

U. S. DEPARTMENT OF THE INTERIOR

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**ANNUAL REPORT**  
OF THE  
**DIRECTOR OF**  
**THE GEOLOGICAL SURVEY**  
TO THE SECRETARY OF THE INTERIOR  
FOR FISCAL YEAR ENDED JUNE 30, 1927

DEPARTMENT OF THE INTERIOR  
Hubert Work, Secretary

U. S. GEOLOGICAL SURVEY  
George Otis Smith, Director

FORTY-EIGHTH ANNUAL REPORT  
OF THE  
DIRECTOR OF  
THE GEOLOGICAL SURVEY

TO THE  
SECRETARY OF THE INTERIOR

FOR THE FISCAL YEAR  
ENDED JUNE 30

1927



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WASHINGTON

1927

## 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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### CONTENTS

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	Page
Appropriations.....	1
Extent of cooperation.....	1
Scope of investigations.....	2
Duty of publicity.....	4
Necrology.....	5
The year's operations.....	5
Geologic branch.....	9
Alaskan branch.....	27
Topographic branch.....	35
Water-resources branch.....	41
Conservation branch.....	50
Work on publications.....	70
Administration.....	73
Index.....	77



ANNUAL REPORT  
OF THE  
DIRECTOR OF THE GEOLOGICAL SURVEY

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DEPARTMENT OF THE INTERIOR,  
GEOLOGICAL SURVEY,  
*October 15, 1927.*

SIR: The appropriations made directly for the work of the Geological Survey for the fiscal year 1927 included 10 items, amounting to \$1,819,440. In addition \$81,000 was appropriated for printing the reports of the Geological Survey, and \$11,000 for miscellaneous printing and binding, and an allotment of \$13,707 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 \$26,620, was \$51,331.24.

**EXTENT OF COOPERATION**

Early in the history of the United States Geological Survey the critical question whether State and Federal surveys were to be competitive or coordinated was answered by a declaration of Federal policy urging the creation and continuance of State surveys. How effective the cooperation has been is shown by the fact that last year 38 States and Hawaii contributed \$738,056 to the mapping and investigative work under the Federal Geological Survey, or a sum equal to two-fifths of the funds appropriated by Congress. In the topographic mapping the Federal appropriation was augmented 90 per cent by State funds, and in the investigations of water resources the States added 200 per cent. This is unmistakable evidence of the growing spirit of cooperation between public officials. The financing of cooperative effort, however, should be more equitably divided between State and Federal Governments in the gaging of streams, where the reasons for a dollar-for-dollar arrangement are similar to those now recognized and generally adopted in the topographic mapping.

There is a common interest of Federal, State, and other governmental agencies in the possession of adequate base maps covering their territory and of authoritative information regarding the natural resources on which depend their present progress and future prosperity. By means of such cooperation the States utilize the trained expert personnel and standardized methods of the Geological

Survey, the overhead costs are limited to one administrative organization instead of being multiplied by distribution among many, profitless duplication of work and effort is avoided, the results of the work have a uniformity that makes them more useful, as well as a high standard that is generally recognized and widely accepted, and other obvious economies to the public in the dissemination of authoritative official information are effected.

In addition to this cooperation with the States, services were rendered to other Federal departments, bureaus, and offices, and to permittees of the Federal Power Commission, to the amount of \$305,631. The total amount of funds made available from all sources for disbursement by the Geological Survey was \$2,388,893, and in addition State funds directly disbursed for work administered by the Federal officials brought the total up to \$2,863,127, which is the proper measure of the amount of work accomplished during the year.

This function of the Federal bureau in effecting a country-wide coordination of investigations within its several fields of activity is not exercised by statutory authority but only because of a growing appreciation of common interest by all parties to the cooperative agreements or arrangements. The coordinated effort is more efficient in results and more economical in costs. The whole public is best served by cooperation.

#### SCOPE OF INVESTIGATIONS

Primarily a field service, the Geological Survey has always put the emphasis on its field projects, its field workers, and the results of its field investigations.

The basic idea of the Geological Survey's work is the application of scientific methods by scientists to practical tasks for the general good. Its fact finding is a continuing inventory of natural resources—an aid to the discovery, development, and wisest use of the country's mineral wealth. The standards in useful geology, in usable topographic maps, in authoritative stream gaging have all become higher as better methods have been developed. Moreover, it is necessary not only to apply the scientific principles already known but also to carry on research so as to develop more knowledge and new principles for the use of future workers both in and outside of the Geological Survey.

In the scope of its field work the Geological Survey changes little from year to year, but there is progress in adapting its investigations to serve better the many purposes incident to national progress. At different periods in its history, therefore, the demand for accurate and authoritative information essential for national development has varied both in kind and in intensity. Thus geologic surveys, which early sought to guide the search for metallic wealth and later gave larger attention to the mineral fuels, now again stress the study of ore deposits directly applied to ore finding. Investigations of the water resources of the country at first sought to furnish the answer to the great agricultural problem of utilizing the wide expanses of arid lands in the West; then stream measurements took on a broader aspect, with power development as an added purpose; quality of

water as well as the quantity available for industrial and municipal use was found to be a necessary subject of study, and aid was also sought in the solution of the great engineering problems connected with land drainage and protection against flood. By similar evolution the topographic mapping has progressed from the small-scale reconnaissance type of surveys to the more detailed and more exact methods that yield a product which can be and is used in planning all kinds of engineering projects, from highway construction to discovery of oil-field structures or of water-storage sites.

All such work is truly productive, though the connection between the preliminary fact finding or the basic survey and the industrial development or engineering construction may be later unrecognized or forgotten. Indeed, the field investigation is doubly productive if it has been made sufficiently in advance to initiate the utilization of the resources of a region and promote their best development. Such was the purpose of the reservoir-site investigations by the Geological Survey in 1889, although some of the sites then discovered and described were not needed for several decades. Fact finding can never be conducted too early to be most effective, for having facts in reserve is the best kind of national preparedness.

Another example of productive investment in fact finding on a comprehensive scale is afforded by the Geological Survey's program of intensive study of the coal fields of the West, continued during the last 20 years. During that period approximately a million dollars of the public funds, appropriated for geologic surveys, has been expended in the areas where the Government itself is owner of many millions of acres of coal lands. That examination of the Nation's landholding and the inventory of the coal in public ownership has not only contributed to the popular realization of the extent of this large estate but also helped materially in bringing about the enactment of laws better fitted to its administration in the public interest. In the seven years since the passage of the leasing law nearly 10,000,000 tons of coal has been mined from these lands, with a return in royalty of approximately \$1,250,000. Last year alone the output of these leases was 2,500,000 tons and the royalties and rents amounted to nearly \$300,000—a fair return on the investment of a million dollars in determining the extent and value of the estate—and of course the mining on these public coal lands has only begun. Moreover, it should be noted that this fact finding has contributed equally to the development of the private coal lands in the same regions, title to which had earlier passed from the Government.

A topographic map often pays for itself in the saving made possible in the selection of an easier railroad cut-off or a shorter highway route, and a single oil pool located by means of a new topographic map may outweigh in value to the country the year's total appropriation for topographic surveys. Or a great power project may have revealed itself to an engineer solely from his study of the topographic map of a drainage basin and the stream gagings of one or more rivers, and through the development of that project the industries of several States will profit for centuries.

Not only can such examples be cited of investments in surveys and examinations and studies that pay handsome dividends to the public, but there is abundant reason to believe that most if not all of these

expenditures for fact finding pay for themselves with a wide margin of profit. Indeed, it is well known that the investigations that yield negative or unfavorable results usually save much greater expenditures in projects that would have proved failures. Such findings of fact are not popular, but they may prevent large waste of capital and labor.

The brief summary of the year's operations, on pages 5-9, and the more detailed catalogue of explorations, investigations, and surveys that make up the body of this administrative report give a picture of the wide variety of work undertaken in the Geological Survey's effort to apply science to serve human needs. Every project is planned to be productive, but much of the work is necessarily fundamental and, although regarded as absolutely essential, is not expected to yield immediate results. The insistent demand by engineers for reprints of some Geological Survey reports many years out of stock is a practical measure of the continuing value of investigations long since made. Scientific fact finding, whether its product is a topographic map or a table of stream discharge or a geologic description, is a piece of productive work, possessing both immediate and future value. Expenditures for such work constitute an economic investment.

#### DUTY OF PUBLICITY

To reach the public with the facts is an essential part of Government research. The Geological Survey's policy in securing prompt and wide publication of the results of its scientific work was described in the Fortieth Annual Report as including the use of newspaper notices of its publications—a type of publicity often criticized yet well warranted if the effort is made to advertise not the bureau or its personnel but its product, utilizing mediums of publication other than the official reports, such as the technical journals, transactions of scientific societies, and the reports of State surveys, and answering every inquiry not only by sending carefully selected publications on the subject but by writing more specific information than is included in Geological Survey reports or by referring to the State surveys as sources of further information.

This policy has continued unchanged, except possibly for the increasing use of the cooperative State surveys for publication and the encouragement of the contribution of timely articles to the technical journals. The guiding test is promptest announcement and widest circulation of facts resulting from the Federal scientific work.

The present rate of expenditure for the Geological Survey's own publications is less than half that of 10 years ago, and the volume bears much the same relation, the number of reports being reduced one-half, with less than half the total number of pages, and the average edition being now less than 3,000 copies, as against 5,000 copies 10 years ago. Yet the number of manuscripts being prepared has not materially decreased nor is the general demand for published reports less, so that the larger printing appropriation available for the present year is well justified. The distribution of reports during the year exceeded by 10 per cent the number currently printed. The distribution by sale has been encouraged, and the report of the Superintendent of Documents shows a constant increase in total sales

of the Geological Survey publications, the number sold and the money received being more than seven times the corresponding figures 20 years ago. Reports 30 and 40 years old continue to sell, and some technical books with special educational value are in daily demand. The most embarrassing demand is the request from engineering organizations and the general public for reprints of several reports long out of stock. The expenditure necessary to meet such requests can not be logically made with so many unpublished manuscripts waiting their turn, yet the demand shows the permanent value of the investigations represented in such reports.

The steadily increasing number of maps sold is likewise proof of public recognition of their usefulness. Last year the number of maps distributed, mostly by sale, exceeded the number printed by nearly 100,000.

The extent of outside publication of scientific results is indicated roughly by the statement that 17 manuscript reports were delivered to cooperating State surveys for publication at their expense, and the scientists and engineers contributed 127 articles dealing with their official work to the technical press. The daily newspapers also gave wide publicity to the statements setting forth the results of work in progress or describing and summarizing the reports as published. The amount of information given in response to mail inquiries can not be measured, but the handling of that type of correspondence has been a heavy burden on the technical staff, although the highly appreciative letters received are convincing evidence that the expenditure of time is a proper and necessary service to the public.

#### NECROLOGY

Charles D. Walcott, Secretary of the Smithsonian Institution, who died on February 9, was the third Director of the Geological Survey. The years of his administration, 1894 to 1907, were the years of largest growth for this Federal bureau, and his service as a public official and as a scientific investigator had a large share in determining the Geological Survey's sphere of usefulness.

Two other of the older members of the geologic staff died during the year—William H. Dall, a paleontologist actively engaged in work of the highest grade since his appointment to the Geological Survey in 1884, and F. H. Knowlton, paleobotanist of the Geological Survey since 1889. These three investigators, working in widely separated fields of paleontologic research, contributed largely to the Geological Survey standards and reputation.

#### THE YEAR'S OPERATIONS

The principal activity of the director, outside of his routine administrative duties, was service as chairman of the advisory committee selected by the four Cabinet officers forming the Federal Oil Conservation Board, to assist them in their general study of the petroleum problem, and as chairman of the Naval Oil Reserve Commission. In addition to this service he made addresses or informal talks at several scientific and technical meetings and contributed articles to the press, in order to give wider circulation to some of the

salient results of the Geological Survey's work that are of general public interest. A list of these addresses and articles is given below.

- "The ever-new West," Western States Convention, Denver, September 22.
- "Geology at work," Johns Hopkins University, October 22.
- "The forward look by the Department of the Interior," Worcester Polytechnic Institute, Massachusetts, March 24.
- "What price distance," International Railway Fuel Association Convention, Chicago, May 10.
- "Practical conservation," a letter to the Secretary of the Interior, released to the press August 17.
- "Cooperative research essential," Oil and Gas Journal, September 23.
- "Fuel for 1927," New York Journal of Commerce, January 1.
- "America in the making," D K E Quarterly, May.
- "The Geological Survey," United States Daily, May 28.
- "Evolution in the natural-gas industry," Oil and Gas Journal, June 16.

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

- "Surveying and mapping in the United States," by C. H. Birdseye, American Society of Civil Engineers, Philadelphia, October 6.
- "The American petroleum situation," by Julian D. Sears, Postgraduate School, Naval Academy, Annapolis, Md., February 5.
- "A trip down the Colorado River," by C. H. Birdseye, Women's City Club, Washington, D. C., March 9.
- "Some post-Tertiary changes in Alaska of possible climatic significance," by Philip S. Smith, American Geophysical Union, April 19.
- "Floods and flood control," by N. C. Grover, Illinois River Flood Control Association, Peoria, Ill., May 7.

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 42 States, Alaska, the District of Columbia, and Hawaii. In this work 17 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 major results of such work are a new geologic map of Alabama, issued by the State Geological Survey, and a new geologic map of Oklahoma, issued by the United States Geological Survey. Contributions were also made to proposed geologic maps of Arkansas, Colorado, Florida, Texas, and Virginia. Cooperative investigations bearing on oil and gas resources were made in five States, on metalliferous deposits in two States, and on general geologic problems in four States. Considerable geologic work was also done in cooperation with other Government organizations and with non-governmental scientific associations. The investigations in search of potash, carried on in cooperation with the Bureau of Mines, centered largely in New Mexico, where three sites for core drilling were selected, and the drilling at two of them was completed. The cores were studied and selected portions analyzed, and preliminary reports on the economic results were nearly finished. Volcanologic studies were carried on in Hawaii, and a station for volcanologic investigations was established in California. 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 2,874 specimens were identified for private persons and 4,268 were chemically or mineralogically examined, including 3,055 samples taken from wells being drilled for oil in the Texas-New Mexico potash field. Further work was done on problems connected with the soda process for petroleum recovery.

#### EXPLORATIONS IN ALASKA

In the field season of 1926 the principal new explorations that were conducted by the Geological Survey in Alaska covered about 7,000 square miles of hitherto unmapped country. Three major exploratory expeditions were en-

gaged in this work—one in extreme northwestern Alaska, another in the Alaska Range north of Mount Spurr, and the third in the wilds north of the Yukon, a little west of the Alaska-Canada boundary. The explorations in extreme northwestern Alaska were part of a search for oil that the Department of the Interior has carried on for several years at the request of the Navy Department. The geologist and topographic engineer assigned to this work left Washington in February, went as far as possible by the customary routes of transportation into central Alaska, and thence, with their own dog teams, traversed more than 700 miles to the settlement nearest the area to be surveyed. There the party procured all the equipment and supplies that would be required for several months' exploration by dog teams and canoes and struck off into the unsurveyed region, to remain as long as conditions permitted. The expedition into the Alaska Range worked with a pack train of 17 horses and subsisted itself and carried on its assigned tasks for more than three months in that remote region, where even travel is extremely arduous and difficult because of the ruggedness of the topography and the swiftness and volume of the streams. The surveys north of Yukon River necessitated strenuous travel with canoes up an unmapped river for scores of miles and scouting trips on foot to such points as would afford sighting stations from which to reconnoiter the adjacent country and determine its geologic and geographic features.

In the field season of 1927, the expenses for which were in part borne by the appropriation for 1926-27, the exploratory work was continued in both the Alaska Range country and in the region north of the Yukon adjacent to areas where work was done during the field season of 1926.

Not all the work in Alaska is of the exploratory type, however, for the Geological Survey's investigations also include study, mapping, and reporting on the already developed mineral deposits in or adjacent to the settlements and in the more accessible and well-known parts of Alaska. In fact, the task of assisting the development of the Territory's mineral resources in any way that lies within its power and resources is regarded as a distinctive duty of the Interior Department.

One of the noteworthy projects undertaken was the photographing from airplanes of a large part of southeastern Alaska by an expedition of the Navy Department in the field season of 1926, at the request of the Department of the Interior. The expedition accomplished noteworthy results in photographing so large a tract of an extremely difficult topographic area under adverse climatic conditions. Nearly 6,000 photographic exposures, each consisting of three separate parts, were made in the course of this work. The photographs were made under such conditions and controls that they can be utilized by the Geological Survey in preparing maps of the region which will serve for bases for further geologic and topographic investigations. At the same time these bases and the maps subsequently to be prepared from further field surveys will be available for the use of all other Government departments concerned with any phase of the development of southeastern Alaska and for prospectors and other people of that region.

#### TOPOGRAPHIC MAPPING

The topographic work was done in cooperation with 26 States, and the area mapped amounted to 17,603 square miles in 30 States, the District of Columbia, and Hawaii. Of this total 14,630 square miles represents new surveys, 1,990 square miles resurveys, and 983 square miles revisions. The total area mapped to June 30, 1927, is 1,300,539 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. Of the total continental United States exclusive of Alaska, 42.8 per cent has been mapped. River surveys amounting to 300 linear miles were also made. In connection with the topographic work 5,198 miles of spirit levels and 3,287 miles of transit traverse were run and 38 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 new base map of the United States was completed.

#### 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 \$301,459. This sum covered work in 30 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 41 States and Hawaii, in which at the end of the year 1,749 gaging stations were being maintained. The work on ground-water resources has been planned to meet the increasing public demand for precise information with increasing need for the water. Investigations relating to ground water and reservoir sites were made in 16 States and Hawaii. Considerable research into the principles of hydrology has been undertaken 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 752 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 and a report on the developed and potential water power of the United States.

#### 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 23 States and Alaska. The number of cases involving land classification acted on during the year was 12,735, and the results accomplished include net decreases of 604,223 acres in the area of outstanding coal withdrawals, of 529,363 acres in outstanding petroleum withdrawals, and of 11,410 acres in outstanding phosphate reserves. At the end of the year the total area classified amounted to 36,539,905 acres in 15 States and the outstanding mineral withdrawals to 44,969,394 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 512,843 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 484,346 acres in the area included in power reserves, making a total of 6,090,008 acres in 21 States, on which about 15,000,000 continuous horsepower can be developed. The net increase in enlarged-homestead designations was 65,078 acres, making a total outstanding of 324,682,893 acres in 16 States, and the net increase in stock-raising homestead designations was 1,042,324 acres, making a total outstanding of 118,100,670 acres in 18 States. There was a net increase of 3,730 acres in public-water reserves, and the total outstanding is now 364,777 acres in 12 States. The supervisory work on public lands subject to the mineral-leasing laws was increased between 10 and 15 per cent by the receipt of 78 leases, 4,749 permits, and 16 licenses, covering 8,588,925 acres. The production of petroleum on such lands during the year was 25,648,101 barrels, on which the royalty value was \$6,006,455, and the production of coal on such lands was 2,513,080 tons. Supervision over oil and gas operations on naval petroleum reserves was continued, and the petroleum produced amounted to 12,725,365 barrels, on which the royalty value was \$3,455,731. Inspectional, regulatory, and advisory service was rendered in connection with the leasing of mineral deposits on Indian lands in seven States.

#### PUBLICATIONS

The publications of the year consisted of 66 books and pamphlets of the regular series (including 1 reprint), 112 new or revised maps, 140 reprinted maps, and numerous circulars, lists of publications, etc. The total number of pages in the new book publications was 8,396. In addition to the publications in the regular series 47 brief reports were issued in mimeographed form as memoranda for the press. The manuscript edited and prepared for printing amounted to 21,377 pages; 1,832 galley proofs and 14,280 page proofs were read and corrected. Indexes were prepared for 32 publications, covering 5,214 pages. The drawings prepared for publications numbered 2,500, and the proofs of

illustrations examined 1,964. Maps for 8 folios were wholly or partly prepared for engraving, and maps and illustrations for 30 other reports were edited. The new topographic maps edited and transmitted for engraving numbered 122, and 713 other maps were edited. Map proofs numbering 611 were read. Of new and reprinted maps and folios 653,535 copies were printed. The publications distributed numbered 950,840, of which 8,023 folios and 609,148 maps were sold for \$46,116.32.

### GEOLOGIC BRANCH

W. C. MENDENHALL, Chief Geologist

#### ORGANIZATION

The work of the geologic branch has been administered during the year through 11 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.  
 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.  
 Areal geology, H. D. Miser, geologist in charge.  
 Geology of fuels, W. T. Thom, jr., 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 section of volcanology was established July 1, 1926, with the Hawaiian station as headquarters, and T. A. Jaggar, jr., in charge. H. D. Miser succeeded Sidney Paige as geologist in charge of the section of areal geology.

The professional force was increased by the appointment of two assistant geologists, two junior geologists, and one junior chemist and the transfer of one assistant topographic engineer and was reduced by one death, two transfers, and the dropping of one. With these changes it now includes 103 geologists of various grades, 8 chemists, 2 physicists, 1 laboratory aid, and 1 assistant topographic engineer. Six draftsmen (2 temporary) and 7 preparators of fossils (2 temporary) constitute the subprofessional force. In the clerical force there were 3 accessions (2 appointed for field offices) and 2 separations, one by transfer to the professional staff and one by resignation, leaving a total of 30 clerks of various grades, 2 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.....	\$337,160
Classification of lands.....	34,300
Mineral leasing.....	900
Investigating potash deposits.....	7,500
Volcanologic surveys.....	25,000
Repayments from other departments.....	2,211
Repayments from State organizations.....	17,183

424,254

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

Geologic investigations (economic and scientific)-----	\$297, 754
Hawaiian volcanology-----	24, 500
Supervision, administration, services of clerical, technical, and skilled-labor forces, etc-----	95, 000
Budget reserve and unexpended balances-----	7, 000
	424, 254

#### COOPERATION

Cooperation in geologic work continues with a number of the States and takes a variety of forms. In general, the Federal Survey staff makes many paleontologic identifications for States and assists in problems of correlation and identification of materials. Usually, however, the cooperation takes the form of a study of specific problems on a cost-sharing basis. These problems may include the preparation of reports on particular resources or particular areas. They not infrequently lead to the preparation of geologic State maps. The resulting maps and reports are published either by the State or by the Federal Survey. By such cooperation there is coordination of State and Federal action, avoidance of duplication, reduction of cost, and standardization of product.

#### GEOLOGY AS AN AID TO MINING

Metal mining in the United States has reached an interesting and to many a baffling stage. During the half century of development that followed the discovery of gold in California one great bonanza after another was discovered in the West. These poured into the coffers of the world a wealth of metals which enriched its finders, the Nation, and all mankind. The country was new. The western half of our continent had remained, in the mining sense, undiscovered. Enterprising Americans in 75 years have concentrated the exploration and development that in the Old World was distributed over many centuries. Viewed historically this development has been startlingly swift; nevertheless it has been remarkably thorough.

Now the pioneer stage of mining has passed. In an untouched country simple methods of prospecting revealed great mineral deposits in quick succession, many of them exposed at the very surface, awaiting merely the touch of the prospector's pick and the assay to confirm his findings. Many of the deposits thus discovered were developed into great mines, which have passed through successive stages of cheap mining of rich oxidized ores at the surface, more expensive but highly profitable mining of enriched sulphides at greater depth, and finally mining of lean primary ores at lower levels, where costs of recovery even with the best modern methods may soon exceed the market value of the product.

But as time has passed fewer and fewer new deposits have been found. The hills have been prospected over and over by the old-time methods from base to summit, from Canada to Mexico, and from the Great Plains to the Pacific. An occasional strike has been made within the last third of a century—Cripple Creek in 1891, Tonopah

and other Nevada camps in 1900 and later—but by far the greater number of the big metal mines of the United States were in operation within two generations after the discoveries in California. The finding of new ore bodies is becoming more difficult, and the difficulty may be expected to increase. The problem of maintaining production involves increasing skill in ore finding and increasing use of lower-grade material. The first is the problem of the geologist and the mining engineer; the second is the problem of the metallurgist and the industrial organizer.

The leaders in the mineral industry are acutely aware of the necessity of finding more ore, even though the rest of the world may be oblivious to this need. The information of mankind in general lags years or decades or generations behind the information of the specially informed groups. The present has been termed peculiarly a mineral civilization, and the future demand for the ores of the useful metals, raw materials absolutely essential to general prosperity, threatens to increase faster than the supply. Any shortage in these essential metals will inevitably result in higher prices paid by consumers and a halt in the increasing use of those raw materials that vitally contribute to our civilization.

To stimulate this necessary search for ore is involving the use of geology more and more as realization of the nature of the problem grows. That is inevitable. Ore deposits are geologic deposits; they are a part of the crust of the earth, with which geology deals, and they have come into existence through the operation of geologic processes. Now that the visible outcropping ore bodies are largely known and developed, the task of finding the hidden reserves becomes peculiarly a task of applying geologic reasoning to geologic fact. It is an obscure and difficult search. Ore deposits are among the most complex of geologic deposits, for the processes which produced them are many and varied; but what is known of them has been learned by the geologists and their allies—the mining engineers, the geochemists, and the geophysicists.

The mining industry now demands all that geology can do to help it solve the problem of ore finding. Some of the great mining companies have organized large geologic staffs, which are constantly engaged in exploration and the direction of development work. Despite the limitations involved in private work of this sort, the results have been highly successful from the point of view of the companies and their associates. But the mining public as a whole has not reaped the full benefit of this work, because the results are not made public.

Mining districts and the public-land States have sought the aid that they have a right to expect from the Government geologic staffs. Their pleas are not uninformed; on the contrary, they are based on wide experience. For nearly 50 years the United States Geological Survey has made monographic studies of the great mining camps. Its publications have not merely represented great advances in the theory that sets forth how and where ore deposits are formed—many of them rank as classics in the world's literature on this subject—but they have been of great practical value. The development of many of the chief centers of mineral production has been guided in an important and constructive way by the relations which these studies

have revealed of ore bodies to particular rock masses and to particular features of the geologic structure.

The old Leadville monograph, published by the Geological Survey in 1886, is referred to by the mining men of Leadville as the miner's Bible, and the professional paper descriptive of the same mining district of to-day has been referred to as "the revised version." The mining industry urges geologic research—not private, not limited to one property or group of properties, not available merely to one board of directors, but available to the whole mining public and directed to its needs.

Geologic work of this type will necessarily guide the prospecting of the future, utilizing all that has been learned about the hiding places of the elusive metals. Making use of geologic maps of high accuracy, it will point out the situations that experience indicates are promising places in which to search for ore. Exploration thus directed must replace the haphazard, largely wasted work of which so much has been done in the past. It will concentrate search in areas where there is reasonable hope of success. It should reveal much ore not now known and should greatly reduce the cost of ore finding.

"Guides to ore in the Leadville district," recently issued as Geological Survey Bulletin 779, is a brief report in which the practical suggestions resulting from a detailed study of the district are summarized in directly usable form. It represents a type of other examples to follow.

The State of Colorado has recently taken practical steps to procure the sort of geologic work that has just been outlined. In the past this State has produced a billion and a half of dollars in metals, but many of its great camps are on the decline because of the exhaustion of the known ore bodies. In its desire to get the benefit of broad, systematic geologic work, directed especially toward the practical end of ore finding, it has proposed and obtained cooperation with the United States Geological Survey. To this end it is utilizing its metal-mining fund, augmented by a special appropriation by the State legislature. The work is under way. Experienced mining geologists from the Geological Survey have been assigned to the State. Topographic base maps on adequate scales are being made where they are needed. The mineral belts of the State will be mapped in detail, beginning with the better-known areas, on many of which good reports already exist, and passing thence to areas that are less well known. The results are expected to be such enlightening guides to a search for ores as can be given by modern geologic science. The revival of metal mining is not merely an ambitious local project; it is part of a necessary national program to safeguard the continuance of national prosperity.

#### WORK IN GEOLOGY BY STATES

##### ALABAMA

Several collections of material from deep wells and surface outcrops were examined and reported on in informal cooperation with the Geological Survey of Alabama. A new colored geologic map of the State, on a scale of about 8 inches to the mile, prepared cooperatively by the Alabama Geological Survey and the United States Geological Survey, has been issued by the State survey.

It is accompanied by an explanatory text, which includes chapters by George I. Adams, of the Alabama Geological Survey, and Charles Butts, L. W. Stephenson, and C. Wythe Cooke, of the United States Geological Survey.

#### ALASKA

A reconnaissance of the Alaskan Peninsula and the Aleutian Islands has been carried on by T. A. Jaggard, with a view to establishing permanent stations for continuous observation of volcanologic and seismologic phenomena.

#### ARIZONA

Brief examinations of the iron-ore deposits near Tucson, Ariz., and of the fluorspar deposits near Yuma, Tucson, and Duncan were made by E. F. Burchard. A report on the Kaiparowits region, in Utah and Arizona, was submitted by H. E. Gregory and R. C. Moore. F. E. Matthes cooperated with the National Park Service in supervising the construction of a relief model of the Grand Canyon, under the auspices of the American Association of Museums. Paleontologic exhibits in situ at points visible from Yavapai Point, Grand Canyon, were prepared by David White, who held conferences regarding the field observation station to be established there. This work was done in cooperation with the National Park Service, American Museum Association, a National Academy committee, and the National Museum. Cooperation with the State Bureau of Mines consisted in the determination of several lots of fossils by Edwin Kirk, G. H. Girty, and W. C. Mansfield. Bulletin 782, by Waldemar Lindgren, "Ore deposits of the Jerome and Bradshaw Mountains quadrangles," which include the famous United Verde and United Verde Extension mines, was issued.

#### ARKANSAS

In studying the occurrence of oil in southern Arkansas and northern Louisiana, geologists have had difficulty in correlating the oil-bearing and associated rock formations penetrated by the drill with the same formations where they rise to the surface north of the oil fields. To help in this problem a careful survey was made of the areal distribution and stratigraphic relations of the formations of Cretaceous age in southwestern Arkansas, and a report by C. H. Dane will be published by the Geological Survey of Arkansas. A preliminary report entitled "Oil-bearing formations of southwest Arkansas" was issued as a press memorandum. The deposits of lead and zinc ores in Sharp and Lawrence Counties, mined in small quantities for many years, have received renewed interest as a result of recent prospecting. In an endeavor to determine the prospective value of the field for mining, a brief study of the old mines and prospects, as well as new workings, was made by H. D. Miser, who gave his results in a memorandum for the press. At the request of the Forest Service, forested areas adjacent to the Ozark National Forest were examined to determine whether geologic conditions are such that the purchase of the areas as additions to the national forest would tend to conserve navigation on White, Arkansas, and Mississippi Rivers, into which their waters flow. The Woodbine sand in Arkansas, made up largely of water-laid volcanic material, was traced westward through Oklahoma into northeastern Texas, and there found to pass into the typical Woodbine sand, only partly composed of volcanic material. A report on these rocks was prepared by C. S. Ross, H. D. Miser, and L. W. Stephenson and transmitted for publication. A paper by H. D. Miser describing the relations of the Lower Cretaceous rocks of southeastern Oklahoma and southwestern Arkansas was published in the Bulletin of the American Association of Petroleum Geologists. The exact age of certain beds of Carboniferous sandstone and shale nearly 3 miles thick in the Ouachita Mountains has long been a puzzle to geologists, because of the scarcity of fossils. A paper on their age has been prepared by Mr. Miser, in collaboration with C. W. Honess, formerly a geologist of the Oklahoma Geological Survey. The study and description of the fauna of the Morrow formations was continued by G. H. Girty. The relations of formations beneath the St. Peter sandstone were studied by E. O. Ulrich. Early Paleozoic invertebrate fossils were collected by R. D. Messler in northeastern Arkansas. A paper by George H. Girty on the fauna of the middle Boone at Batesville, with a brief description by H. D. Miser of the Boone chert near Batesville, was transmitted for publication. Much information has been supplied for a new colored geologic map of Arkansas, which is in preparation by the Arkansas Geological Survey.

## CALIFORNIA

The general geology and oil possibilities of the southwestern and west-central parts of Humboldt County, Calif., were investigated in a reconnaissance by H. W. Hoots. The Montebello-Santa Monica district, Los Angeles County, is being studied by Mr. Hoots, who has reviewed the work previously done by W. S. W. Kew and extended it westward to Topanga Canyon. The oil possibilities of certain areas in the southern part of San Joaquin Valley were discussed by Mr. Hoots in a press memorandum. Other reports completed or being prepared by Mr. Hoots include a paper on the oil possibilities of an area northeast of Petaluma, Sonoma County, and a brief paper entitled "Oil shale in a producing oil field of California." The geology of the Elk Hills oil field, including naval reserve No. 1, has been investigated by P. V. Roundy and W. P. Woodring, who are now preparing a report. A group of silver mines and prospects in the Panamint mining district were examined by F. C. Schrader for the Department of Justice. A geologic survey of the Ivanpah quadrangle was continued by D. F. Hewett in that part which lies in San Bernardino County. This work was undertaken primarily on account of the numerous ore deposits that have been exploited, but the region is yielding many structural data that will aid in studies near by. The quadrangle contains an exceptionally complete stratigraphic record as well as extensive areas of igneous rocks of two epochs. Preparation of a report on the Alleghany district was continued by H. G. Ferguson, who devoted a large part of his time to a detailed study of the mineralogy of the veins, in the hope of determining the principal factors that have controlled the deposition of the gold. The report on the resurvey of the Mother Lode district has been practically completed by Adolph Knopf. Deposits of iron ore near Amboy and Baxter and of fluorspar in southeastern California near Baxter were examined by E. F. Burchard, in connection with an estimate of the fluorspar reserves. Carboniferous invertebrate fossils were studied by G. H. Girty, and Jurassic invertebrates from the Mariposa shale and Eocene invertebrates from Mendocino County were identified by T. W. Stanton. Preparation of a paper on the physiography of the upper San Joaquin Basin was continued by F. E. Matthes. Papers on the borate deposits in the Kramer district, Kern County, and on a colemanite deposit near Shoshone, by L. F. Noble, were published during the year as Bulletins 785-C and 785-D. The San Andreas rift and some other active faults in the desert region of southeastern California are being studied by Mr. Noble, and a preliminary report was sent to the advisory committee on seismology of the Carnegie Institution of Washington. A station for volcanologic investigation was established at Mineral, to be known as the Lassen station, with R. H. Finch in charge.

## COLORADO

The coal resources, structure, and stratigraphy of the Eastern Yampa coal field, Colorado, were investigated by M. R. Campbell, who is now preparing a report. Coal and oil shale along the Little Book Cliffs near Grand Junction, in western Garfield and Mesa Counties, were studied further by a party in charge of C. E. Erdmann, in order to connect the geologic mapping with that being done by D. J. Fisher on the Book Cliffs in Utah. The relations of the Mesaverde and Mancos formations in the valleys of White and Yampa Rivers and in the region between Rangely and Craig were studied by J. B. Reeside, jr., and E. M. Spieker, who are now preparing a report on the region. Studies of the Green River formation were continued by W. H. Bradley. A study of the mining geology of Colorado, in charge of B. S. Butler, carried on in cooperation with the Metal Mining Fund, was begun early in the year; the survey of the Montezuma quadrangle was begun by T. S. Lovering, and the mapping of the geology and study of the mines in the more productive part of the mineralized belt is well advanced. The study of the Breckenridge district was begun by B. S. Butler. The geology of the Bonanza district proved to be very complicated, and the study is not yet complete, though W. S. Burbank worked in the area for several months and Mr. Butler for several weeks.

A critical study of topographic and geologic mapping in the Mosquito Range was begun to determine the amount of revision necessary to meet present-day requirements for economic geology and to outline areas that should be mapped on a large scale. F. C. Calkins reviewed old mapping and did local detailed work in the Tenmile district, on the west side of the range, and reviewed the

mapping and examined mines and prospects in the Alma district, on the east side. Particular attention was given to the Mosquito fault and the highly faulted area at Kokomo. New developments of critical importance in the Leadville and Cripple Creek districts were studied by G. F. Loughlin, and conclusions already reached were verified. Mr. Loughlin continued the preparation of a preliminary report on deep levels in the Cripple Creek district. Reconnaissance study of the glacial geology and physiography of Sweetwater and Carbon Counties, Wyo., as a part of the general study of these problems in Wyoming and adjacent States, was extended into Routt County, Colo.

Material for the revision of the geologic map of Colorado was contributed to the Colorado Geological Survey, which will issue the map. The San Juan Mountains of southwestern Colorado contain valuable deposits of precious and other metals, thick series of volcanic rocks, and records of glaciation in the past. A comprehensive report on the volcanic and other rocks of the entire region is being prepared by Whitman Cross, E. S. Larsen, and C. S. Ross. As a product of the general investigation, a paper on the physiography of the San Juan Mountains has been prepared by W. W. Atwood and K. F. Mather and is now being reviewed preparatory to publication. A paper on a new gastropod genus from the lower Ordovician of Colorado, by Edwin Kirk, will be published in the Proceedings of the United States National Museum. Fluorspar deposits at Jamestown, Wagon Wheel Gap, and North Gate were examined by E. F. Burchard, who prepared a report on the fluorspar resources of Colorado and Washington for a committee of the Mining and Metallurgical Society. A report on the flora of the Denver formation, by the late F. H. Knowlton, was edited by E. W. Berry.

#### CONNECTICUT

A paper on the geology of the Taconic belt of western Connecticut and the adjacent portions of New York and southwestern Massachusetts has been prepared by Mrs. E. B. Knopf for publication in the American Journal of Science.

#### DISTRICT OF COLUMBIA

The age relations and suitability for foundations of gravel, sand, clay, and other kinds of rock as found in excavations in the city of Washington were studied by Arthur Keith and Laurence LaForge, who have frequently furnished data to engineers and contractors desiring information as to conditions likely to be encountered in proposed excavations and have also furnished information to the Supervising Architect's Office and to the Park and Planning Commission.

#### FLORIDA

For a revised report on the geology of Florida, prepared in cooperation with the Florida Geological Survey, C. W. Cooke conducted extensive field studies and is engaged in preparing a new geologic map and text. He was associated in the field with Stuart Mossom, assistant State geologist, and was assisted by W. C. Mansfield, who identified the fossils collected from the Miocene and later formations. A critical study of fossil shells found in the Chocotaw-hatchee marl in the northwestern part of the State was continued by Mr. Mansfield, whose report will be published by the Florida Geological Survey. Beds containing human and other bones near Melbourne, on the east coast, and near St. Petersburg, on the west coast, which had been examined in cooperation with the Bureau of American Ethnology, were described by C. W. Cooke in a paper published in the American Journal of Science. Drill samples from an oil prospect well at Monticello, Fla., were studied by Mr. Cooke to determine the character and age of the rocks penetrated.

Four chapters of Professional Paper 142, on the molluscan fauna of the Alum Bluff group of Florida, by Julia Gardner, were issued.

#### GEORGIA

As an aid to future exploration and development of the marble deposits of the Tate quadrangle, in northern Georgia, which have been worked for many years, their complicated structural relations have been studied by Arthur Keith, in cooperation with W. S. Bayley, who is preparing a report on these deposits for the Georgia Geological Survey.

**HAWAII**

From the headquarters of the section of volcanology, T. A. Jaggar in charge, at Volcano House, Hawaii, on the rim of the crater of Kilauea, observations of the volcanic phenomena in the island group were made systematically. By cooperation with the Coast Survey, a precise-level line connecting tidewater at Hilo with the summit of Mauna Loa was run. From this line as a base, local level lines are extended from time to time to check the changes in altitude and the tilt in the land surfaces indicated by the seismographs. A set of shallow borings was begun on the floor of Kilauea crater to study the distribution of temperatures over this area. In cooperation with the Hawaiian Volcano Research Association four seismograph stations were maintained on the island of Hawaii, and 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.

**IDAHO**

Cooperation with the Idaho Bureau of Mines and Geology was continued through investigations by C. P. Ross, who furnished reports to the State organization on a disseminated-lead prospect in northern Boise County; the Vienna district, Blaine County; ore deposits in Tertiary lavas in the Salmon River Mountains; and the Deadwood district, Valley County. The detailed survey of the Casto quadrangle was also continued by Mr. Ross. In connection with a general study of the glacial geology and physiography of the region, W. C. Alden made a reconnaissance in Fremont County. An especially complete report describing the geography, geology, and mineral resources (principally phosphate) of southeastern Idaho, by G. R. Mansfield, with a discussion of the paleontology by G. H. Girty, was sent to the printer in January and will appear as Professional Paper 152. Mr. Mansfield also transmitted for publication a report on the geology and mineral resources of the Portneuf quadrangle and began another on the Paradise Valley and Ammon quadrangles. Small lots of Tertiary and Triassic invertebrates from Idaho were examined by W. C. Mansfield and T. W. Stanton. The gold placer deposits extending about 20 miles along Crooked River in the Banner district were examined by F. C. Schrader for the Department of Justice, in connection with an investigation of the properties of the Idaho Hydraulic Corporation. The Bellevue mining district was revisited by D. F. Hewett, with the geologist of the principal operating company, in order to revise the text of a geologic report on the district. Mr. Hewett also examined a manganese deposit near Cleveland, Bannock County, and prepared a brief report for publication. A brief reconnaissance of iron-ore deposits in northern Idaho was made by E. F. Burchard as a basis for any future plans that may be formulated in connection with a study of western iron ores.

**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, conducted by Charles Butts, has been made in cooperation with the Illinois Geological Survey.

**INDIANA**

A report on the grading of Indiana limestone was prepared by G. F. Loughlin, who also visited southern Indiana in connection with the investigation of concrete aggregates. Outcrop material from Indiana was studied by P. V. Roundy during his studies in micropaleontology.

**IOWA**

Some of the coal deposits in Iowa were sampled by M. R. Campbell in connection with the classification of the Carboniferous coals of the Mississippi Valley.

**KANSAS**

A study of the oil and gas resources and possibilities of Kansas was continued in cooperation with the Kansas Geological Survey. Investigations in Cowley County were completed by N. W. Bass, and a map of the county was

compiled for publication by the State Survey. An extension of the work from Cowley County into Kingman, Sumner, Reno, Sedgwick, Rice, and Harper Counties was begun. Microfossils that have been collected from outcrops of rocks in the State and Carboniferous invertebrate fossils were studied by P. V. Roundy. Office work on the report on the Wyandotte quadrangle, with which the report on the Kansas lead and zinc mines will be incorporated, was continued by C. E. Siebenthal.

#### • 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 and partly in Illinois.

#### LOUISIANA

In informal cooperation with W. C. Spooner and several other geologists of Shreveport, an attempt was made by Julia Gardner to determine the relation of certain of the geologic formations of Tertiary age of northern Louisiana to those of corresponding age in northeastern Texas. The presence in Louisiana of the Eagle Ford shale, a formation closely associated with the petroleum deposits of central Texas, was definitely determined through the examination of core samples from several wells in DeSoto, Red River, and Natchitoches Parishes by L. W. Stephenson. Well cuttings from the recently drilled Caster No. 1 gas well, in Monroe County, were examined by H. D. Miser and P. V. Roundy and were found to indicate that the gas sand is of Mississippian age. Invertebrate fossils from the Comanche formation from several deep wells in northwestern Louisiana were identified by T. W. Stanton, and Pleistocene mollusks from outcrops by W. C. Mansfield.

#### MAINE

Preparation of a folio describing the Portland and Casco Bay quadrangles, Maine, was continued by Laurence LaForge. The geology of the area is fairly simple but is important in that an understanding of it furnishes a key for the interpretation of the geology of much of southern Maine.

#### MARYLAND

Detailed study of the geology of Carroll and Frederick Counties, Md., was continued by A. I. Jonas in informal cooperation with the Maryland Geological Survey, which will issue the reports. Additional knowledge of several of the younger geologic formations of Maryland, Virginia, and North Carolina resulted from investigations by W. C. Mansfield, who prepared a paper entitled "Some peculiar fossil forms from Maryland," published in the Proceedings of the United States National Museum, and transmitted for publication "Notes on Pleistocene faunas from Maryland and Virginia and Pliocene and Pleistocene faunas from North Carolina."

#### MASSACHUSETTS

The Boston folio was completed and revised by Laurence LaForge. The Boston area is a striking example of a district in which some of the problems can not be solved from information obtained within the area, and the unraveling of its geology has required not only a detailed and laborious study of the area itself but years of careful work in a considerable surrounding area. The geology of southwestern Massachusetts has been studied by E. B. Knopf in connection with her investigation of the southern Taconic belt in this State and the adjacent portions of New York and Connecticut. A paper giving results of the investigation has been prepared for publication in the American Journal of Science. Further studies of a part of the Taconic belt in northwestern Massachusetts and the adjacent portions of Vermont and New York have been made by L. M. Prindle.

#### MICHIGAN

In informal cooperation with the Michigan Geological Survey a considerable part of the Paleozoic section of the State was studied by E. O. Ulrich, who also gave special attention to the Devonian fauna. Progress was made on the

description of the Carboniferous invertebrate fauna of the Marshall sandstone by G. H. Girty, who spent a few days in the field collecting fossils from selected localities.

#### MISSOURI

Studies of early Paleozoic stratigraphy and paleontology in Missouri, with special reference to the Cotter, Powell, and Proctor formations, were continued by E. O. Ulrich. Work was continued upon the report on the geology and ore deposits of the Wyandotte quadrangle, which includes a strip about 6 miles wide in the southwest corner of Missouri.

#### MONTANA

A study of metalliferous deposits in a region west and north of Helena, Mont., was begun by J. T. Pardee. A preliminary report issued as a press memorandum covers the Zosell (Emery), Scratch Gravel Hills, Towsley Gulch, Seven-up Pete Gulch, Gould, Stemple, and Heddleston districts. The results of Mr. Pardee's investigations of the Montana earthquake of June 27, 1925, were published in Professional Paper 147-B. He has in preparation a paper on late Tertiary and Quaternary faults in southwestern Montana. Progress was made toward the completion of a report on the geologic structure of the Bearpaw Mountains and the surrounding plains area, by Frank Reeves. The structural features are unique, for the circular mountainous area of Tertiary volcanic rocks occupies the crest of a domed area and is adjoined on the north and south by portions of the plains in which thrust faults lie concentrically arranged with reference to the mountains. Recommendations for drilling for oil and gas in the belt of faulted rocks south of the Bearpaw Mountains were discussed by Mr. Reeves in a press memorandum. The Kevin-Sunburst oil field and the Sweetgrass arch are described in a report prepared by A. J. Collier, and a report on the structure and oil possibilities in the plain adjacent to the Highwood Mountains, Mont., has been submitted for publication by Frank Reeves. Data of value in the search for oil in the plains around the Big Snowy Mountains were obtained by Mr. Reeves, who made a field study of the rocks in the mountains. Cretaceous invertebrates from the Sweetgrass arch and the Highwood Mountains and Jurassic invertebrates from the north end of the Big Horn Mountains were identified by J. B. Reeside, jr., and T. W. Stanton. The revised report by A. A. Baker on the northern extension of the Sheridan coal field was completed and submitted for publication. Reports on the Ingomar anticline and the Cat Creek and Devils Basin oil fields were published as Bulletins 786-A and 786-B.

#### NEVADA

A portion of the Carson Sink region, Nevada, was studied by F. C. Schrader to complete some investigations of the region begun several years ago. Most of the surface geology in the Chalk Mountain and Quartz Mountain districts was mapped and the stratigraphy studied. The mines and principal prospects in these districts and in the Gold Basin district were examined, and a preliminary report on the districts was prepared for publication. Mr. Schrader also examined the mines and prospects in the Contact district, where, since the construction of the railroad in 1925, extensive development work is being done on the copper deposits, which occur in a quartzite-limestone-shale series of upper Carboniferous age and are genetically connected with Cretaceous intrusive granodiorite and related rocks.

In connection with field work in the Ivanpah quadrangle, several mines in the Goodsprings district were revisited by D. F. Hewett, whose observations were embodied in a report on the district recently completed. The survey of the Pioche district was continued by L. G. Westgate, who mapped the surface geology of the Panaca quadrangle and the southeastern part of the Pioche Range. Edwin Kirk spent some time with Mr. Westgate in unraveling the Cambrian to Devonian stratigraphic section of the region. The economic geology of an area near Pioche was studied by Adolph Knopf, and a preliminary paper on the geology of the district was prepared by Messrs. Westgate and Knopf for presentation at the meeting of the American Institute of Mining and Metallurgical Engineers in New York City. The final report is in course of preparation. Detailed mapping of the Las Vegas quadrangle was continued by C. R. Longwell. Fossils collected by him were studied by Edwin

Kirk. A paper on the flora of the Esmeralda formation in western Nevada, by E. W. Berry, was approved for publication in the Proceedings of the United States National Museum.

#### NEW ENGLAND

The earthquake, usually referred to as the St. Lawrence earthquake, which so greatly disturbed New Englanders on February 28, 1925, was but one, though the most severe, of a series of quakes that affected a large area in the north-eastern United States and Canada between July, 1924, and March, 1926. In addition to the recording by seismographs, the St. Lawrence quake was noted by the human senses in an area of about a million square miles. The causes and effects of the earthquake were investigated by Arthur Keith, who prepared a memorandum for the press on this subject and presented a paper entitled "Recent earthquakes in New England" at the meeting of the eastern section of the Seismological Society of America at Boston in May, 1927.

#### NEW JERSEY

The effects of the explosion at Lake Denmark, N. J., July 10, 1926, were investigated by G. R. Mansfield, at the request of and in cooperation with the Navy Department, to determine the possibilities of damage to property by ground shock. Glacial formations and attendant features in western New Jersey were studied by Frank Leverett, in cooperation with the New Jersey Geological Survey. The Ordovician section in the Delaware Water Gap was studied by E. O. Ulrich.

#### NEW MEXICO

The potash investigations of the year centered largely in New Mexico, where three sites for core drilling, all in Eddy County, were selected and reported to the Bureau of Mines as a part of the cooperative potash investigation authorized by the Federal potash act, under which \$100,000 was appropriated for the fiscal year 1927. Contracts were made for core tests at these sites, and the drilling of two of them was completed. The cores were delivered to the Geological Survey for study, and portions were selected for analysis. Preliminary reports describing the economic results of the work are in an advanced stage of preparation. Core samples from a private potash test on the McNutt permit in sec. 4, T. 21 S., R. 30 E., Eddy County, were submitted to the Geological Survey for study and analysis. Two press memoranda on the McNutt core test and the Texas-New Mexico potash area were prepared by G. R. Mansfield. A paper on "Potash investigations in 1924," by W. B. Lang, was published as Bulletin 785-B. The Great Eagle fluorspar mine, near Lordsburg, was visited by E. F. Burchard in connection with a study of fluorspar reserves by a committee of the Mining and Metallurgical Society of America. The manuscript of a report on the Santa Rita district, by A. C. Spencer, is nearing completion.

#### NEW YORK

The study of several major problems in the part of the Taconic belt lying in south-western Vermont, eastern New York, and north-western Massachusetts was continued by L. M. Prindle, who examined the Hoosick, Bennington, Berlin, Greylock, and adjoining quadrangles, between the parts of the Taconic belt that have been studied by Arthur Keith farther north in New York and Vermont and by E. B. Knopf farther south in New York, Massachusetts, and Connecticut. A correlation chart of the exposed formations of eastern New York and Vermont was prepared by Arthur Keith in connection with his stratigraphic and structural studies of the Taconic area. Geologic results have been obtained in the southern Taconic area of eastern New York, western Connecticut, and south-western Massachusetts. Although the geology of this area is complicated, much information has been obtained on the stratigraphy, structure, and metamorphism of the rocks. E. B. Knopf, who has worked on this problem, has written a paper entitled "Some results of recent field work in the southern Taconic area," which will be published in the American Journal of Science.

#### NORTH CAROLINA

A short paper on some Cretaceous fossils from North and South Carolina was prepared by L. W. Stephenson for publication in the Proceedings of the United States National Museum. Fossil shells were collected from several of the

younger geologic formations of the Coastal Plain by W. C. Mansfield and W. P. Popenoe. Some of the results of these studies are included in a paper by Mr. Mansfield entitled "Notes on Pleistocene faunas from Maryland and Virginia and Pliocene and Pleistocene faunas from North Carolina," transmitted for publication. A brief cooperative report on an unsuccessful oil-prospecting well near Havelock, prepared by Mr. Mansfield, was published by the North Carolina Department of Conservation and Development. One of the important facts recorded in this report is the depth to the crystalline bedrock (2,318 feet) which underlies the Coastal Plain formations. A field study was made of a portion of the proposed Great Smoky Mountains National Park of western North Carolina and eastern Tennessee by Arthur Keith in connection with his resurvey of parts of the Mount Guyot quadrangle.

#### NORTH DAKOTA

A paper on the Fox Hills and Lance formations in the northern Great Plains is being prepared by C. E. Dobbin and J. B. Reeside, jr.

#### OHIO

Preparation of a geologic folio on the Cleveland, Berea, and Euclid quadrangles, Ohio, by Frank Leverett, F. R. Van Horn, and H. P. Cushing, was continued. A structure contour map of the northern Appalachian region in portions of Pennsylvania, Ohio, and West Virginia was compiled by G. B. Richardson during his studies of oil and gas fields. The glacial deposits in eastern Ohio between East Liverpool and Kinsman were examined by Frank Leverett in connection with comprehensive glacial and physiographic studies in the older drift areas.

#### OKLAHOMA

The first colored geologic map of the entire State of Oklahoma ever published, prepared in cooperation with the National Research Council, the Oklahoma Geological Survey, and the geologists and oil companies of the State, was issued. The map is an important addition to the knowledge of the geology of the United States. It is on a scale of about 8 miles to 1 inch, measures 36 by 65 inches, and is printed in 22 colors, with 105 separate colored patterns. The map was compiled by Hugh D. Miser, chiefly from about 1,000 maps of parts of the State that were obtained from numerous sources, though he visited and mapped a few small areas. Unpublished as well as published maps were used—in fact, the new geologic mapping not heretofore published covers more than half the State. A revised edition of the map of the oil and gas fields, pipe lines, and refineries of the State was nearly completed under the supervision of G. B. Richardson. A field study has been made of the geology of the Ouachita Mountains of southeastern Oklahoma with a view to completing a report on the rocks and mineral resources. The study was made by Mr. Miser, in cooperation with the Oklahoma Geological Survey and with geologists of the State. A description of water-laid volcanic deposits of Upper Cretaceous age in the southeastern part of the State is contained in a report by C. S. Ross, H. D. Miser, and L. W. Stephenson, transmitted for publication. A paper on the age of the Carboniferous rocks of the Ouachita Mountains of Oklahoma and Arkansas has been written largely by H. D. Miser, in collaboration with C. W. Honess, formerly a geologist of the Oklahoma Geological Survey. A description of the fauna of the Moorefield shale by G. H. Girty and a study of its micro-fauna by P. V. Roundy are in progress. Sales of Osage leases at Pawhuska on September 30, 1926, and March 28, 1927, were attended by P. V. Roundy, at the request of the Office of Indian Affairs, to give advice concerning the adequacy of bids. A brief study of the geology of a portion of Osage County has been made by Mr. Roundy. A geologic study of the Stigler coal field was made by W. T. Thom, jr., to obtain information not only on the coals but also on the gas possibilities of the area. A report giving the results of the study has been prepared for the official use of the conservation branch. The Joplin region of Missouri, Kansas, and Oklahoma remains the most productive zinc-lead ore district in the United States. Office work on a report covering the richest portion of the region, near Picher, Okla., in the Wyandotte quadrangle, and in the adjoining part of Kansas, was continued by C. E. Siebenthal, who also prepared a contour map showing the subshale surface from Cardin to Scammon Hill, with text discussing the principal features, chief of which is the Commerce trough.

## OREGON

The Ladysmith iron-ore tract, the Pisgah tract, the tract of ore land of the Oregon Iron Ore Corporation, and the Bunker Hill tract in Columbia County, Oreg., were examined by E. F. Burchard. Methods and extent of prospecting and character of ore were noted, analyses were obtained, and studies were made of the possible markets for the ore.

## PENNSYLVANIA

Geologic studies were made in different parts of Pennsylvania, largely in cooperation with the Pennsylvania Topographic and Geologic Survey. A cooperative report on the Lancaster quadrangle has been prepared by G. W. Stose, of the United States Geological Survey, and A. I. Jonas, for the Pennsylvania survey, and will be published by the State. A report on the geology of Adams County by Mr. Stose will be issued by the State. A geologic map of Pennsylvania, which is being compiled by the State survey, has been prepared in part by Mr. Stose. In the York, Middletown, and Hanover quadrangles field investigations have been continued by Mr. Stose and Miss Jonas, in cooperation with the State. The manuscripts for the geologic folios on the Somerset and Windber quadrangles, by G. B. Richardson, and on the Fairfield and Gettysburg quadrangles, by Mr. Stose and Florence Bascom, were completed. Progress was made on the New Kensington folio, by G. B. Richardson; the Bellefonte folio, by E. S. Moore and Charles Butts; and the Quakertown-Doylestown folio, by Miss Bascom and Mr. Stose. Several scientific papers relating to the above-mentioned work have been prepared for outside publication as follows: "Summary of the pre-Cambrian geology of Pennsylvania and Maryland," by A. I. Jonas and E. B. Knopf; "Ordovician shale and lava in southeastern Pennsylvania," by G. W. Stose and A. I. Jonas; "Tectonics of southeastern Pennsylvania," by G. W. Stose; "Possible post-Cretaceous faulting in the Appalachians," by G. W. Stose; "Ordovician shale of Pennsylvania," by G. W. Stose. The cooperative studies of glacial geology in Pennsylvania were continued by Frank Leverett, who investigated the relative ages of the deposits of the three glacial stages represented in northwestern Pennsylvania and the distribution and character of gravel deposits in valley trains laid down by water flowing from the ice front. These deposits constitute a valuable source of road material. Mr. Leverett also studied glacial formations and attendant features in eastern Pennsylvania. A structure-contour map of the northern Appalachian region in portions of Pennsylvania, Ohio, and West Virginia was compiled by G. B. Richardson in connection with his studies of oil and gas fields. Stone quarries in western Pennsylvania were visited by G. F. Loughlin, who conferred with highway engineers and others regarding the qualities of certain stone for concrete aggregates.

## SOUTH CAROLINA

A description of the geologic section at Mars Bluff, Peedee River, S. C., a list of fossil shells, and the description of one new species from the same section are included in a paper entitled "Additions to the Upper Cretaceous invertebrate faunas of the Carolinas," by L. W. Stephenson, prepared for publication in the Proceedings of the United States National Museum.

## SOUTH DAKOTA

The oil and gas possibilities of part of the region near Edgemont, S. Dak., were described by W. W. Rubey in a press memorandum. Well cuttings from the northern part of the State were examined by T. W. Stanton to determine the age of the rocks penetrated by the drill. The Fox Hills and Lance formations in the northern Great Plains are described in a paper which is being prepared by C. E. Dobbin in collaboration with J. B. Reeside, jr. Cretaceous fossil plants from the Black Hills were studied by F. H. Knowlton and E. W. Berry and invertebrate fossils from the same region by Mr. Reeside.

## TENNESSEE

A field study was made of a portion of the proposed Great Smoky Mountains National Park in eastern Tennessee and western North Carolina by Arthur Keith. Western Tennessee is included in the Mississippi Embayment, a north-

ward extension of the Gulf Coastal Plain. The geologic formations of Tertiary age in this area have yielded large collections of beautifully preserved fossil plants, which are described and illustrated in a report by E. W. Berry, transmitted for publication. Early Paleozoic sections in eastern Tennessee were studied and paleontologic collections obtained by E. O. Ulrich, Charles Butts, and R. D. Mesler. The fauna of the Ripley formation on Coon Creek, Tennessee, is described by Bruce Wade in Professional Paper 137, and the ores of Ducktown by W. H. Emmons and F. B. Laney in Professional Paper 139.

#### TEXAS

Development of the petroleum resources of the Coastal Plain of central and northeastern Texas has emphasized the necessity for an exact knowledge of the oil-bearing and associated formations of that area, and several projects with that end in view were continued. Progress was made on the preparation of a cooperative geologic map of the State, and important additional knowledge was gained of the surface distribution and structural and stratigraphic relations of the Cretaceous and Tertiary formations. This work was carried on partly in cooperation with the Texas Bureau of Economic Geology and partly as independent projects, by L. W. Stephenson, Julia Gardner, and C. H. Dane. The final results will appear as maps and reports published by the Geological Survey and by the Texas Bureau. Mapping of large areas in west-central Texas, in preparation for the proposed geologic map of the State, was continued by N. H. Darton. The Comanche stratigraphy of the Edwards Plateau and adjacent areas was studied by T. W. Stanton in cooperation with Mr. Darton, and many collections of Comanche invertebrates were identified by Mr. Stanton. The fauna of the Cisco formation is being described by G. H. Girty, and other Carboniferous collections were studied by Messrs. Girty and Roundy. Potash investigations were continued in Texas chiefly by W. B. Lang, who watched oil-drilling operations, procured samples, and obtained data for the selection of drilling sites in Crockett and Ector Counties. A contract for drilling at the Ector County site was closed by the Bureau of Mines near the end of the year. Two press notices on the Texas-New Mexico potash area were prepared by G. R. Mansfield. The new edition of the oil and gas map of Texas compiled under the direction of G. B. Richardson was nearly ready for distribution at the end of the year. The map is printed in colors and shows oil and gas fields, oil pipe lines, salt domes, and refineries. A paper describing Upper Cretaceous water-laid deposits of volcanic materials in northeastern Texas, by C. S. Ross, H. D. Miser, and L. W. Stephenson, was transmitted for publication.

#### UTAH

The coal resources and oil possibilities of eastern and southeastern Utah were investigated by three parties under the field supervision of C. E. Dobbin, as follows: Mapping of the rock formations and topographic features of the canyon-trenched country lying between Colorado and Green Rivers was continued by a party in charge of E. T. McKnight; mapping of the rocks and topographic features of the rugged country adjacent to Colorado River near Moab was continued by A. A. Baker and assistants; and the investigation of the coal resources of the Book Cliffs was continued by D. J. Fisher and party. A final report on the Book Cliffs coal field is being prepared by Mr. Fisher. Some of the results that were obtained during the field season of 1926 by the McKnight and Baker parties have been embodied in a paper, "Notes on the stratigraphy of the Moab region," which will be published in the Bulletin of the American Association of Petroleum Geologists. The major geologic features were described in a memorandum to the press. The Wasatch Plateau coal field is described in a report by E. M. Spieker to be published as a bulletin. The rock formations and coal near Manti and the rocks in Round Valley were studied by Mr. Spieker. Fossil collections from Sanpete Valley were studied by J. B. Reeside, jr. The sedimentary rocks of the San Rafael Swell and some adjacent areas in eastern Utah are described in a report by James Gilluly and Mr. Reeside, transmitted for publication. The igneous rocks in the San Rafael Swell are described in two papers by Mr. Gilluly, of which one on the analcite diabase and analcite syenite was submitted for publication in a scientific journal. The Green River formation has been studied further by W. H. Bradley, who has completed two papers on the subject. One entitled "Algae reefs and oolites of the Green River formation" will be published by the

Geological Survey. Work on a report on the stratigraphy of the Green River formation in Colorado and Utah was continued. The coal and the possibilities for oil and gas in portions of Garfield and Kane Counties are described in a report by R. C. Moore. Further investigation has been made of the Cottonwood-American Fork district, which contains valuable deposits of silver, lead, copper, and some gold and a little zinc. The report on the ore deposits has been written by B. S. Butler; that on the general geology is being written by F. C. Calkins. Areal mapping with a study of the stratigraphy and ore deposits of the Stockton and Fairfield quadrangles, including the Ophir district, was continued by James Gilluly, in association with Edwin Kirk and George H. Girty in the stratigraphic studies. The Gold Hill and neighboring districts were studied by T. B. Nolan, who has in preparation a general report on the geology and ore deposits of the Gold Hill quadrangle and a paper on the structure and stratigraphy. Messrs. Kirk and Girty cooperated with Mr. Nolan in the study of the stratigraphy and paleontology. Some silver and lead mines and prospects occurring in Paleozoic limestone, shale, and quartzite in the Ashbrook district were examined by F. C. Schrader, who also investigated the relations of the Raft River Mountains uplift to that of the Contact district, Nevada. A paper on the Kaiparowitz region, by Herbert E. Gregory and Raymond C. Moore, a region which has long remained geologically unknown and within which surveys were needed for the correlation of strata and structure described in surrounding areas, was transmitted for publication. Cycads in the Shinarump conglomerate of southern Utah were described by E. W. Berry in a paper that appeared in the *Journal of the Washington Academy of Sciences*. Fluorspar deposits near Ogden were examined by E. F. Burchard. A report on the potash-bearing brines of the Great Salt Lake Desert, prepared by T. B. Nolan, was published as Bulletin 795-B.

#### VERMONT

Stratigraphic and structural studies of the Taconic area in Vermont were continued by Arthur Keith, and studies of a part of the Taconic belt in southwestern Vermont, eastern New York, and northwestern Massachusetts by L. M. Prindle.

#### VIRGINIA

Field investigations for a geologic map of Virginia were continued in cooperation with the Virginia Geological Survey, work being done in a portion of the Appalachian Valley belt by Charles Butts, of the Federal survey, and in the Piedmont belt by A. I. Jonas for the State survey. Structural conditions in the vicinity of Early Grove were found favorable for the possible accumulation of oil and gas in commercial quantities, and a report on the locality by Mr. Butts has been published by the State survey. A report describing a series of fensters along the Pine Mountain overthrust has been prepared by Mr. Butts and will be published by the State survey. A reconnaissance investigation in the vicinity of Brems Bluffs was made for the State survey by G. W. Stose. E. F. Burchard conferred with officials of iron companies and examined iron-ore deposits in Alleghany, Bland, Botetourt, Craig, and Washington Counties, in cooperation with the Virginia Geological Survey, for the purpose of reviewing the present conditions affecting the iron industry in the State. Investigations of some of the younger formations of the Coastal Plain were continued by W. C. Mansfield, who completed a paper on the Miocene stratigraphy of Virginia and another paper containing descriptions of Pleistocene faunas from Virginia. Mr. Mansfield also reported on small collections of Miocene fossils obtained by C. K. Wentworth northeast of Richmond.

#### WASHINGTON

The Latah formation in the neighborhood of Spokane, Wash., a considerable flora from which had previously been described by F. H. Knowlton, was studied by him in the field and additional collections made. The new species in these collections and in others received from the Spokane Museum were described by E. W. Berry. Collections of fossil plants were obtained from the Puget formation by Mr. Knowlton in cooperation with R. W. Chaney, and the description of the Puget flora was in progress at the time of Mr. Knowlton's death, November 22, 1926, and has since been continued by E. W. Berry. Deposits of iron ore in eastern Washington and of fluorspar at Keller were examined by

E. F. Burchard, who prepared a report on the fluorspar reserves of Washington for a committee of the Mining and Metallurgical Society. J. T. Pardee examined dam sites on Skagit River for the water-resources branch. A short paper on the platinum deposits of Washington was prepared by Mr. Pardee, and his report on manganese-bearing deposits near Lake Crescent and Humptulps was issued as Bulletin 795-A.

#### WEST VIRGINIA

A structure-contour map of the northern Appalachian region in portions of West Virginia, Ohio, and Pennsylvania was compiled by G. B. Richardson in connection with his studies of oil and gas fields. Glacial and associated physiographic deposits in the Ohio Valley region of West Virginia were studied by Frank Leverett.

#### WISCONSIN

Progress was made in the office review of a report on the Sparta and Tomah quadrangles, in the Driftless Area of Wisconsin, prepared by F. T. Thwaites, W. H. Twenhofel, and Lawrence Martin under a cooperative agreement with the Wisconsin Geological and Natural History Survey.

#### WYOMING

A report on the Black Hills region of Wyoming and South Dakota that will be of special value to those who prospect the region for oil and gas has been partly completed by W. W. Rubey in connection with his studies of the geology and certain structural features of the rim of the Black Hills, and a paper on some of the structural features of the Black Hills has also been partly written. A paper entitled "Origin of the siliceous Mowry shale in the Black Hills region" has been transmitted for publication. A paper entitled "Possible natural soda drive in the Salt Creek type of pool, and its significance in terms of increased oil recoveries" was presented by W. T. Thom, jr., before the petroleum division of the American Institute of Mining and Metallurgical Engineers at Tulsa, Okla., October 12, 1926. Two papers on Wyoming oil fields—"The geology of the Rock Creek oil field and adjoining areas in Carbon and Albany Counties," by C. E. Dobbin, H. W. Hoots, C. H. Dane, and E. T. Hancock, and "The geology and coal and oil resources of the Hanna and Carbon Basins, Carbon County," by C. E. Dobbin, C. F. Bowen, and H. W. Hoots—have been submitted for publication. A report which describes the geology and the oil, gas, and coal resources of the southwestern part of the Big Horn Basin, covered by the Oregon Basin, Meeteetse, and Grass Creek Basin quadrangles, by D. F. Hewett, was issued as Professional Paper 145. The geology of the coal fields of Wyoming is treated in a summary paper written by Mr. Dobbin for publication in the series of technical papers of the Bureau of Mines. A paper on the Fox Hills and Lance formations of the northern Great Plains was partly written by Mr. Dobbin in collaboration with J. B. Reeside, jr. A paper on the algae reefs and oolites of the Green River formation of Wyoming and the adjacent parts of Colorado and Utah was completed by W. H. Bradley. A geologic examination of the south end of the Little Snake River coal field, Wyoming and Colorado, was made by M. R. Campbell and J. B. Reeside, jr. Asphalt deposits near Baggs were examined by E. M. Spieker, and the preparation of a report on them was begun. Field and office studies of the physiography and glacial geology of Sweetwater, Carbon, Albany, Natrona, Lincoln, and Fremont Counties, the Fort Washakie Reservation, and Yellowstone National Park were continued by W. C. Alden. Inspection of the iron-ore deposits in the Seminole Mountains was completed by E. F. Burchard, accompanied part of the time by T. S. Lovering. A report on these deposits is in course of preparation by Mr. Lovering. A report entitled "Earthquakes in the Big Horn Mountains, Wyoming," was prepared by J. T. Pardee for publication in the Bulletin of the Seismological Society of America.

#### FOREIGN

A monographic study of Miocene mollusks from Bowden, Jamaica, carried on in cooperation with the Carnegie Institution of Washington, was completed by W. P. Woodring, and the second and final volume of his monograph on these

fossil shells was transmitted to the institution for publication. The first volume was published in 1925. Collections of late Tertiary fossils from Jamaica, submitted by Dr. C. A. Matley, former Government geologist of Jamaica, were reported on by Mr. Woodring.

The first reported occurrence of rocks of Eocene age on the south slope of the Andes in the State of Zamora, Venezuela, was recorded by W. P. Woodring in the Bulletin of the American Association of Petroleum Geologists, as the result of a study of material collected and submitted by N. H. Darton. Cretaceous and Tertiary invertebrates collected by Mr. Darton in Venezuela were identified by J. B. Reeside, jr., and Mr. Woodring.

A paper on tectonic features of the Caribbean region was prepared by W. P. Woodring for presentation at the Pan-Pacific Science Congress in Japan.

A paper entitled "A reexamination of the lead sulphosalt keeleyite from Bolivia" was written by M. N. Short and Earl V. Shannon for the American Mineralogist.

A paper entitled "Additional data on the properties of pumpellyite and its occurrence in the Republic of Haiti, West Indies," was prepared by W. S. Burbank for the American Mineralogist.

An upper Ordovician fauna from the Rocky Mountains of British Columbia was described by Edwin Kirk.

#### WORK IN CHEMISTRY

The work in chemistry comprised the partial and complete analyses of rocks and other geologic products, the identification and analyses of minerals, the study of geochemical problems, and researches in mineralogical chemistry. During the year 7,142 specimens were examined; 2,874 were identified for persons not connected with the Geological Survey, and 4,268 were chemically or mineralogically examined to furnish data for use in connection with problems being studied by Geological Survey members.

More time was spent on the chemical and mineralogical study of the potash salts of the Texas-New Mexico field than on any other one subject, 3,055 samples taken from wells being drilled for oil in this field having been examined. As a result of these tests a well sponsored by private interests was drilled in search for potash about 20 miles east of Carlsbad, N. Mex., and the owners of the well generously furnished the Geological Survey with a quarter section of selected portions of the core. The analysis and study of this material indicated a promising prospect for a commercial deposit of potash in this area. Thirty-five strata ranging in thickness from 10 inches to 4 feet were encountered which contained from 12 to 18 per cent of potash ( $K_2O$ ). One stratum which was particularly promising consisted of two 3-foot layers containing 15 per cent of potash, separated by only 30 inches of rock salt. Polyhalite, a potassium-calcium-magnesium sulphate of remarkable purity, was found in a number of the strata. One 18-inch layer containing langbeinite, a rare potash mineral, was found at the 1,430-foot level. Several of the thicker potash strata were composed of sylvinite, a mixture of potassium chloride (sylvite), and rock salt. Other minerals identified in this core were kainite, kieserite, anhydrite, and magnesite. This is the first occurrence noted of kainite and langbeinite in the American continent.

The cores from the first two wells drilled for potash under the appropriation made by Congress for investigating potash deposits, 1927, were received and are now being chemically and mineralogically examined by R. K. Bailey, E. P. Henderson, W. T. Schaller, E. T. Erickson, and J. J. Fahey.

Radioactive minerals were studied with special reference to the determination of their geologic age by means of the lead-uranium ratio by R. C. Wells, in cooperation with the National Research Council's committee on the estimation of geologic time by this method. M. F. Connor, formerly chemist in the Geological Survey of Canada, collaborated as guest chemist during May and June, 1927, in studying analytical methods best suited for the separation and determination of lead, thorium, and uranium, the elements on which the estimate of age depends. Mr. Wells also wrote papers on evaporation from Chesapeake Bay and the element "mosandrum" of J. Lawrence Smith.

A minute study of polyhalite and other minerals of the Texas-New Mexico salt field, including a research into their origin, was made by W. T. Schaller. He also conducted laboratory and field investigations on the study of the origin of pegmatites and described in an article published in the *American Mineralogist* a new commercial boron mineral, called kernite, from California.

A bibliography and description of chemical work done during the year having a bearing on the problem of sedimentation was prepared by George Steiger for the committee on sedimentation of the National Research Council. Experimental laboratory work on the disintegration and solubility of Indiana limestone was also done by Mr. Steiger.

The problem of the formation of hydrocarbons from plant and animal remains was studied experimentally by E. T. Erickson, who also did some work on the separation of small quantities of the platinum group of metals.

#### WORK IN PHYSICS

Investigations of deep-earth temperatures and molecular geophysics occupied most of the time of the two physicists.

In the investigation of deep-earth temperatures C. E. Van Orstrand completed a summary of observations made in foreign countries and prepared memoranda for the press on the subject of the utilization of the earth's internal heat and the possible use of temperature measurements in prospecting for oil. A somewhat extended paper on the "Interpretation of earth temperatures" was published in the *Oil and Gas Journal*. In the absence of the usual allotment for field work, the National Research Council supplemented the work of the Geological Survey by the appointment of three research associates, one each at the Universities of Oklahoma, Texas, and California. During February and March Mr. Van Orstrand visited each institution, the field expenses being paid by the council, for the purpose of giving advice and instruction in regard to the construction of the necessary apparatus and the method of procedure in making the observations. Some work was done in the field of mathematical statistics relative to the representation and interpretation of petroleum production curves and the mathematical representation of the distribution of grain diameters of a sand. A paper entitled "Mathematical representation and interpretation of petroleum production curves" was published in the *Oil and Gas Journal*, and a short paper on the analytical and graphic representation of the arithmetic, geometric, and other means was completed.

In the field of molecular physics P. G. Nutting continued his work on the physical properties of silts and sands related to the recovery of petroleum in spent fields, held two conferences with operators in the Bradford field of Pennsylvania on field tests of the soda and other processes of petroleum recovery, investigated the fundamental laws governing adhesion and movement of fluids through porous solids, made numerous tests of sands and silts, developed improved test methods, answered numerous inquiries relating to the soda process, and published a number of papers bearing on these and related subjects. The results of the first field tests of the soda process for petroleum recovery, initiated in the summer of 1925, have been so encouraging that two of the leading producers have for some time been putting soda in all their recovery wells, and three others are now preparing to do so. These and other producers have constantly called on Mr. Nutting for advice as to the best concentration and amount of solution to use, the rate of introduction into the wells, the best backing pressure, and other problems concerned in the development of the field technique of the process. Many special problems have been solved in the physical laboratory, including the effect of carbonates and sulphates in the sands and of coatings of oxides and silicates on the sand grains on the movement of oil and soda solutions through them. To forestall innumerable inquiries three general papers were prepared—one on the best field practice, one on the physical and chemical principles underlying the process, and one on the development of the soda process, the results of field tests, and the patent situation to date.

An intensive study has been made of the forces of adhesion and adsorption between liquids and solids and between solids wet with liquids. Molecular physics in general, and selective adsorption in particular, are the keys to many important geologic changes, and a good beginning is being made in uncovering fundamental principles and data.

A small amount of office space in the physical laboratory has been assigned temporarily to F. C. Weaver, who is conducting an investigation, under the auspices of the National Research Council, on the thermal conductivity of gases. The investigation has for its object the determination of certain fundamental constants which when determined will provide a simple means of gas analysis, including the determination of the gaseous products of combustion, the gaseous content of rocks and minerals, and in particular the helium and hydrocarbon content of the natural gases found in the oil fields.

#### 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 investigations of the mineral resources of Alaska \* \* \*." In this act for the fiscal year 1926 the amount was \$72,000; for 1927, \$50,000; for 1928, \$60,000. 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, 1927, 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. The two types of work indicated will be described for conveniences as the mineral-resources work and the mineral-leasing work.

#### MINERAL-RESOURCES WORK

Expenditures during the fiscal year beginning July 1, 1926, to June 30, 1927, from the 1926-27 appropriation may be distributed among the following major heads:

*Expenditures from funds appropriated for mineral-resources investigations in Alaska for the fiscal year 1927*

Projects, season of 1926.....	\$6,150
Projects, season of 1927.....	6,815
Administrative salaries.....	4,375
Other technical salaries.....	24,160
Other clerical and drafting salaries.....	6,565
Office maintenance and supplies.....	1,935

50,000

Only the amounts expended from the appropriation for 1927 are tabulated above, but most of the projects included in the item for the season of 1926 were started in the previous fiscal year, and \$16,735 was put into the start of these projects from funds carried in the appropriation for 1926. Similarly only a beginning of the projects included in the item for the season 1927 was made during the fiscal year 1927, and \$18,485 additional has been allotted from the appropriation for 1928 to complete them. These items do not include any charge for the technical services of the personnel assigned to these field projects and paid from the appropriation for 1927. Of this amount \$19,630 was for the technical services of the personnel assigned to the projects of 1926 and \$4,530 for those assigned to the projects of 1927. In addition technical salaries to the extent of \$6,080 were paid from the appropriations for 1926 for the projects of 1926, and an amount estimated at \$19,685 will be required from the appropriations for 1928 to complete the projects of 1927.

#### PRINCIPAL RESULTS OF THE YEAR

The principal results of the field investigations during the year have been the mapping both geologically and topographically of about 7,250 square miles of country. All of this except 350 square miles is country that had not been hitherto surveyed. The 350 square miles represents mapping in more detail of country that had hitherto been mapped on a much smaller scale on only exploratory standards. The following table indicates the area covered by surveys that have

been made in Alaska up to the present time by the Geological Survey. No report is made for the field season of 1927, because all the parties are out of communication, and it is not practicable to give the precise area surveyed up to the end of the fiscal year. This, however, is offset for all practical purposes, because for the field season of 1926 all of the area surveyed is reported, even though the work in it was commenced in the fiscal year 1925. In this way the amount of work done in the fiscal year 1926 on projects of 1926 presumably balances the amount of work that was done on the projects of 1927 during the fiscal year 1927.

*Areas surveyed by Geological Survey in Alaska, 1898-1926, 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)
1898-1925.....	75,500	154,505	5,977	55,980	190,150	4,066
1926.....	-350	7,250	-----	-350	7,250	-----
	75,150	161,755	5,977	55,630	197,400	4,066
Percentage of total area of Alaska.....	41.1			43.5		

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," although of course there is duplication between these two sets of surveys, the geologic and topographic work having been done in substantially the same areas. In other words, when a map on a reconnaissance standard, for example, includes an area formerly mapped on an exploratory scale, the entire area is included in the column of reconnaissance surveys and the appropriate amount is deducted from the area previously reported as having been mapped on an exploratory scale. It is for this reason that a deduction is shown in the column for exploratory surveys. The necessity for remapping some areas on a more detailed scale is apparent. For many areas in Alaska exploratory mapping is all that is warranted for some time. For others it has been necessary to do the more rapid and less expensive exploratory work to meet urgent demands for immediate information, with the intention that in selected areas or as funds and personnel could be made available the more detailed surveys would be made. Even a reconnaissance survey is entirely inadequate for many types of investigation, and unquestionably more detailed maps and reports should be undertaken in the areas that are of economic importance. The fact, therefore, that at present a little more than two-fifths of Alaska has been mapped on some scale does not tell the entire story. Much of the area now covered only by exploratory surveys should be resurveyed on a reconnaissance scale, and some of the area mapped on a reconnaissance scale should be remapped on a detailed scale. The inadequacy of information on which to base sound business enter-

prise in a region where the best maps available are on a scale of 4 miles to the inch is apparent not only to engineers but to all business men. At the rate at which the work is now being conducted it will be more than half a century before maps on even exploratory or reconnaissance scales will be available of those parts of the Territory that hold promise of commercial development.

#### PUBLICATIONS

During the year seven Alaskan reports have been issued. Thirteen reports that have been completed by the authors and approved for editing or printing are now in various stages of publication. Six reports are in active course of preparation, and several other reports have been begun, but additional field work will be required before their completion, and the time of publication is remote.

#### PROJECTS OF THE SEASON OF 1926

The projects carried on during the season of 1926 were distributed through all parts of the Territory and dealt with a wide range of subjects connected with the development of the mineral resources of Alaska.

#### *Approximate cost and distribution of work for the field season of 1926*

Region	Appropriation for 1926		Appropriation for 1927		Total
	Expenses	Salaries	Expenses	Salaries	
Southeastern Alaska.....	\$450	\$575	\$1,140	\$3,815	\$5,980
Copper River.....			210	640	850
Alaska Range.....	4,300	1,085	1,085	6,395	12,865
Yukon.....	4,115	800	1,815	3,150	9,800
Northern Alaska.....	7,870	3,620	1,400	3,840	16,730
General.....			500	1,340	1,840
Mineral resources.....				* 1,925	1,925
	16,735	6,080	6,150	21,105	50,000

\* Includes \$1,475 clerical salaries.

The work in southeastern Alaska was all related to the airplane mapping of that region that was carried on in 1926 by the Navy Department in response to a request from the Geological Survey. The items listed in the foregoing table do not include \$7,000 that was turned over to the Navy from an earlier appropriation for the necessary photographic supplies, nor does it include any of the expenditures made by the Navy. It includes only the salary and expenses of the Geological Survey representative, R. H. Sargent, topographer, who accompanied the expedition, and certain of the office expenses and salaries connected with printing the films and preparing them for use in map compilations from the pictures. This work was continued during the entire winter, and an additional allotment from the funds for projects of 1927 was made for it. The Navy expedition accomplished noteworthy results, and the whole-hearted cooperation of the many Government organizations that made this work a success is gratefully acknowledged.

The work in the Copper River region was of a general character and was directed principally toward the determination of the conditions under which the copper deposits of that area occur. This work was done by Fred H. Moffit in the course of the general investigations of the mineral resources of Alaska.

Combined geologic and topographic surveys were made on the eastern flanks of the Alaska Range in the vicinity of Skwentna River by a party in charge of S. R. Capps, geologist, and K. W. Trimble, topographer. Through cooperation

with the Alaska Railroad the transportation of the party from Anchorage to the mouth of Skwentna River was facilitated, and through the generosity of William N. Beach, who supplied an extensive pack train at a merely nominal charge, the cost of the work was reduced about \$4,000. No new areas of mineralization were discovered, but the geologic observations brought to light many data on the history of the region, and the topographic work affords reconnaissance maps of over 1,000 square miles.

North of Yukon River, in the unmapped valley of Sheenjek River, a combined geologic and topographic party in charge of J. B. Mertie, jr., geologist, with J. O. Kilmartin, topographer, did reconnaissance mapping. Unfortunately, one of the camp assistants was injured in the course of the work, so that it was necessary to make a short season and return to Fort Yukon for medical attention. In spite of the early close of this work about 1,200 square miles of hitherto unsurveyed country was mapped, and its principal geologic features were determined.

The work in northwestern Alaska was a continuation of the surveys first started in 1923, principally at the request of the Navy Department and at that department's expense, to determine the possibilities of petroleum in naval petroleum reserve No. 4. Although the Navy Department decided not to allot any more money to that work for the season of 1926, there were many points concerning the geology of the reserve and contiguous area that the Geological Survey felt required further examination before its task of exploring the region could be considered reasonably complete. A party consisting of Philip S. Smith, geologist, and Gerald FitzGerald, topographer, left for this region in February, 1926, and continued work there until late in August, when the last vessels which could be counted on for transportation left for the season. As a result of this work the geology and topography of an area of about 5,000 square miles was surveyed. Although this project cost more than any of the others that were undertaken in the season of 1926 and was in a most inaccessible region, where costs might be expected to be especially high, the extremely long season that was utilized and the consequently greater area covered made the unit cost of the work unusually low.

The work here grouped under general investigations includes a number of special studies. Among these may be mentioned the work done by F. H. Moffit relating to the general situation of the mineral industry in Alaska with a view to assisting in keeping track of the new work in progress and determining places in which further surveys would be most likely to bring productive results. Paleobotanic studies were made by C. A. Hollick with the aim of assisting the geologist in the correlation of coal-bearing beds in northern Alaska. Studies were made by J. B. Mertie of the igneous rocks which are in many regions the source of mineralization that has produced deposits of commercial value. In addition Mr. Mertie spent considerable time in the revision of a manuscript covering earlier work in northern Alaska.

In connection with the study of the Silurian fauna two new genera have been described by Edwin Kirk, in a paper to be published in the Proceedings of the United States National Museum. The description of the Permian fauna has been begun by G. H. Girty. Later Mesozoic invertebrates from northern Alaska were identified by J. B. Reeside, jr., and Triassic invertebrates from northern Alaska and Chitina Valley by T. W. Stanton.

Although no direct field expenditure is incurred for the collection of data on the production of minerals and ores, all the field geologists and engineers of the Geological Survey who are engaged in Alaskan work contribute much material as a by-product that would require the expenditure of several thousand dollars if the same data were collected as a separate investigation. As it is, the only expense of this work is part of the time of a clerk and about a month of the time of the chief Alaskan geologist. The result of this annual canvass of the mineral industry is a preliminary estimate of the production for the calendar year, issued on the succeeding January 1, and a more complete report issued as soon thereafter as final figures for the mineral production are available.

#### PROJECTS FOR THE SEASON OF 1927

The projects undertaken during the field season of 1927 have been under way only a short time at the end of the fiscal year, and all the parties are out of touch with any ordinary means of communication, so that it is not possible to make a detailed statement of the work actually accomplished during the fiscal year or the

precise cost of the work. The following table, however, sets down in summary form the areas in which the work is being done, the amounts allotted to the field work, and an estimate of the amounts for salaries that will be required for the surveys and for the necessary office work in completing for publication the maps and reports that will be prepared as an outcome of that work. In estimating the salaries it has been assumed that the work will be completed by the 1st of May, so that the field personnel will be available to start on the field projects of 1928 by that time; otherwise approximately \$3,700 additional for technical salaries will be required.

*Approximate cost and distribution of work for the field season of 1927*

Region	Appropriation for 1927		Appropriation for 1928		Total
	Expenses	Salaries	Expenses	Salaries	
Copper River.....	\$575	\$575	\$1,925	\$3,070	\$6,145
Alaska Peninsula.....	1,800	1,445	6,200	8,170	17,615
Yukon.....	4,250	2,510	2,750	6,420	15,930
Airplane map compilation.....			6,800		6,800
General.....	190		810	1,575	2,575
Mineral resources.....				* 1,950	1,950
	6,815	4,530	18,485	21,185	51,000

\* Includes \$1,500 for clerical services.

The projected work in the Copper River region has been planned to gather data regarding the geology of part of the Nizina and Chitina Valleys. Only a small party, in charge of F. H. Moffit with one camp hand, has been assigned to this work. This survey is necessary to correlate certain of the investigations that have been made in the region in earlier years, and to supplement those more general observations by studying certain areas in greater detail and by visiting new areas. All these studies are directed toward solving the geologic conditions relating to the formation of the copper ores of the district, and aiding in determining the geologic history of that part of Alaska. Mr. Moffit will also collect data regarding the general development of the mining industry in the Copper River region and will visit such operating mines as time and other conditions permit.

In the Alaska Peninsula the work planned is practically a continuation of the surveys made at the head of Skwentna River in the season of 1926. A combined geologic and topographic party in charge of S. R. Capps, geologist, with R. H. Sargent, topographer, left in May to carry on this work. The party planned to land on the west side of Cook Inlet and to survey the route westward to the mountains. On reaching the mountains connection with the surveys of 1926 will be effected if practicable, and the rest of the season will be spent in covering as much of the unmapped area as time and other conditions permit. This is a region about which practically nothing is known except that there is a broad lowland between the coast of Cook Inlet and the foothills, west of which are high, rugged mountains, many of which support glaciers. It is believed that mineralized rock similar to that found in other points along the Alaska Range may also occur in these mountains. Part of the lowlands are undoubtedly underlain by coal beds.

Geologic and topographic surveys to cover parts of the unexplored region north of the Yukon have been approved. These surveys will connect with the earlier surveys made in part of the Chandalar River valley and will be carried through as much of the country to the north and east as practicable, so as to join with the surveys made in the season of 1926 on Sheenjek River. In order to take advantage of the better traveling conditions that are found before the snow disappears, Gerald FitzGerald, topographer, left in February to go by the usual routes to Fairbanks, and thence overland to Fort Yukon, where he procured the necessary supplies for a six-months field season. According to the plans Mr. FitzGerald and the outfit were then to proceed over the snow to a suitable place on the East Fork of Chandalar River and thence to distribute the supplies in convenient caches for use during the summer. With the opening of navigation J. B. Mertie, jr., geologist, in charge of the

party, went by the usual routes down the Yukon and after picking up supplies and equipment at Fort Yukon proceeded up Chandalar River to join Mr. FitzGerald. The region is so little known that no forecast of what the party will find in it can yet be made, but presumably parts of the region are mineral bearing.

Work on the task of compiling maps from the airplane pictures taken by the Navy Department has been kept continuously under way, and an additional allotment has been made from the appropriation for 1928 to cover the cost of preparing the photographs and taking from them the essential data to be incorporated in the maps.

The only work of a general character that was to be done in the field season of 1927 is a general survey of the mineral industry, especially in the southwestern part of Alaska. This work was assigned to Philip S. Smith, who left Washington June 26 to study certain of the mining camps in Seward Peninsula and along the southwestern part of Yukon River.

#### SALARIES AND OTHER EXPENDITURES

The item for other technical services includes all payments made for salaries of the permanent technical force of geologists and engineers. It covers all time spent on various projects, exclusive of administrative duties.

There has been a material reduction in the technical personnel employed during the season of 1927. This has been caused by the small amount of funds available, which has made it necessary to dispense with all but two topographers. Even a further reduction in field activities would have been required had not a furlough of five months been granted to one of the topographers. The curtailment resulted in setting free some funds, but was probably a greater loss to the Government than the total saving, because important work had to be laid aside or handled less efficiently by others not so conversant with the details, all of which took more time and gave less sure results. Furthermore, the necessity for all the highest-grade men doing many minor jobs because of the virtual elimination of assistants of lower grades and salary slowed up the work and doubtless made the unit cost higher.

The item for administrative salaries covers only those salaries that are related to the administration of the branch as a whole. The amount expended for administration is unusually low because, owing to the shortage of funds, it has been necessary to eliminate as much administration as possible and use the customary administrative officers on field projects.

All the clerical and drafting work is performed by one chief clerk, one assistant clerk, and one draftsman. Part of the time of the chief clerk, Miss L. M. Graves, was spent in branch administration. About three-fourths of the time of the assistant clerk is devoted to the preparation of the statistical inquiries relating to the annual mineral production of the Territory and tabulating and computing the results from the replies to these inquiries. The clerical personnel is entirely too small to handle the large volume of work, so that only the most pressing matters can be attended to, and many jobs that might better and more cheaply be done by a clerk must now be done by the technical members rather than incur the otherwise inevitable delay.

The miscellaneous expenses for the operation of the branch are comparatively small and do not include any items directly required in connection with the field projects, such as equipment and supplies, which are charged directly against the specific projects for which they are bought.

#### MINERAL-LEASING WORK

The mineral-leasing work in Alaska was conducted from an allotment of \$19,500 from a separate item in the appropriation for the Geological Survey. In order that the policies and practices that have been developed for handling the much larger volume of similar work in the States should be maintained so far as they are applicable or appropriately modified to meet Alaskan conditions and in order to utilize the existing agency that is conversant with Alaskan affairs, the general administration of the leasing work in Alaska rests jointly with the conservation branch and the Alaskan branch. For

the conduct of the field work an office is maintained at Anchorage, Alaska, in charge of B. D. Stéwart, supervising mining engineer, with a staff of two other engineers, together with the necessary clerical assistance. During the fiscal year 1927 the following was the approximate distribution of funds expended by this office:

Administrative salaries .....	\$3, 500
Other technical salaries.....	12, 000
Clerical salaries .....	1, 500
Field and office expenses.....	2, 500

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

The principal leasing activities during the year centered around the coal-mining operations along the line of the Alaska Railroad in the Matanuska and Healy River fields. Here the work of the Federal engineers served not only to take care of the Government's direct interest in its various leases but also to assist the operators with sound technical advice, which enabled them to solve some of their problems and was thus of indirect benefit to the Government and the mining industry. Investigations were also made during the year in the Porcupine region, Hyder district, and part of the Ketchikan region of southeastern Alaska; in the Teikel region, north of Valdez; in the Port Wells district and other parts of the country adjacent to Prince William Sound; in the Kenai district; in the vicinity of Fairbanks; at many places in the Kuskokwim Valley; and in most of the mining districts of Seward Peninsula.

In addition to the principal assigned work of this group of engineers, their familiarity with mining matters throughout many parts of the Territory and their availability for consultation enabled them 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 office also acts as a local distributing office for handling publications of the Geological Survey and assists in furnishing the main office with information on many phases of the mineral industry.

The Alaska office was one of the activities transferred to the Geological Survey from the Bureau of Mines when that bureau was taken over into the Department of Commerce at the beginning of the last fiscal year. One of the reasons for that change was that economies of operation might be effected. It has not yet been practicable to put into effect many of the changes that would produce closer coordination between the two types of work carried on by the Alaskan branch, because both appropriations have been materially reduced, so that the work could not be maintained even on its former scale. It is planned, however, that when funds are available fuller utilization of this office in the regular mineral-resources work of the Alaskan branch will be made and that it will participate in many of the activities now carried on under the other appropriation.

For the field season of 1927, the beginning of which is financed from 1927 funds and the later part from 1928 funds, there will be some further curtailment, as only \$14,500 has been allotted for this work from the 1928 appropriation. This amount will be barely sufficient to pay the salaries of the permanent force engaged in leasing work with a small allowance for the maintenance of the office and the necessary traveling expenses. The present plans, therefore, contemplate the continuance of only the most pressing of the investigations and will doubtless necessitate even further reduction of personnel if the essential duties are to be performed. Under these conditions no broad, systematic scheme of investigation can be planned in advance, but instead only a few of the specific jobs as they arise can be given attention.

## 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 except that J. H. Wheat, topographic engineer in charge of section of photographic mapping, has succeeded T. P. Pendleton, who resigned.

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, 2 topographic and geodetic engineers, 122 associate, assistant, and junior topographic, geodetic, or cartographic engineers, and 27 engineering field aids and draftsmen, a total of 169. The clerical force comprised 13 clerks.

## EXPENDITURES

*Appropriations and expenditures for topographic surveys for the fiscal year ended June 30, 1927*

State or project	Appropriation, topographic surveys	Repayments for work performed for other Federal units	Total Federal funds	State cooperative funds	Total funds
Appropriations and allotments.....	\$451,700.00	\$43,831.75	\$495,531.75	\$409,393.70	\$904,925.45
Credits on account of refunds.....	1,358.94	573.05	1,931.99		1,931.99
<b>Total funds available.....</b>	<b>453,058.94</b>	<b>44,404.80</b>	<b>497,463.74</b>	<b>409,393.70</b>	<b>906,857.44</b>
<b>Expenditures:</b>					
Alabama.....	16,219.51		16,219.51	13,938.21	30,157.72
Arizona.....	24,003.11	5,157.63	29,160.74	25,000.00	54,160.74
Arkansas.....	43.33		43.33		43.33
California.....	26,242.34	5,092.86	31,335.20	14,000.84	45,336.04
Colorado.....	17,951.88		17,951.88	14,714.43	32,666.31
Delaware.....	9,230.16		9,230.16	2,915.25	12,145.41
Georgia.....	561.18		561.18	1,073.60	1,634.78
Hawaii.....	24,606.39		24,606.39	19,001.86	43,608.25
Idaho.....	3,631.46	5,539.19	9,170.65		9,170.65
Illinois.....	40,938.74		40,938.74	53,049.67	93,988.41
Iowa.....	1,466.98		1,466.98	1,434.67	2,901.65
Kansas.....	5,838.93		5,838.93		5,838.93
Kentucky.....	49,323.41		49,323.41	49,998.30	99,321.71
Maine.....	5,580.87		5,580.87	7,048.46	12,629.33
Michigan.....	17,844.38		17,844.38	19,166.41	37,010.79
Missouri.....	16,241.20		16,241.20	13,500.05	29,741.25
Nevada.....	1,038.78		1,038.78		1,038.78

*Appropriations and expenditures for topographic surveys for the fiscal year ended June 30, 1927—Continued*

State or project	Appropriation, topographic surveys	Repayments for work performed for other Federal units	Total Federal funds	State cooperative funds	Total funds
<b>Expenditures—Continued.</b>					
New Hampshire.....	\$9,804.49	\$11,845.59	\$21,650.08	\$25,089.93	\$46,740.01
New Mexico.....	130.72	-----	130.72	3,000.00	3,130.72
New York.....	10,153.38	-----	10,153.38	20,000.00	30,153.38
North Dakota.....	10,451.69	-----	10,451.69	15,983.80	26,435.49
Oklahoma.....	841.28	-----	841.28	-----	841.28
Oregon.....	5,338.37	2,238.27	7,576.64	2,307.76	9,884.40
Pennsylvania.....	29,857.90	-----	29,857.90	29,750.51	59,608.41
Tennessee.....	15,300.70	-----	15,300.70	11,529.03	26,829.73
Texas.....	18,095.93	-----	18,095.93	21,277.03	39,372.96
Utah.....	6,108.87	-----	6,108.87	7,056.98	13,165.85
Vermont.....	1,792.04	-----	1,792.04	5,098.62	6,890.66
Virginia.....	11,573.10	-----	11,573.10	15,612.81	27,185.91
Washington.....	5,915.77	-----	5,915.77	1,476.59	7,392.36
West Virginia.....	2,960.55	-----	2,960.55	-----	2,960.55
Wisconsin.....	16,834.01	-----	16,834.01	16,368.89	33,202.90
Books for library.....	147.17	-----	147.17	-----	147.17
Computing.....	<sup>a</sup> 3,794.55	-----	3,794.55	-----	3,794.55
Contingent.....	6,057.24	-----	6,057.24	-----	6,057.24
Field distribution offices.....	1,003.33	-----	1,003.33	-----	1,003.33
Field instruments.....	<sup>a</sup> 2,085.35	-----	2,085.35	-----	2,085.35
Field stationery.....	150.00	-----	150.00	-----	150.00
Geographic names.....	3,826.36	-----	3,826.36	-----	3,826.36
Inspection and editing.....	<sup>a</sup> 4,139.34	-----	4,139.34	-----	4,139.34
Map information.....	3,199.38	-----	3,199.38	-----	3,199.38
One-millionth maps.....	8,275.57	-----	8,275.57	-----	8,275.57
Miscellaneous repay.....	-----	14,531.26	14,531.26	-----	14,531.26
Office salaries.....	<sup>a</sup> 5,404.44	-----	5,404.44	-----	5,404.44
Photographic mapping.....	<sup>a</sup> 855.29	-----	855.29	-----	855.29
Relief maps.....	1,413.89	-----	1,413.89	-----	1,413.89
Total expenditures.....	<sup>b</sup> 446,273.36	44,404.80	490,678.16	409,393.70	900,071.86
Budget reserve.....	5,800.00	-----	5,800.00	-----	5,800.00
Unexpended balance.....	985.58	-----	985.58	-----	985.58
	453,058.94	44,404.80	497,463.74	409,393.70	906,857.44

<sup>a</sup> Represents 26 per cent of expenditure; balance of 74 per cent included in charges for State cooperation  
<sup>b</sup> \$381,911.83 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 and in the computation and adjustment of the results of control field work. The preparation of a new base map of the United States was completed. A map of the Tacna-Arica area was prepared for the Department of State, and a map of the town of Arica was made for the Boundary Survey Commission. Cooperation with the Air Corps, United States Army, was continued whereby aerial photographs were furnished for use in topographic mapping.

#### SUMMARY OF RESULTS

The status of topographic surveys on June 30, 1927, is shown in the following table:

*New topographic surveys in the United States, July 1, 1926, to June 30, 1927, 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, 1927 (square miles)	Percentage of total area of State mapped to June 30, 1927	River surveys, scale 1: 31,680 (linear miles)	Spirit levels (miles)	Transit traverse (miles)	Triangulation stations occupied	
		12,000	24,000	31,680	48,000	62,500	125,000	250,000	Revision	Resurvey	New survey							
Alabama	20					769					769	21,240	40.8				231	
Arizona	5, 25, 100					1,426					1,426	58,398	51.3	72		125		6
Arkansas												21,494	40.3					
California	5, 50		70	730	83					143	740	125,091	79.0			190	191	
Colorado	20, 25, 50	25		14		537					562	55,163	33.0			401		
Connecticut												4,965	100.0					
Delaware	10					203					203	2,370	100.0					
District of Columbia	10			30							30	70	100.0					
Florida												4,716	8.0					
Georgia	20					71					71	24,835	41.9			13		
Idaho	5, 100							245			245	29,951	35.7		191			
Illinois	5, 10, 20		483			920					448	28,746	50.7			584	217	
Indiana	5		18								18	3,662	10.1					
Iowa	20					122					122	12,842	22.9					
Kansas												64,159	78.0				218	
Kentucky	20, 50					1,712					180	22,255	54.8			862	730	
Louisiana												8,810	18.2					
Maine	20					317					317	12,252	37.0			103	20	
Maryland	10			50							50	12,327	100.0					
Massachusetts												8,266	100.0					
Michigan	5, 10, 20					840						12,329	21.3			448	93	
Minnesota												7,354	8.7					
Mississippi												3,881	8.3					
Missouri	20					342					8	43,079	62.1			304	635	
Montana												41,590	28.5					
Nebraska												27,117	35.0					
Nevada	50, 100			60							120	44,642	40.3					
New Hampshire	20					925						6,221	66.6			406		
New Jersey												8,224	100.0					
New Mexico	25, 50							40			40	40,452	33.0					
New York	10, 20	59				309					368	49,245	100.0			94		
North Carolina												19,003	36.2					
North Dakota	20					939						11,388	16.0			321	234	
Ohio												41,040	100.0					
Oklahoma												39,908	57.0					
Oregon	5, 20, 50, 100							460			30	29,981	31.0	37		88		
Pennsylvania	20					1,026					20	34,296	76.0			345	431	18
Rhode Island												1,248	100.0					

*New topographic surveys in the United States, July 1, 1926, to June 30, 1927, and total area surveyed in each State—Continued*

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, 1927 (square miles)	Percentage of total area of State mapped to June 30, 1927	River surveys, scale 1: 31,680 (linear miles)	Spirit levels (miles)	Transit traverse (miles)	Triangulation stations occupied	
		12,000	24,000	31,680	48,000	62,500	125,000	250,000	Revision	Resurvey	New survey							
South Carolina												13,737	44.3					
South Dakota												19,243	24.8					
Tennessee	20					659						659	54.6		247	105		
Texas	2, 5, 10, 20		263			472						735	32.5					
Utah	5, 25		179									179	22.4		30			
Vermont	20					324						324	76.0		44			
Virginia	10, 20, 50			70		685			70	531	154	37,546	88.0		335			14
Washington	100						95				95	34,534	50.0					
West Virginia	50					789			789			24,170	100.0					
Wisconsin	20					426					426	17,376	31.0		134	182		
Wyoming												30,102	30.7					
Total continental United States (exclusive of Alaska)		84	1,013	894	143	13,813	840	120	983	1,990	13,934	1,294,853	42.8	300	5,170	3,287		38
Hawaii	50					696					696	5,686	88.2		28			

## FIELD SURVEYS

*Alabama.*—In cooperation with the State geologist of Alabama the survey of the Montgomery, Adger, and Eutaw quadrangles was completed.

*Arizona.*—In cooperation with the State water commissioner of Arizona the survey of the Bridge Canyon, Stoval, and Sentinel No. 2 quadrangles and of a dam site on Williams River, in Yuma County, was completed and that of the Big Horn Mountains, Kim, Sentinel No. 3, Quartzsite No. 1, Quartzsite No. 2, Powell No. 1, and Powell No. 4 quadrangles was begun. For the conservation branch a plan and profile survey of Little Colorado River was completed.

*California.*—In cooperation with the State engineer of California the survey of the Angiola, Stratford, Porterville, Delano, Pixley, Earlimart, Allensworth, Ducor, Richgrove, No. 47, No. 48, and No. 54 quadrangles and of the Terra Bella project (parts of the Ducor, Porterville, Success, and No. 49 quadrangles) was completed and that of the No. 55 quadrangle was begun. At the request of the National Park Service the survey of the Lassen Volcanic National Park was completed. The survey of the Elk Hills Naval Reserve was begun.

*Colorado.*—In cooperation with the Colorado School of Mines the survey of the Grand Valley, Roan Creek, and Highmore quadrangles was completed and that of the Taylor Park quadrangle was begun. In cooperation with the Colorado Metal Mining Fund the survey of Bonanza and vicinity was extended. At the request of the National Park Service the culture was revised for a part of the Mesa Verde National Park.

*Delaware.*—In cooperation with the State Highway Department of Delaware the resurvey of the Deepwater Point quadrangle was continued and that of the Naxontown Pond quadrangle was begun (areas previously surveyed on a smaller scale).

*Georgia.*—In cooperation with the State geologist of Georgia the resurvey of the Tate quadrangle was completed (area previously surveyed on a smaller scale).

*Hawaii.*—In cooperation with the commissioner of public lands of the Territory of Hawaii the survey of the Waiki NE.  $\frac{1}{4}$  and SE.  $\frac{1}{4}$ , Kaohe SE.  $\frac{1}{4}$  and NE.  $\frac{1}{4}$ , Humuula SW.  $\frac{1}{4}$  and NW.  $\frac{1}{4}$ , and Mauna Kea SE.  $\frac{1}{4}$  quadrangles and the island of Niihau was completed and that of the Humuula NE.  $\frac{1}{4}$  quadrangle was begun.

*Idaho.*—At the request of the Forest Service the survey of the Casto quadrangle was completed. For the conservation branch a plan and profile survey of Clark Fork from Horse Creek, Mont., to Albany Falls, Idaho, and Pend Oreille Lake was completed.

*Illinois.*—In cooperation with the Illinois Department of Registration and Education, Geological Survey, the survey of the Normal and Mount Sterling quadrangles and the Illinois part of the Vera and Nebo quadrangles was completed and that of the Pearl, Meredosia, Glasford, Iuka, Danvers, McLean, and Le Roy quadrangles and the Illinois part of the Alton quadrangle was begun. The resurvey of the Springfield quadrangle was completed. The resurvey of the Wheeling, Highland Park, Harvey, Chicago Loop, Park Ridge, Jackson Park, Calumet City, Evanston  $7\frac{1}{2}'$ , Tinley Park, Englewood, and Elmhurst quadrangles was completed and that of the Calumet Lake and Mokena quadrangles was begun (areas previously surveyed on a smaller scale).

*Indiana.*—In cooperation with the Illinois Department of Registration and Education the resurvey of the Indiana part of the Calumet Lake and Calumet City quadrangles was completed.

*Iowa.*—In cooperation with the director of the Iowa Geological Survey the survey of the Bondurant quadrangle was begun.

*Kentucky.*—In cooperation with the State geologist of Kentucky the survey of the Taylorsville quadrangle and of the Kentucky part of the Paducah, Greenup, Big Stone Gap, Byrdstown, Lillydale, Tompkinsville, Mound City, and Smithland quadrangles was completed and that of the La Grange, Big Clifty, Creelsboro, and Chilesburg quadrangles was begun. The resurvey of the Kentucky part of the Middlesboro, Hagan, and Sneedville quadrangles was completed (areas previously surveyed on a smaller scale).

*Maine.*—In cooperation with the Public Utilities Commission of Maine the survey of the Dixfield quadrangle was completed and that of the Rumford Falls, Stockholm, and Bigelow quadrangles was begun. In cooperation with the War Department the survey of the Lake Duncan quadrangle was begun.

*Michigan.*—In cooperation with the Michigan Department of Conservation, Geological Survey, the survey of the Mount Clemens, Corunna, Three Oaks, South Haven, and Glen Lord quadrangles was completed and that of the Benton Harbor, Niles, and Breedsville quadrangles was begun.

*Missouri.*—In cooperation with the State geologist of Missouri the survey of the Des Arc quadrangle was completed and that of the Knob Lick and Twelve-mile quadrangles and the resurvey of the Fulton No. 2 quadrangle was begun.

*Nevada.*—At the request of the geologic branch the survey of the Lowry Peak quadrangle was completed. At the request of the Navy Department a reconnaissance survey of Dry Valley, in the vicinity of Sand Pass, Washoe County, was completed.

*New Hampshire.*—In cooperation with the Highway Department of New Hampshire the survey of the Mount Kearsarge, Hillsboro, and Lovewell Mountain quadrangles and the New Hampshire part of the Claremont quadrangle was completed and that of the Danbury and Mascoma Lake quadrangles was begun. In cooperation with the War Department the survey of the New Hampshire part of the Averill quadrangle was completed and that of the Second Lake quadrangle was begun.

*New Mexico.*—In cooperation with the State engineer of New Mexico the survey of the Tucumcari quadrangle was begun.

*New York.*—In cooperation with the New York State engineer the resurvey of the Cohoes and Cossackie quadrangles was completed and that of the Schenectady quadrangle was resumed. In cooperation with the commissioners of the Palisades Interstate Park the survey of the Palisades Park was begun.

*North Dakota.*—In cooperation with the State engineer of North Dakota the survey of the Kongsburg, Coleharbor, Benedict, Minot, Dogden, and Sawyer quadrangles was completed and that of the Drake quadrangle was begun.

*Oregon.*—In cooperation with the State engineer of Oregon the survey of the Bend quadrangle was completed. At the request of the Forest Service the survey of the Elkhorn quadrangle was completed. For the conservation branch plan and profile surveys of the Middle Fork of Willamette River and Sandy River were completed.

*Pennsylvania.*—In cooperation with the Pennsylvania Department of Forests and Waters, Topographic and Geological Survey, the survey of the Youngsville quadrangle was completed; that of the Eagles Mere, Titusville, Townville, and Tidioute quadrangles was continued; and that of the Clearville and Hyndman quadrangles was begun.

*Tennessee.*—In cooperation with the Tennessee State geologist the survey of the Gordonsville and Decherd quadrangles was completed and that of the Erin quadrangle was begun.

*Texas.*—In cooperation with the Texas Board of Water Engineers the survey of the Quana 3-a and Quana 3-b quadrangles was completed. In cooperation with the State Reclamation Department of Texas the survey of the Upper Brazos River project, Marlin to Jones Bridge, was completed. In cooperation with Orange County, Tex., the survey of the Orange County part of the Lakeview, Mauriceville, Texla, Terry, Orangefield, Vidor, Echo, and Orange quadrangles was completed. In cooperation with separate interests acting through the Texas Board of Water Engineers the survey of the Lufkin 4-b, Lufkin 4-c, Lufkin 4-d, Zavalla 3-c, Zavalla 3-d, Colmesneil 2-b, and Livingston 1-a quadrangles of the Neches River project was begun.

*Utah.*—In cooperation with Weber and Davis Counties, Utah, and the Bureau of Reclamation the survey of these counties was continued.

*Vermont.*—In cooperation with the State geologist of Vermont the survey of the Vermont part of the Claremont and Walpole quadrangles was completed and that of the Hyde Park quadrangle was begun. In cooperation with the War Department the survey of the Vermont part of the Averill quadrangle was completed.

*Virginia.*—In cooperation with the director of the Geological Survey of Virginia the survey of the Critz quadrangle was completed. The resurvey of the Covesville quadrangle was completed and that of the Remington and Speedwell quadrangles was begun (areas previously surveyed on a smaller scale).

*Washington.*—In cooperation with the Department of Conservation and Development of Washington the survey of the Chewelah quadrangle was resumed. At the request of the Forest Service the survey of the Washington part of the Hood River quadrangle was completed.

*West Virginia.*—In cooperation with the State geologist of West Virginia the culture was revised for the Logan and Holden quadrangles and for the West Virginia part of the Matewan and Naugatuck quadrangles.

*Wisconsin.*—In cooperation with the Geological and Natural History Survey of Wisconsin the survey of the Whitehall, North Bend, and Galesville quadrangles and the Wisconsin part of the Winona quadrangle was completed, that of the Strum quadrangle resumed, that of the Montana quadrangle continued, and that of the La Crescent quadrangle 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 3 in the technical force. At the end of the year the force comprises 118 technical and 25 clerical employees.

## FUNDS

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

Gaging streams-----	\$151,000.00
Repayments by cooperating Government or State organizations-----	132,565.31
	<hr/>
	283,565.31

## 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-----	\$17,000.00
California:	
State-----	\$23,513.07
County and city (gaging streams)-----	18,644.87
Municipal (ground water)-----	3,422.76
	<hr/>
	45,580.70
Colorado-----	806.02
Hawaii:	
Territory-----	\$26,827.92
Municipal-----	1,080.07
	<hr/>
	27,907.99
Idaho:	
Gaging streams-----	13,861.32
Ground water-----	250.00
	<hr/>
	14,111.32
Illinois:	
State-----	4,791.70
Municipal-----	60.00
	<hr/>
	4,851.70
Iowa-----	1,492.81
Kansas:	
State-----	\$1,666.53
Municipal-----	60.00
	<hr/>
	1,726.53
Maine-----	5,215.27

Maryland :			
State.....		\$296. 46	
Municipal.....		136. 12	
			\$432. 58
Massachusetts.....			3, 801. 44
Minnesota.....			378. 53
Missouri.....			9, 881. 92
Montana.....			4, 943. 43
Nevada.....			1, 687. 11
New Hampshire.....			1, 395. 31
New Jersey :			
Stream gaging.....	\$11, 249. 35		
Ground water.....	7, 878. 19		
			19, 127. 54
New Mexico :			
State.....		347. 16	
County.....		2, 615. 78	
			2, 962. 94
New York :			
State.....	17, 595. 88		
Municipal.....	84. 00		
			17, 679. 88
North Carolina :			
State.....		6, 793. 08	
Municipal.....		727. 83	
			7, 520. 91
Ohio.....			25, 315. 65
Oregon :			
State.....	\$4, 991. 24		
Municipal.....	1, 413. 93		
			6, 405. 17
Pennsylvania.....			1, 684. 00
Tennessee.....			13, 724. 46
Texas.....			25, 035. 96
Utah.....			6, 495. 49
Virginia.....			14, 099. 03
Washington :			
State.....	\$6, 751. 82		
Municipal.....	1, 372. 58		
			8, 124. 40
West Virginia.....			399. 86
Wisconsin.....			6, 844. 93
Wyoming.....			4, 826. 01
			<hr/>
			301, 458. 89

The work done under cooperative agreements with the States has been restricted to studies of stream flow, except in Idaho, New Jersey, New Mexico, and Pennsylvania, where ground-water investigations have been made. (See pp. 48, 49.)

*Bureau of Reclamation.*—The measurement of streams that are to furnish water to reclamation projects under construction was continued in cooperation with the Bureau of Reclamation. The field work was done by Geological Survey engineers, and the cost was met by the Bureau of Reclamation through transfer of funds. Geologic investigations were made for the Bureau of Reclamation in New Mexico and Washington.

*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.

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

*Forest Service.*—A study of stream flow in the Angeles National Forest, in southern California, was continued in cooperation with the Forest Service.

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

*Office of the Chief of Engineers.*—Stream gaging has been done in the basins of Tennessee and Cumberland Rivers in cooperation with the office of the Chief of Engineers.

*Bureau of Mines.*—An examination for a ground-water supply near Amarillo, Tex., was made for the Bureau of Mines.

*Department of Justice.*—A study of the ground-water supply for a Federal institution near Alderson, W. Va., was made for the Department of Justice.

*Department of State.*—Within the year the Geological Survey has taken over from the Department of State the stream gaging related to the division between the United States and Canada of the waters of Milk and St. Mary Rivers and between the United States and Mexico of the waters of the Rio Grande. An investigation is being made for the Department of State of seepage losses in the Rio Grande with especial view to the possible location of reservoir sites. The cost of all this work is met by funds transferred to the Geological Survey from the Department of State.

*Federal Power Commission.*—The operations of 1 licensee of the Federal Power Commission in Arizona, 14 in California, 1 in Colorado, 7 in Idaho, 1 in Montana, 2 in Nevada, 9 in Oregon, 1 in Utah, 6 in Washington, and 1 in Wisconsin and of 3 permittees of the commission in Arizona, 1 in Colorado, 4 in Idaho, 2 in Oregon, 1 in Wyoming-Utah, and 1 in Wyoming were supervised by the Geological Survey. All stream gaging by permittees of the commission is done in cooperation with the Geological Survey. Such cooperative stream gaging is in progress in Alabama, Arkansas, California, Colorado, 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.

#### PUBLICATIONS

The publications of the year prepared by the water-resources branch comprised 17 reports and 4 separate chapters. At the end of the year 8 other reports were in press and 27 manuscripts were awaiting editorial work or 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 41 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 com-

puted, are collected. At the end of the year 1,749 gaging stations were being maintained; 234 stations were discontinued and 253 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 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 order to provide a more secure basis for ground-water investigations. Work on the laws of head and flow of artesian water has been done in the investigations of four great artesian basins—that of the Dakota sandstone in North and South Dakota, that of the Coastal Plain of New Jersey, the Roswell Basin in New Mexico, and the basin in the vicinity of Honolulu. Critical studies of the principles of recharge and discharge of ground water, fluctuations of the water table, and the relation of vegetation to ground water have been made especially in the investigations in the Escalante Valley, Utah, and the Mokelumne area in California. 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. One of the products of this work is a paper by O. E. Meinzer on the compressibility and elasticity of artesian aquifers. During the year considerable attention was given by Mr. Meinzer to the geology of large springs, the occurrence and behavior of ebbing and flowing springs, the history of the development of quantitative methods in ground-water work in this country and in Europe, the data and laws of seepage losses from streams, and the general problem of making inventories of the water that falls as rain or snow.

In recent years most of the geologic investigations of reservoir sites have been made by the division of ground water, and much attention has been given to the principles involved and to the available methods of investigation. A brief general paper on the geology of reservoir and dam sites, with a bibliography, has been prepared by Kirk Bryan for publication as a water-supply paper. During the year investigations relating to ground water and reservoir sites were conducted in 16 States and Hawaii. About 40 investigations were in progress, of which 18 were completed and reports thereon submitted. Of the completed reports 12 related to ground water and 6 to reservoir sites. Eight reports that were completed in this or previous years were published, 3 of them by the Geological Survey and 5 by the State of New Mexico. Cooperation was continued with the North Dakota and Minnesota well drillers' associations, especially with the committees of these associations on specifications for class A farm wells. Attention was also given to projects for organizing associations in several other States with a view to developing higher standards and better results in water-well drilling. The division was instrumental in bringing about a conference in the National Research Council on well drilling and well records, which resulted in the organization of a committee on conservation of scientific results of

drilling and improvement of drilling methods and equipment, which functions as a committee of the National Research Council and also as the national committee of the International Well Drilling Congress. Mr. Meinzer serves as the representative of water-well drilling on this committee and also as the representative of hydrology on the council's committee on sedimentation. 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*.

The work on quality of water involved the examination of 534 samples of water with reference to their dissolved mineral matter and of 218 samples taken in connection with the study of silt carried by streams. Information as to the chemical character of surface and ground water is collected and is made available through publication and by correspondence. The methods used for the analysis of water are described in a manuscript that was nearly completed for publication during the year 1927. A short paper on "Natural sodium bicarbonate waters in the United States," by W. D. Collins and C. S. Howard, was published in *Industrial and Engineering Chemistry*, and a note on "The radioactivity of natural waters," by W. D. Collins, was published in *Public Health Reports*.

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, 1927, 2,058 companies operating 3,805 power plants with a total capacity of generators of 25,398,000 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.

*Electricity produced at public-utility power plants in the United States, 1919-1926*

Year	Total		Water power			Fuel power		
	Kilowatt-hours	Change from previous year (per cent)	Kilowatt-hours	Per cent of total	Change from previous year (per cent)	Kilowatt-hours	Per cent of total	Change from previous year (per cent)
1919....	38,921,000,000	-----	14,606,000,000	37.5	-----	24,315,000,000	62.5	-----
1920....	43,555,000,000	+11.9	16,150,000,000	37.1	+10.6	27,405,000,000	62.9	+12.7
1921....	40,975,000,000	-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....	59,013,000,000	+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

*Fuel consumed in the production of electricity at public-utility power plants in the United States, 1919-1926*

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

The marked improvement in the utilization of fuel by electric public-utility power plants during the period covered by these power reports was continued during 1926, when the average consumption of coal was 1.95 pounds per kilowatt-hour, a decrease of about 7 per cent from the figure for 1925. The conservation of fuel due to this increase in efficiency in the seven years since 1919 amounted to about 100,000,000 tons of coal. Tables showing the capacity of all prime movers used in the production of power in the United States and the amount of power produced by electric public-utility power plants were compiled and prepared for publication in Water Supply Paper 579, which will contain the following separate papers: "The development of horsepower equipment in the United States," by C. R. Daugherty; "Developed and potential water power in the United States and monthly production of electricity by public-utility power plants, 1919-1926," by A. H. Horton; and "Growth of water-power development in the United States," by R. W. Davenport.

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. 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 maintained by the Geological Survey and cooperating parties for the year ended June 30, 1927

State or Territory	Geological Survey alone	Bureau of Reclamation	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.....					6			1		9	1	15	5		57	7
Arizona.....	1		3		3			42	4	2	15	40	2	1	995	12
Arkansas.....										1	1	1	1	1	6	
California.....			20	1			5	223	64	97	185	225	13	14	3,396	414
Colorado.....		2						32	3	7	11	33	2	1	142	3
Connecticut.....										2		2			7	
Delaware.....																
Florida.....										6		6	4		52	26
Georgia.....										10		10	3		70	59
Idaho.....		6	6			2		106	132	80	91	241	123	125	2,169	367
Illinois.....					2	2		34	1	5	10	34	4	1	58	1
Indiana.....								1		1	1	1		1	3	
Iowa.....						6		11		6	2	21			83	5
Kansas.....						3		24	1	3	7	24			92	1
Kentucky.....					12					13	12	13		1	48	17
Louisiana.....																
Maine.....								19		9	9	19	2		125	1
Maryland.....	2							2	4	2	2	8	2		83	5
Massachusetts.....								17		1	1	17		1	108	8
Michigan.....										2		2			3	
Minnesota.....					2			5		7		14		2	21	
Mississippi.....																
Missouri.....					1	2		56		20	23	56	4	5	337	10
Montana.....		2	2				23	40		7		74	10	2	281	10
Nebraska.....																
Nevada.....				2				18		8	10	18	1	2	48	1
New Hampshire.....								16		13	13	16	1		60	6
New Jersey.....						1		36	8	5	14	36	1	1	264	57
New Mexico.....															1	1
New York.....					1			76	1	42	44	76	6	4	559	5
North Carolina.....					16			41	11	13	37	44	2	15	179	21
North Dakota.....																
Ohio.....					5	3		92	15	6	29	92	9		375	30
Oklahoma.....										2		2			14	
Oregon.....			1			8		88	23	51	83	88	12	15	576	54
Pennsylvania.....								2		2		2	2			
Rhode Island.....										7		7	3		46	8
South Carolina.....																
South Dakota.....																
Tennessee.....					58	6		61		10	74	61	6		378	10
Texas.....						12	5	101	15	14	46	101		14	790	58
Utah.....		4				1		54	1	16	22	54	5	5	162	31
Vermont.....										5		5			8	
Virginia.....						1		57	3	11	15	57	10	1	257	8
Washington.....	1		2	4	1		2	48	22	30	48	62	10	6	321	164
West Virginia.....					7			1	1	8		17		5	20	
Wisconsin.....					1			36		9	10	36	2	6	142	10
Wyoming.....		6		4		1	7	21		6	6	39	4	1	137	2
Hawaii.....								80	6	22	28	80	5	3	292	140
	3	21	31	14	112	50	43	1,441	315	570	851	1,749	253	234	12,765	1,551

*Alaska.*—Five samples of spring water were analyzed for the Alaska Railroad.

*Arizona.*—Some progress was made on a report on the geology and water resources of San Pedro Valley, by Kirk Bryan and G. E. P. Smith. Water-Supply Paper 596-B, "Quality of water of Colorado River, 1925-26," was prepared and analyses were made of additional samples collected from the river throughout the year at Grand Canyon, Topock, and Yuma. Field studies by C. S. Howard at the sampling points improved the methods of sampling and made the results more useful. Hydraulic engineers accompanied a topographic survey party that mapped Little Colorado River from Tolchico to the mouth of the river. Surveys of all dam sites in that stretch were made under their supervision, and a report on the potential water power and storage capacities of the dam sites is in preparation.

*Arkansas.*—Studies of the temperature and mineral composition of the water of Hot Springs National Park were continued by Mr. Bryan.

*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 23 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. The work has been extended, at the request of the State division of water rights, to include the adjacent fan of Calaveras River. Some of the large and hot springs in the region of volcanic rock in northeastern California were examined by Messrs. Meinzer and Stearns, and Mr. Stearns prepared a brief paper on the geology of the Lava Beds National Monument. The geology of the Mill Creek and Elk Creek dam sites and Round Valley reservoir site, on the Middle Fork of Eel River, in Mendocino County, was examined by Mr. Stearns, who prepared a report on the subject. Field and office studies were made of the probable future stages of Salton Sink, and a report is being prepared for office use in determining whether the amount of land withdrawn from settlement along the shore shall be increased or decreased.

*Colorado.*—Reports have been completed on the water-power resources of the upper San Juan River and on the utilization of Colorado River in Colorado and Utah to the mouth of Green River.

*District of Columbia.*—Analyses were made of 16 samples of boiler water and scale in connection with studies of the Bureau of Mines on the operation of Government boiler plants in the District.

*Florida.*—Eight additional analyses were made for the report on the chemical character of the waters of Florida, which had been transmitted for publication in September, 1925.

*Hawaii.*—The report on methods of exploring and repairing leaky artesian wells on the island of Oahu by John McCombs was published as a part of Water Supply Paper 596-A. The report on "Geology and ground-water resources of the Kau district, Island of Hawaii," by H. T. Stearns and W. O. Clark, with an introductory chapter on the ground-water conditions in the Hawaiian Islands by O. E. Meinzer, was completed and is to be published as a water-supply paper.

*Idaho.*—Observations were continued in the Mud Lake Basin, and some progress was made by Mr. Stearns and L. L. Bryan on the final report on this basin. The geology and water supplies of the Craters of the Moon National Monument were studied in cooperation with the Idaho Bureau of Mines and Geology by Mr. Stearns, who prepared a report concerning an improved water supply for the monument, which was transmitted to the National Park Service, and a report on the volcanic features of the monument, which was transmitted to the Idaho Bureau of Mines and Geology for publication. A manuscript report on the power resources of the Clearwater River Basin was completed and opened for public inspection.

*Louisiana.*—Six waters associated with oil and gas wells in and near Ouachita Parish were analyzed.

*Montana.*—Progress on the reports on the ground-water resources of Big Horn and Fergus Counties was made by G. M. Hall. An office study was made of the water supply of streams in the Clark Fork Basin.

*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. The work was in charge of D. G. Thompson, who was assisted in the first part of the year by E. W. Downs and later by H. C. Barksdale. A report on the Asbury Park area was completed and transmitted to the Department of Conservation and Development for publication, and progress was made on a report on the Camden area. Observations were continued, as in previous years, at two experiment stations and on numerous observation wells. New work was begun on water in the Triassic rocks in the Metropolitan district. Analyses of 54 samples of water were made, and 36 were tested with reference to contamination with salt water.

*New Mexico.*—Five reports prepared by the division of ground water were published in the Seventh Biennial Report of the New Mexico State Engineer, as follows: "Report on investigations in the Roswell Artesian Basin," by A. G. Fiedler; "Geology and artesian water prospects in the San Jose-Rio Puerco Valley, in Sandoval County," by B. C. Renick; "Ground-water reconnaissance in Socorro County," by Kirk Bryan; "Ground-water reconnaissance in DeBaca County," by Kirk Bryan; and "Geology and ground-water resources of the drainage basin of the Rio Penasco above Hope," by B. C. Renick. The investigation of the Roswell artesian basin was continued by Mr. Fiedler and S.

Spencer Nye, with financial support from the State and from Chaves and Eddy Counties. The geology of the country along Gallinas River with reference to possible seepage losses was examined by A. M. Piper for the Bureau of Reclamation, in connection with the adjudication of water rights on the Pecos River system. The geology of two reservoir sites along the Rio Penasco was studied by Mr. Nye, and a report thereon was transmitted to the State engineer. The geology of the vicinity of the Avalon Reservoir, in the Carlsbad project, was investigated by Kirk Bryan with reference to possible leakage if the reservoir were enlarged, and a report was transmitted to the Bureau of Reclamation.

*North Carolina.*—A paper on "Surface waters of North Carolina," by Margaret D. Foster, was published in Industrial and Engineering Chemistry. The 18 new analyses in this paper and 41 others were transmitted to the State Department of Conservation and Development for publication with other analyses to be made by the State.

*Oregon.*—A report on reservoir and tunnel sites in the Owyhee irrigation project, by Mr. Bryan, was completed for publication in a water-supply paper. Geologic examinations of 43 dam sites in the western part of the State were made by Mr. Stearns, who prepared a report on these sites. Mr. Stearns also partly completed a report on the geology and water resources of the middle Deschutes Basin.

*Pennsylvania.*—A report on the ground water in 14 counties in southeastern Pennsylvania, including Philadelphia, was nearly completed by Mr. Hall. A survey of the ground-water conditions in six counties in the southwestern part of the State, including Pittsburgh, was made by Mr. Piper, and a report on this area was partly prepared by him. Analyses were made of 98 samples of water collected by Mr. Piper. The ground-water work in Pennsylvania is conducted in cooperation with the State geologist.

*Rhode Island.*—A report on the chemical character of the waters of Rhode Island, for which analyses were made in 1926, was practically completed.

*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.

*South Dakota.*—A paper entitled "Problems of the soft-water supply of the Dakota sandstone, with special reference to the conditions at Canton, S. Dak.," was prepared by Mr. Meinzer for publication as a contribution to hydrology.

*Tennessee.*—Plans were perfected for a survey of ground water in Tennessee, to be undertaken, in cooperation with the State Geological Survey, in the fiscal year 1928.

*Texas.*—Several days were spent by Mr. Meinzer, in company with J. A. Norris, chairman of the State Board of Water Engineers, and C. E. Ellsworth, district engineer, in a study of the decline in head in the artesian basin in the vicinity of Glen Rose. An examination in the vicinity of Amarillo was made by Mr. Nye to assist the Bureau of Mines in locating a water supply for a helium-processing plant. The chemical character of nine samples of water was determined by partial analyses.

*Utah.*—The study of discharge of ground water in Escalante Valley, Utah, was continued by W. N. White, and he prepared a preliminary report on the subject. Considerable progress has been made on a report on the utilization of Green River in Wyoming, Colorado, and Utah. Data on the power value of lands along Ogden and Provo Rivers and in Tooele County were prepared for office use. A supplementary report, based on a field investigation made in a previous year on an application for right of way for a canal on Huntington River, was made at the request of the Federal Power Commission. In connection with the supervision of investigational work and construction under permits and licenses of the Federal Power Commission a report was made to the commission on the application of the Utah Power & Light Co. for a license to develop power at the Flaming Gorge site on Green River.

*Virginia.*—At the request of the State geologist, an examination of the ground-water conditions in the vicinity of Pulaski was made by Mr. Meinzer, who prepared a report on the sources for an enlarged water supply for that city. This report was transmitted by the State geologist to the city authorities. Observations were made by Mr. Meinzer on two of the ebbing and flowing springs in the State. A project was begun to make weekly measurements of the water level in a well in Arlington County in order to have reliable information as to the stage of the water table.

*Washington.*—A brief report on the geology of the proposed pressure tunnel on the Kittitas division of the Yakima project was prepared by Mr. Bryan and

transmitted to the Bureau of Reclamation. Analyses of six samples and partial analyses of three samples of surface waters were made for the city of Tacoma in connection with studies of additional water supply. Work has been continued on river surveys and power investigations of streams draining the Olympic Range.

*West Virginia.*—An examination of the ground-water conditions at the Federal prison near Alderson was made by Mr. Meinzer, and a report by him, with recommendations for drilling, was transmitted to the Department of Justice.

### CONSERVATION BRANCH

HERMAN STABLER, Chief

The field work of the conservation branch is coextensive with the public domain of the United States, including Alaska, and with the principal mineral-producing Indian reservations. Its duties include the classification of lands according to their highest use, the protection of the public interest in undeveloped mineral, water power, and agricultural resources, and the promotion of economical and efficient development of mineral deposits on public and Indian land.

### PERSONNEL CHANGES

During the fiscal year there were 30 separations, all resignations except four terminations by reason of discontinuance of work, and 34 appointments were made. On June 30, 1927, the personnel of the branch, both office and field, numbered 141, consisting of 79 professional and subprofessional and 62 clerical employees. The turnover of professional field employees was reduced from 50 to 33 per cent during the year.

### FUNDS

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

Classification of lands.....	\$240,000
Supervision of leasing operations.....	292,500
Supervision of naval-reserve operations.....	50,000
	582,500

This is a decrease of more than \$38,000 from the appropriations for the preceding year.

### CORRESPONDENCE

During the year 24,170 letters were received in the Washington office, a decrease of 436 from the fiscal year 1926. In addition, about 27,500 pieces of miscellaneous correspondence were received for information, transmitted to the appropriate field office, or filing. Within the same period 18,652 letters and reports were prepared and sent out, a decrease of 1,135. In addition, about 10,850 pieces of miscellaneous correspondence were sent out. There was, however, a material increase in pending material or unfinished business.

### SUMMARY OF OPERATIONS BY STATES

*Alaska.*—Work limited mostly to handling in the Washington office of applications under public-land laws and maintaining records of and furnishing advice for mineral-leasing operations, which include 1,039 oil and gas prospecting permits, 9 coal leases, 20 coal permits, and 3 coal licenses; coal production, 93,416 tons. Increased power-site reserves by 4,531 acres.

*Alabama.*—Supervised coal lease of 1,840 acres, production 22,845 tons; made reconnaissance of oil and gas operations.

*Arizona.*—Made field investigation of homestead applications; designated 9,680 acres under the enlarged and 41,407 acres under the stock-raising homestead act; reserved 15,286 acres as power sites and eliminated 9,666 acres from power-site reserves; increased public-water withdrawals by 2,295 acres; made survey and began report on water power and irrigation of basin of Little Colorado River; supervised operations on 3 coal permits, 810 oil and gas permits, 3 sodium permits, and 22 potash permits, and on Indian lands.

*Arkansas.*—Increased power-site reserves by 1,120 acres; supervised 4 oil and gas permits.

*California.*—Made field examinations of homestead applications; designated 21,764 acres under the enlarged and 75,990 acres under the stock-raising homestead act; increased public-water withdrawals by 3,731 acres; added 144,596 acres to power-site reserves and eliminated 1,754 acres; examined and reported on power sites in Eel River Basin and requirements of drainage reservoir for Salton Sea Basin; examined structural conditions with respect to oil and gas in parts of Ventura and Kern Counties; supervised 5 coal permits, 5 potash leases with production of 5,911 tons of salts, 1 sodium permit, and 2,755 oil and gas permits and 140 leases with production of 19,759,637 barrels and royalty of \$4,415,740.80; maintained office and oil-field camp at Taft.

*Colorado.*—Made field examination of homestead applications and general agricultural classification of plains area; designated 36,041 acres under the enlarged and 155,565 acres under the stock-raising homestead act; increased public-water withdrawals by 80 acres; reserved 24,175 acres as power sites; made power surveys, investigations, or reports on Colorado, Green, and San Juan Rivers; eliminated 60,741 acres from coal-land withdrawal and classified 19,080 acres as coal land; defined the "known geologic structure" of the North McCallum oil and gas field; made coal investigations in Routt, Mesa, and Moffat Counties; made oil and gas investigations in Baca and parts of adjacent counties; supervised 34 coal permits, 8 licenses, and 60 leases with production of 448,552 tons, 3 potash permits, and 3,078 oil and gas permits and 8 leases with production of 723,193 barrels and royalty of \$55,456.24; maintained offices at Denver.

*Florida.*—Eliminated 6,330 acres from phosphate withdrawal; investigated phosphate lands in Charlotte, Glades, Highlands, and Lee Counties.

*Idaho.*—Made field examination of homestead applications; designated 20,095 acres under the enlarged and 81,953 acres under the stock-raising homestead act; increased public-water withdrawals by 160 acres; added 122,738 acres to power-site reserves and eliminated 5,221 acres; made investigations and surveys of power possibilities on Middle and South Forks of Salmon River, Boise River and tributaries, and Clark Fork, including Pend Oreille Lake; eliminated 5,080 acres from phosphate withdrawal; made miscellaneous mineral examinations; supervised 7 coal permits, 1 sodium permit, 2 phosphate leases with production of 23,854 tons, and 168 oil and gas permits.

*Kansas.*—Made field examination of homestead applications and general agricultural classification of western part; designated 320 acres under the enlarged-homestead act; supervised 5 oil and gas permits.

*Louisiana.*—Made reconnaissance of oil and gas operations; supervised 45 oil and gas and sulphur permits with production of 26,371 barrels and royalty of \$12,013.32.

*Michigan.*—Supervised 1 oil and gas permit.

*Mississippi.*—Made reconnaissance of oil and gas operations, classified 42 acres as oil and gas land, supervised 2 oil and gas permits.

*Montana.*—Made field examination of homestead applications and general agricultural classification of plains region; designated 42,244 acres under the enlarged and 133,444 acres under the stock-raising homestead act; eliminated 40 acres from public-water reserves; added 177 acres to power-site reserves and eliminated 2,000 acres; eliminated 277,109 acres from coal withdrawal and classified 142,028 acres as coal land; revised definition of "known geologic structure" of Cat Creek oil and gas field; made coal investigations in Carbon, McCone, and Powder River Counties; supervised 12 coal permits, 7 licenses, and 45 leases with production of 278,896 tons, 3,077 oil and gas permits and 40 leases with production of 1,226,274 barrels and royalty of \$139,474.88, and operations on Indian lands; maintained offices at Billings, Shelby, and Cat Creek.

*Nebraska.*—Made field examination of homestead applications and general agricultural classification of western part; designated 5,235 acres under the stock-raising homestead act; supervised 9 oil and gas permits.

*Nevada.*—Made field examination of homestead applications; designated 1,845 acres under the enlarged and 45,961 acres under the stock-raising home-

stead act; designated 17,040 acres under the ground-water reclamation act, added 1,110 acres to public-water reserves; added 398 acres to power-site reserves; supervised 3 coal permits, 15 sodium permits, 1 sodium lease with production of 302 tons of salts, 2 potash permits, and 836 oil and gas permits.

*New Mexico.*—Made field examination of homestead applications; designated 105,356 acres under the stock-raising homestead act; added 925 acres to public-water reserves; eliminated 2,797 acres from power-site reserves; made survey and examination of power and irrigation possibilities of San Juan Basin; eliminated 73,713 acres from coal withdrawal and classified 12,288 acres as coal land; examined oil and gas regions and prepared structural map of Artesia oil field; supervised 60 coal permits and 9 leases with production of 85,905 tons, 1 sodium permit, 24 potash permits, and 3,616 oil and gas permits and 6 leases with production of 39,804 barrels and royalty of \$9,445.74; maintained offices at Shiprock and Roswell; supervised oil and gas operations on Navajo Indian Reservation.

*North Dakota.*—Made field examination of homestead applications and general agricultural classification of western part; designated 955 acres under the enlarged-homestead act; supervised 3 coal permits, 2 licenses, and 32 leases with production of 215,540 tons, and 25 oil and gas permits.

*Oklahoma.*—Made field examination of homestead applications; designated 2,057 acres under the stock-raising homestead act; made coal examination in the vicinity of Stigler; revised definition of "known geologic structure" of Red River oil fields; prepared structural map of Red River oil fields; supervised lead, zinc, coal, oil, and gas leasing operations on Indian lands, and made aero-photographic map of Quapaw lead and zinc lands; supervised 58 oil and gas permits and 17 leases on public lands with production of 491,254 barrels and royalty of \$182,829.59; maintained offices at Muskogee, Cushing, Okmulgee, Shawnee, Sapulpa, McAlester, Miami, and Ardmore.

*Oregon.*—Made field examination of homestead applications; designated 3,253 acres under the enlarged and 58,352 acres under the stock-raising homestead act; added 320 acres to public-water reserves; added 98,746 acres to power-site reserves, and eliminated 1,931 acres; made power surveys, investigations, and reports on Middle Fork of Willamette, Sandy, Umpqua, McKenzie, and Siletz Rivers; supervised 4 coal permits and 2 coal leases with production of 423 tons, 1 sodium permit, 1 potash permit, 1 oil-shale lease, and 59 oil and gas permits.

*South Dakota.*—Made field examination of homestead applications and general agricultural examination of western part; designated 11,105 acres under the stock-raising homestead act; added 40 acres to power-site reserves; supervised 1 coal lease with production of 912 tons and 137 oil and gas permits.

*Utah.*—Made field examination of homestead applications; designated 116,360 acres and eliminated 239,160 acres from designation under the enlarged-homestead act; designated 164,103 acres and eliminated 5,640 acres from designation under the stock-raising homestead act; eliminated 560 acres from public-water reserves; added 10,455 acres to power-site reserves and eliminated 2,964 acres; continued preparation of report on power resources of Colorado and Green Rivers; eliminated 106,225 acres from coal withdrawal and classified 18,383 acres as coal land; eliminated 529,363 acres from oil withdrawal; made coal investigations in Grand and Sanpete Counties, asphalt investigations near Vernal, and oil and gas investigations in Grand, Wayne, and San Juan Counties; supervised 24 coal permits, 3 licenses, and 43 leases with production of 282,564 tons, 1 sodium permit, 40 potash permits, and 4,379 oil and gas permits and 2 leases with royalty of \$1,070.52; maintained offices at Salt Lake City.

*Washington.*—Made field examination of homestead applications; designated 5,250 acres under the enlarged and 7,540 acres under the stock-raising homestead act; added 100,145 acres to power-site reserves and eliminated 1,025 acres; made surveys, investigations, and reports on power possibilities of rivers of Olympic Peninsula; supervised 8 coal permits and 1 coal lease with production of 30,974 tons, 2 sodium permits, and 72 oil and gas permits.

*Wisconsin.*—Added 643 acres to power-site reserves.

*Wyoming.*—Made field examination of homestead applications and general agricultural classification of plains region; designated 46,431 acres under the enlarged and 149,896 acres under the stock-raising homestead act; eliminated 600 acres from public-water withdrawals; added 62 acres to power-site reserves and eliminated 1,938 acres; began report on power resources of Green River; eliminated 86,435 acres from coal withdrawal and reduced area classified as coal land by 2,391 acres; defined "known geologic structure" of Elk Basin

and Wertz dome oil and gas fields; prepared structural maps of Big Sand Draw and Powder River Station-Country Club district, Natrona County; made coal investigations in Park County, asphalt investigations near Baggs, and phosphate investigations in Sublette County; remapped Teapot dome, Natrona County; supervised 12 coal permits, 5 licenses, and 33 leases with production of 1,053,037 tons, 4,929 oil and gas permits and 272 leases with production of 16,463,982 barrels and royalty of \$4,753,317.31, and operations on Indian lands; maintained offices at Casper, Midwest, and Thermopolis.

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. It is regretted that in spite of strenuous effort and the voluntary overtime work of an efficient personnel it proved impossible to keep the work on cases current during the year. During the preceding year the case work of the branch dropped behind about half a month. In the fiscal year 1927, though more cases were acted on, nearly 10 per cent more were up for action, and the work dropped behind about one month additional. As the work is delayed it is inevitably increased by the necessity of answering additional inquiries as to status of cases.

General summary of cases involving land classification

Class of cases	Record for fiscal year 1926-27						Record since receipt of first case	
	Pending July 1, 1926	Received during fiscal year	Total	Acted on during fiscal year	Pending June 30, 1927	Gain or loss during fiscal year	Received	Acted on
General Land Office requests:								
General.....	226	1,632	1,858	1,378	480	-254		
Time extensions.....	46	667	713	666	47	-1	1,001	954
Oil development.....	261	1,428	1,689	1,104	585	-324	3,245	2,660
Applications for classification as to								
mineral.....	0	3	3	2	1	-1	6	5
Coal.....	5	6	11	6	5		773	768
Oil.....	288	709	997	841	156	+132	6,163	6,007
Phosphate.....	0	0	0	0	0		35	35
Applications for mineral permits.....	422	5,631	6,053	5,050	1,003	-581	44,035	43,032
Applications for mineral leases.....	23	122	145	127	18	+5	1,116	1,098
Applications for patent, potassium.....	0	0	0	0	0		123	123
Federal Power Commission cases:								
Preliminary permits.....	6	3	9	3	6		59	53
Licenses.....	11	0	11	1	10	+1	22	12
Determinations under section 24.....	11	30	41	36	5	+6	158	153
Applications for reclassification as to								
water resources.....	6	21	27	20	7	-1	678	671
Applications for rights of way.....	37	124	161	128	33	+4	5,920	5,887
Irrigation project reports.....	0	6	6	1	5	-5	898	893
Applications under enlarged-homestead acts.....	146	328	474	231	243	-97	56,067	55,824
Applications under stock-raising homestead act.....	1,272	3,000	4,272	3,101	1,171	+101	118,545	117,374
Applications under ground-water reclamation act.....	20	34	54	27	27	-7	863	836
Indian Office requests for information.....	2	3	5	5	0	+2	9,505	9,505
Cases in national forests.....	2	7	9	8	1	+1	312	311
	2,784	13,754	16,538	12,735	3,803	-1,019		

## 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.

Because of small personnel and the volume and pressure of demands in connection with the handling of cases, particularly those involving the administration of the mineral-leasing laws, the branch made little headway during the year in classifying the vast areas throughout the West that are still embraced in mineral withdrawals. The results accomplished include, however, net decreases of 604,223 acres in the total area of outstanding coal withdrawals, of 529,363 acres in the total area of outstanding petroleum withdrawals, and of 11,410 acres in the total area of outstanding phosphate reserve.

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, 1927, in acres*

State	Coal		Oil		Oil shale		Phosphate		Potash (with-drawn)
	With-drawn	Classi-fied as coal land	With-drawn	Clas-sified as oil land	With-drawn	Classi-fied as oil-shale land	With-drawn	Clas-sified as phos-phate land	
Alaska		56,993							
Arizona	139,415		92,496						
Arkansas		61,160							
California	17,603	8,720	1,178,392						90,518
Colorado	4,180,736	3,193,502	218,997		64,560	952,239			
Florida							78,192	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	1,270,972	1,341,264		91,464	2,703,755	301,945	160	
Washington	691,801	141,444							
Wyoming	2,260,604	6,738,516	545,737			460,103	992,969	25,293	
	29,941,092	32,054,219	5,279,196	71,884	156,147	4,116,097	2,044,582	297,705	7,548,377

Since February, 1920, the principal activity of the mineral-classification division has been connected with the administration of the mineral-leasing laws. Every application for a prospecting permit or lease under any of these laws is carefully scrutinized, and a report is made to the Commissioner of the General Land Office or the Secretary of the Interior on the geologic conditions involved. Applications for coal permits require a determination of the necessity for prospecting any or all of the land sought. Applications for coal leases entail a division of the area sought into logical operating or leasing units consistent in area and content of coal with the scale of mining operations proposed and the recommendation of appropriate requirements as to royalty, minimum investment, and minimum annual production. Applications for oil and gas prospecting permits require a determination of the structural relations of the land sought with respect to those of other permit and lease holdings of the applicant elsewhere in the same State and with respect to the "known geologic structure" of any producing oil or gas field and, if in conflict with an unperfected entry under the nonmineral-land laws, classification as to the prospective oil and gas value of the entered land. Applications for oil and gas leases involve a determination of the validity and sufficiency of the oil or gas discovery alleged and a recommendation of appropriate royalty requirements. Applications for sodium permits or leases, potassium permits, leases, or patents, and oil-shale leases entail generally similar determinations and recommendations.

The following table summarizes the results of the year's work to the extent that they involve specific applications for permit or lease rights under the leasing laws. No applications for patent rights were received during the year.

*Applications received, acted on, and pending under the mineral-leasing acts, fiscal year 1926-27*

Mineral	Permits			Leases		
	Received	Acted on	Pending	Received	Acted on	Pending
Oil and gas.....	5,242	4,671	968	27	32	2
Coal.....	209	194	31	86	91	10
Phosphate.....				6		
Sodium.....	20	22		1	2	
Potassium.....	159	162	4	1	1	
Oil shale.....				1	1	
Sulphur.....	1	1				

In addition to the work summarized the division determines and defines the limits of the "known geologic structure" of producing oil and gas fields and reports on the structural relations of lands involved in proposed assignments of leases or permits, on the status and structural significance of drilling on or adjacent to lands involved in permit relinquishments or cancellations, on the feasibility of permit and lease consolidations, on the propriety of time extensions based

on alleged contributions to drilling on lands other than those described in the permit of the contributor, and on the beneficial or adverse effects on present or future mineral development of all applications for rights of way across withdrawn, classified, or defined public lands. The net area included in outstanding definitions of the "known geologic structure" of producing oil and gas fields on June 30, 1927, was 512,843 acres in California, Colorado, Montana, New Mexico, Oklahoma, Utah, and Wyoming.

Other phases of division activity include the scrutiny of all enlarged and stock-raising homestead designations for the elimination of any lands within the limits of defined or producing oil or gas "structures," the examination of all right-of-way applications for the prevention of interference with operations on lands valuable for coal or other minerals, and the preparation of reports at the request of the General Land Office and Office of Indian Affairs on the mineral possibilities of lands sought under certain nonmineral-land laws.

Geologic field work undertaken by this division to provide the basis for appropriate action on pending petitions for mineral classification or reclassification and on applications for mineral permits and leases included areal and structural mapping and detailed economic studies of small areas in many parts of the public-land States. Numerous areas in New Mexico, Colorado, Wyoming, and Idaho were examined, and structure contour maps were prepared for the Artesia oil field, New Mexico; the Big Sand Draw gas field, Wyoming; and the Powder River Station-Country Club district, Natrona County, Wyo. The occurrence of coal in the Silvertip anticline, Park County, Wyo., and Carbon County, Mont., was mapped in detail, the occurrence of rock phosphate in the Tump Range, Sublette County, Wyo., was investigated, and a structural reconnaissance of Baca County, Colo., and parts of contiguous counties was made. Structural conditions in parts of Ventura and Kern Counties, Calif., were investigated, and a reconnaissance of oil and gas operations in Alabama, Mississippi, and parts of Louisiana was made. The remapping of the Teapot dome, Natrona County, Wyo., was begun. The occurrence of bone phosphate in parts of Charlotte, Glades, Highlands, and Lee Counties, Fla., was investigated.

The large items of field work undertaken by the geologic branch but financed largely by the conservation branch during the year included areal and structural examinations in Grand, Wayne, and San Juan Counties, Utah; coal investigations in the vicinity of Stigler, Okla., in Routt, Mesa, and Moffat Counties, Colo., in Grand and Sanpete Counties, Utah, and in McCone and Powder River Counties, Mont.; and asphalt investigations near Baggs, Wyo., and Vernal, Utah.

#### 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 larger field projects undertaken during the year to obtain information for power classification include plan and profile surveys and power-site and reservoir-site investigations on Quinault and Wynooche Rivers, Washington; Middle Fork of Willamette and Sandy Rivers, Oreg.; Middle and South Forks of Salmon River, Boise River, and Clark Fork, including Pend Oreille Lake, Idaho; and Little Colorado River, Ariz. Studies were continued leading to the preparation of reports on Green and Colorado Rivers in Colorado, Utah, and Wyoming; San Juan River and tributaries in Colorado and New Mexico; Eel River and Salton Sea basin in California; and Umpqua, McKenzie, and Siletz Rivers in Oregon. Geologic examinations were made at over 40 reservoir and dam sites. Because of decrease in appropriation projects previously undertaken in Idaho, Arizona, and California were dropped toward the end of the year and a number of projects planned were not begun.

The information obtained 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. 53).

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 1926. The total installation of the reporting companies is 1,970,000 kilowatts, of which 1,430,000 kilowatts is installed at hydraulic plants. The total energy generated was 7,800,000,000 kilowatt-hours, of which more than 6,500,000,000 kilowatt-hours was generated by water power.

*Power output of permittees and grantees, 1916-1926*

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				

*Power-site reserves, in acres*

[Includes all areas reserved or classified as valuable for power purposes and withheld subject to disposal 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, 1926	Eliminated prior to July 1, 1926	Reserves outstanding prior to July 1, 1926	Reserved during fiscal year	Eliminated during fiscal year	Reserves outstanding June 30, 1927
Alabama	2,377		2,377			2,377
Alaska	213,646	520	213,126	4,531		217,657
Arizona	1,270,395	114,344	1,156,051	5,286	9,666	1,151,671
Arkansas	28,551		28,551	1,120		29,671
California	1,170,617	28,489	1,142,128	144,596	1,754	1,284,970
Colorado	507,098	75,783	431,315	24,175		455,490
Florida	486		486	533		1,019
Idaho	467,807	186,300	281,507	122,738	5,221	399,024
Michigan	1,240		1,240			1,240
Minnesota	19,062	532	18,530			18,530
Mississippi	3		3			3
Montana	303,589	94,379	209,210	177	2,000	207,387
Nebraska	761		761			761
Nevada	300,798	480	300,318	398		300,716
New Mexico	270,878	7,714	263,164		2,797	260,367
Oregon	654,437	110,317	544,120	98,746	1,931	649,935
South Dakota	12		12	40		52
Utah	746,254	122,434	622,820	10,455	2,964	630,311
Washington	292,617	52,810	239,807	100,142	1,025	338,924
Wisconsin	1,210	226	984	643		1,627
Wyoming	222,560	73,408	149,152	62	1,938	147,276
	6,474,398	868,736	5,605,662	513,642	29,296	6,090,008

*Summary of outstanding water resources, withdrawals, and classifications June 30, 1927, in acres*

State	Power reserves					Reser- voir with- drawals	Public- water with- drawals	Ground- water reclama- tion designa- tions
	With- drawals	Classi- fics- ations	Designa- tions <sup>a</sup>	Miscel- laneous	Total			
Alabama.....	120	1,735		522	2,377			
Alaska.....	93,415	43,005		81,237	217,657			
Arizona.....	386,259	37,182	528,239	199,991	1,151,671	23,040	17,575	
Arkansas.....	22,354	1,590		5,727	29,671			
California.....	287,391	292,974		704,605	1,284,970	1,160	171,282	
Colorado.....	231,910	174,661		48,919	455,490	1,728	2,300	
Florida.....				1,019	1,019			
Idaho.....	205,637	184,049		9,338	399,024		13,345	
Michigan.....	1,240				1,240			
Minnesota.....	12,309			6,221	18,530			
Mississippi.....				3	3			
Montana.....	129,944	53,452		23,991	207,387	9,080	8,057	
Nebraska.....	761				761			
Nevada.....	27,492	28,026		245,198	300,716		9,256	1,576,295
New Mexico.....	117,206		143,161		260,367		9,881	
North Dakota.....						1,569		
Oregon.....	372,738	192,292	15,250	60,655	640,935	10,619	20,501	
South Dakota.....				52	52		240	
Utah.....	442,375	162,826		25,110	630,311	80	32,915	
Washington.....	97,086	180,691		61,147	338,924	35,943	920	
Wisconsin.....				1,627	1,627			
Wyoming.....	80,891	25,621		40,764	147,276	1,714	79,305	
	2,509,128	1,378,104	686,650	1,516,126	6,090,008	84,933	365,577	1,576,295

<sup>a</sup> Designated and not otherwise withdrawn.

AGRICULTURAL DIVISION

The functions of the agricultural division, formerly called the homestead 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. 53). There was a slight increase in the number received, but the work of the division was kept substantially current. In the field broad areal studies were made in the central Great Plains region in Colorado, Kansas, Nebraska, and Wyoming. Detailed examination of lands embraced in specific applications for designation under the enlarged and stock-raising homestead laws was continued in all the public-land States west of the one hundredth meridian. A report, begun in 1925 in cooperation with the Department of Agriculture, on agriculture and land utilization in the northern Great Plains region, was practically completed during the year, and a preliminary edition of a map in eight sheets showing the agricultural classification of lands in this region was produced.

During the year the area designated under the Nevada ground-water reclamation act, as a result of the work of the division, was increased from 1,559,255 to 1,576,295 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 February 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 March 3, 1915 (38 Stat. 953), applicable to Kansas; act of March 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 February 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, 1926	Cancellations prior to July 1, 1926	Designations outstanding prior to July 1, 1926	Designations during fiscal year	Cancellations during fiscal year	Designations outstanding June 30, 1927
Arizona .....	31,421,499	5,870,874	25,550,625	9,680	-----	25,560,305
California .....	13,255,780	238,453	13,017,327	21,764	-----	13,039,091
Colorado .....	33,682,752	195,508	33,487,244	36,041	-----	33,523,285
Idaho:						
Total .....	13,670,724	460,925	13,209,799	20,095	-----	13,229,894
Nonresidence .....	572,747	4,233	568,514	-----	-----	568,514
Kansas .....	650,084	-----	650,084	320	-----	650,404
Montana .....	53,415,606	245,728	53,169,878	42,244	-----	53,212,122
Nevada .....	50,166,320	3,580,717	46,585,603	1,845	-----	46,587,448
New Mexico .....	43,772,180	227,732	43,544,448	-----	-----	43,544,448
North Dakota .....	12,276,749	3,848	12,272,901	955	-----	12,273,856
Oregon .....	21,273,454	989,902	20,283,552	3,253	-----	20,286,805
South Dakota .....	16,336,096	348,170	15,987,926	-----	-----	15,987,926
Utah:						
Total .....	11,535,394	460,924	11,074,470	116,360	* 239,160	10,951,670
Nonresidence .....	1,645,969	78,600	1,567,369	1,920	2,960	1,566,329
Washington .....	6,649,942	251,842	6,398,100	5,250	-----	6,403,350
Wyoming .....	29,547,901	162,043	29,385,858	46,431	-----	29,432,289
	337,654,481	13,036,666	324,617,815	304,238	239,160	324,682,893

\* Includes 920 acres previously designated under secs. 1-5, now designated under sec. 6.

Summary of stock-raising homestead designations, in acres

[Areas classified as nonirrigible, 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, 1926	Cancellations prior to July 1, 1926	Designations outstanding prior to July 1, 1926	Designations during fiscal year	Cancellations during fiscal year	Designations outstanding June 30, 1927
Arizona	13,947,097	887,580	13,059,517	41,407		13,100,924
Arkansas	1,120		1,120			1,120
California	7,812,909	1,400	7,810,909	75,990		7,886,899
Colorado	8,355,936	18,840	8,337,096	155,565		8,492,661
Florida	480					
Idaho	5,367,664	1,854	5,365,810	81,953		5,447,763
Kansas	114,139		114,139			114,139
Michigan	3,451		3,451			3,451
Montana	15,206,290	17,081	15,189,209	133,444		15,322,653
Nebraska	189,574		189,574	5,235		194,809
Nevada	520,133	3,120	517,013	45,961		562,974
New Mexico	31,179,252	636	31,178,616	105,356		31,283,972
North Dakota	375,892		375,892			375,892
Oklahoma	80,025		80,025	2,057		82,082
Oregon	6,252,407	3,128	6,249,279	58,352		6,307,631
South Dakota	6,485,433	550	6,484,883	11,105		6,495,988
Utah	1,437,667	880	1,436,787	164,103	5,640	1,645,250
Washington	682,721	1,134	681,487	7,540		689,027
Wyoming	19,939,652	6,213	19,933,539	149,896		20,083,435
	118,001,242	942,896	117,058,346	1,047,964	5,640	118,100,670

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 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. During the year the known area included in public-water reserves, mainly for stock watering, was increased as follows:

	Acres		Acres
Arizona	2,335	New Mexico	1,085
California	120	Oregon	320
Colorado	80	Utah	80
Idaho	160	Wyoming	160
Nevada	1,110		

The eliminations from such reserves were as follows:

	Acres		Acres
Arizona-----	40	Utah-----	640
New Mexico-----	160	Wyoming-----	840
Montana-----	40		

Outstanding withdrawals of public land for public watering places are tabulated in the summary of water-resources withdrawals and classifications (p. 59).

#### 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

The supervisory work of the mineral-leasing division on public lands subject to the mineral-leasing laws, in so far as it can be measured by the number of cases, was increased about 20 per cent during the year by the receipt of issued prospecting permits, leases, and licenses as follows: Oil and gas permits 4,591, 8,292,516.09 acres; oil and gas leases 53, 23,781.97 acres; coal permits 88, 98,148.58 acres; coal leases 25, 8,780.32 acres; coal licenses 16, 649.95 acres; sodium permits 11, 26,229.11 acres; potash permits 59, 138,819.29 acres; total leases 78, permits 4,749, licenses 16, covering 8,588,925.31 acres. No sodium, phosphate, oil-shale, sulphur, or potash leases were issued. Although no sulphur permits or leases have been issued under the act of April 17, 1926, the 45 oil and gas permits covering 7,299.85 acres in Louisiana are given a right under the sulphur-leasing act to acquire a lease should sulphur be discovered in prospecting for oil or gas.

The following tables show, by States and by minerals, the total number of prospecting permits, leases, and licenses involving public land issued and the number under supervision at the end of the fiscal year, together with important data relative thereto:

*Mineral leases, licenses, and permits issued by the Secretary of the Interior and notification received by the Geological Survey up to June 30, 1927*

State	Coal			Potash		Sodium		Oil shale (leases)	Phosphate (leases)	Oil and gas	
	Leases	Permits	Li-censes	Leases	Permits	Leases	Permits			Leases	Permits
Alaska	11	35	73								1,133
Alabama	1										
Arizona		6			26		3				923
Arkansas		1									4
California		16		17	70		6			158	3,246
Colorado	67	196	18		4					10	3,331
Idaho		21			1		1		2		219
Kansas											5
Louisiana										7	56
Michigan											1
Mississippi											11
Montana	56	97	10		2					40	3,441
Nebraska					4						13
Nevada		42			75	1	42				963
New Mexico	11	131			34		4			6	4,042
North Dakota	35	11	3				5				30
Oklahoma											65
Red River										18	11
Oregon	2	35			2		1	1			60
South Dakota	1	5	1								167
Utah	55	113	4		345		1			2	4,711
Washington	2	52					2				81
Wyoming	40	175	19	1			1	1		274	5,356
	281	936	128	18	563	1	66	2	2	515	27,869

Total, 819 leases, 29,434 permits, 128 licenses. Required investment, \$10,297,370. Total area, 2,454,292.73 acres. Minimum annual production of coal required, 4,168,740 tons. Estimated quantity of coal in leased lands, 834,000,000 tons.

*Mineral leases, licenses, and permits on the public domain under supervision of the Geological Survey June 30, 1927*

State	Coal						Oil and gas	
	Leases		Permits		Licenses		Leases (number)	Permits (number)
	Number	Acres	Number	Acres	Number	Acres		
Alaska	9	11,307.28	20	29,912.21	3	30.00		1,039
Alabama	1	1,840.00						
Arizona			3	7,600.00				810
Arkansas								4
California			5	2,916.16			140	2,755
Colorado	60	9,416.43	34	18,846.28	8	320.08	8	3,078
Idaho			7	8,557.96				168
Kansas								5
Louisiana							6	45
Michigan								1
Mississippi								2
Montana	45	6,590.96	12	3,956.06	7	279.95	40	3,077
Nebraska								9
Nevada			3	6,001.21				836
New Mexico	9	3,761.10	60	95,942.08			6	3,616
North Dakota	32	4,264.75	3	800.00	2	80.00		25
Oklahoma								47
Red River							17	11
Oregon	2	2,095.24	4	1,840.00				59
South Dakota	1	79.04						137
Utah	43	35,523.07	24	26,324.10	3	160.00	2	4,379
Washington	1	600.00	8	4,594.30				72
Wyoming	33	14,997.55	12	11,329.48	5	199.95	272	4,929
	236	90,475.42	195	218,619.84	28	1,069.98	491	25,104

*Mineral leases, licenses, and permits on the public domain under supervision of the Geological Survey June 30, 1927—Continued*

State	Sodium				Potash			
	Leases		Permits		Leases		Permits	
	Number	Acres	Number	Acres	Number	Acres	Number	Acres
Arizona.....			3	7,360.00			22	55,040.00
California.....			1	2,560.00	5	9,783.80		
Colorado.....							3	7,040.00
Idaho.....			1	2,454.11				
Nevada.....	1	1,440.00	15	35,360.00			2	3,520.00
New Mexico.....			1	2,560.00			24	54,080.00
Oregon.....			1	920.00			1	2,560.00
Utah.....			1	2,560.00			40	85,764.29
Washington.....			2	766.30				
	1	1,440.00	25	54,540.41	5	9,783.80	92	208,004.29

Also Idaho, 2 phosphate leases, 1,700 acres; Oregon, 1 oil-shale lease, 2,680 acres. Total, 736 leases, 28 licenses, 25,416 permits.

The repeal of the potash act of October 2, 1917, and what amounts to the extension of the general mineral-leasing law to include potassium minerals was a much needed piece of legislation. Under the act of 1917 a potash permittee had the right upon making discovery of potash to patent one-fourth the land contained in his permit. Prior to June 30, 1927, 563 permits, covering 1,266,005.64 acres, were issued under this act. Of this number 123 patent applications, covering about 75,000 acres, have been received for consideration by the Geological Survey. Although potash may be produced eventually from lands patented under the act, the discoveries for the most part involved inexpensive prospecting and have little present commercial interest. Potash that appears to have present commercial importance was discovered on a permit near Carlsbad, N. Mex. As a result of this discovery many additional permits have been granted, and active prospecting by core drilling is being carried out in that vicinity. The deposits discovered compare favorably in probable quantity and quality with the deposits of France and Germany, the present source of much of the American supply. The location is unfavorable for the distribution of cheap fertilizer to the farming communities of the eastern markets on account of the distance and prevailing freight rates.

#### PRODUCTION

Statistics relating to the production of petroleum, natural gas, natural-gas gasoline, coal, potash, phosphate, and sodium under Government lease, permit, and license involving public land are summarized in the following tables:

*Petroleum produced from public lands*

Fiscal year	Production (barrels)	Royalty oil (barrels)	Royalty value			
			Oil	Gas	Gasoline	Total
1921.....	5,789,803.48	1,025,985.19	\$1,939,963.68	\$23,678.33	\$5,993.91	\$1,969,635.92
1922.....	14,352,826.24	2,568,964.02	3,320,891.86	86,909.24	12,864.46	3,420,665.56
1923.....	28,443,357.80	5,466,171.00	8,071,051.30	121,885.01	59,834.26	8,252,770.57
1924.....	39,437,658.44	7,872,073.04	12,033,294.00	88,555.13	70,355.38	12,192,204.51
1925.....	30,310,308.05	4,951,024.27	7,573,293.63	77,515.59	102,149.69	7,752,958.91
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
	173,694,931.60	29,877,905.69	46,631,645.96	583,848.13	578,635.72	47,794,129.81

*Petroleum produced from public lands, by States*

State	Fiscal year	Production (barrels)	Royalty oil (barrels)	Royalty value			
				Oil	Gas	Gasoline	Total
California.....	1920-21	2,201,116.28	311,570.19	\$573,266.63	None.	\$4,332.06	\$577,598.69
	1921-22	3,739,448.30	616,491.09	792,444.87	None.	2,986.56	795,431.43
	1922-23	4,666,523.03	674,899.86	619,391.36	\$309.31	7,673.96	627,374.63
	1923-24	4,702,623.55	620,170.36	561,064.90	897.28	3,457.22	565,419.40
	1924-25	6,978,882.39	874,515.54	1,033,142.91	1,337.33	9,723.77	1,044,204.01
	1925-26	6,467,196.06	916,301.77	983,952.57	1,581.13	18,878.41	1,004,412.11
	1926-27	7,034,271.78	951,357.05	932,806.17	3,008.48	24,195.53	960,010.18
		35,790,061.39	4,965,305.86	5,496,069.41	7,133.53	71,247.51	5,574,450.45
Colorado.....	1921-22	36.00	7.20	10.08	None.	None.	10.08
	1922-23	272.67	54.52	57.47	None.	None.	57.47
	1923-24	17,730.08	3,391.14	2,973.47	None.	None.	2,973.47
	1924-25	409,057.34	32,748.60	36,750.75	None.	None.	36,750.75
	1925-26	825,180.92	44,601.98	64,287.99	6.60	None.	64,294.59
	1926-27	723,193.03	40,344.11	55,294.24	162.00	None.	55,456.24
		1,975,470.04	121,147.55	159,374.00	168.60	-----	159,542.60
Louisiana.....	1920-21	2,716.00	221.02	583.62	None.	None.	583.62
	1921-22	1,970.36	92.34	131.69	None.	None.	131.69
	1922-24	None.	None.	None.	None.	None.	None.
	1924-25	2,270.60	283.82	472.87	None.	65.01	537.88
	1925-26	2,089.52	261.20	553.35	None.	81.77	635.12
	1926-27	26,371.06	820.11	11,186.96	689.92	136.44	12,013.32
		35,417.54	1,678.49	12,928.49	689.92	283.22	13,901.63
Montana.....	1920-21	169,634.63	9,385.64	15,406.07	None.	None.	15,406.07
	1921-22	1,535,775.75	70,443.66	185,157.86	None.	None.	185,157.86
	1922-23	2,067,446.93	153,011.71	293,978.83	None.	None.	293,978.83
	1923-24	1,496,303.77	91,885.19	202,765.36	3.20	None.	202,768.56
	1924-25	1,510,356.21	83,393.60	160,294.86	None.	None.	160,294.86
	1925-26	2,332,851.97	148,370.25	332,421.63	295.15	None.	332,716.78
	1926-27	1,226,273.71	68,819.82	139,350.75	124.13	None.	139,474.88
		10,338,642.97	625,309.87	1,329,375.36	422.48	-----	1,329,797.84
New Mexico.....	1925-26	15,902.58	2,211.70	3,609.13	66.75	None.	3,675.88
	1926-27	39,804.17	6,199.31	8,739.83	678.00	27.91	9,445.74
		55,706.75	8,411.01	12,348.96	744.75	27.91	13,121.62
Oklahoma.....	1925-26	112,160.75	17,351.41	44,353.24	None.	1,460.04	45,813.28
	1926-27	491,254.69	87,899.17	179,882.86	None.	2,946.73	182,829.59
		603,415.44	105,250.58	224,236.10	-----	4,406.77	228,642.87
Utah.....	1925-26	2,496.41	499.29	499.29	None.	None.	499.29
	1926-27	None.	None.	None.	1,070.52	None.	1,070.52
		2,496.41	499.29	499.29	1,070.52	-----	1,569.81

*Petroleum produced from public lands, by States—Continued*

State	Fiscal year	Production (barrels)	Royalty oil (barrels)	Royalty value			
				Oil	Gas	Gasoline	Total
Wyoming	1920-21	3,416,336.57	704,808.34	\$1,350,707.36	\$23,678.33	\$1,661.85	\$1,376,047.54
	1921-22	9,075,595.83	1,881,929.73	2,343,147.36	86,909.24	9,877.90	2,439,934.50
	1922-23	21,709,115.17	4,638,204.91	7,157,623.64	121,575.70	52,160.30	7,331,759.64
	1923-24	33,221,001.04	7,156,626.35	11,266,490.27	87,654.65	66,898.16	11,421,043.08
	1924-25	21,409,741.51	3,960,082.71	6,342,632.24	76,178.26	92,360.91	6,511,171.41
	1925-26	19,954,997.95	3,301,966.03	6,521,988.32	91,558.66	133,845.21	6,747,392.19
	1926-27	16,106,932.99	2,406,684.97	4,414,225.16	86,063.49	145,865.98	4,646,154.63
		124,893,721.06	24,050,303.04	39,396,814.35	573,618.33	502,670.31	40,473,102.99
Grand total		173,694,931.60	29,877,905.69	46,631,645.96	583,848.13	578,635.72	47,794,129.81

*Coal produced from public lands, in tons*

State	1920-21	1921-22	1922-23	1923-24
Alaska	* 65,000.00	86,551.79	116,105.99	88,645.82
Colorado	540.90	52,613.27	219,627.24	257,294.46
Montana	100.00	2,046.44	9,575.05	22,317.19
New Mexico		8,255.18	19,654.38	28,150.14
North Dakota	378.00	33,507.50	123,711.79	168,642.90
Oregon				51.20
South Dakota			586.75	427.50
Utah		26,185.08	103,676.44	218,439.96
Washington		25,565.05	60,284.64	52,757.66
Wyoming	226,091.70	314,016.10	445,775.49	645,379.44
	292,110.60	548,713.41	1,098,997.77	1,482,106.27
State	1924-25	1925-26	1926-27	Total
Alaska	99,193.83	98,144.74	93,416.14	647,058.31
Alabama		10,056.00	22,845.00	32,910.00
Colorado	297,795.51	353,433.61	448,552.09	1,629,857.08
California			3.00	3.00
Montana	218,934.90	198,602.15	278,896.48	730,472.21
New Mexico	18,367.56	37,461.86	85,905.31	197,794.43
North Dakota	127,455.19	163,533.79	215,540.12	832,769.29
Oregon	637.77	628.88	423.58	1,741.43
South Dakota	828.98	1,074.00	912.35	3,823.98
Utah	139,029.14	172,433.36	282,564.80	942,301.78
Washington	25,673.08	16,910.29	30,974.32	212,165.04
Wyoming	857,836.30	962,490.51	1,053,037.36	4,504,626.90
	1,785,751.66	2,014,769.19	2,513,079.55	9,735,539.45

\* Estimated.

*Salts disposed of from potash leases (California), in tons*

1920-21	112.18	1925-26	430.09
1921-22	569.01	1926-27	5,911.35
1922-23	1,036.10		
1923-24	926.51		9,486.74
1924-25	501.50		

*Phosphate disposed of from public lands (Idaho), in tons*

1920-21	1,566.90	1925-26	343.20
1921-22	1,982.18	1926-27	23,854.61
1922-23	2,085.86		
1923-24	497.50		30,330.25

*Sodium disposed of from public lands (Nevada), in tons*

1924-25 -----	248.21	1926-27 -----	302.53
1925-26 -----	233.53		784.27

**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 is being 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. Statistics of the production of petroleum, natural gas, and natural-gas gasoline from naval petroleum reserves are summarized below:

*Petroleum produced from naval petroleum reserves*

Fiscal year	Production (barrels)	Royalty oil (barrels)	Royalty value			
			Oil	Gas	Gasoline	Total
			<b>Total</b>			
1920-21-----	1,614,448.12	266,339.59	\$574,166.09	\$4,336.80	\$11,582.71	\$590,085.60
1921-22-----	3,863,994.87	1,014,481.32	1,474,669.88	8,440.79	10,511.26	1,493,621.93
1922-23-----	9,461,445.67	2,180,874.92	2,173,724.67	64,899.22	57,226.73	2,295,850.62
1923-24-----	12,605,519.22	2,863,999.70	2,692,223.03	101,994.76	58,346.08	2,852,563.87
1924-25-----	12,870,750.26	3,056,065.95	3,770,876.53	119,199.32	93,818.67	3,983,894.52
1925-26-----	12,755,382.16	2,779,100.13	3,310,658.54	114,247.75	152,480.36	3,577,386.65
1926-27-----	12,775,365.02	2,902,243.85	3,175,882.25	110,204.62	169,643.75	3,455,730.62
	65,886,905.32	15,063,105.46	17,172,200.99	523,323.26	553,609.56	18,249,133.81

**By States**

<b>California:</b>						
1920-21-----	1,614,448.12	266,339.59	\$574,166.09	\$4,336.80	\$11,582.71	\$590,085.60
1921-22-----	3,863,994.87	1,014,481.32	1,474,669.88	8,440.79	10,511.26	1,493,621.93
1922-23-----	9,034,795.29	2,106,645.04	2,046,619.04	63,770.20	57,198.08	2,167,587.32
1923-24-----	11,246,134.92	2,675,674.75	2,409,799.27	93,917.00	58,336.98	2,556,053.25
1924-25-----	12,123,571.89	2,962,668.64	3,628,039.50	117,527.57	93,818.67	3,839,385.74
1925-26-----	12,234,702.16	2,714,015.11	3,187,461.22	100,089.27	151,296.95	3,438,847.44
1926-27-----	12,368,315.70	2,857,612.68	3,094,331.59	90,475.99	163,760.36	3,348,567.94
	62,485,962.95	14,597,437.13	16,409,086.59	478,557.62	546,505.01	17,434,149.22
<b>Wyoming:</b>						
1922-23-----	416,650.38	74,229.88	127,105.63	1,129.02	28.65	128,263.30
1923-24-----	1,359,384.30	188,324.95	288,342.76	8,077.76	9.10	296,510.62
1924-25-----	747,178.37	93,397.31	142,837.03	1,671.75	None.	144,508.78
1925-26-----	520,680.00	65,085.02	123,197.32	14,158.48	1,183.41	138,539.21
1926-27-----	357,049.32	44,631.17	81,550.66	19,728.63	5,883.39	107,162.68
	3,400,942.37	465,668.33	763,114.40	44,765.64	7,104.55	814,984.59

**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 of mineral deposits on tribal and restricted allotted Indian lands.

At the end of the year there were outstanding 53 departmental lead and zinc leases on restricted Quapaw Indian lands in Oklahoma covering 7,024.35 acres. The production from these lands amounts to 22 per cent of the zinc and 6 per cent of the lead mined in the United States. The royalty for the fiscal year, amounting to \$1,307,114.54, was 9.25 per cent of the sale value of the ore mined. Four mills on restricted Indian lands introduced desliming and flotation in the treatment of ores during the year, a very large additional recovery of concentrates was obtained from the ores mined, and former waste dumps are being re-treated at a profit. These processes permit the mining of lower-grade ores and greatly increase the potential ore reserves and royalties.

The area of Choctaw and Chickasaw coal and asphalt lands segregated was 441,107.15 acres, of which 112,830.75 acres has been leased; all leases now in effect expire between 1928 and 1932. Congress provided for the disposal of both leased and unleased lands by sale, and during the year two unleased coal tracts containing 1,927.72 acres were sold. There were removed from supervision by the making of final payments seven unleased tracts containing 4,910.93 acres, five leased tracts containing 4,437.40 acres, and three asphalt tracts containing 1,960 acres, a total of 11,308.33 acres. The total area removed from supervision to date is 44,405.70 acres, which is about 10 per cent of the entire segregated area. In addition areas amounting to 32,259.91 acres have been sold but remain under supervisory control because final payments have not been made.

At the end of the year 79 coal leases covering 73,450.60 acres were in force, under 37 of which coal was produced during the year through 60 mines. One lease was canceled during the year. There are 30 suspended and 62 abandoned mines on the segregated leased coal lands. The production of coal for the year from leased and unleased areas was 896,353.21 tons, with a royalty and rental value of \$69,340.73. Only one asphalt lease remains in effect, and it has not been producing.

At the beginning of the year there were 66 coal and asphalt leases on restricted Indian lands comprising 6,493.50 acres. During the year 13 leases comprising 1,263 acres were reinstated, 3 new leases covering 260 acres approved, and 10 leases covering 1,212.50 acres canceled, leaving a total of 72 coal leases covering 7,188.64 acres in effect at the end of the year; 21 of the leases were producing and 51 not producing, as follows:

*Coal and asphalt leases on restricted Indian lands*

Tribe	Not producing		Producing		
	Number	Advance royalty	Number	Output (tons)	Royalty and rentals
Cherokee.....	6	\$292.50	3	7,840.90	\$932.62
Creek.....	8	203.00	7	12,155.40	1,431.46
Choctaw.....	37	2,258.83	11	138,782.41	14,817.80
	51	2,754.33	21	158,778.71	17,181.88

Of segregated and allotted lands, areas amounting to 25,392 acres were examined geologically to determine their coal value, so that appraisal may be intelligently made when applications are received for sale of restricted lands within the area.

In Oklahoma the supervision of oil and gas activities includes 10,786 leases, covering 1,005,601.04 acres, on which there are 7,748 producing oil and gas wells, summarized by jurisdiction or Indian agencies as follows:

*Oil and gas leases in Oklahoma*

	Leases		Producing wells		
	Number	Acres	Oil	Gas	Total
Five Civilized Tribes.....	8,804	788,574.00	7,232	298	7,530
Kiowa Indian Agency.....	250	40,604.83	24	6	30
Pawnee Indian Agency.....	328	34,087.99	83	1	84
Ponca Indian Agency.....	847	83,540.35	80	0	80
Shawnee Indian Agency.....	557	58,793.87	21	3	24
	10,786	1,005,601.04	7,440	308	7,748

In addition to the oil leases in Oklahoma aid was given to the Indian Office in supervising oil and gas leases on tribal and restricted allotted Indian lands as follows:

*Status of oil and gas leases on Indian land June 30, 1927*

	Leases			Wells			
	Produc- ing	Non- produc- ing	Under super- vision	Being drilled	Produc- ing	Aban- doned	Total
Montana:							
Blackfeet, tribal.....	0	2	2	2	0	1	3
Crow, tribal.....	1	3	4		3	12	15
Crow, allotted.....	2	7	9		2	3	5
New Mexico:							
Navajo, tribal.....	3	13	16	7	31	23	61
Wyoming:							
Shoshone, tribal.....				5	41	31	77
Shoshone, allotted.....				1	28	26	55

The following additional mining leases and lease applications were investigated or reported on at the instance of the Indian Office:

California: Tule River Indian Reservation, 1 for limestone; Paiute Indian Reservation, 1 for building stone.

Idaho: Nez Perce Indian Reservation, 3 for limestone.

Nevada: Pyramid Lake Indian Reservation, 1 for lead and silver, 1 for marl.

Oklahoma: Osage Reservation, 1 for lead, gold, and silver.

Wyoming: Shoshone Indian Agency (tribal), 1 for coal; same (allotted), 1 for coal.

**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

through the Bureau of Mines with the Safety in Mines Research Board of Great Britain in the classification of coals on Government lands.

#### COST OF SUPERVISION AND STATE BENEFITS

Preliminary estimates indicate that the cost of the supervisory work of the mineral-leasing division averages about 2 per cent of the aggregate rents and royalties involved, or only one-fifth of the estimated cost of administration when the leasing law was enacted. This cost for essential engineering supervision is materially less than that of similar supervision of operations under private ownership and is more than covered by the economies effected and reflected in immediate royalty returns. The future values preserved by conservation measures established by the supervisory forces and the eventual royalties to be derived therefrom far exceed the current monetary returns from the work of the division.

Twenty-three States and Alaska are directly interested in the results of mineral leasing on public lands, as they receive without expense to themselves 37.5 per cent of all royalties and rentals, and 52.5 per cent is spent in these States through the Bureau of Reclamation.

#### WORK ON PUBLICATIONS

##### BOOK PUBLICATION

##### TEXTS

During the year 21,377 pages of manuscript were edited and prepared for printing by the section of texts, and proof sheets comprising 1,832 galley proofs and 14,280 page proofs were read and corrected. Indexes were prepared for 32 publications covering 5,214 pages. Copy and proof or stencils for 922 pages of multi-graph 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 2,500, including 184 maps, 582 sections and diagrams, 624 photographs, and 1,110 paleontologic drawings; 170 miscellaneous jobs were also done by the section. The illustrations transmitted to accompany 35 reports numbered 659, to be reproduced by chromolithography, photolithography, halftone, and zinc etching. The number of proofs received and examined was 1,964. At the end of the year material for illustrating 48 reports is in hand. The section now consists of 11 employees.

##### MAP EDITING

#### GEOLOGIC EDITING AND DRAFTING OF MAPS AND ILLUSTRATIONS

Maps and illustrations for 31 geologic reports were drawn and prepared for geologists in the geologic branch. The geologic map of Oklahoma was published. Progress was made on the color-stone

work of the New Mexico geologic map. Compilation of the geologic map of Texas and of the map of the United States was begun.

The maps of the Bessemer-Vandiver (Ala.) folio were ready for printing at the end of the year. The maps of the Coatesville-West Chester (Pa.) and of the Gaffney-Kings Mountain (S. C.-N. C.) folios were sent for transfer to stone. Engraving of the Fairfield-Gettysburg (Pa.) and Somerset-Windber (Pa.) maps was begun. The Montevallo-Columbiana (Ala.) and Hollidaysburg-Huntingdon (Pa.) folios were partly prepared for engraving. The Boston (Mass.) folio was received for publication and its preparation begun.

Maps and illustrations for 30 reports besides folios were edited during the year.

#### INSPECTION AND EDITING OF TOPOGRAPHIC MAPS

During the year 122 new topographic maps were edited and transmitted for engraving; 185 published topographic maps, 9 State maps, and 8 State index circulars were edited for reprint; 12 plan and profile river-survey sheets were edited for photolithography; 7 miscellaneous maps were edited for engraving or photolithography; and 492 maps were edited as illustrations for Geological Survey reports—a total of 835 maps edited. First, second, combined, and woodland proofs of engravings for new topographic maps and reprints numbering 429 and proofs of maps reproduced by photolithography numbering 182 were read. At the end of the year 138 new topographic maps were in progress of engraving and printing and 120 new topographic maps and projects were in preparation for submission for reproduction.

#### DISTRIBUTION

A total of 318 publications, comprising 64 new books and pamphlets, 1 reprinted book, 1 new geologic folio, 112 new or revised topographic and other maps, and 140 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 179,355 books and pamphlets, 8,785 geologic folios, and 644,750 topographic and other maps, a grand total of 832,890.

The division distributed 198,584 books, 9,438 folios, and 742,818 maps, a total of 950,840, of which 8,023 folios and 609,148 maps were sold. The sum received and deposited in the Treasury as the result of sales of publications was \$46,116.32, including \$40,779.28 for topographic and geologic maps and \$5,337.04 for geologic folios. In addition to this \$984.52 was repaid by other Government establishments at whose request maps or folios were furnished. The total receipts, therefore, were \$47,100.84.

The division received and answered 88,238 letters.

#### ENGRAVING AND PRINTING

##### TOPOGRAPHIC MAPS AND GEOLOGIC FOLIOS

During the year 72 new topographic maps were engraved and printed, including 14 revised maps. Forty new maps were photolithographed and printed, making a total of 112 new maps printed

and delivered. Corrections were engraved on the plates of 166 maps. Reprint editions of 135 engraved topographic maps and 5 photolithographed State and other maps were printed and delivered. In addition 58 new topographic maps had been engraved and were in press June 30, and the engraving of 18 other new topographic maps was nearly completed. Of new and reprinted maps 256 different editions, amounting to 644,750 copies, were delivered. One new geologic folio was printed, its edition amounting to 8,785 copies.

#### OTHER GOVERNMENT MAP PRINTING

A large amount of work was done for the Government Printing Office, office of the Secretary of the Interior, 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 Plant Industry, Bureau of Biological Survey, Forest Service, Weather Bureau, Bureau of Standards, Bureau of Lighthouses, Bureau of Navigation, Department of Labor, Department of State, War Department, Post Office Department, Treasury Department, Department of Justice, Department of Commerce, Interstate Commerce Commission, Federal Power Commission, Public Buildings Commission, Commission of Fine Arts, Smithsonian Institution, National Research Council, Coast Guard, Bureau of Internal Revenue, Veterans' Bureau, Federal Board for Vocational Education, Engineer Map Reproduction Plant, National Sesquicentennial Exposition, Pan-Pacific Conference, American Red Cross, Purdue University, Regional Plan of New York and its Environs, and the States of Alabama, Idaho, Kansas, Missouri, New Hampshire, Oklahoma, and West Virginia. This work done for other branches of the Government and State governments included many reprints, and the charges for it amounted to about \$140,000, for which the appropriation for engraving and printing geologic maps was reimbursed by transfer of credit on the books of the Treasury Department. Transfer impressions numbering 165 were made during the year, including 69 furnished to contracting lithographic printers on requisition of the Government Printing Office, 47 furnished to private firms, 47 furnished to the War Department, and 2 furnished to the Weather Bureau. Other miscellaneous work was done for A. Hoen & Co., Heliotype Co., Dennison Manufacturing Co., Williams & Heintz Co., Mrs. Charles S. Fayerweather, Clark University, University of Texas, and North Dakota Agricultural College. The amount turned over to miscellaneous receipts from this work was \$210.75.

Of contract and miscellaneous work of all kinds 2,902,551 copies were printed. Including topographic maps and geologic folios, a grand total of 3,556,086 copies were printed and delivered.

#### PHOTOGRAPHIC LABORATORY

The output of the photographic laboratory consisted of 8,503 negatives (1,853 wet, of which 840 were for photolithographs, 129 paper, 2,238 dry, 3,752 field negatives developed, and 531 lantern slides), 54,295 prints (26,219 maps and diagrams and 28,076 photographs for

illustrations), 2,700 zinc plates, 292 zinc etchings, 77 celluloid prints, 197 lantern slides colored, 9 transparencies colored, 43 prints colored, 6 crayons colored, and 3,247 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 836, 10 less than at the end of the fiscal year 1926. The changes in personnel were 683, including 118 appointments, 128 separations, and 437 miscellaneous. During the calendar year 1926, 72 per cent of the possible annual leave and 15 per cent of the possible sick leave was granted. Leave without pay and furloughs amounting to 4,320 days were also granted.

### LIBRARY

Accessions to the library numbered 17,737 books, pamphlets, and periodicals and 755 maps. The recorded loans were 6,265 books and 432 maps, not including those used by 10,893 readers who consulted the library in person. The catalogue was increased by the addition of 8,104 cards. In accordance with the cooperative cataloguing arrangements, 665 title entries were furnished to the Library of Congress for printing, the proof reading of which involved 87 galleys.

The correspondence, consisting of 2,132 letters written and 1,682 received, largely concerned the exchange of publications. This correspondence involved the translation of many letters in foreign languages. Foreign articles and letters translated for other divisions of the Geological Survey numbered 205. There were 917 books collated and prepared for binding and 666 newly bound books accessioned and labeled.

Cooperation in the compilation of the "Union list of serials in the libraries of the United States and Canada," to be published under the auspices of the American Library Association, was continued.

The proof of the bibliography of North American geology for 1923 and 1924 (Bulletin 784) was read, and the preparation of the bibliography for 1925 and 1926 was continued.

### 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, 1927 <sup>a</sup>

Appropriation	Funds available				Total	Expenditures			Balance
	Amount of appropriation	Repayments on account of work performed		For other Geological Survey units		Disbursements	Outstanding liabilities	Total	
		For cooperating agencies							
		Made	To be made						
Salaries.....	\$130,000.00				\$130,000.00	\$126,733.17		\$126,733.17	\$3,266.83
Topographic surveys.....	451,700.00	\$108,333.48	\$23,253.73	\$14,429.57	657,726.78	647,334.98	\$3,556.22	650,941.20	6,785.58
Geologic surveys.....	337,160.00	15,870.39	5,888.79	476.41	359,395.59	346,180.48	5,271.89	351,452.37	7,943.22
Volcanologic surveys.....	25,000.00	33.44			25,033.44	21,777.17	<sup>b</sup> 2,853.59	24,630.76	402.68
Mineral resources of Alaska.....	50,000.00	43.70		363.46	50,407.16	44,581.00	<sup>b</sup> 5,609.92	50,190.92	216.24
Gaging streams.....	151,000.00	107,357.42	22,739.10	2,468.79	283,565.31	277,862.64	2,716.63	280,579.27	2,986.04
Classification of lands.....	240,000.00	988.37	218.96	1,317.50	242,524.83	234,674.30	3,685.40	238,359.70	4,165.13
Geologic maps of the United States.....	97,000.00	100,547.22	18,011.07	22,151.68	237,709.97	203,873.06	31,064.35	234,937.41	2,772.56
Preparation of illustrations.....	25,580.00	23.48		19.20	25,622.68	25,009.12		25,009.12	613.56
Mineral leasing.....	312,000.00	4.35		304.07	312,308.42	280,061.73	10,067.29	290,129.02	22,179.40
	1,819,440.00	393,201.85	70,111.65	41,540.68	2,324,294.18	<sup>c</sup> 2,208,137.65	64,825.29	<sup>b c</sup> 2,272,962.94	<sup>d</sup> 51,331.24

<sup>a</sup> In addition to these appropriations, items of \$81,000 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 \$13,707 for miscellaneous supplies from the appropriation for contingent expenses of the Interior Department.

<sup>b</sup> Of these totals \$5,177 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.

<sup>c</sup> Included in this amount is \$41,540.68 covering work performed by Geological Survey units for other Geological Survey units, necessarily reported in combining totals, but otherwise a duplication.

<sup>d</sup> A budget reserve of \$26,620 is included in this balance.

Classification of expenditures by the United States Geological Survey pertaining to the fiscal year ended June 30, 1927

Object of expenditure	Geological Survey salaries	Topographic surveys	Geologic surveys	Volcanologic surveys	Mineral resources of Alaska	Gaging streams	Classification of lands	Geologic maps of the United States	Preparation of illustrations	Mineral leasing	Total
Personal services.....	\$126,733.17	\$475,650.54	\$295,586.77	\$15,373.85	\$36,232.61	\$221,163.45	\$190,613.19	\$172,686.01	\$24,371.13	\$205,520.01	\$1,763,930.73
Stationery and office supplies.....		8,262.79	730.54	151.84	240.69	1,526.35	264.89	36,163.77	37.90	3,995.96	51,374.73
Scientific and educational supplies.....		831.20	1,096.31	56.04	112.46	350.94	176.22		25.84	724.63	3,373.64
Sundry supplies.....		3,011.95	361.81	647.21	22.75	1,171.07	464.66	7,838.29	16.35	1,130.37	14,664.46
Subsistence and care of animals and storage and care of vehicles.....		1,026.20	255.00								
Telegraph service.....		573.22	102.17	13.96	63.24	295.46	82.78	18.59		536.26	1,685.68
Telephone service.....		179.71	71.60	61.56	3.63	700.46	146.00			1,894.03	3,056.99
Other communication service.....		20.70				20.00	7.00			42.10	89.80
Travel expenses.....		74,030.19	24,966.96	2,786.08	5,630.96	21,008.34	21,692.70	36.68		21,010.30	171,162.21
Attendance at meetings.....		463.29	2,096.99			251.18				253.88	3,065.34
Hire, maintenance, operation, and repair of horse-drawn and motor-propelled passenger-carrying vehicles.....		5,719.10	2,515.50	598.48	103.50	8,645.89	6,941.88	2.25		21,322.34	45,848.94
Transportation of things.....		32,146.75	6,908.02	1,031.50	319.08	2,931.70	5,218.62	127.39		1,370.38	50,053.44
Lithographing, engraving, and engrossing.....		11,743.73	413.05		12.82	199.42	495.81	198.27	185.44	192.95	13,441.49
Stenographic work, typewriting, and duplicating work, etc. (job work).....		23.75	8.10			26.05	2.85	3.23		11.60	75.58
Photographing and making photographs and prints.....		2,885.66	2,591.22	76.00	286.47	703.65	953.43		360.47	554.08	8,410.98
Heat, light, power, water, and electricity.....		5.40		41.50						2,116.83	2,163.73
Rents.....		99.24		1.00	5.00	229.52				5,151.00	5,485.76
Repairs and alterations.....		125.48	485.83	275.02	7.10	970.63	33.94	759.05	1.02	1,024.89	3,682.96
Special and miscellaneous current expenses.....		13,743.91	852.03	17.50	37.90	1,077.42	80.59	550.61		7,607.34	23,967.30
Purchase of passenger-carrying vehicles.....		710.00		295.30		4,496.30	3,366.20			9,070.10	17,937.90
Furniture, furnishings, and fixtures.....		839.16	501.95	891.17	40.00	626.87	534.37	126.95		1,554.40	5,114.87
Educational and scientific equipment.....		5,460.22	7,123.78	1,199.75	279.39	8,611.20	1,603.05	1,645.89	8.73	1,266.27	27,198.25
Livestock.....			64.00				85.00				149.00
Other equipment.....		11,857.20	2,148.26	331.70		5,304.98	2,008.97	14,150.50		2,406.56	38,208.17
Miscellaneous transfers and adjustments.....		1,531.81	2,572.48	104.30	2,293.32	268.39	3,587.55	629.93	2.24	1,372.74	12,362.76
	126,733.17	650,941.20	351,452.37	23,953.76	45,690.92	280,579.27	238,359.70	234,937.41	25,009.12	290,129.02	2,267,785.94

ADMINISTRATION

GEORGE OTIS SMITH,  
Director.



# INDEX

	Page		Page
Accounts.....	73-75	Maryland, surveys and reports.....	17
Administration.....	73-75	Massachusetts, surveys and reports.....	17
Aerial photographic topography.....	7	Mendenhall, W. C., work of the geologic branch.....	9-27
Agricultural lands, classification.....	59-62	Michigan, surveys and reports.....	17-18, 40, 51
Alabama, surveys and map.....	12-13, 39, 50	Mineral-land classification.....	54
Alaska, mineral-leasing work.....	33-35, 50	Mineral-land leasing.....	55-56, 62-64
mineral-resources work.....	28-33, 47	Mining aided by geology.....	10-12
surveys and reports.....	6-7, 13	Mississippi, surveys and reports.....	51
Alaskan branch, work of.....	6-7, 27-35	Missouri, surveys.....	18, 40
Appropriations and expenditures.....	1, 9-10, 27-28, 30, 32, 33, 34, 35-36, 41-42, 50, 73-75	Montana, surveys and reports.....	18, 48, 51
Arizona, surveys and reports.....	13, 39, 47, 51	Naval reserve lands, production of petroleum.....	67
Arkansas, surveys and reports.....	13, 47, 51	Nebraska, surveys and reports.....	51
Birdseye, C. H., work of the topographic branch.....	35-41	Necrology.....	5
California, surveys and reports.....	14, 39, 48, 51	Nevada, surveys and reports.....	18-19, 40, 51-52
Chemical tests.....	25-26	New England earthquake.....	19
Coal lands investigated.....	3, 54	New Hampshire, surveys.....	40
Colorado, survey of mineral resources.....	12	New Jersey, surveys and reports.....	19, 48
surveys and reports.....	14-15, 39, 48, 51	New Mexico, surveys and reports.....	19, 40, 48-49, 52
Connecticut, report.....	15	New York, surveys and reports.....	19, 40
Conservation branch, investigations and reports.....	50-70	North Carolina, surveys and reports.....	19-20, 49
Cooperation by and with States and other Federal bureaus.....	1-2, 10, 41-43	North Dakota, surveys and reports.....	20, 40, 52
Correspondence and records.....	73	Ohio, surveys and reports.....	20
Delaware, surveys.....	39	Oklahoma, mapping.....	20
Director, work and addresses.....	5-6	surveys and reports.....	20, 52
Distribution of publications.....	71	Oregon, surveys and reports.....	21, 40, 49, 52
District of Columbia, studies of building materials and water.....	15, 48	Pennsylvania, surveys and reports.....	21, 40, 49
Editing.....	70-71	Photographic work.....	72-73
Engraving and printing.....	71-72	Physical tests.....	26-27
Florida, surveys and reports.....	15, 48, 51	Potash, search and reports.....	6, 19
Foreign fields, surveys and reports.....	24-25	Power resources, surveys and reports.....	45-46, 56-59
Geologic branch, work of the.....	6-7, 9-27	Public lands, classifying and leasing.....	8, 50-64
Georgia, surveys and reports.....	15, 39	petroleum, coal, and other products from.....	64-67
Grover, N. C., work of the water-resources branch.....	41-50	Publications prepared and issued.....	4-5, 8-9, 70
Hawaii, surveys and reports.....	16, 39, 48	Publicity, means and extent.....	4-5
Homestead lands, classification.....	59-62	Rhode Island, waters.....	49
Idaho, surveys and reports.....	16, 39, 48, 51	Scope of investigations.....	2-4
Illinois, surveys and reports.....	16, 39	Smith, Philip S., work of the Alaskan branch.....	27-35
Illustrations prepared.....	70	South Carolina, reports.....	21, 49
Indian lands, leasing mineral deposits.....	67-69	South Dakota, surveys and reports.....	21, 49, 52
Indiana, surveys and reports.....	16, 39	Stabler, Herman, work of the conservation branch.....	50-70
Iowa, surveys.....	16, 39	Tennessee, surveys and reports.....	21-22, 40, 49
Kansas, surveys and reports.....	16-17, 51	Texas, surveys and reports.....	22, 40, 49
Kentucky, surveys.....	17, 39	Topographic branch, work of the.....	7, 35-41
Land classification.....	8, 53-62	Utah, surveys and reports.....	22-23, 40, 49, 52
Library.....	73	Virginia, surveys and reports.....	23, 40, 49
Louisiana, surveys and reports.....	17, 48, 51	Vermont, surveys.....	23, 40
Maine, surveys.....	17, 39	Volcanology.....	9, 13, 14, 16
Maps edited and printed.....	70-72	Washington, surveys and reports.....	23-24, 40, 49-50, 52
		Water-resources branch, work and publica- tions.....	7-8, 41-50
		West Virginia, surveys and reports.....	24, 40, 50
		Wisconsin, surveys and reports.....	24, 41, 52
		Wyoming, surveys and reports.....	24, 52-53