1926–27 and will be continued for several years is the compilation and working up into maps of the aerial pictures of a large part of southeastern Alaska, taken by the Navy Department, at the request of the Geological Survey. This work has been largely under the technical direction of R. H. Sargent, with the cooperation of F. H. Moffit in special phases of the work. The photographs are prepared for cartographic use and assembled into large-scale drawings by members of the topographic branch, and the assembly sheets are then adjusted by members of the Alaskan branch to correct their scale and position and compiled. A drainage map of a tract of about 2,000 square miles that includes all of Revillagigedo Island and some of the near-by islands was completed during the year.

Another of the major projects of the branch is the annual compilation of statistics of the production of mineral commodities in the Territory. The production is reported on the basis of the calendar year, but the work of canvassing

the producers and assembling data goes on uninterruptedly throughout the year.

In addition to the office work that is an essential part of completing the current field projects, there are a number of former field projects on which the office work had not been completed during the season in which the field work was done. This work includes laboratory examination of some of the material collected, the preparation of manuscript, and the critical reading of proof. Considerable work of this sort was accomplished during the season, and as a result three reports that had been begun in earlier seasons were completed and are now in various stages of editing or publication. In all the office work on the technical reports the members of the Alaskan branch have received considerable assistance and advice from their associates in other branches of the Geological Survey. Among the special services of this sort may be mentioned the identification of the collections of fossils by the paleontologists of the geologic branch, notably G. H. Girty, J. B. Reeside, jr., and Edwin Kirk.

PROJECTS FOR THE SEASON OF 1928

The projects for the field season of 1928 had been under way only a short time at the end of the fiscal year 1928, and it is not practicable in this report to make any detailed statement of the work accomplished or to give much more than an outline of its principal objects. Six field projects were under way—reconnaissance topographic mapping in the Ketchikan region of southeastern Alaska, detailed topographic mapping on Admiralty Island, southeastern Alaska, geologic reconnaissance in the Nizina district of the Copper River region, geologic reconnaissance in the upper Tanana and Yukon regions west of the international boundary, combined geologic and topographic reconnaissance in the Alaska Range, and a general inspectional trip to check up recent mining activities and to visit some of the field parties.

The reconnaissance topographic mapping in the Ketchikan district, which is in charge of R. H. Sargent, was planned primarily to furnish an adequate topographic map of this important district. This is part of the area covered by the drainage map compiled from aerial photographs, noted above. In addition, therefore, to furnishing a useful map, this survey should supply many valuable tests by which to compare the accuracy and relative cost of the base made by phototopographic methods with those of a map made by ordinary ground methods. Very probably the tests will show that certain combinations of the two methods may be desirable.

The other topographic work in southeastern Alaska is being performed by a Geological Survey topographer, R. K. Lynt, who is attached to a timber cruising party of the Forest Service. The cost of this work is being borne entirely by the Forest Service through transfer of funds to the Geological Survey, and it is therefore not included in the table of expenditures given on page 33. The work is regarded by the Forest Service as an indispensable part of its activities in developing the paper-pulp industry of southeastern Alaska. Obviously adequate topographic maps are among the first things needed in laying out plans for the efficient and economical development of the natural resources of the region. The work will be done on a scale of 1:62,500, which is much more detailed than most of the Geological Survey's maps of Alaska, except those within the immediate neighborhood of the richest mining camps. The area covered will therefore probably be small, but the quality of the map should be excellent.

The work that is being undertaken in the Copper River region has been so planned as to form a continuation of the work that has been in progress there during the last three seasons by amplifying the observations of earlier geologists and reviewing their conclusions from the vantage ground of the added experience and information which has accumulated in the score of years that have elapsed since the earlier work was done. This work is to be done by a party consisting of F. H. Moffit and one camp assistant. These more thorough studies seem to be essential to working out the true geologic history of the region, and until that history is better understood no satisfactory conclusions can be drawn regarding the true origin of the great copper deposits of that region or their probable extension into adjacent regions where they are not yet known. In addition to these more strictly geologic duties Mr. Moffit while in the field will collect general information regarding all the mining activities in the Copper

River region and will visit such operating mines as time and other conditions permit.

The reconnaissance geologic and topographic survey in the Alaska Range region west of Mount Spurr is perhaps the most difficult project that is being undertaken in the summer of 1928. This work is in charge of S. R. Capps, geologist, with Gerald FitzGerald, topographer, and four camp assistants. The plans of the party contemplate the hire of commercial airplanes to transport perhaps half a season's supply of food and equipment and the geologist, topographer, and one assistant to a lake discovered by the party during the season of 1927, where work that joins with those earlier surveys will be started. In the meantime a pack train of 13 horses and 3 camp assistants, with supplies for half the season, will go overland to this lake by way of the trail made in 1927. The mountains will be crossed at a pass discovered and described by R. H. Merrill, an aviator whose headquarters are at Anchorage and who has made many flights across the range. The party will then carry surveys into the valleys of the streams on the west side of the range that are tributary to Kuskokwim River. If other passes across the range are discovered in the course of that work, the party in the fall may cross back to the east side of the mountains by one of them; if not, it will return by way of its outgoing route and be picked up about the middle of September at Trading Bay by a boat sent out through the courtesy of the Alaska Railroad. The geographic results of this expedition should be of great interest, as the surveys will traverse a large tract of hitherto unexplored country that has long remained a blank area on maps.

North of Tanana River adjacent to the international boundary and extending westward for more than a hundred miles is a triangular tract of country that lies south of the Fortymile placer district. A reconnaissance topographic map of this tract was made a number of years ago, but the geology was not mapped.

In this tract a geologic party in charge of J. B. Mertie, jr., with two camp assistants and a small pack train, was to make geologic surveys during the season of 1928. A serious injury to one of the members of the party necessitated a return to Eagle in order to send the man to the hospital. As the party was too short-handed to undertake the job without additional assistance and as in that remote region it might be impossible to obtain a packer without too much delay, the original plans were suspended and alternative plans suggested. At the time that this report is submitted selection between these plans had not been made, but whatever the choice, it will involve carrying on some geologic work in the general tract between Yukon and Tanana River.

The only field work of a general character that is to be conducted by the chief Alaskan geologist during the season of 1928 is the customary broad survey of recent developments in the mining industry as a whole, with special visits to some of the more active mining camps or those that have not recently been visited by members of the Geological Survey. In the course of this work it is proposed to visit as many of the field parties and local offices as can be reached without too much delay, so as to be in close personal touch with the problems of each.

EXPENDITURES

The funds available for the regular work of the Geological Survey on Alaskan mineral resources during part of the fiscal year 1928 were appropriated in the Interior Department appropriation acts for the fiscal years 1928 and 1929. However, for the season of 1927 there was also available, until June 30, 1927, any unexpended balances from the appropriation for the fiscal year 1927. For a large part of the time, therefore, two appropriations were running concurrently. All the expenditures from these different appropriations have been properly accounted for, but the mere bookkeeping statement does not give any clear picture of the real conduct of the work. In spite of the difficulty of presenting a simple statement of the expenditures the following generalized analysis of the actual expenditures from the appropriation for 1928 may be of service:

Expenditures from funds appropriated for investigations of mineral resources in Alaska for the fiscal year 1928

Projects for season of 1927	$16,180
Projects for season of 1928	7,560
Administrative salaries, fiscal year 1928	3,250
All other professional and scientific salaries, fiscal year 1928	24,933
All other clerical and drafting salaries	5,888
Office maintenance and expenses	1,511
Bureau of the Budget reserve	678
	60,000

In the first two items in the foregoing table no charges are included for salaries of any of the permanent employees of the branch, as these are all carried in the three following items. Proper proportional charges for these services, as well as for the expenditures listed as office maintenance and expenses, might well have been included in these first two items, for practically every expenditure of the branch relates directly to these projects.

The following tables prepared on a seasonal basis will make the true relation of the work to sources of funds more apparent:

Approximate cost and distribution of work by geographic divisions for the season of 1927

Region or work	Appropriation for 1927		Appropriation for 1928		Total
	Expenses	Salaries	Expenses	Salaries	
Southeastern Alaska			$6,190	[a] $3,332	$9,522
Copper River	$575	$575	1,790	2,300	5,240
Alaska Range	1,800	1,445	4,782	6,633	14,660
Yukon	4,250	2,510	2,551	4,140	13,451
General	190		867	1,350	2,407
Mineral resources				[b] 2,133	2,133
Office work on former projects				4,043	4,043
	6,815	4,530	16,180	23,931	51,456

[a] Includes $1,000 of drafting salaries. [b] Includes $1,683 for clerical salaries.

Approximate cost and distribution of work by geographic divisions for the season of 1928

Region or work	Appropriation for 1928		Appropriation for 1929		Total
	Expenses	Salaries	Expenses	Salaries [a]	
Southeastern Alaska [b]	$1,900	$765	$4,700	$3,067	$10,432
Copper River	660	765	2,440	3,067	6,932
Alaska Range	2,600	1,445	5,800	6,230	16,075
Yukon-Tanana region	2,400	700	2,600	2,450	8,150
General			1,500	1,900	3,400
Mineral resources				[c] 1,750	1,750
Alaska district office					[d] 4,500
Office work on former projects				3,218	3,218
	7,560	3,675	17,040	21,682	54,457

[a] Exclusive of changes in rates of pay made through operation of the Welch bill.
[b] Exclusive of $2,150 transferred from Forest Service for special work ($750, 1927–28; $1,400, 1928–29).
[c] Includes $1,300 for clerical services.
[d] Not separately apportioned for expenses and salaries but larger part for salaries and excluded except in last column.

The item of $3,250 for administrative salaries, shown in the table on page 33, includes only those salaries that are directly related to the administration of the work of the branch as a whole and do not include administration such as each party chief is called on to perform with regard to the units under his charge. The amount expended for administration is exceedingly low, because much of the time of the principal administrative officer is spent on specific technical and related projects, which therefore bear their proportional share of the charge for his salary. Although this practice undoubtedly makes the cost of administration low, it is not regarded as good because it leads to the loss of real directive handling of many matters. With the present personnel of the Alaskan branch, made up of men long familiar with the work and well qualified to solve many of the problems as they arise, the loss is not so apparent, but it is believed to be no less real.

The item of expenditures for clerical and drafting salaries covers the salary of a chief clerk, Miss L. M. Graves, a junior clerk, and a draftsman. Part of the pay of the chief clerk is included in the item for administration, as during much of the field work she is in charge of the office. Three-quarters of the time of the junior clerk is devoted to the computation of the statistics of the production of minerals and work related thereto. The drafting work of the branch is done by J. B. Torbert. The clerical personnel is entirely too small to handle the large volume of work expeditiously and thoroughly, but it has been cut down to the lowest limits to provide funds for the important field projects.

Only about 2½ per cent of the entire appropriation for Alaska work was spent for items that are included in the table as office maintenance and expenses. This item does not cover purchases of supplies and equipment for specific field projects, as those expenses are included in the allotments for the individual projects. It does, however, include the general repair of all instruments or the purchase of such instruments and material to be used in the field as are not directly assigned to an individual project.

LEASING WORK

The leasing work in Alaska in 1928 was conducted from an allotment of $14,500 made from a separate item in the appropriation for the Geological Survey. The general conduct of the leasing work in Alaska is shared between the conservation branch and the Alaskan branch. Local offices are maintained at Juneau and Anchorage, Alaska, in charge of B. D. Stewart, supervising mining engineer, with a staff of two other engineers, together with the necessary clerical assistance.

The Territorial Government of Alaska cooperates in some of the work conducted under this allotment to the extent of furnishing office facilities and clerical services at Juneau and supplying funds for such travel expenses as are performed in the interests of the Territory. This arrangement eliminates much duplication that would be necessary if the Federal and Territorial Governments each maintained separate organizations to conduct the work desired by them, much of which is identical in character.

The primary purpose of these local offices in Alaska is to supervise the operations under the coal and oil leases issued by the Government.

Nearly all the coal mining and much of the oil drilling in Alaska is done on public lands held temporarily by private individuals or companies under leases or permits. The interest of the Government in these lands requires that the developments shall be supervised so as to insure that proper methods of extracting the minerals are employed and undue waste thus prevented and that the lives, health, and welfare of those employed in the work are properly safeguarded. The coal-mining developments are carefully supervised, and wherever possible assistance is given to the operators by outlining and putting into effect economical and safe development and mining programs. Special attention is given to the installation and maintenance of safe and efficient hoisting and tramming equipment; to mine ventilation; to the reduction of fire, explosion, and blasting hazards; and to the provision of adequate pillars in advance of all mining operations. During the year there was one fatality in connection with coal mining—the second to occur during a period of six years—one accident that resulted in permanent partial disability, and four serious and four slight accidents that together caused the injured employees a loss of time amounting to 147 days. This record is exceedingly good, as on the average 95 men were employed throughout the year in coal mining and about 32,000 man-shifts were worked.

The care and maintenance of the coal properties and equipment that the Government owns at Eska, Chickaloon, Sutton, and Coal Creek devolves upon the members of this unit. All these properties are now idle, but the Eska mine and camp are kept in condition for immediate reopening in case an emergency should arise that might jeopardize the coal supply for the Alaska Railroad.

During the season of 1927 it was also practicable for the engineers attached to the local offices in Alaska to conduct general investigations and be of assistance to miners in many of the districts of southeastern Alaska and in the country adjacent to the Alaska Railroad. Work of this kind was done at Taku River, Windham Bay, Chichagof Island, Hyder, Chickamin River, and Willow Creek.

Their familiarity with mining matters throughout many parts of the Territory and their availability for consultation enabled Mr. Stewart and his staff to give much valuable information and advice to many of the Federal and Territorial agencies in Alaska, as well as to many individuals, including the Alaska Railroad, the Forest Service, the governor, members of the Territorial legislature, and many operators and prospectors. The Alaska offices also act as local distribution offices for handling publications of the Geological Survey and assist in furnishing the main office at Washington with information on many phases of the mineral industry.

During the fiscal year funds expended by this office were distributed approximately as follows:

Administrative salaries	$3,200
Other technical salaries	8,000
Clerical salaries	1,500
Field and office expenses	1,800
	14,500

Much of the time of the administrative officer in Alaska is given to field work and other duties not regarded as strictly administrative in character, so that only a proportional part of his salary is charged

as a direct administrative expense and the rest is included in the item "Other technical salaries."

Some of the activities of the members of the Alaskan branch who have been paid from appropriations for the leasing work can not strictly be considered as closely related to that work. To remove any possible difficulties that might arise from this condition, it was decided to carry the two different kinds of work in separate appropriations. In the appropriations for 1929 $4,500 was added to the amount for investigating the mineral resources of Alaska, to cover work of this type, and the appropriation for leasing work was reduced a similar amount. Henceforth, therefore, the two kinds of work will be accounted for separately, and for the fiscal year 1929 the amount allotted to the strictly leasing work will be $10,000. No decided change is contemplated in the future handling of either phase of the work. The result of the separation of funds should be not only to get on a strictly accurate basis but also to give greater flexibility to the use of the funds appropriated for the general investigative work and place more definitely the responsibility for planning the use of those funds so that they may be used to best advantage by removing duplication and causing closer coordination between all the units that have a share in fostering the mineral industry of the Territory.

TOPOGRAPHIC BRANCH

C. H. BIRDSEYE, Chief Topographic Engineer

ORGANIZATION AND PERSONNEL

The organization of the topographic branch at the end of the year remains unchanged.

The technical force at the end of the year comprised 1 chief topographic engineer, 3 senior topographic engineers in charge of divisions, 12 topographic engineers, 2 geodetic engineers, 126 associate, assistant, and junior topographic, geodetic, or cartographic engineers, and 52 engineering field aides and draftsmen of various grades, a total of 196. The clerical force comprised 13 clerks.

EXPENDITURES

Appropriations and expenditures for topographic surveys for the fiscal year ended June 30, 1928

State or project	Appropriation for topographic surveys	Repayments for work performed for other Federal units	Total Federal funds	State cooperative funds	Total funds
Topographic surveys, 1928	$510,200.00	$39,491.33	$549,691.33	$386,962.87	$936,654.20
Bureau of Mines transfer (helium)	4,600.00		4,600.00		4,600.00
Great Smoky National Park, 1928–29	2,949.16		2,949.16		2,949.16
Shenandoah National Park, 1928–29	2,562.46		2,562.46		2,562.46
Credits on account of refunds	293.95		293.95		293.95
Total funds available	520,605.57	39,491.33	560,096.90	386,962.87	947,059.77
Expenditures:					
Alabama	10,017.60		10,017.60	10,000.00	20,017.60
Arizona	7,059.64		7,059.64		7,059.64
Arkansas	5,207.86	46.65	5,254.51	5,050.00	10,304.51
California	20,332.39		20,332.39	17,507.14	37,839.53
Colorado	12,299.98		12,299.98	8,802.48	21,102.46
Connecticut				361.73	361.73
Hawaii	24,479.37		24,479.37	24,779.61	49,258.98

Appropriations and expenditures for topographic surveys for the fiscal year ended June 30, 1928—Continued

State or project	Appropriation for topographic surveys	Repayments for work performed for other Federal units	Total Federal funds	State cooperative funds	Total funds
Expenditures—Continued.					
Idaho	$11,146.93	$2,897.32	$14,044.25		$14,044.25
Illinois	65,406.70	693.82	66,100.52	$53,701.50	119,802.02
Iowa	2,350.72		2,350.72	1,337.60	3,688.32
Kansas	1,902.76		1,902.76		1,902.76
Kentucky	10,746.06		10,746.06	37,763.98	48,510.04
Maine	45,460.45	7,591.98	53,052.43	26,982.39	80,034.82
Michigan	18,302.71		18,302.71	14,611.80	32,914.51
Mississippi		179.34	179.34		179.34
Missouri	2,734.01		2,734.01	163.35	2,897.36
Montana	5,687.50		5,687.50	1,873.08	7,560.58
Nevada		849.12	849.12		849.12
New Hampshire	23,688.57	7,247.29	30,935.86	18,677.56	49,613.42
New Mexico	15,778.00		15,778.00	11,273.15	27,051.15
New York	8,700.95		8,700.95	17,562.67	26,263.62
North Dakota	13,817.07		13,817.07	10,360.33	24,177.40
Oklahoma	15,610.29	39.44	15,649.73	16,433.27	32,083.00
Oregon	13,365.02		13,365.02	897.55	14,262.57
Pennsylvania	27,663.30		27,663.30	19,069.70	46,733.00
Tennessee	10,006.16		10,006.16	12,999.76	23,005.92
Texas	15,853.78	1,460.38	17,314.16	9,504.47	26,818.63
Utah	6,750.04		6,750.04	1,439.65	8,189.69
Vermont	5,044.50	2,655.57	7,700.07	5,577.46	13,277.53
Virginia	28,194.58		28,194.58	39,838.45	68,033.03
Washington	10,135.98		10,135.98	2,538.49	12,674.47
West Virginia	2,435.36		2,435.36	2,496.49	4,931.85
Wisconsin	10,320.33		10,320.33	15,359.21	25,679.54
Wyoming	6,690.24		6,690.24		6,690.24
Books for library	114.82		114.82		114.82
Computing	[a] 4,264.36		4,264.36		4,264.36
Contingent	16,783.52		16,783.52		16,783.52
D. C. map revision	1,296.63		1,296.63		1,296.63
Field distribution offices	1,034.84		1,034.84		1,034.84
Field instruments	[a] 4,735.70		4,735.70		4,735.70
Field stationery	[1] 210.00		210.00		210.00
Inspection and editing	[a] 7,716.87		7,716.87		7,716.87
Map information	3,084.26		3,084.26		3,084.26
One-millionth maps	7,113.79		7,113.79		7,113.79
Miscellaneous repay		15,830.42	15,830.42		15,830.42
Office salaries	[a] 7,465.77		7,465.77		7,465.77
Photographic mapping	[a] 2,368.54		2,368.54		2,368.54
Relief maps	755.16		755.16		755.16
Total expenditures	[b] 514,133.11	39,491.33	553,624.44	386,962.87	940,587.31
Unexpended balance	6,472.46		6,472.46		6,472.46
	520,605.57	39,491.33	560,096.90	386.962.87	947,059.77

[a] Represents 35 per cent of total cost; balance of 65 per cent included in charges for State cooperation.
[b] $386,231.83 expended on State cooperation.

GENERAL OFFICE WORK

General office work consisted in the inking and inspection and editing of the topographic field sheets prior to their submission for reproduction, in the computation and adjustment of the results of control field work, and in the preparation of partial culture and drainage bases from aerial photographs. In cooperation with the State Highway Department of New Hampshire a shaded relief and highway map of New Hampshire was compiled. In cooperation with the Virginia Geological Survey a contour map of Virginia was compiled. Cooperation with the Air Corps, United States Army, was continued whereby aerial photographs were furnished for use in topographic mapping. (See also p. 72.)

SUMMARY OF RESULTS

The status of topographic surveys on June 30, 1928, is shown in the following table:

New topographic surveys of the United States, July 1, 1927, to June 30, 1928, and total area surveyed in each State

State	Publication contour interval (feet)	Mapped in fiscal year (square miles) for publication on scale of 1 to—							Total area mapped in fiscal year (square miles)			Total area mapped to June 30, 1928 (square miles)	Percentage of total area of State mapped to June 30, 1928	River surveys, scale 1: 48,000 (linear miles)	Spirit levels (miles)	Transit traverse (miles)	Triangulation stations occupied
		12,000	20,000	24,000	31,680	48,000	62,500	125,000	Revision	Resurvey	New survey						
Alabama	20						142			142		21,240	40.8		387	226	
Arizona	100							386		386		58,398	51.3				
Arkansas	20						236				236	21,730	40.7		266		
California	5, 10, 20			29	830					29	830	125,921	79.5		252	30	44
Colorado	25, 50, 100	33		75				367		108	367	55,530	53.4		160	20	
Connecticut												4,965	100.0		13		
Delaware	10						53			53		2,370	100.0				
District of Columbia	10				42				42			70	100.0				
Florida												4,716	8.0				
Georgia												24,835	41.9				
Idaho	2, 100	18						495		18	495	30,446	36.3				
Illinois	5, 10, 20			260			1,608			101	1,767	30,513	53.8		846	416	
Indiana	5			3							3	3,665	10.1				
Iowa	20						181				181	13,023	23.2		68		
Kansas												64,159	78.0				
Kentucky	20						977				977	23,232	57.2		573	669	
Louisiana	20						13				13	8,823	18.2				
Maine	20			1			1,083			1	1,083	13,335	40.3		491	126	83
Maryland	10				193				193			12,327	100.0				
Massachusetts												8,266	100.0				
Michigan	10, 20		11				598				609	12,938	22.4		223	492	
Minnesota												7,354	8.7				
Mississippi												3,881	8.3		3		
Missouri	20						36			32	4	43,083	62.1				
Montana	2, 5, 100	1						243			244	41,834	28.7	14	55		
Nebraska												27,117	35.0				
Nevada												44,642	40.3		15		
New Hampshire	20			1			933			1	933	7,157	76.6		410	16	1
New Jersey												8,224	100.0				
New Mexico	25, 50							1,303		245	1,058	41,510	35.9		292		29
New York	10, 20	51					280			331		49,245	100.0				
North Carolina	20						31				31	19,034	36.3				
North Dakota	10, 20			61			740				801	12,189	17.1		249	339	
Ohio												41,040	100.0				
Oklahoma	20						476				476	40,384	57.7		594	122	
Oregon	100							669			669	30,650	31.7		28		
Pennsylvania	20						593				593	34,889	77.3		387	554	
Rhode Island												1,248	100.0				

South Carolina													13,737	44.3			
South Dakota													19,243	24.8			
Tennessee	20, 50						376			99	277		23,227	55.3		117	86
Texas	5, 20	[a] 1		172		117	65			26	329		86,615	32.6		79	200
Utah	5, 25, 50			64		25				27	62		19,097	22.5			
Vermont	10, 20			22			84			3	103		7,367	77.1		137	
Virginia	10, 20, 50			170	80		793		80	805	158		37,704	88.4		384	750
Washington	100							400			400		34,934	50.6		66	
West Virginia	50						1,222		1,222				24,170	100.0			
Wisconsin	20						463				463		17,839	31.8		110	
Wyoming	100							272			272		30,374	31.0		67	
Total continental United States (exclusive of Alaska)		104	11	858	1,145	142	10,050	4,135	1,537	2,407	13,434	1,308,287	43.2	14	6,272	4,046	157
Hawaii	10, 50		[b] 235		[b] 108		[c] 343				343	6,029	93.5		38		

[a] Mapped on scale of 1: 4,800.
[b] Advance editions in 10-foot contours; final publication in 50-foot contours and on a scale of 1: 62,500.
[c] Advance editions on scales of 1: 24,000 and 1: 31,680 with 10-foot contours.

FIELD SURVEYS

Alabama.—In cooperation with the State geologist of Alabama the resurvey of the Searles and Cottondale quadrangles (previously surveyed on a smaller scale) was begun.

Arizona.—At the request of the Forest Service the resurvey of the Turret Peak quadrangle (previously surveyed on a smaller scale) was begun.

Arkansas.—In cooperation with the State geologist of Arkansas the survey of the El Dorado quadrangle was completed.

California.—In cooperation with the State engineer of California the survey of the Pond, Wasco, Famosa, Jasmine, Semitropic, Wheatville, Hamlin School, Miramonte Ranch, No. 28, No. 29, No. 31, No. 32, No. 60, and No. 64 quadrangles was completed. At the request of the geologic branch the survey of the Elk Hills naval reserve was completed.

Colorado.—In cooperation with the Colorado Metal Mining Fund the survey of the Climax mining district was completed and that of the Mosquito Range mining region and the Ouray mining district was begun. At the request of the Forest Service the survey of the Glenwood Springs quadrangle was completed.

Delaware.—The resurvey of the Noxontown Pond and Bay Side quadrangles (previously surveyed on a smaller scale) was completed.

Hawaii.—In cooperation with the commissioner of public lands of the Territory of Hawaii the survey of the Humuula NE. ¼, Humuula SE. ¼, Honolulu, and Barbers Point quadrangles was completed and that of the Wahaiwa, Waianae, Mokapu, Kaneohe, Waipaho, Ewa, Koko Head, and Schofield quadrangles, on the island of Oahu, was begun.

Idaho.—At the request of the geologic branch the survey of the Bay Horse quadrangle was begun. At the request of the Forest Service the survey of the Newsome quadrangle was begun. At the request of the State Department the survey of Kootenai River was begun.

Illinois.—In cooperation with the Department of Registration and Education of Illinois, Geological Survey, the survey of the Danvers, Edwardsville, Glasford, Hardin, Pearl, Alton, Bonfils, and Brussels quadrangles and the northern part of the Dyer, Steger, Frankfort, and Brisbane quadrangles was completed; that of the Mackinaw, Meredosia, Arenzville, Morrison, Thebes, Mound City, Hettick, Hannibal, and Barry quadrangles was begun; that of the Manito quadrangle was continued; and the resurvey of the Calumet Lake, Blue Island, and Mokena quadrangles (previously surveyed on a smaller scale) was completed, and that of the Geneva quadrangle was begun.

Indiana.—The survey of the northern part of the Dyer quadrangle was completed.

Iowa.—In cooperation with the Geological Survey of Iowa the survey of the Bondurant quadrangle was completed, and that of the Indianola quadrangle was begun.

Kentucky.—In cooperation with the State geologist of Kentucky the survey of the Lexington, Big Clifty, and La Grange quadrangles was completed and that of the Joppa, Eddyville, Pleasureville, Adolphus, Buck Lodge, and Burnside quadrangles was begun.

Louisiana.—The survey of the El Dorado quadrangle was completed.

Maine.—In cooperation with the Public Utilities Commission of Maine the survey of the Rumford, Stockholm, Square Lake, and Katahdin quadrangles was completed; that of the Stratton quadrangle was continued; and that of the Spencer, Great Pond, Upper Lake, and Eagle Lake quadrangles was begun. In cooperation with the War Department the survey of the Sandy Bay, Moose Bog, and Second Lake quadrangles was completed.

Maine-New Hampshire.—In cooperation with the Highway Commission of Maine and the Highway Department of New Hampshire a survey of the boundary between these two States north of the outlet of Great East Pond was begun.

Michigan.—In cooperation with the Department of Conservation of Michigan, Geological Survey, the survey of the Benton Harbor, Breedsville, Niles, and Hartford quadrangles was completed and that of the Marcellus, Gobleville, Fletcher, and Fennville quadrangles was begun.

Missouri.—In cooperation with the State geologist of Missouri the survey of the Coldwater quadrangle was completed and the resurvey of the Fulton No. 2 quadrangle (previously surveyed on a smaller scale) was continued.

Montana.—At the request of the geologic branch the survey of the Libby quadrangle was begun. In cooperation with the State engineer of Montana a survey in the vicinity of Flathead Lake was begun.

New Hampshire.—In cooperation with the Highway Department of New Hampshire the survey of the Danbury, Mascoma, Bellows Falls, and Silver Lake quadrangles was completed and that of the Rumney and Campton quadrangles was begun. In cooperation with the War Department the survey of the Second Lake and Moose Bog quadrangles was completed.

New Mexico.—In cooperation with the State engineer of New Mexico the survey of the Tucumcari quadrangle was completed and the resurvey of the Sulphur Spring quadrangle—previously surveyed on a smaller scale—was begun.

New York.—In cooperation with the Department of Public Works of New York the resurvey of the Schenectady quadrangle was completed and that of the Amsterdam quadrangle was begun. In cooperation with the commissioners of the Palisades Interstate Park the survey of the Palisades Interstate Park was completed.

North Carolina.—The survey of the Stuart quadrangle was begun.

North Dakota.—In cooperation with the State engineer of North Dakota the survey of the Drake, Hamar, and Peking quadrangles was completed; that of the Tokio, Skogmo, Devils Lake, and Oberon quadrangles was begun, and that of the Souris River was extended.

Oklahoma.—In cooperation with the Highway Commission of Oklahoma the survey of the McLoud and Drumright quadrangles was completed and that of the Yale, Skedee, and Stroud quadrangles was begun.

Oregon.—At the request of the Forest Service the survey of the Mount Jefferson quadrangle was completed. In cooperation with the State engineer of Oregon the survey of the Madras quadrangle was begun.

Pennsylvania.—In cooperation with the Department of Internal Affairs of Pennsylvania, Topographic and Geologic Survey, the survey of the Eagles Mere, Townville, Tidioute, Titusville, Hyndman, and Clearville quadrangles was completed and that of the Ariel and Snowshoe quadrangles was begun.

Tennessee.—In cooperation with the State geologist of Tennessee the survey of the Erin and Red Boiling Springs quadrangles was completed, that of the Monoville quadrangle was begun, and the resurvey of the Middlesboro quadrangle (previously surveyed on a smaller scale) was completed.

Texas.—In cooperation with separate interests acting through the Board of Water Engineers of Texas the survey of the Lufkin 4–c, Lufkin 4–d, and Zavalla 3–c quadrangles of the Neches River project was completed and that of the Lufkin 3–a and Lufkin 3–d quadrangles was begun. In cooperation with the Board of Water Engineers of Texas the survey of the Frio River reservoir site, near Dilley, was completed and that of the Floresville quadrangle was begun. In cooperation with the Reclamation Department of Texas the survey of the Sulphur River project, in the vicinity of Long Lake, and the Little River project, in the vicinity of Reeds Lake, was completed. At the request of the Bureau of Mines large-scale surveys were begun in the vicinity of Amarillo. The survey of the Bassett quadrangle was completed.

Utah.—In cooperation with Salt Lake County and the Bureau of Reclamation the survey of this county was continued. At the request of the geologic branch a survey of the East Tintic mining district was completed and that of the North Tintic mining district was begun.

Vermont.—In cooperation with the State geologist of Vermont the survey of the Hyde Park quadrangle was completed. In cooperation with the War Department stream surveys were begun for navigation, power development, flood control, and irrigation. In cooperation with the Vermont Flood Control Commission stream surveys were begun for flood control.

Virginia.—In cooperation with the Conservation and Development Commission of Virginia, Geological Survey, the resurvey of the Remington, Speedwell, Max Meadows, and Middlesboro quadrangles was completed and that of the Bonsacks, Salem, and the tentative boundary of the proposed Shenandoah National Park was begun (areas previously surveyed on a smaller scale), and the survey of the Stuart quadrangle was begun.

Washington.—In cooperation with the Department of Conservation and Development of Washington the survey of the Chewelah quadrangle was completed and that of the Colville quadrangle was begun.

West Virginia.—In cooperation with the acting State geologist of West Virginia the culture was revised for the Montgomery, Bald Knob, and Fayetteville quadrangles and cultural revision was begun for the Eccles, Beckley, and Flattop quadrangles.

Wisconsin.—In cooperation with the Geological and Natural History Survey of Wisconsin the survey of the Strum, La Crosse, and La Crescent quadrangles

was completed, that of the Shamrock quadrangle was continued, and that of the Alma, Mondovi, and Durand quadrangles was begun.

Wyoming.—At the request of the geologic branch the survey of the Cheney quadrangle was begun.

WATER-RESOURCES BRANCH

N. C. GROVER, Chief Hydraulic Engineer

ORGANIZATION AND PERSONNEL

The organization of the water-resources branch is the same as last year, and the changes in personnel show a net increase of 13. At the end of the year the force comprises 131 technical and 23 clerical employees.

FUNDS

The funds available for disbursement by the Geological Survey for the work on water resources were as follows:

Gaging streams	$147,000.00
Transfers from Federal agencies	47,886.23
Repayments by Federal agencies	40,448.42
Funds furnished by States and other non-Federal governmental agencies	338,818.81
Funds furnished by permittees and licensees of the Federal Power Commission	32,424.71
	606,578.17

COOPERATION

Work in the branch is largely conducted in cooperation with Federal bureaus; State, county, municipal, and other governmental agencies; and permittees and licensees of the Federal Power Commission. A major part of this cooperation is set forth below.

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

Arizona		$20,381.97
Arkansas		2,713.31
California:		
State	$24,799.29	
County and city (gaging streams)	13,890.18	
Municipal (ground water)	9,169.20	
		47,858.67
Colorado		617.85
Connecticut		1,359.42
Hawaii:		
Territory	$29,702.90	
Municipal	3,679.75	
		33,382.65
Idaho		16,979.87
Illinois		4,658.22
Maine		6,113.57
Maryland (municipal)		130.44
Massachusetts		5,323.09
Minnesota		296.00
Missouri		8,324.56
Montana:		
Gaging streams	$6,096.93	
Ground water	1,334.24	
		7,431.17

Nevada		$1,147.62
New Hampshire		2,409.72
New Jersey:		
Gaging streams	$11,674.02	
Ground water	1,585.15	
		13,259.17
New Mexico:		
State (gaging streams)	500.00	
State (ground water)	4,289.88	
County (ground water)	1,665.91	
		6,455.79
New York:		
State	17,086.96	
Municipal	478.65	
		17,565.61
North Carolina		11,168.35
Ohio		30,116.57
Oregon		7,085.45
Pennsylvania (ground water)		433.32
Tennessee		13,284.84
Texas		32,107.03
Utah		7,469.74
Vermont		2,596.42
Virginia		16,824.47
Washington:		
State	$7,760.85	
Municipal	1,393.55	
		9,154.40
West Virginia		228.82
Wisconsin		6,439.97
Wyoming		5,500.73
		338,818.81

The work done under cooperative agreements with States and municipalities has been restricted to studies of stream flow, except in California, Idaho, Montana, New Jersey, New Mexico, Pennsylvania, and Tennessee, where ground-water investigations have been made. (See pp. 49–50.)

Bureau of Reclamation.—The measurement of streams that are to furnish water to reclamation projects was continued in cooperation with the Bureau of Reclamation on the Black Canyon and Yakima projects and on the lower Colorado River. A geologic investigation was made for the Bureau of Reclamation in New Mexico.

Office of Indian Affairs.—In accordance with authorization by the Office of Indian Affairs, stream gaging was continued in the Colville, Western Shoshone, and Walker River Reservations and on Gila and San Carlos Rivers. A geologic investigation was made of the Zuni Dam in New Mexico.

National Park Service.—Streams in the Yellowstone National Park 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.

Weather Bureau.—Stream gaging has been continued on Colorado River in Arizona in cooperation with the Weather Bureau.

Bureau of Mines.—A report on a ground-water supply near Amarillo, Tex., was made to the Bureau of Mines.

Department of State.—Stream gaging for the Department of State has been continued on the Rio Grande on the Mexican boundary

and on St. Mary and Milk Rivers on and near the Canadian boundary. At the end of the year the work on the Canadian boundary was being extended to include Kootenai River, and plans had been made for establishing, during the next year, gaging stations on the Skagit, the Columbia and its tributaries that cross to or from Canada, and the Roseau. The cost of all this work is being met by funds transferred to the Geological Survey from the Department of State.

Corps of Engineers, United States Army.—Stream gaging has been continued in the basins of Tennessee and Cumberland Rivers. During the later part of the fiscal year arrangements were made with several of the district engineers of the Corps of Engineers for the Geological Survey to conduct the stream gaging needed in connection with studies and reports to be made under House Document No. 308 of the Sixty-ninth Congress, first session. Such arrangements have been made with the district engineers of the Army at Boston, Providence, New York, Philadelphia, Washington, Norfolk, Huntington, Chattanooga, Nashville, Florence, Montgomery, Mobile, Jacksonville, Vicksburg, Louisville, Cincinnati, St. Paul, Kansas City, Seattle, Portland, and San Francisco. At the end of the year the work of selecting sites and establishing and equipping the stations was in progress. The cost of this work is being reimbursed to the Geological Survey from funds of the Corps of Engineers.

Federal Power Commission.—The stream gaging required by the Federal Power Commission in permits and licenses issued for the development of water power under the Federal water power act has been performed or supervised by engineers of the Geological Survey in Alabama, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Idaho, Illinois, Indiana, Kentucky, Maine, Michigan, Minnesota, Missouri, Montana, New Mexico, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, South Carolina, Utah, Virginia, Washington, West Virginia, Wisconsin, and Wyoming. The operation of constructed projects or those under construction has been supervised in Arizona, California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wisconsin, and Wyoming.

PUBLICATIONS

The publications of the year prepared by the water-resources branch comprised 10 reports and 7 separate chapters. At the end of the year 14 other reports were in press, 7 manuscripts were awaiting editorial work, and 23 were awaiting funds for publication.

CHARACTER AND METHOD OF WORK

The study of surface waters, which consists primarily of the measurement of the flow of streams, has been conducted in 40 States and Hawaii at selected gaging stations at which the volume of water carried by the streams is measured and records of stage and other data, from which the daily flow of the stream is computed, are collected. At the end of the year 1,830 gaging stations were being maintained; 249 stations were discontinued and 330 new stations established during the year. Records for about 130 additional stations were received, ready for publication, from Government bureaus and private persons, and a number of Government and State organizations and individuals cooperated in the maintenance of the regular gaging stations.

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 as watering places for livestock and desert travelers. Each year surveys are made of selected areas where problems of water supply are urgent, and the results are generally published in water-supply papers that include maps showing the ground-water conditions. The investigations relating to the chemical composition of the water are made in cooperation with the division of quality of water. Projects involving large expenditures for drilling wells to develop water supplies are considered each year by the several departments of the United States Government, and the ground-water division is called upon to furnish information and advice on many of these projects. During the fiscal year about 40 investigations relating to ground-water and reservoir sites were in progress, and work was conducted in 15 States. The demands of the public for precise information in regard to ground-water resources are becoming more and more exacting with increasing need for the water. In recent years considerable research into the principles of ground-water hydrology has been undertaken in the division in order to provide a more secure basis for ground-water investigations. Critical studies are in progress in regard to the laws of head and flow of artesian water, the principles of recharge and discharge of ground water, fluctuations of the water table, and the relation of vegetation to ground water. In connection with these studies a hydrologic laboratory and three experiment stations have been maintained, about 30 automatic water-stage recorders have been installed over observation wells, and thousands of measurements of water levels in wells have been made. A paper on the compressibility and elasticity of artesian aquifers, by O. E. Meinzer, was published in Economic Geology. Considerable attention has also been given by Mr. Meinzer to the occurrence and behavior of ebbing and flowing springs and the history of the science of ground-water hydrology in this country and in Europe. In recent years most of the geologic investigations of reservoir sites have been made by this division, and much attention has been given to the principles involved and to the available methods of investigation. A systematic effort is made to maintain contact with European hydrologists, and abstracts of papers published in this country on ground-water hydrology are furnished to the Revue de Géologie and the Zentralblatt. Cooperation was continued with the State associations of water-well drillers in North Dakota, Minnesota, Wisconsin, and Illinois. In February Mr. Meinzer addressed a conference of Illinois drillers at Urbana and assisted in the organization of the Illinois Association of Water-Well Drillers. He also addressed the annual convention of the Minnesota Well Drillers' Association, and has acted as chairman of a committee that was called to organize the American Association of Water-Well Drillers.

The work on quality of water involved the examination of 550 samples of water with reference to their dissolved mineral matter and of 251 samples of silt taken in connection with the study of the silt carried by streams. The samples analyzed included some for nearly all the studies of ground water in the different States as noted below. Manuscripts were prepared by C. S. Howard on the chemical char-

acter of the water of Colorado River and on the silt carried by the river. A summary of the results of this work was presented by W. D. Collins and Mr. Howard at the St. Louis meeting of the American Chemical Society in April, 1928, and published in Industrial and Engineering Chemistry.

The work of the division of power resources comprised the preparation of monthly and annual reports of the production of electricity and consumption of fuel by public-utility power plants, a report of the developed water power of the United States, and compilations of the stocks of coal held by electric public-utility power plants for inclusion in reports of commercial stocks of coal undertaken quarterly by the Bureau of Mines of the Department of Commerce. The monthly and annual figures of output of electricity and fuel consumption are based on reports submitted by concerns producing electricity for public use. On January 1, 1928, 1,820 companies operating 3,705 power plants with a total capacity of generators of 27,691,000 kilowatts were on the list of companies requested to submit reports of the operation of their power plants. Plants whose output is less than 10,000 kilowatt-hours a month are not included. Reports are received from plants representing over 95 per cent of the capacity of all plants listed. The output of plants not reporting is estimated.

Annual production of electricity by public-utility power plants in the United States, 1919–1927

Year	Total		Water power			Fuel power		
	Kilowatt-hours	Change from preceding year	Kilowatt-hours	Per cent of total	Change from preceding year	Kilowatt-hours	Per cent of total	Change from preceding year
		Per cent			*Per cent*			*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	40,975,000,000	−5.9	14,970,000,000	36.5	−7.3	26,005,000,000	63.5	−5.1
1922	47,654,000,000	+16.3	17,207,000,000	36.1	+14.9	30,447,000,000	63.9	+17.1
1923	55,665,000,000	+16.8	19,343,000,000	34.8	+12.4	36,322,000,000	65.2	+19.3
1924	59,014,000,000	+6.0	19,969,000,000	33.8	+3.2	39,044,000,000	66.2	+7.5
1925	65,870,000,000	+11.6	22,356,000,000	33.9	+11.9	43,514,000,000	66.1	+11.4
1926	73,791,000,000	+12.0	26,189,000,000	35.5	+17.1	47,602,000,000	64.5	+9.4
1927	80,205,000,000	+8.7	29,875,000,000	37.2	+14.1	50,330,000,000	62.8	+5.7

Annual consumption of fuel in the production of electricity by public-utility power plants in the United States, 1919–1927

Year	Coal		Fuel oil		Gas	
	Short tons	Change from preceding year	Barrels	Change from preceding year	M cubic feet	Change from preceding year
		Per cent		*Per cent*		*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
1922	34,179,000	+8.2	13,197,000	+9.6	27,172,000	+14.5
1923	38,966,000	+14.0	14,684,000	+11.3	31,483,000	+15.9
1924	37,556,000	−3.6	16,630,000	+13.3	48,443,000	+53.9
1925	40,222,000	+7.1	10,246,000	−38.4	46,521,000	−4.0
1926	41,311,000	+2.7	9,399,000	−8.3	53,207,000	+14.4
1927	41,888,000	+1.4	6,782,000	−27.8	62,919,000	+18.3

The improvement in the utilization of fuel in the generation of electricity by public-utility power plants is shown in the following table:

Average consumption of coal[a] per kilowatt-hour by public-utility power plants in the United States, 1919–1927

Year	Pounds	Per cent of rate in 1919	Year	Pounds	Per cent of rate in 1919
1919	3.2	100	1924	2.2	69
1920	3.0	94	1925	2.1	66
1921	2.7	84	1926	1.95	61
1922	2.5	78	1927	1.84	57
1923	2.4	75			

[a] Oil and gas included as equivalent coal.

The improvement year by year in the utilization of fuel in the generation of electricity is of special interest. This improvement has conserved a large amount of fuel, as, although the production of electricity by the use of fuels in 1927 was more than double that for 1919, the consumption of fuels in 1927 was only 18 per cent more than in 1919. The use of water power since 1919 in the production of electricity, notwithstanding the remarkable increase in the efficiency of fuel-burning plants, has maintained its position and during the last three years has shown a relative increase in production of electricity as compared with the amount of electricity produced by fuel. Water Supply Paper 579, Power Capacity and Production in the United States, which contains the monthly figures of production of electricity from 1919 to 1926, as well as a large amount of information about power and its use, was released in March, 1928.

The investigation of the water-power and irrigation resources of the public lands has been continued during the year in areas designated and with the use of funds provided by the conservation branch. The work has been done by a small personnel working from three field offices, one of which was discontinued early in the year. It has consisted of the examination of streams, including the location and survey of power and reservoir sites and of neighboring lands to determine their value for power or irrigation and the preparation of reports, either for office use or for publication, on the power value of streams.

WORK OF THE YEAR BY STATES

The following table shows by States the number of gaging stations maintained for the collection of stream-flow records and the interest in those stations of the agencies cooperating with the Geological Survey:

Gaging stations and cooperating parties for the year ended June 30, 1928

State or Territory	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					14			1		8	2	21	8	2	92	11
Arizona		1		3		3		48	6		18	43	3		990	2
Arkansas						3		12		8	11	12	14	3	70	6
California			20	1			5	223	63	100	187	225	14	14	3,293	381
Colorado		2						31	3	7	12	31		2	102	11
Connecticut										2		2			2	
Florida										7		7	1		79	9
Georgia					1					7		8	1	3	74	12
Idaho		6	6			2	33	104	3	205	88	271	152	122	2,459	62
Illinois					5	3		31	1	2	8	34	3	3	53	
Indiana					6			7		1	7	7	7	1	5	
Iowa														21		
Kansas														24		
Kentucky					20					9	8	21	11	3	34	
Maine								19		9	9	19			137	
Maryland	2				2				5			9	3	2	44	2
Massachusetts								19		1	1	19	2		88	1
Michigan										1		1		1	3	8
Minnesota					4			5		4		13	2	3	13	
Mississippi																3
Missouri					1	2		58		21	24	58	2		305	7
Montana		2	2				33	41		3		81	11	4	338	4
Nevada				1				15		7	8	15		3	30	2
New Hampshire					1			16		12	12	17	1		42	6
New Jersey						1		39	9	6	16	39	3		291	17
New York					1			83	1	48	50	83	11	4	373	5
North Carolina					15			50	14	16	44	51	11	4	230	5
Ohio					5	3		98	14	5	27	98	7	1	339	10
Oklahoma										2		2	1	1	20	
Oregon			1	1	8			94	25	54	89	94	14	8	492	40
Pennsylvania								2		2	2	2				
South Carolina										7		7			55	1
South Dakota								1				1	1		1	
Tennessee					56	5		59		10	71	59	3	5	435	17
Texas	8					11		97	13	13	37	105	8	4	912	278
Utah		4					1	56	1	16	22	56	2		122	16
Vermont								2		7	2	7	2		10	19
Virginia								58	2	12	14	58	3	2	211	40
Washington			2	4	2		2	50	20	35	49	66	8	4	341	42
West Virginia					3			8	1	9		21	4		6	3
Wisconsin					1			38		11	12	38	2		113	4
Wyoming		5		4		1	7	30		5	7	45	10	4	119	15
Hawaii								83	7	26	33	84	5	1	497	1,489
	10	20	31	14	145	34	81	1,478	188	698	870	1,830	330	249	12,820	2,528

Alabama.—Plans were made for a systematic survey of the ground-water resources of Alabama in cooperation with the State Geological Survey. Field work is to begin about July 1, 1928.

Arkansas.—At the request of representatives of the rice-growing industry, Mr. Meinzer made a preliminary field study in September, 1927, of the ground-water supply that is used for the irrigation of rice in the area about Stuttgart, Ark., and arrangements were made with the State Geological Survey for an intensive study of this area. The water levels in 16 selected wells were measured in September, 1927, and in April, 1928.

California.—Water levels were measured in selected wells in southern California under the direction of F. C. Ebert. The record now covers a period of 24 years. Work was actively continued on an investigation of the ground water in the alluvial fan of Mokelumne River by H. T. Stearns, T. W. Robinson, B. S. Barnes, and G. H. Taylor. This investigation receives financial support from the East Bay Municipal Utility District. A report on the probable future stages of Salton Sink was completed in manuscript and opened to public inspection.

Colorado.—The report on the utilization of Colorado River in Colorado and Utah to the mouth of Green River was revised preparatory to its publication as a water-supply paper.

Idaho.—A comprehensive investigation of the ground-water conditions in the Snake River Plains and of the relation of the ground-water supply in this region to losses from Snake River and other streams and to the flow of the large springs in the Snake River Canyon was begun by H. T. Stearns and Lynn Crandall. This investigation is being made in cooperation with the Idaho Bureau of Mines and Geology and the Idaho Bureau of Reclamation. Geologic examinations of certain reservoir sites in southeastern Idaho were also made by Mr. Stearns.

Montana.—A study of ground-water levels in an area north of Flathead Lake, Mont., in relation to fluctuations in the lake level was begun by A. H. Tuttle.

New Jersey.—The investigation of the quantities of ground water available in different parts of New Jersey was continued during the year in cooperation with the State Department of Conservation and Development. A report on the Camden area was completed by D. G. Thompson, and progress was made by him on a report on the Passaic area. Observations were continued at two experiment stations and on numerous observation wells. This work was placed in charge of H. C. Barksdale, of the State Department of Conservation and Development.

New Mexico.—The investigation of the Roswell artesian basin, N. Mex., was continued by A. G. Fiedler and S. S. Nye, with financial support from the State Department of Engineering and from Chaves and Eddy Counties. The field work on this project was completed, and much progress was made in the preparation of the report. An investigation of the quantity of ground water available for irrigation in the Mimbres Valley was begun in cooperation with the New Mexico Department of Engineering. A preliminary field study was made by Mr. Fiedler, who prepared a report that was transmitted to the State engineer. A geologic examination of the reservoir of the Zuni Dam on the Zuni Indian Reservation was made by Kirk Bryan for the Office of Indian Affairs. A supplemental report on the Avalon Reservoir of the Carlsbad irrigation project was prepared by Mr. Bryan and transmitted to the Bureau of Reclamation. A report on the geology and ground-water resources of western Sandoval County was nearly completed by B. C. Renick.

North Carolina.—An investigation of the salt-water problem of the public supply for New Bern, N. C., was made by W. N. White, who prepared a report with recommendations which was transmitted to the city authorities.

Oregon.—Reports were prepared by H. T. Stearns on the geology and water resources of the middle Deschutes Basin and the upper McKenzie Basin, Oreg. Both reports are to be published as contributions to hydrology. A reconnaissance was made by O. E. Meinzer in the Willamette Valley, and arrangements were completed with the agricultural experiment station of the Oregon Agricultural College for making a comprehensive study of the ground-water supplies available for irrigation in this valley.

Pennsylvania.—The reports on ground water in southeastern Pennsylvania, by G. M. Hall, and in southwestern Pennsylvania, by A. M. Piper, were nearly completed, and similar work was begun by R. M. Leggette in the northwestern part of the State. All the ground-water work in Pennsylvania is conducted in cooperation with the State geologist.

Rhode Island.—A report on the geology and ground water of Rhode Island was prepared by C. W. Brown, superintendent of the Natural Resources Survey of Rhode Island. This report is to be combined with a report on the chemical character of the waters of the State by W. D. Collins and Margaret D. Foster.

South Carolina.—Some progress was made on a report on the geology and ground-water conditions of the Coastal Plain of South Carolina by C. W. Cooke, of the geologic branch.

Tennessee.—A systematic survey of the ground waters of Tennessee was undertaken in cooperation with the State Geological Survey. Field work was completed in 12 counties in north-central Tennessee by A. M. Piper, and similar work was begun in the southwestern part of the State by F. G. Wells. Ebbing and flowing springs near Rogersville and Lenoir City were examined by G. M. Hall, who presented a paper on the subject before the Tennessee Academy of Sciences.

Texas.—A report on ground-water conditions in the vicinity of Amarillo, Tex., by S. S. Nye, was transmitted to the Bureau of Mines. Field work was also done by Mr. Nye on ground-water conditions in 12 counties in the Nueces area of the Coastal Plain, in parts of which considerable land is being brought under irrigation by means of water derived from wells.

Utah.—Field work on the intensive study of ground-water discharge in Escalante Valley, Utah, was completed by W. N. White, and a report on the results of this investigation is being prepared. The report on the utilization of Green River, in Wyoming, Colorado, and Utah, was completed and will be published as a water-supply paper.

Virginia.—Weekly measurements of the water level in the observation well in Arlington County, Va., were continued during the first part of the year, but later a water-stage recorder was installed over the well in order to obtain a continuous record of the fluctuations of the water table. The ground-water conditions in the vicinity of Manassas were examined by O. E. Meinzer, and a brief report with recommendations by him was transmitted to the city authorities. A water-stage recorder was installed over an ebbing and flowing spring (known as the Tide Spring), near Broadway, and a continuous record of the performance of this spring for nearly a year was obtained. An intensive study of the thermal springs of the State was begun, and several months were spent in field work by Frank Reeves, of the geologic branch, and R. P. Meacham, of the State Geological Survey, on a survey of the springs of the western part of the State with special reference to their temperature. The investigations of the ebbing and flowing spring and of the thermal springs of the State are carried on in cooperation with the State geologist.

Washington.—Work has been continued on river surveys and power investigations of streams draining the Olympic Range, Wash.

CONSERVATION BRANCH

HERMAN STABLER, Chief

The work of the conservation branch, comprising the classification of public lands with respect to mineral, water-power, and agricultural value and the technical supervision of mineral and power development on such lands and of mineral development on Indian lands increased materially during the fiscal year 1928. It was directed in that year through four administrative divisions as follows:

Mineral classification division, J. D. Northrop, senior geologist, in charge.
Power division, B. E. Jones, hydraulic engineer, in charge.
Agricultural division, J. F. Deeds, hydraulic engineer, in charge.
Mineral leasing division, H. I. Smith, chief mining supervisor, in charge.

PERSONNEL

Personnel changes during the fiscal year include 15 separations (12 resignations, 2 deaths, and 1 transfer) and 18 additions. On June 30, 1928, the personnel of the branch, both office and field, numbered 142, consisting of 83 professional and subprofessional and 59 clerical employees. Of these, 3 were on detail the entire year to the Federal Power Commission.

FUNDS

The funds appropriated or transferred for the work of the conservation branch in the fiscal year were as follows:

Classification of lands	$200,000
Supervision of leasing operations	288,500
Supervision of naval reserve operations	58,700
Repay, Federal Power Commission	2,592
	549,792

This aggregate is about $35,000 less than in 1927 and about $72,000 less than in 1926. With annually diminishing funds and annually increasing demands for service the task of affording even reasonable protection of the public interest in its natural resources, undeveloped and under development, is increasingly difficult.

CORRESPONDENCE

During the year 35,076 letters were received in the Washington office, an increase of 10,906, or 45 per cent, over 1927. About 36,800 pieces of miscellaneous correspondence were also received for information, for reference to the appropriate field office, or for filing. Within the same period 27,152 letters were answered, an increase of 8,500, or nearly 46 per cent, and about 13,600 additional pieces of miscellaneous correspondence were sent out.

SUMMARY OF LAND-CLASSIFICATION CASES

The activities of the conservation branch with respect to land classification include the preparation of reports in response to requests for data or action on specific cases, the preparation of orders of withdrawal and restoration of lands not involved in specific requests, and the promulgation of broad areal classifications. The following table summarizes activity with respect to requests for data or action on specific cases, and the terms "gain" and "loss" signify, respectively, decrease and increase in the number of cases pending. In spite of strenuous effort and the voluntary overtime work of an efficient personnel the number of cases pending was greater by 685, or 20 per cent, at the end of the year than at its beginning.

General summary of cases involving land classification

Class of cases	Record for fiscal year 1927–28						Record since receipt of first case	
	Pending July 1, 1927	Received during fiscal year	Total	Acted on during fiscal year	Pending June 30, 1928	Gain or loss during fiscal year	Received	Acted on
General Land Office requests:								
General	480	950	1,430	1,086	344	+136		
Time extensions	47	676	723	682	41	+6	1,677	1,636
Oil development	585	9,613	10,198	8,591	1,607	−1,022	12,858	11,251
Application for classification as to mineral:								
General	1	4	5	4	1		10	9
Coal	5	4	9	6	3	+2	777	774
Oil	156	543	699	601	98	+58	6,706	6,608
Phosphate		2	2	2			37	37
Applications for mineral permits	1,003	4,722	5,725	5,342	383	+620	48,757	48,374
Applications for mineral leases	18	114	132	120	12	+6	1,230	1,218
Applications for patent, potassium		1	1		1	−1	124	123
Federal Power Commission cases:								
Preliminary permits	6	10	16	6	10	−4	69	59
Licenses	10	2	12	12		+10	24	24
Determinations under sec. 24	5	40	45	37	8	−3	198	190
Applications for reclassification as to water resources	7	33	40	22	18	−11	711	693
Applications for rights of way	33	149	182	151	31	+2	6,069	6,038
Irrigation project reports	5	11	16	12	4	+1	909	905
Applications under enlarged homestead acts	243	345	588	374	214	+29	56,412	56,198
Applications under stock-raising homestead acts	1,171	3,395	4,566	2,862	1,704	−533	121,940	120,236
Applications under ground-water reclamation act	27	15	42	34	8	+19	878	870
Indian Office requests for information							9,505	9,505
Cases in national forests	1	12	13	12	1		324	323
	3,803	20,641	24,444	19,956	4,488	−685		

SUMMARY OF FIELD OPERATIONS BY STATES

Alaska.—Expended $14,500 through the Alaskan branch for supervision of 9 coal leases, 7 coal prospecting permits, and 1,028 oil and gas prospecting permits. Coal produced, 106,382.66 tons; accrued rent and royalty, $19,495.19.

Alabama.—Supervised 1 coal lease and 4 oil and gas prospecting permits. Coal produced, 43,523 tons; accrued rent and royalty, $4,352.30.

Arizona.—Examined 20 tracts for agricultural classification. Investigated a reported occurrence of sodium near Camp Verde, Yavapai County. Supervised 7 coal prospecting permits, 5 sodium permits, 28 potassium permits, and 568 oil and gas permits. Reported on metalliferous leases and lease applications involving lands in three Indian reservations and on a coal supply for agency use on four reservations.

Arkansas.—Supervised 1 coal prospecting permit and 13 oil and gas permits.

California.—Investigated oil and gas development in the Poso Creek and Round Mountain districts, Kern County. Examined 48 tracts for agricultural classification. Supervised 125 oil and gas leases, 2,087 oil and gas prospecting permits, 6 coal permits, 4 sodium permits, 4 potassium leases, and 1 potassium permit, involving public lands. Oil produced, 6,334,749 barrels; natural gas, 568,656,000 cubic feet; natural-gas gasoline, 4,139,839.32 gallons; coal, 3 tons; sodium borate, 3,809.90 tons; sodium carbonate, 6,051.30 tons. Total rent and royalty accrued, $684,050.49. Supervised 26 oil and gas leases on Naval Petroleum Reserves Nos. 1 and 2. Oil produced, 9,690,573.93 barrels; natural gas, 9,077,967,000 cubic feet; natural-gas gasoline, 24,797,264 gallons. Total rent and royalty accrued, $2,198,412.07.

Colorado.—Examined 5 tracts in Las Animas County for oil and gas classification and 1 tract in La Plata County for coal classification. Made structural reconnaissance of 30 townships in Bent, Prowers, and Las Animas Counties. Investigated geologic structure of lands adjacent to Whiskey Creek oil seep, in Garfield County. Examined 40 tracts for agricultural classification and made

regional investigations of agricultural utility precedent to broad areal classification in the eastern and northwestern parts of the State. Supervised 12 oil and gas leases, 68 coal leases, 7 coal licenses, 3,129 oil and gas prospecting permits, 32 coal permits, and 19 potassium permits. Oil produced, 921,641 barrels; natural gas, 14,360,000 cubic feet; natural-gas gasoline, 93,465 gallons; coal, 439,650.40 tons. Total rents and royalties accrued, $102,707.44.

Florida.—Examined 1 area in Alachua County and 2 areas in Citrus County for phosphate classification.

Idaho.—Investigated power resources of North, Middle, and South Forks of Boise River and geologic conditions affecting one dam site on the South Fork. Examined 53 tracts for agricultural classification. Supervised 2 phosphate leases, 247 oil and gas prospecting permits, 4 coal permits, and 2 sodium permits. Phosphate rock produced, 23,459.95 tons. Accrued rents and royalties, $2,529.85.

Kansas.—Made regional investigations in western Kansas precedent to broad areal classification as to agricultural utility. Supervised 6 oil and gas prospecting permits.

Louisiana.—Investigated the status of oil and gas development in the Cross Lake district, Caddo Parish. Supervised 6 oil and gas leases and 50 prospecting permits. Oil produced, 9,509 barrels; natural gas, 339,308,000 cubic feet; natural-gas gasoline, 74,535 gallons. Total rents and royalties accrued, $3,829.21.

Michigan.—Supervised 1 oil and gas prospecting permit.

Mississippi.—Supervised 3 oil and gas prospecting permits.

Montana.—Examined through the geologic branch 6 townships in Powder River County and 14 townships in McCone County, for coal classification, and determined the geologic canditions affecting one dam site on the South Fork of Flathead River. Examined 83 tracts for agricultural classification. Supervised 47 oil and gas leases, 51 coal leases, 11 coal licenses, 1,855 oil and gas prospecting permits, and 17 coal permits involving public lands. Oil produced, 768,286 barrels; natural gas, 193,824 cubic feet; coal, 278,886.33 tons. Total rent and royalty accrued, $107,964.87. On behalf of the Office of Indian Affairs exercised supervision over 49 oil and gas leases involving tribal and restricted lands of the Blackfeet and Crow Indians, and examined land sought under a lead-silver lease on the Rocky Boy Indian Reservation.

Nebraska.—Examined 10 tracts for agricultural classification and made regional investigations in western Nebraska to afford basis for broad areal classification as to agricultural utility. Supervised 4 oil and gas-prospecting permits.

Nevada.—Examined 40 tracts for agricultural classification. Supervised 1 sodium lease, 506 oil and gas-prospecting permits, 3 coal permits, and 8 sodium permits. Sodium sulphate produced 750 tons, coal produced 91.15 tons. Total rents and royalties accrued, $1,462.79.

New Mexico.—Examined 41 tracts in Guadalupe, Quay, Curry, Roosevelt, De Baca, Chaves, Eddy, Lea, Valencia, San Juan, and Rio Arriba Counties for oil and gas classification. Made geologic examination and published structure-contour map of the Artesia oil field, Eddy County. Began geologic examination through the geologic branch of McKinley and Sandoval Counties for coal classification. Supervised 13 coal leases, 6 oil and gas leases, 4,286 oil and gas-prospecting permits, 59 coal permits, 71 potassium permits, and 2 sodium permits, involving public lands. Coal produced 74,462.82 tons, oil 72,384 barrels, natural gas (volume not measured), natural-gas gasoline 6,991 gallons. Total rents and royalties accrued $25,456.39. On behalf of the Office of Indian Affairs, exercised supervision over 60 oil and gas leases, involving tribal and allotted lands of the Navajo Indians, and rendered advisory service in connection with the leasing of coal lands or with obtaining coal for school and agency use on four Indian reservations.

North Dakota.—Examined 7 tracts for agricultural classification. Supervised 41 coal leases, 2 coal licenses, 5 coal-prospecting permits, and 29 oil and gas-prospecting permits. Coal produced 404,456.71 tons, or 22 per cent of the entire coal production of the State. Total rent and royalty accrued, $30,323.88.

Oklahoma.—Continued, in cooperation with the Oklahoma Geological Survey, the geologic examination of segregated Choctaw and Chickasaw coal lands begun in 1927. Supervised on public lands 18 oil and gas leases involving lands in the bed of Red River, Tillman County, and 85 oil and gas-prospecting permits. Oil produced 602,165 barrels; natural-gas gasoline, 1,298,568 gallons; total rents and royalties accrued, $147,974.25. Supervised on Indian lands 10,515 oil and gas leases involving 929,753 acres and 5,731 producing wells; accrued rents and royalties, $6,140,090.76. Supervised on segregated lands of

the Choctaw and Chickasaw Nations 78 coal leases and 1 asphalt lease, on restricted allotted lands of the Cherokee Nation 10 coal leases and 1 lead and zinc lease, on restricted allotted lands of the Creek Nation 43 coal leases and 1 volcanic-ash lease, and on restricted allotted lands of the Choctaw Nation 10 coal leases; total area under supervision, 399,428 acres; coal produced, 654,920.87 tons from 67 leaseholds. Supervised on restricted Quapaw lands, 55 lead and zinc leases involving 7,284 acres and 49 subleases involving 2,374 acres; concentrates produced, 215,993 tons; sale value $9,425,525.78, accrued royalty $894,820.30.

Oregon.—Investigated power resources on Umpqua and Molalla Rivers. Examined 40 tracts for agricultural classification. Supervised 2 coal leases, 1 oil-shale lease, 50 oil and gas-prospecting permits, 1 coal permit, and 1 potassium permit. Coal produced, 1,280.03 tons. Accrued rents and royalties, $948.

South Dakota.—Examined 16 tracts for agricultural classification. Supervised 1 coal lease and 118 oil and gas-prospecting permits. Coal produced, 422.68 tons; accrued rent and royalty $43.32.

Utah.—Investigated power resources on Provo River. Examined one tract in Uintah County for asphalt classification and another in the same county for coal classification. Continued through the geologic branch broad areal investigation of stratigraphy and structure in Grand and San Juan Counties for oil and gas classification. Began geologic investigations in Cache County for phosphate classification. Examined 64 widely scattered tracts for agricultural classification. Supervised 43 coal leases, 2 coal licenses, 4 oil and gas leases, 3,289 oil and gas prospecting permits, 21 coal permits, 17 potassium permits, and 3 sodium permits. Coal produced, 432,708 tons; petroleum, 2,255 barrels; natural gas, 1,064,726,000 cubic feet. Total rents and royalties accrued, $78,719.70.

Washington.—Investigated power resources on Elwha, Quinault, Hoh, and Soleduck Rivers and geologic conditions affecting two dam sites on Columbia River. Examined 5 tracts for agricultural classification. Supervised 1 coal lease, 9 coal prospecting permits, 74 oil and gas permits, and 1 sodium permit. Coal produced, 33,724 tons. Accrued rents and royalties, $3,495.22.

West Virginia.—Provided technical testimony on behalf of the State in the prosecution and conviction of A. D. Williams and E. D. Fry for violation of the West Virginia speculative securities act in the circuit court for Pocahontas County, and on behalf of the Federal Government in the indictment, prosecution, and conviction of the same defendants for using the mails to defraud, in the District Court of the United States for the Southern District of West Virginia at Charleston; these actions resulting from sales of stock involving an oil and gas prospecting permit in Natrona County, Wyo.

Wyoming.—Examined lands in Lincoln County for phosphate classification and lands in Sublette, Teton, Big Horn, and Converse Counties for oil and gas classification. Examined 55 widely scattered tracts for agricultural classification. Supervised on public lands 299 oil and gas leases, 35 coal leases, 5 coal licenses, 4,285 oil and gas prospecting permits, 15 coal permits, and 1 sodium permit. Petroleum produced, 14,659,561 barrels; natural gas, 16,741,152,000 cubic feet; natural-gas gasoline, 34,084,894 gallons; coal, 1,184,658 tons; total rents and royalties accrued, $2,909,405.61. Supervised 57 productive wells on naval petroleum reserve No. 3, which produced 149,285 barrels of petroleum, 795,854,000 cubic feet of natural gas, and 743,179 gallons of natural-gas gasoline, the aggregate royalty value of which was $33,963.32. Supervised on tribal and allotted restricted lands of the Shoshone Indians, 74 oil and gas leases.

MINERAL-CLASSIFICATION DIVISION

The work of the mineral-classification division involves the withdrawal, classification, and restoration of public lands according to their mineral value and the determination of all questions of geologic fact or inference arising prior to the issuance of a prospecting permit or a lease for publicly owned mineral lands or mineral deposits. It includes also the planning and execution, chiefly through the geologic branch, of field investigations required to provide the basis for appropriate action or recommendation. The results of its work take the form of mineral classifications, of orders of withdrawal, modification, and restoration, and of reports concerning the mineral

character of specific lands for the information and guidance of Government bureaus and departments charged with the administration of the public-land and Indian-land laws.

Little progress was made in 1928 in classifying the vast areas throughout the West that are still embraced in mineral withdrawals. The results accomplished include, however, net decreases of 720 acres in the total area of outstanding coal withdrawals, of 3,960 acres in the total area of outstanding petroleum withdrawals, and of 13,276 acres in the total area of outstanding phosphate reserves.

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, 1928, in acres

State	Coal		Oil		Oil shale		Phosphate		Potash
	Withdrawn	Classified as coal land	Withdrawn	Classified as oil land	Withdrawn	Classified as oil-shale land	Withdrawn	Classified as phosphate land	Withdrawn
Alaska		56,993							
Arizona	139,415		92,496						
Arkansas		61,160							
California	17,603	8,720	1,178,392						90,357
Colorado	4,180,016	3,145,867	218,997		64,560	952,239			
Florida							68,596	120	
Idaho	4,761	4,603					391,532	268,299	
Louisiana			466,990	4,233					
Montana	7,883,164	8,560,671	1,350,426	67,651			279,944	3,833	
Nevada	83,673				123				39,422
New Mexico	5,084,069	570,372							7,418,437
North Dakota	5,954,364	11,178,286	84,894						
Oregon	4,361	18,887							
South Dakota		250,093							
Utah	3,636,541	1,267,697	1,341,264		91,464	2,703,755	301,945	160	
Washington	691,801	141,444							
Wyoming	2,260,604	6,738,516	541,777			460,103	989,289	25,293	
	29,940,372	32,003,309	5,275,236	71,884	156,147	4,116,097	2,031,306	297,705	7,548,216

The functions of this division in connection with administration of the mineral leasing laws, fully described in earlier reports, were materially increased in 1928 by reason of an intensive campaign in the General Land Office to cancel oil and gas prospecting permits the terms of which had had no compliance. This action is predicated on reports from the Geological Survey showing that the physical condition of each permit holding interposes no bar and that no test well competent to establish the oil or nonoil character of the land is being drilled elsewhere within the limits of the geologic structural feature involved. Requests for reports of this type numbered 9,613 in 1928, compared with 1,428 in 1927, and more than 1,000 were awaiting response on June 30, 1928.

The following table summarizes the year's work to the extent that it involves technical reports on original applications for permit or lease rights under the leasing laws. One application for patent under the potassium law of October 2, 1917, was received during the year and was pending at its end.

Applications received, acted on, and pending under the mineral-leasing acts, fiscal year 1928

Mineral	Permits			Leases		
	Received	Acted on	Pending	Received	Acted on	Pending
Oil and gas	4,434	5,025	377	1	3	
Coal	164	189	6	99	100	9
Phosphate				4	9	1
Sodium	12	12		1	1	
Potassium	112	116		5	3	2
Oil shale				4	4	
Sulphur						

In furtherance of the task delegated to the Geological Survey by section 2 of the departmental regulations pertaining to oil and gas leases and prospecting permits, definitions of the "known geological structure" of the following producing fields were prepared and promulgated during the year:

Ashley Creek, Utah; 1,240 acres; promulgated October 14, 1927.
Lost Soldier, Wyo.; 960 acres; promulgated July 28, 1927.
South Sunshine, Wyo.; 2,702 acres; promulgated August 4, 1927.

The net area included in outstanding definitions of the "known geological structure" of producing oil and gas fields on June 30, 1928, was 517,745 acres, in California, Colorado, Montana, New Mexico, Oklahoma, Utah, and Wyoming.

Geologic field work required in the solution of the problems of this division is performed in part by summer detail of Washington employees, in part by a division geologist with permanent headquarters in Denver, Colo., and in part by the geologic branch at the expense of the conservation branch. The work accomplished in 1928 is included in the branch summary of field operations by States beginning on page 52.

POWER DIVISION

The work of the power division consists primarily in obtaining and making available for use in the administration of the public land laws information as to the water-power resources of the public lands. The specific problems on which reports are made ordinarily involve the ascertainment of the potential power resources of areas that are or may be subject to disposal under public land laws. An endeavor is made to determine the proper administrative action by which the possibility of power development may be preserved with minimum interference with agricultural, transportation, or other interests. In the course of this work a review of all power reserves is carried on in order that all land having primary value for the development of power, and only such land, shall be reserved for that purpose. The extent of this task is indicated by the fact that areas aggregating more than 6,000,000 acres are now included in power reserves whose use will be required for the development of about 15,000,000 continuous horsepower.

In order that this information may be made substantially complete, areas not thoroughly surveyed are designated for examination by the topographic and water-resources branches of the Geological Survey. The field projects undertaken during the year to obtain information for power classification, including plan and profile surveys, power-site and reservoir-site investigations, and geologic studies of dam sites, are included in the branch summary of field operations by States (pp. 52–54).

The information obtained in the field is indexed and incorporated in an inventory of water resources which, when complete, will enable the Geological Survey 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. Copies of many of the reports on the power possibilities of the streams examined have been placed in the district offices of the Geological Survey for public inspection, and notices of the availability of the reports have been sent to the press.

The work of the division is briefly summarized in the accompanying tables showing power-site reserves and outstanding water-resources withdrawals and classifications and in the general summary of cases involving land classification (p. 52).

Pursuant to instructions of the Secretary of the Interior 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 since January 1, 1913, were called upon for detailed reports of the operation or development of their power systems during the calendar year 1927. The total installation of the reporting companies is 2,650,000 kilowatts, of which 2,024,000 kilowatts is installed at hydraulic plants. The total energy generated was 8,116,000,000 kilowatt-hours, of which more than 7,546,000,000 kilowatt-hours was generated by water power. That generated by steam has decreased 710,000,000 kilowatt-hours, but the energy generated by water power has increased 1,026,000,000 kilowatt-hours, making the net increase 316,000,000 kilowatt-hours.

Power output of permittees and grantees, 1916–1927

Year	Kilowatt-hours	Increase or decrease		Year	Kilowatt-hours	Increase or decrease	
		Kilowatt-hours	Per cent			Kilowatt-hours	Per cent
1916	1,200,000,000			1922	4,947,000,000	+1,222,000,000	+33
1917	2,000,000,000	+800,000,000	+67	1923	5,910,000,000	+963,000,000	+19
1918	3,200,000,000	+1,200,000,000	+60	1924	6,100,000,000	+164,000,000	+3
1919	3,100,000,000	−100,000,000	−3	1925	6,930,000,000	+830,000,000	+14
1920	4,300,000,000	+1,100,000,000	+35	1926	7,800,000,000	+870,000,000	+13
1921	3,725,000,000	−475,000,000	−11	1927	8,116,000,000	+316,000,000	+4

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, 1927	Eliminated prior to July 1, 1927	Reserves outstanding prior to July 1, 1927	Reserved during fiscal year	Eliminated during fiscal year	Reserves outstanding June 30,1928
Alabama	2,377		2,377			2,377
Alaska	218,177	520	217,657	28,889		246,546
Arizona	1,275,681	124,010	1,151,671	7,295	2	1,158,964
Arkansas	29,671		29,671		360	29,311
California	1,315,213	30,243	1,284,970	52,823		1,337,793
Colorado	531,273	75,783	455,490	6,247	1,237	460,500
Florida	1,019		1,019	112		1,131
Idaho	590,545	191,521	399,024	15,097	13	414,108
Michigan	1,240		1,240			1,240
Minnesota	19,062	532	18,530			18,530
Mississippi	3		3			3
Montana	303,766	96,379	207,387	723		208,110
Nebraska	761		761			761
Nevada	301,196	480	300,716			300,716
New Mexico	270,878	10,511	260,367			260,367
Oregon	753,183	112,248	640,935	16,021	11,715	645,241
South Dakota	52		52	584		636
Utah	756,709	126,398	630,311	15,224	120	645,415
Washington	392,759	53,835	338,924	5,256		344,180
Wisconsin	1,853	226	1,627	13		1,640
Wyoming	222,622	75,346	147,276	9,855	938	156,193
	6,988,040	898,032	6,090,008	158,139	14,385	6,233,762

Summary of outstanding water resources, withdrawals, and classifications June 30, 1928, in acres

State	Power reserves					Reservoir withdrawals	Public-water reserves
	Withdrawals	Classifications	Designations[a]	Miscellaneous	Total		
Alabama	120	1,735		522	2,377		
Alaska	93,415	70,825		82,306	246,546		
Arizona	386,259	37,182	528,237	207,286	1,158,964	23,040	20,150
Arkansas	21,994	1,590		5,727	29,311		
California	287,391	322,129		728,273	1,337,793	1,160	198,786
Colorado	230,673	175,770		54,057	460,500	1,728	4,860
Florida				1,131	1,131		
Idaho	205,637	195,117		13,354	414,108		13,905
Michigan	1,240				1,240		
Minnesota	12,309			6,221	18,530		
Mississippi				3	3		
Montana	129,944	53,452		24,714	208,110	9,080	8,857
Nebraska	761				761		
Nevada	27,492	28,026		245,198	300,716		11,176
New Mexico	117,206		143,161		260,367		9,881
North Dakota						1,569	
Oregon	361,063	203,872	15,250	65,056	645,241	10,619	21,261
South Dakota				636	636		240
Utah	442,375	168,943		34,097	645,415	80	33,930
Washington	97,086	180,691		66,403	344,180	35,943	920
Wisconsin				1,640	1,640		
Wyoming	79,953	35,407		40,833	156,193	1,714	79,425
	2,494,918	1,474,739	686,648	1,577,457	6,233,762	84,933	403,391

[a] Designated and not otherwise withdrawn.

AGRICULTURAL DIVISION

The functions of the agricultural division consist of the classification of lands under the enlarged homestead law as nonirrigable; the classification of lands under the Nevada ground-water reclamation law as nontimbered and not known to be susceptible of successful irrigation; the preparation of reports on the sufficiency of the water supply and the general feasibility of irrigation projects that require some form of Federal approval in connection with the administration of public land laws; the initiation of withdrawals of land for reservoir sites and for public watering places; and the classification as stock-raising lands under the stock-raising homestead law of tracts whose surface is chiefly valuable for grazing and raising forage crops, does not contain merchantable timber, is not susceptible of successful irrigation from any known source of water supply, and is of such character that 640 acres is reasonably required for the support of a family.

Applications for classification are disposed of in accordance with the results of field examinations by members of the division and with information obtained from other sources. Applications in some regions lead to the planning and execution of broad field studies that result in the classification of large areas and provide in advance the basis for appropriate action on new applications.

The number of cases received and acted on during the fiscal year by the agricultural division is shown in the general summary of cases (p. 52). It increased about 12 per cent above the number received in 1927 and resulted in an arrearage 33 per cent greater at the end of 1928 than at the end of 1927.

In the field broad areal studies were continued in the central Great Plains region in Colorado, Kansas, Nebraska, and Wyoming and were begun in the Colorado Basin region in northwestern Colorado and southwestern Wyoming.

The first of a series of maps showing the agricultural utility of the central Great Plains was published, together with a brief text discussing the agricultural characteristics of each of its several parts. This series of maps is uniform with the series of eight relating to the northern Great Plains prepared in cooperation with the Department of Agriculture in 1927 and published in a preliminary edition in that year.

During the fiscal year 1928 the area designated under the Nevada ground-water reclamation act as a result of the work of the division was increased 42,920 acres, to a total of 1,619,215 acres. Outstanding withdrawals, aggregating 11,530 acres, under the act of October 2, 1888 (25 Stat. 527), on the basis of a selection by the Director of the Geological Survey, remained unchanged. Other results of the division's work are tabulated in the summaries of enlarged and stock-raising homestead designations and the general summary of cases.

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, 1927	Cancellations prior to July 1, 1927	Designations outstanding prior to July 1, 1927	Designations during fiscal year	Cancellations during fiscal year	Designations outstanding June 30, 1928
Arizona	31,431,179	5,870,874	25,560,305	71,405		25,631,710
California	13,277,544	238,453	13,039,091	55,682	2,000	13,092,773
Colorado	33,718,793	195,508	33,523,285	91,834		33,615,119
Idaho:						
Total	13,690,819	460,925	13,229,894	63,371	[a] 440	13,292,825
Nonresidence	572,747	4,233	568,514	480		568,994
Kansas	650,404		650,404	960		651,364
Montana	53,457,850	245,728	53,212,122	27,800		53,239,922
Nevada	50,168,165	3,580,717	46,587,448			46,587,448
New Mexico	43,772,180	227,732	43,544,448	65,177		43,609,625
North Dakota	12,277,704	3,848	12,273,856	3,000		12,276,856
Oregon	21,276,707	989,902	20,286,805	5,604		20,292,409
South Dakota	16,336,096	348,170	15,987,926	4,665		15,992,591
Utah:						
Total	11,651,754	700,084	10,951,670	3,022	[b] 1,400	10,953,292
Nonresidence	1,647,889	81,560	1,566,329	3,022	320	1,569,031
Washington	6,655,192	251,842	6,403,350	5,260		6,408,610
Wyoming	29,594,332	162,043	29,432,289	82,960		29,515,249
	337,958,719	13,275,826	324,682,893	480,740	3,840	325,159,793

[a] Previously designated under secs. 1–5, now designated under sec. 6.
[b] Includes 1,080 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, 1927	Cancellations prior to July 1, 1927	Designations outstanding prior to July 1, 1927	Designations during fiscal year	Cancellations during fiscal year	Designations outstanding June 30, 1928
Arizona	13,988,504	887,580	13,100,924	68,162		13,169,086
Arkansas	1,120		1,120			1,120
California	7,888,299	1,400	7,886,899	77,605	2,000	7,962,504
Colorado	8,511,501	18,840	8,492,661	136,077	80	8,628,658
Florida	480	480				
Idaho	5,449,617	1,854	5,447,763	95,674		5,543,437
Kansas	114,139		114,139	1,000		115,139
Michigan	3,451		3,451	40		3,491
Montana	15,349,734	17,081	15,332,653	137,389		15,470,042
Nebraska	194,809		194,809	7,375		202,184
Nevada	566,094	3,120	562,974	19,995		582,969
New Mexico	31,284,608	636	31,283,972	79,345		31,363,317
North Dakota	375,892		375,892	7,808		383,700
Oklahoma	82,082		82,082	1,528		83,610
Oregon	6,310,759	3,128	6,307,631	44,619		6,352,250
South Dakota	6,496,538	550	6,495,988	13,510		6,509,498
Utah	1,651,770	6,520	1,645,250	144,379	1,280	1,788,349
Washington	690,161	1,134	689,027	4,525	40	693,512
Wyoming	20,089,648	6,213	20,083,435	188,463	160	20,271,738
	119,049,206	948,536	118,100,670	1,027,494	3,560	119,124,604

By blanket order of withdrawal creating public water reserve No. 107, which received Executive approval April 17, 1926, every smallest legal subdivision of the public-land surveys which is vacant unappropriated public land and contains a spring or water hole and all land within a quarter of a mile of every spring or water hole located on unsurveyed public land was reserved for public use and in aid of pending legislation. This order obviated the necessity for future withdrawals of specific tracts containing springs or water holes valuable for stock watering but requires a determination by the division with respect to all entries of public land, whether or not any of the subdivisions involved are in fact affected by it. On the basis of such determination orders of interpretation are issued from time to time listing by legal subdivisions of the public-land survey any tracts found to contain a water supply affected by the order. New withdrawals of this type are made to reserve lands along streams and are also made from time to time for special public purposes. The extent of outstanding reserves of this type and of current action affecting them is shown in the following table:

Public-water reserves, in acres

[Includes areas withdrawn under the act of June 25, 1910 (41 Stat., 1063), as amended by the act of Aug. 24, 1912 (37 Stat., 497), and reserved for public use of springs or water holes in accordance with the provisions of sec. 10 of the act of Dec. 29, 1916 (39 Stat., 862), or for watershed protection, drainage reservoirs, or other similar miscellaneous public purposes involving water conservation]

State	Reserved prior to July 1, 1927	Eliminated prior to July 1, 1927	Reserves outstanding prior to July 1, 1927	Reserved during fiscal year	Eliminated during fiscal year	Reserves outstanding June 30, 1928
Arizona	19,177	1,602	17,575	2,605	30	20,150
California	178,412	7,130	171,282	27,512	8	198,786
Colorado	2,660	360	2,300	2,560		4,860
Idaho	13,755	410	13,345	560		13,905
Montana	9,209	1,152	8,057	800		8,857
Nevada	12,506	3,250	9,256	1,920		11,176
New Mexico	10,401	520	9,881			9,881
Oregon	21,789	1,288	20,501	760		21,261
South Dakota	240		240			240
Utah	39,791	6,876	32,915	1,735	720	33,930
Washington	920		920			920
Wyoming	92,605	13,300	79,305	240	120	79,425
	401,465	35,888	365,577	38,692	878	403,391

MINERAL-LEASING DIVISION

The work of the mineral-leasing division is supervisory (both inspectional and regulatory) with respect to operations for the discovery and development of petroleum, natural gas, oil shale, coal, phosphate, sodium, potassium, and sulphur on public lands; of petroleum and natural gas on naval petroleum reserves; and of a variety of minerals on Indian lands. This work is carried on with a minimum of administrative supervision from Washington through district offices and suboffices at or near the primary centers of mining or drilling activity, under the direction of responsible engineers who have full authority to represent the Government within their jurisdiction and to enforce compliance with the law and regulations under which operations are conducted.

ACTIVITIES ON THE PUBLIC DOMAIN

Supervisory work on lands containing publicly owned mineral deposits was increased during the fiscal year 1928 by the issuance of leases, licenses, and prospecting permits as follows:

	Number	Acres		Number	Acres
Leases:			Permits:		
Oil and gas	47	21,945.83	Oil and gas	4,406	7,559,993.26
Coal	37	9,126.05	Coal	83	100,468.63
Licenses:			Potassium	85	197,307.83
Coal	8	320.00	Sodium	14	21,421.00
				4,588	7,879,190.72

During the same period supervisory work was decreased by reason of the cancellation of 5 coal leases, 1 oil and gas lease, 5 coal prospecting permits, 1 sodium permit, 50 potassium permits, and 7,765 oil and gas permits.

The following table shows, by States and by minerals, the total number of prospecting permits, leases, and licenses involving public land under supervision at the end of the fiscal year:

Mineral leases, licenses, and permits on the public domain and naval petroleum reserves under supervision of the Geological Survey June 30, 1928

State	Coal						Oil and gas	
	Leases		Permits		Licenses		Leases (number)	Permits (number)
	Number	Acres	Number	Acres	Number	Acres		
Alaska	9	11,307.28	7	12,115.66				1,028
Alabama	1	1,840.00						4
Arizona			7	16,560.00				568
Arkansas			1	120.00				13
California			6	4,478.51			[a] 151	2,087
Colorado	68	11,907.65	32	20,252.00	7	280.00	12	3,129
Idaho			4	5,402.91				247
Kansas								6
Louisiana							6	[b] 50
Michigan								1
Mississippi								3
Montana	50	6,694.21	9	7,600.00	8	319.95	47	1,855
Nebraska								4
Nevada			3	6,021.88				506
New Mexico	13	6,410.38	59	98,660.21			6	4,286
North Dakota	41	5,856.44	2	320.46	1	40.00		29
Oklahoma								74
Red River							18	11
Oregon	2	1,895.24	1	40.00				50
South Dakota	1	79.04						118
Utah	43	33,052.77	21	22,492.64	2	120.00	4	3,298
Washington	1	600.00	9	5,862.33				74
Wyoming	35	15,982.98	15	11,914.69	5	199.95	299	4,285
	264	95,625.99	176	211,841.29	23	959.99	543	21,726

[a] Includes 15 leases on naval petroleum reserves Nos. 1 and 2 under the act of Feb. 25, 1920, and 11 on naval petroleum reserves Nos. 1 and 2 under the act of June 4, 1920.

[b] Oil and gas permits in Louisiana include the right to lease sulphur deposits discovered while prospecting for oil and gas.

Mineral leases, licenses, and permits on the public domain and naval petroleum reserves under supervision of the Geological Survey June 30, 1928—Contd.

State	Sodium				Potassium			
	Leases		Permits		Leases		Permits	
	Number	Acres	Number	Acres	Number	Acres	Number	Acres
Arizona			5	12,480.00			23 [c] 5	57,440.00 9,040.00
California			4	5,115.96	4	7,783.80	1	2,559.58
Colorado							18 [c] 1	37,945.00 2,538.67
Idaho			2	3,254.11				
Nevada	1	1,440.00	8	16,661.04				
New Mexico			2	5,120.00			20 [c] 51	42,960.00 120,960.00
Oregon							1	2,560.00
Utah			3	3,840.00			17	36,998.68
Washington								
Wyoming			1	1,245.00				
	1	1,440.00	25	47,716.11	4	7,783.80	137	313,001.93

[c] Act of Feb. 7, 1927.

Also Idaho, 2 phosphate leases, 1,700 acres: Oregon, 1 oil-shale lease, 2,680 acres. Total, 815 leases; 23 licenses; 22,054 permits; grand total 22,892.

The total number of licenses and permits issued by the Secretary of the Interior had been 318 leases, 1,019 permits, and 136 licenses for coal, 18 leases and 648 permits for potash, 1 lease and 80 permits for sodium, 2 leases each for oil shale and phosphate, and 591 leases and 32,256 permits for oil and gas.

PRODUCTION

In the fiscal year 1928 an increase of 487,550 tons, or 19 per cent, was recorded in the production of coal and of 9,914 tons, or 160 per cent, in the production of sodium minerals from public lands, compared with 1927. In the same period a decrease of 2,277,552 barrels, or 8 per cent, was recorded in the production of petroleum and of 394 tons, or about 1.6 per cent, in the production of phosphate rock. Prospecting for potassium minerals was continued with good success in Eddy County, N. Mex., but no potassium salts were produced there nor from public lands under potassium lease in the Searles Lake district, California, or the Salduro district, Utah.

Statistics relating to the production of petroleum, natural gas, natural-gas gasoline, coal, phosphate, and sodium under Government leases, permits, and licenses involving public land are summarized in the following tables:

Petroleum produced from public lands

Total

Fiscal year	Production (barrels)	Royalty oil (barrels)	Royalty value			Total
			Oil	Gas	Gasoline	
1921–1925	118, 333, 954. 01	21, 884, 217. 52	$32, 938, 494. 47	$398, 543. 30	$251, 197. 70	$33, 588, 235. 47
1926	29, 712, 876. 16	4, 431, 563. 63	7, 951, 665. 52	93, 508. 29	154, 265. 43	8, 199, 439. 24
1927	25, 648, 101. 43	3, 562, 124. 54	5, 741, 485. 97	91, 796. 54	173, 172. 59	6, 006, 455. 10
1928	23, 370, 549. 38	3, 142, 027. 63	3, 519, 810. 55	108, 570. 86	107, 070. 00	3, 735, 451. 41
	197, 065, 480. 98	33, 019, 933. 32	50, 151, 456. 51	692, 418. 99	685, 705. 72	51, 529, 581. 22
1928, by States						
California	6, 334, 748. 72	818, 731. 50	$649, 039. 95	$3, 000. 61	$22, 606. 78	$674, 647. 34
Colorado	921, 640. 81	74, 270. 82	48, 229. 73	3, 292. 25	109. 45	51, 631. 43
Louisiana	9, 509. 01	973. 00	1, 749. 58	1, 868. 24	211. 39	3, 829. 21
Montana	768, 285. 87	44, 634. 02	75, 923. 93	2, 009. 32		77, 933. 25
New Mexico	72, 383. 96	12, 618. 56	12, 054. 11	1, 187. 00	7. 74	13, 248. 85
Oklahoma	602, 165. 40	95, 079. 98	144, 168. 50		3, 805. 75	147, 974. 25
Utah	2, 254. 83	315. 64	430. 64	4, 353. 36		4, 784. 00
Wyoming	14, 659, 560. 78	2, 095, 404. 11	2, 588, 214. 11	92, 860. 08	80, 328. 89	2, 761, 403. 08

State details for previous years are given in the Forty-eighth Annual Report. In addition to the accrued royalties shown above, bonuses on sale of oil leases amounted to $672,000 in California and $500 in Wyoming in 1928.

Coal produced from leases, licenses, and permits on public lands, in tons, by fiscal years

State	1921–1925	1926	1927	1928	Total
Alaska	455, 497. 43	98, 144. 74	93, 416. 14	106, 382. 66	753, 440. 97
Alabama		10, 056. 00	22, 854. 00	43, 523. 00	76, 433. 00
California			3. 00	3. 00	6. 00
Colorado	827, 871. 38	353, 433. 61	448, 552. 09	439, 650. 40	2, 069, 507. 48
Montana	252, 973. 58	198, 602. 15	278, 896. 48	278, 886. 33	1, 009, 358. 54
Nevada				91. 15	91. 15
New Mexico	74, 427. 26	37, 461. 86	85, 905. 31	74, 462. 82	272, 257. 25
North Dakota	453, 695. 38	163, 533. 79	215, 540. 12	404, 456. 71	1, 237, 226. 00
Oregon	688. 97	628. 88	423. 58	1, 280. 03	3, 021. 46
South Dakota	1, 842. 63	1, 074. 00	531. 11	422. 68	3, 870. 42
Utah	487, 303. 62	172, 433. 36	282, 564. 80	432, 707. 96	1, 375, 009. 74
Washington	164, 280. 43	16, 910. 29	30, 974. 32	33, 723. 99	245, 889. 03
Wyoming	2,489,099.03	962, 490. 51	1,053,037.36	1,184,657.65	5, 689, 284. 55
	5,207,679.71	2,014,769.19	2,512,698.31	3,000,248.38	12,735,395.59

Sodium salts disposed of from potassium leases (California), in tons, by fiscal years

1921–1925	3, 145. 30	1928	15, 377. 99
1926	430. 09		
1927	5, 911. 35		24, 864. 73

Phosphate disposed of from phosphate leases (Idaho), in tons, by fiscal years

1921–1925	6, 132. 44	1928	23, 459. 95
1926	343. 20		
1927	23, 854. 61		53, 790. 20

Sodium disposed of from sodium leases (Nevada), in tons, by fiscal years

1921–1925	248. 25	1928	750. 00
1926	233. 53		
1927	302. 53		1, 534. 31

ROYALTY, RENTALS, AND BONUSES

The following table summarizes the accrued income from mineral leases, licenses, and prospecting permits, except oil and gas, involving public lands, under the Alaskan coal land leasing act of October 20, 1914, the potassium act of October 2, 1917, the general mineral-land leasing act of February 25, 1920, and the potassium act of February 7, 1927:

Royalty, rentals, and bonuses accrued from operations on public lands, by fiscal years and States

	Coal		Phosphate	Potash	Bonuses	Total
	Leases	Permits				
1914–1919						
Alaska	$2,205.00					$2,205.00
California				$835.20		835.20
Wyoming				230.00		230.00
	2,205.00			1,065.20		3,270.20
1920						
Alaska	2,970.00					2,970.00
California				1,670.40		1,670.40
Wyoming				460.00		460.00
	2,970.00			2,130.40		5,100.40
1921						
Alaska	4,588.71					4,588.71
California				2,216.34		2,216.34
Colorado	60.00					60.00
Idaho			$185.63			185.63
Montana		$63.88				63.88
North Dakota	43.70				$175.00	218.70
Utah	800.50				20.00	820.50
Wyoming	22,835.18			460.00	5,200.00	28,495.18
	28,328.09	63.88	185.63	2,676.34	5,395.00	36,648.94
1922						
Alaska	5,504.46					5,504.46
California				2,231.88		2,231.88
Colorado	4,429.81	1,613.21				6,043.02
Idaho			226.53			226.53
Montana	259.00	476.25			2,505.00	3,240.25
New Mexico	1,566.47	157.19			495.00	2,218.66
North Dakota	1,743.20					1,743.20
Utah	5,455.97	49.22			50,174.00	55,679.19
Washington	30.00	6,393.26				6,423.26
Wyoming	32,112.34	327.05		460.00	10.00	32,909.39
	51,101.25	9,016.18	226.53	2,691.88	53,184.00	116,219.84
1923						
Alaska	4,379.57	3,919.19				8,298.76
California				2,231.88		2,231.88
Colorado	18,108.30	6,931.44			935.00	25,974.74
Idaho			180.00			180.00
Montana	1,034.69	1,092.82				2,127.51
New Mexico	2,190.41	1,577.20				3,767.61
North Dakota	6,705.17	335.00				7,040.17
South Dakota		125.93				125.93
Utah	21,641.46	55.11			238.00	21,934.57
Washington	5,285.98	2,006.45				7,292.43
Wyoming	40,369.80	2,083.50		460.00	6.00	42,919.30
	99,715.38	18,126.64	180.00	2,691.88	1,179.00	121,892.90

Royalty, rentals, and bonuses accrued from operations on public lands—Contd.

	Coal		Sodium	Phosphate	Potash	Bonuses	Total
	Leases	Permits					
1924							
Alabama	$460.00					$85,000.00	$85,460.00
Alaska	5,938.74						5,938.74
California					$5,203.76		5,203.76
Colorado	22,783.92	$3,881.85				25.00	26,690.77
Idaho				$180.00			180.00
Montana	1,648.02	1,216.29					2,864.31
New Mexico	3,650.99	692.83					4,343.82
North Dakota	9,569.90	21.56				400.00	9,991.46
Oregon		14.35					14.35
South Dakota		96.50					96.50
Utah	21,386.93	296.37				104.00	21,787.30
Washington	5,335.76	489.44					5,825.20
Wyoming	62,967.41	268.76			920.00		64,156.17
	133,741.67	6,977.95		180.00	6,123.76	85,529.00	232,552.38
1925							
Alabama	920.00						920.00
Alaska	5,636.75						5,636.75
California					7,079.19		7,079.19
Colorado	32,062.84	1,033.85				1,151.00	34,247.69
Idaho				339.22			339.22
Montana	23,517.41	632.25					24,149.66
Nevada			$301.07				301.07
New Mexico	2,469.57	1,083.98					3,553.55
North Dakota	10,035.26						10,035.26
Oregon	872.45	65.35					937.80
South Dakota	58.94	118.23					177.17
Utah	38,328.27	311.20				1,050.00	39,689.47
Washington	2,665.02						2,665.02
Wyoming	90,892.19	930.98					91,823.17
	207,458.70	4,175.84	301.07	339.22	7,079.19	2,201.00	221,555.02
1926							
Alabama	1,005.60						1,005.60
Alaska	9,227.63						9,227.63
California					6,031.78		6,031.78
Colorado	60,342.95	87.66					60,430.61
Idaho				695.00			695.00
Montana	22,114.17	423.94					22,538.11
Nevada			2,160.00				2,160.00
New Mexico	3,288.34	7,304.66					10,593.00
North Dakota	12,248.50	67.00				5.00	12,320.50
Oregon	972.80						972.80
South Dakota	91.09	136.25					227.34
Utah	84,770.71	461.79				551.00	85,783.50
Washington	1,721.04						1,721.04
Wyoming	114,857.82	504.83					115,362.65
	310,640.65	8,986.13	2,160.00	695.00	6,031.78	556.00	329,369.56
1927							
Alabama	2,285.40						2,285.40
Alaska	11,327.50						11,327.50
California		.75			6,217.60		6,218.35
Colorado	53,563.28	6,548.69				5.00	60,116.97
Idaho				2,549.41			2,549.41
Montana	32,845.58	445.17					33,290.75
Nevada			1,440.00				1,440.00
New Mexico	9,873.85	1,450.00				125.00	11,448.85
North Dakota	15,251.37	27.77					15,279.14
Oregon	1,048.00						1,048.00
South Dakota	40.86						40.86
Utah	69,789.08					5.00	69,794.08
Washington	3,096.57						3,096.57
Wyoming	114,148.44	565.81					114,714.25
	313,269.93	9,038.19	1,440.00	2,549.41	6,217.60	135.00	332,650.13

Royalty, rentals, and bonuses accrued from operations on public lands—Contd.

	Coal		Sodium	Phosphate	Potash	Bonuses	Total
	Leases	Permits					
1928							
Alabama	$4,352.30						$4,352.30
Alaska	19,470.99	$24.20					19,495.19
California		.75			$9,402.40		9,403.15
Colorado	50,507.26	563.75				$5.00	51,076.01
Idaho				$2,529.85			2,529.85
Montana	29,981.64	49.98					30,031.62
Nevada		22.79	$1,440.00				1,462.79
New Mexico	10,620.54	1,187.00				400.00	12,207.54
North Dakota	29,143.40	600.48				580.00	30,323.88
Oregon	948.00						948.00
South Dakota	43.32						43.32
Utah	70,344.38	3,591.32					73,935.70
Washington	3,492.84	2.38					3,495.22
Wyoming	147,548.81	453.72					148,002.53
	366,453.48	6,496.37	1,440.00	2,529.85	9,402.40	985.00	387,307.10

Summary

1919	$2,205.00				$1,065.20		$3,270.20
1920	2,970.00				2,130.40		5,100.40
1921	28,328.09	$63.88		$185.63	2,676.34	$5,395.00	36,648.94
1922	51,101.25	9,016.18		226.53	2,691.88	53,184.00	116,219.84
1923	99,715.38	18,126.64		180.00	2,691.88	1,179.00	121,892.90
1924	133,741.67	6,977.95		180.00	6,123.76	85,529.00	232,552.38
1925	207,458.70	4,175.84	$301.07	339.22	7,079.19	2,201.00	221,555.02
1926	310,640.65	8,986.13	2,160.00	695.00	6,031.78	556.00	329,069.56
1927	313,269.93	9,038.19	1,440.00	2,549.41	6,217.60	135.00	332,650.13
1928	366,453.48	6,496.37	1,440.00	2,529.85	9,402.40	985.00	387,307.10
	1,515,884.15	62,881.18	5,341.07	6,885.64	46,110.43	149,164.00	1,786,266.47

ACTIVITIES ON NAVAL PETROLEUM RESERVES

On behalf of the Bureau of Engineering, Department of the Navy, the mineral-leasing division supervises oil and gas operations in naval petroleum reserves Nos. 1 and 2, in California, and No. 3, in Wyoming. On March 17, 1927, by Executive order, the administration on all naval petroleum reserves was vested in the Department of the Navy. In pursuance of this order a cooperative agreement was worked out under which supervision will be continued by the Geological Survey under the direction of the Secretary of the Navy as to matters of policy. Production from naval petroleum reserve No. 3, in Wyoming, was definitely suspended in January, 1928. The total production to date of suspension is given below. Supervision for the present is confined to observation of gas pressure and consultation with the Navy Department. At the time of suspension there were 85 wells on the reserve—61 oil wells, 12 gas wells, 2 water wells, 8 abandoned wells, and 2 suspended wells (one above the second Wall Creek sand and one deep test well). Five derricks had been erected without drilling. Statistics of the production of petroleum, natural gas, and natural-gas gasoline from naval petroleum reserves are summarized as follows:

Petroleum produced from naval reserves, by fiscal years

Total

	Production (barrels)	Royalty (barrels)	Royalty value			
			Oil	Gas	Gasoline	Total
1921–1925	40, 406, 158. 14	9, 381, 761. 48	$10, 685, 660. 38	$298, 874. 65	$231, 485. 45	$11, 216, 020. 48
1926	12, 755, 382. 16	2, 779, 100. 13	3, 310, 658. 54	114, 247. 75	152, 480. 36	3, 577, 386. 65
1927	12, 725, 365. 02	2, 902, 243. 85	3, 175, 882. 25	110, 204. 62	169, 643. 75	3, 455, 730. 62
1928	9, 839, 859. 19	2, 303, 557. 85	1, 933, 880. 81	133, 819. 74	164, 674. 84	2, 232, 375. 39
	75, 726, 764. 51	17, 366, 663. 31	19, 106, 081. 98	657, 146. 76	718, 284. 40	20, 481, 513. 14

1928, by States

California:						
1921–1925	9, 690, 573. 93	2, 284, 897. 18	$1, 909, 711. 11	$125, 866. 88	$162, 834. 08	$2, 198, 412. 07
Wyoming:						
1922–1927	3, 400, 942. 37	465, 668. 33	763, 114. 40	44, 765. 64	7, 104. 55	813, 984. 59
1928	149, 285. 26	18, 660. 67	24, 169. 70	7, 952. 86	1, 840. 76	33, 963. 32

State details for previous years are given in the Forty-eighth Annual Report.

ACTIVITIES ON INDIAN LANDS

On behalf of the Office of Indian Affairs the functions of the division include inspectional, regulatory, and advisory service in connection with the leasing and development of mineral deposits on tribal and restricted allotted Indian lands.

At the end of the year there were outstanding 55 departmental lead and zinc leases on restricted Quapaw Indian lands in Oklahoma, covering 7,284.43 acres. The production from these lands amounts to 15.5 per cent of the zinc and 3.9 per cent of the lead mined in the United States. The royalty for the fiscal year, amounting to $894,-820.30, was 9.49 per cent of the sale value of the ore mined. One lead and zinc lease was approved for restricted Cherokee lands, but no production was made during the year.

All operating mills on restricted Quapaw Indian lands are now equipped with flotation units, resulting in an increased recovery of approximately 11 per cent of the value of the rock. This equipment permits the mining of lower-grade ores and the re-treatment of former waste, with a corresponding increase of ore reserves and of royalties accruing to the Indians.

An aerial photographic mosaic of the lead and zinc district of the Quapaw Reservation, in northeastern Oklahoma, was completed in cooperation with the War Department and the Chamber of Commerce of Picher, Okla. The map depicts an area of about 150 square miles and has been of material aid in locating drill holes, estimating the volume of chat piles, selecting locations for remilling sites, and, to the Oklahoma Geological Survey, in preparing a map of the district.

The area of segregated Choctaw and Chickasaw coal and asphalt lands was reduced to 393,409.51 acres by sales and completion of payments. The area now under lease is 72,819.11 acres. Of 78 coal leases in effect 39 are being operated. Sixty mines are in operation, 35 are shut down, and 65 have been abandoned. The reported pro-

duction of coal for the year was 654,920.87 tons, with a royalty value of $72,746.37.

On allotted restricted Cherokee, Choctaw, and Creek lands there were 22 producing and 41 nonproducing coal leases and 1 volcanic-ash lease in 1928. A production of 110,602.37 tons of coal and 19 tons of volcanic ash, with accrued royalty and rental value of $13,788.16, was reported. The geologic work of remapping the outcrops of the several coal beds on segregated and allotted lands, begun in 1927, was continued, and approximately 580,000 acres had been examined up to September 1, 1928. More than 65,000 acres of coal previously unexplored was mapped in the course of this reexamination. A new map of the Stigler area resulting from the work done in 1927 was furnished to the Office of Indian Affairs during the year. About 200 miles of coal outcrop was photographed aerially by the War Department, and additional maps are now in preparation for publication by the Oklahoma Geological Survey. During the year an audit was made of all amounts due under coal leases on Indian lands in Oklahoma and submitted to the Office of Indian Affairs.

The supervision of oil and gas activities in Oklahoma, exclusive of the Osage Reservation, includes 10,515 leases, covering 929,753.17 acres, on which there are 5,731 producing oil and gas wells, summarized by jurisdiction or Indian agencies as follows:

Oil and gas leases in Oklahoma exclusive of the Osage Reservation

	Leases			Wells		Total royalty and rentals
	Nonproducing	Producing	Total	Producing	Being drilled	
Five Civilized Tribes:						
Cherokee		401				
Choctaw		67				
Creek		648				
Chickasaw		18				
Seminole		69				
	7,369	1,203	8,572	5,516	96	$5,574,345.99
Kiowa Indian Agency:						
Kiowa	110	0	110	0	0	
Comanche	177	19	196	23	0	
Apache	4	6	10	16	0	
Wichita	34	0	34	0	0	
Caddo	41	0	41	0	0	
	366	25	391	39	0	98,528.52
Pawnee Indian Agency:						
Ponca	243	14	257	54	1	
Otoe	273	2	275	2	0	
Tonkawa	17	0	17	0	0	
Pawnee	205	21	226	55	2	
Kaw	57	4	61	34	0	
	795	41	836	145	3	244,491.27
Shawnee Indian Agency:						
Iowa	31	0	31	0	0	
Kickapoo	77	0	77	0	1	
Pottawattomie	71	3	74	7	4	
Sac and Fox	173	9	182	24	0	
Shawnee	201	0	201	0	0	
	553	12	565	31	5	176,107.64
Cheyenne and Arapaho Indian Agency	151	0	151	0	0	32,911.84
Grand total	9,234	1,281	10,515	5,731	104	6,126,385.26

Outside Oklahoma supervision was exercised over oil and gas leases on tribal and restricted allotted Indian lands as follows:

Oil and gas leases on Indian lands outside Oklahoma

State and tribe	Being tested	Producing	Non-producing	Under supervision	Total wells
Colorado:					
Ute tribal	5	3	4	7	20
Ceded Utes					50
Montana:					
Blackfeet, tribal	1	0	3	3	0
Blackfeet, allotted	0	0	10	10	3
Crow, tribal	4	1	4	5	15
Crow, allotted	9	2	29	31	5
New Mexico:					
Navajo, tribal	3	3	12	15	56
Navajo, allotted	0	0	45	45	
Utah:					
Navajo, executive order	1	0	1	1	5
Wyoming:					
Shoshone, tribal	1	13	48	61	82
Allotted	2	8	5	13	130
	26	30	161	191	366

In connection with mining operations in progress or contemplated on Indian lands, special investigations were made for the Office of Indian Affairs in 1928 as follows:

Arizona: Colorado River Indian Reservation, 1 application for gold and lead lease; Fort Apache Indian Reservation, 1 coal operation, 2 asbestos leases; San Carlos Indian Reservation, 2 asbestos leases, 1 application for building-stone lease; Pima Indian Reservation, 1 application for feldspar and mica lease.

Colorado: Southern Ute Reservation, 1 tribal coal lease.

Montana: Rocky Boy Indian Reservation, 1 application for silver and lead lease.

OTHER COOPERATIVE WORK

The division cooperated with the Bureau of Mines and Bureau of Standards in connection with tests of mine stoppings to withstand explosions of gas and coal dust; with the Bureau of Mines in its rock-dusting, ventilation, and experimental mine programs and in its oil and gas technologic instigations; with the Industrial Commission of Utah in inspecting mines for the safety of the employees; with the Treasury Department in a report on the possibility of damage resulting from mining operations under the post-office building at Butte, Mont.; with the Bureau of Reclamation in reporting on the plant and coal mine at Williston, N. Dak.; with the National Research Council on the conservation of the scientific results of drilling and the improvement of drilling methods and equipment; and with the committee appointed by the Governor of Oklahoma to revise the mining law of Oklahoma.

Cooperation with State conservation agencies and individual oil and gas operators has resulted in more effective use of cement in plugging and abandoning wells under State supervision, and in the reduction of the amount of gas used in oil production and of that wasted at casing-head gasoline plants.

In cooperation with State officials, oil and gas operators, and Indian agencies in Oklahoma a daily waste of natural gas, conserva-

tively estimated at 100,000,000 cubic feet, has been stopped, and the gas conserved for domestic and industrial use.

Cooperation with oil operators in the Iles field, Colorado, has resulted in the development of a casing program that has reduced drilling costs and assured protection of oil and gas deposits in five productive zones. Peg models of the Elk Basin and Hudson oil fields, Wyoming, have been constructed in cooperation with the operators in those fields.

COST OF SUPERVISION AND STATE BENEFITS

Leases and permits involving publicly owned mineral deposits have been issued in 21 States and Alaska. These States receive direct, without expense to themselves, 37.5 per cent of all royalties, rentals, and bonuses derived from leases and permits within their respective boundaries and participate likewise in the benefits resulting from the expenditure of an additional 52.5 per cent of such funds by the Bureau of Reclamation. Only 10 per cent of the income is paid into the Federal Treasury to be available for paying the costs of necessary Federal administration.

Preliminary estimates indicate that the cost of the supervisory work of the mineral-leasing division averaged less than 2.5 per cent of the aggregate income from the leases on public and Indian lands in the fiscal year 1928. This indicates a slight increase in supervisory cost compared with 1927, but the increase is apparent rather than real and is due entirely to decrease in 1928 in the sale value of oil, gas, lead, and zinc.

WORK ON PUBLICATIONS

TEXTS

During the year 23,193 pages of manuscript were edited and prepared for printing by the section of texts, and 2,686 galley proofs and 11,260 page proofs were read and corrected. Indexes were prepared for 24 publications, covering 5,670 pages. Copy and proof or stencils for 1,114 pages of multigraph and mimeograph matter were read. At the end of the fiscal year five persons were employed in this section.

ILLUSTRATIONS

The number of drawings prepared by the section of illustrations was 2,605, including 133 maps, 307 sections and diagrams, 408 photographs, and 1,687 paleontologic drawings; 183 miscellaneous jobs were also done by the section. The illustrations transmitted to accompany 60 reports numbered 1,416, to be reproduced by chromolithography, photolithography, halftone, and zinc etching. The number of proofs received and examined was 1,423. At the end of the year material for illustrating 23 reports is in hand. The section consists of 11 employees.

GEOLOGIC EDITING AND DRAFTING OF MAPS AND ILLUSTRATIONS

The geologic map of New Mexico reached the stage of color proof and was approved for printing. Folio 221 (Bessemer-Vandiver, Ala.) was published during the year. The maps and sections of

folios 223 (Coatesville-West Chester, Pa.) and 225 (Fairfield-Gettysburg, Pa.) were well advanced toward color proof. The maps of folio 222 (Gaffney-Kings Mountain, S. C.-N. C.) were approved for transfer to stone. The maps of folios 224 (Somerset-Windber, Pa.) and 226 (Montevallo-Columbiana, Ala.) were partly engraved. The maps of the Boston (Mass.) folio were prepared for engraving. The Hollidaysburg-Huntingdon (Pa.) folio was partly prepared for engraving, and the Cleveland (Ohio) folio, covering the Berea, Cleveland, and Euclid quadrangles, was received for publication. Maps and illustrations for 47 reports other than folios were edited for geology during the year, and geologic maps and illustrations for 28 reports were drawn for geologists in the geologic branch. Considerable progress was made on the compilation of the geologic map of the United States. The geologic map of Virginia was compiled in cooperation with the Virginia Geological Survey, and its publication was well advanced toward color proof. The geologic map of Pennsylvania, which is being compiled in cooperation with the Pennsylvania Geological Survey, was well advanced and nearly ready for engraving.

INSPECTION AND EDITING OF TOPOGRAPHIC MAPS

During the year 86 new topographic maps were edited and transmitted for engraving; 208 published topographic maps, 8 State maps, and 18 State index circulars were edited for reprint; 25 plan and profile river-survey sheets were edited for two-color photolithography; 4 miscellaneous new maps were edited for photolithography; and 357 maps were edited as illustrations for Geological Survey reports—a total of 706 maps edited. First, second, combined, and woodland proofs of engravings for new topographic maps and reprints numbering 577 and proofs of maps reproduced by photolithography in one to four colors numbering 178 were read. At the end of the year 121 new topographic maps were in progress of engraving and printing and 115 new topographic maps and projects were in preparation for submission for reproduction.

DISTRIBUTION

A total of 368 publications, comprising 47 new books and pamphlets, 5 reprinted books, 1 new geologic folio, 150 new or revised topographic and other maps, and 165 reprinted topographic and other maps were received by the division of distribution during the year. A number of special pamphlets and forms for administrative use were also delivered and distributed. The total units of all publications received numbered 144,212 books and pamphlets, 4,428 geologic folios, and 750,415 topographic and other maps—a grand total of 899,055.

The division distributed 148,825 books and pamphlets, 6,103 geologic folios, and 851,960 maps—a total of 1,006,888, of which 5,111 folios and 699,365 maps were sold. The sum received and deposited in the Treasury as the result of sales of publications was $48,762.35, including $46,781.29 for topographic and geologic maps and $1,981.06 for geologic folios. In addition to this, $1,796.38 was repaid by other establishments of the Federal Government at whose request maps or folios were furnished. The total receipts, therefore, were $50,558.73.

The division received and answered 88,200 letters.

ENGRAVING AND PRINTING

TOPOGRAPHIC MAPS AND GEOLOGIC FOLIOS

During the fiscal year 106 new topographic maps were engraved and printed, including 18 revised maps, and 44 new maps were photolithographed and printed, making a total of 150 new maps printed and delivered. Corrections were engraved on the plates of 175 maps. Reprint editions of 155 engraved topographic maps and 10 photolithographed State and other maps were printed and delivered. In addition, 36 new topographic maps had been engraved and were in press June 30, and the engraving of 15 other new topographic maps was nearly completed. Of new and reprinted maps, 315 different editions, amounting to 748,860 copies, were delivered. One new geologic folio was printed, its edition amounting to 4,428 copies. Extra geologic sheets of folios numbering 1,555 copies were also delivered.

OTHER GOVERNMENT MAP PRINTING

A large amount of work was done for the Government Printing Office, the office of the Secretary of the Interior, the Bureau of Mines, Bureau of Reclamation, Bureau of Education, General Land Office, National Park Service, Office of Indian Affairs, Alaska Railroad, Bureau of Public Roads, Bureau of Agricultural Economics, Bureau of Animal Industry, Bureau of Plant Industry, Forest Service, Bureau of Standards, Bureau of Lighthouses, Bureau of Foreign and Domestic Commerce, Department of Labor, Department of State, War Department, Post Office Department, Treasury Department, Department of Agriculture, Department of Commerce, Interstate Commerce Commission, Federal Power Commission, National Capital Park and Planning Commission, Commission of Fine Arts, International Boundary Commission, Federal Trade Commission, Civil Service Commission, Smithsonian Institution, National Research Council, Bureau of Internal Revenue, Veterans' Bureau, Federal Board for Vocational Education, Office of the Chief of Engineers, Bureau of Efficiency, Marine Corps, Regional Plan of New York and its Environs, Purdue University, and the States of Virginia, Idaho, Illinois, Oklahoma, Tennessee, North Carolina, and Arkansas. This work, done for other branches of the Government and State governments, included many reprints, and the charges for it amounted to about $130,000, for which the appropriation for engraving and printing geologic and topographic maps was reimbursed by transfer of credit on the books of the Treasury Department.

Transfer impressions numbering 363 were made during the year, including 274 furnished to contracting lithographic printers on requisition of the Government Printing Office, 88 furnished to private firms, and 1 furnished to the American Zinc Institute. Other miscellaneous work was done for A. Hoen & Co., Williams & Heintz Co., Carnegie Institution, Encyclopædia Britannica, A. J. Nystrom Co., and the State of Illinois. The amount turned over to miscellaneous receipts from this work was $225.91.

Of contract and miscellaneous work of all kinds, 2,453,534 copies were printed. Including topographic maps and geologic folios, a grand total of 3,208,377 copies were printed and delivered.

PHOTOGRAPHIC LABORATORY

The output of the photographic laboratory consisted of 7,531 negatives (638 wet, 126 paper, 2,132 dry, 3,945 field negatives, and 690 lantern slides), 33,191 prints (4,549 maps and diagrams and 28,642 photographs for illustrations), 2,478 zinc plates, 284 zinc etchings, 77 celluloid prints, 64 lantern slides colored, 34 transparencies colored, 1 print colored, and 2,406 prints mounted.

ADMINISTRATION

CORRESPONDENCE AND RECORDS

The work of the section of correspondence and records was of the same general character as during the preceding fiscal year. At the end of the year the appointees of the Secretary numbered 877, 42 more than at the end of the fiscal year 1927. The changes in personnel were 796, including 166 appointments, 124 separations, and 506 miscellaneous. During the calendar year 1927, 73 per cent of the possible annual leave and 13 per cent of the possible sick leave was granted. Leave without pay and furloughs amounting to 5,372 days were also granted.

LIBRARY

The year's accessions to the library comprised 14,316 books, pamphlets, and periodicals and 726 maps. The recorded loans were 5,686 books and 240 maps, in addition to those used by 9,105 readers who consulted the library in person. The catalogue was increased by the addition of 10,323 cards. Title entries to the number of 579 were furnished to the Library of Congress for printing, the proof reading of which involved 118 galleys.

Correspondence handled included 2,066 letters received and 1,991 letters sent. Letters and other writings in foreign languages to the number of 159 were translated for other divisions of the Geological Survey. There were 1,250 volumes collated and prepared for binding, and 1,078 newly bound volumes were labeled, plated, and shelf listed.

Numerous loans were made to libraries, both in Washington and other places, and a considerable volume of reference work was done in the usual course of the library's service to specialists and students both in the Geological Survey and others.

The manuscript of the bibliography of North American geology for 1925 and 1926 (Bulletin 802) was completed, and the proofs were read.

ACCOUNTS

Condensed statements covering the expenditures from Federal funds during the year are given on the following pages. The amounts expended by States for cooperative work are set forth in the reports of the field branches.

Amounts appropriated for and expended by the United States Geological Survey pertaining to the fiscal year ending June 30, 1928 [a]

Appropriation	Funds available						Expenditures			Balance
	Amount of appropriation	Repayments and transferred funds on account of work performed				Total	Disbursements	Outstanding liabilities	Total	
		For cooperating agencies		For other Geological Survey units	Transferred funds					
		Made	To be made							
Salaries	$126,500.00					$126,500.00	$126,303.72		$126,303.72	$196.28
Topographic surveys	510,200.00	$189,287.12	$31,231.99	$8,589.18	$4,600.00	743,908.29	722,094.87	[b] $17,019.90	739,114.77	4,793.52
Geologic surveys	328,200.00	17,538.09	6,828.64	80.40	9,745.58	362,392.71	348,637.23	6,515.92	355,153.15	7,239.56
Volcanologic surveys	20,000.00					20,000.00	18,151.26	883.52	19,034.78	965.22
Mineral resources of Alaska	60,000.00	191.42			707.30	60,898.72	53,367.09	[b] 7,346.63	60,713.72	185.00
Gaging streams	147,000.00	139,331.15	40,872.87	5,490.49	50,281.69	382,976.20	376,747.76	5,925.31	382,673.07	303.13
Classification of lands	200,000.00	2,905.27				202,905.27	194,699.97	3,023.64	197,723.61	5,181.66
Geologic and topographic maps of the United States	88,400.00	90,363.36	18,158.69	20,247.37	17,395.00	234,564.42	220,327.98	9,605.60	229,933.58	4,630.84
Preparation of illustrations	24,580.00					24,580.00	23,702.99	2.65	23,705.64	874.36
Mineral leasing	303,000.00	240.53			58,210.06	361,450.59	353,821.58	3,697.10	357,518.68	3,931.91
	1,807,880.00	439,856.94	97,092.19	34,407.44	140,939.63	2,520,176.20	[3] 2,437,854.45	54,020.27	[c d] 2,491,874.72	[d] 28,301,48

[a] In addition to these appropriations, items of $109,000 for printing and binding Geological Survey publications and $11,000 for miscellaneous printing and binding were contained in the appropriation act, but the accounts for these items were not kept in the Geological Survey. There was also an allotment of $15,763.95 for miscellaneous supplies from the appropriation for contingent expenses of the Interior Department.

[b] Of these totals, $7,097.53 is in the hands of special disbursing agents and therefore has not been included in the classification of expenditures, as no vouchers covering disbursements have been received.

[c] Included in this amount is $34,407.44 covering work performed by Geological Survey units for other Geological Survey units, necessarily reported in combining totals but otherwise a duplication.

[d] A budget reserve of $850 is included in this balance.

Classification of expenditures by the United States Geological Survey pertaining to the fiscal year ended June 30, 1928

Object of expenditure	Geological Survey salaries	Topographic surveys	Geologic surveys	Volcanologic surveys	Mineral resources of Alaska	Gaging streams	Classification of lands	Geologic and topographic maps of the United States	Preparation of illustrations	Mineral leasing	Total
Personal services	$126,303.72	$527,766.99	$300,561.21	$15,782.83	$38,827.41	$278,258.76	$153,455.64	$177,401.65	$23,279.65	$265,272.34	$1,906,910.20
Stationery and office supplies		8,087.37	609.61	174.64	1,144.50	1,200.23	184.77	21,949.11		151.78	33,502.01
Scientific and educational supplies		1,268.04	1,269.94	140.72	1,652.02	248.86	315.14		24.42	291.67	5,210.81
Sundry supplies		2,520.80	1,046.69	181.91	118.79	1,700.62	386.03	5,699.33	18.66	846.21	12,519.04
Subsistence and care of animals and storage and care of vehicles		986.50	223.13								1,209.63
Storage of passenger-carrying vehicles		41.04					78.75			38.00	157.79
Storage of freight-carrying vehicles		955.94	42.88				21.00				1,019.82
Telegraph service		643.93	156.06	2.92	83.04	378.06	55.25	3.18	.25	417.29	1,739.98
Telephone service		216.92	149.96	27.80	1.20	825.21	74.80			2,590.10	3,885.99
Other communication service		13.85				16.50	1.50			57.00	88.85
Travel expenses		87,087.89	22,532.66	1,429.80	5,064.97	37,331.45	18,656.80	87.20		25,955.45	198,146.22
Attendance at meetings		450.55	1,357.29		45.25	179.22				798.04	2,830.35
Hire, maintenance, operation, and repair of horse-drawn and motor-propelled passenger-carrying vehicles		2,958.91	2,961.30	536.06	10.00	8,380.73	6,457.88			20,094.33	41,399.21
Transportation of things		35,021.56	5,638.61	130.11	2,723.63	4,400.23	4,311.60	80.60	9.01	1,818.36	54,133.71
Lithographing, engraving, and engrossing		12,135.58	396.56			597.06	591.09	42.86	133.19	54.16	13,950.50
Stenographic work, typewriting, and duplicating work, etc. (job work)			8.20			6.00	.60			.50	15.30
Photographing and making photographs and prints		2,375.17	3,761.30	84.93	172.14	847.46	3,321.30		204.47	2,819.28	13,586.05
Heat, light, power, water, and electricity			29.40	42.00	40.08					4,430.04	4,541.52
Rents		49.14				1,739.47				7,211.28	8,999.89
Repairs and alterations		209.51	118.60	79.50	27.25	1,284.15	264.88	597.67		1,392.19	3,973.75
Special and miscellaneous current expenses		19,756.40	711.12	13.80	134.73	1,217.75	233.85	10,944.47		577.41	33,589.53
Purchase of passenger-carrying vehicles			621.60			6,297.67	1,555.21			8,253.23	16,727.71
Furniture, furnishings, and fixtures		613.44	585.22	33.41	47.93	922.75	557.48			2,781.58	5,541.81
Educational and scientific equipment		2,782.96	5,221.48	53.99	654.77	18,837.29	2,392.79	2,264.83	35.99	1,515.87	33,759.97
Livestock					375.00						375.00
Other equipment		27,278.39	6,145.26	239.76	41.00	14,813.90	3,422.55	5,232.55		1,095.59	58,269.00
Miscellaneous transfers and adjustments		4,371.36	1,005.07	80.60	3,975.01	3,189.70	1,384.70	5,630.13		9,056.98	28,693.55
	126,303.72	737,592.24	355,153.15	19,034.78	55,138.72	382,673.07	197,723.61	229,933.58	23,705.64	357,518.68	2,484,777.19

GEORGE OTIS SMITH,
Director.

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