UNITED STATES DEPARTMENT OF THE INTERIOR

ANNUAL REPORT OF THE DIRECTOR OF THE GEOLOGICAL SURVEY

TO THE SECRETARY OF THE INTERIOR

FOR FISCAL YEAR ENDED JUNE 30, 1929

UNITED STATES DEPARTMENT OF THE INTERIOR

FIFTIETH ANNUAL REPORT

OF THE

DIRECTOR OF THE GEOLOGICAL SURVEY

TO THE

SECRETARY OF THE INTERIOR

1929

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Directors of the Geological Survey

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

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ANNUAL REPORT

OF THE

DIRECTOR OF THE GEOLOGICAL SURVEY

DEPARTMENT OF THE INTERIOR,
GEOLOGICAL SURVEY,
October 15, 1929.

SIR: The appropriations made directly for the work of the Geological Survey for the fiscal year 1929 included 14 items, amounting to $2,135,609. In addition $120,000 was appropriated for printing and binding for the Geological Survey, and an allotment of $14,765 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 July 31 was $28,165.

The total amount of funds made available for disbursement by the Geological Survey, together with State funds directly disbursed for work administered by the Federal officials, was $3,875,332.

FIFTY YEARS OF SERVICE

The United States Geological Survey was created by act of Congress approved March 3, 1879. It was the successor of four Federal organizations that had been making topographic, geologic, and other scientific and economic surveys in the territory west of the one hundredth meridian, under the leadership of Clarence King, F. V. Hayden, G. M. Wheeler, and J. W. Powell. On March 21, 1879, President Hayes appointed Clarence King the first Director of the United States Geological Survey. In the half century that has passed since that time the Geological Survey has grown in stature, widened its field of endeavor, and increased its usefulness, but it has not grown old. Its outstanding characteristic, which has tinged all its work and been its chief asset, is the fact that it is primarily a field service—its men have traveled far and wide and know by intimate contact the country that the organization serves. Through these 50 years thousands of young men have come under that broadening influence. The far-reaching outlook of specialized public service that is possessed by many men in high position in this country is a by-product of the United States Geological Survey.

During this half century the Federal funds made available annually for the work of the Geological Survey have increased from $100,000 to more than $2,000,000. The total expenditures for the 50 years have been $75,000,000, of which nearly $10,0000,000 has been contributed by States for cooperative work. Most of the work on

which these millions have been expended may be described by the simple term "fact finding." The Geological Survey has been continuously engaged in research—in bringing to light facts that have been of essential importance in the marvelous development of our country since 1879. When the Geological Survey made its first census of mineral production, the treasure house of the country had hardly been opened; since then the mineral industry has increased fifteenfold. The research work of the Geological Survey has not been confined to investigations whose immediate economic value is self-evident. Realizing that the pure science of to-day becomes the applied science of to-morrow, it has neglected no phase of the study of the earth. Its methods of work and the men it has trained have powerfully shaped the course of development of the science of geology.

The topographic maps that have been necessary to provide an accurate base upon which to represent the facts ascertained by the geologic work have now attained so high a degree of exactness that they are sought for themselves alone by all classes of the people—from engineer to vacation tourist. The investigations of water, our greatest mineral resource, have thrown light on the complex problems of public water supply, inland navigation, flood prevention, reclamation by both drainage and irrigation, and the development of power. The activities of the Geological Survey in respect to the vast mineral estate comprised in the public land, of which nearly 200,000,000 acres still remains unappropriated, have been based on the practical policy of planning for its future use without waste of the resources and for the intelligent distribution of that use as to time—between our day and our children's day.

Not the least of the accomplishments of the Geological Survey during its first half century has been its service as the mother of other organizations that are playing essential parts in the study of our country and the development of its resources. The work that is being done by the Bureau of American Ethnology, the Forest Service, the Bureau of Reclamation, the Bureau of Mines, and the Geophysical Laboratory of the Carnegie Institution had its beginnings in the Geological Survey.

The publications by which the results of the multiform investigations of the Geological Survey have been made available in permanent form now comprise more than 400,000 printed pages and occupy 120 feet of shelf room—twenty-four "5-foot shelves" of recorded facts and conclusions concerning the unequaled natural resources of the United States.

PUBLICATIONS OF THE YEAR

The following publications were issued during the fiscal year 1929:

ANNUAL REPORT

Forty-ninth Annual Report of the Director of the Geological Survey.

PROFESSIONAL PAPERS

144. The copper deposits of Michigan, by B. S. Butler and W. S. Burbank, in collaboration with T. M. Broderick, L. C. Graton, C. D. Hohl, Charles Palache, M. J. Scholz, Alfred Wandke, and R. C. Wells.

150. Shorter contributions to general geology, 1927.
153. Studies of Basin Range structure, by G. K. Gilbert.
154–B. The fauna of the middle Boone near Batesville, Ark., by G. H. Girty.
154–C. Salinity of the water of Chesapeake Bay, by R. C. Wells, R. K. Bailey, and E. P. Henderson.
154–D. Origin of the siliceous Mowry shale of the Black Hills region, by W. W. Rubey.
154–E. Oil shale in a producing oil field in California, by H. W. Hoots.
154–F. Water-laid volcanic rocks of early Upper Cretaceous age in southwestern Arkansas, southeastern Oklahoma, and northeastern Texas, by C. S. Ross, H. D. Miser, and L. W. Stephenson.
154–G. Algae reefs and oolites of the Green River formation, by W. H. Bradley.
154–H. A revision of the flora of the Latah formation, by E. W. Berry.
154–I. *Exogyra olisiponensis* Sharpe and *Exogyra costata* Say in the Cretaceous of the Western Interior, by J. B. Reeside, jr.
154–J. Additions to the flora of the Green River formation, by R. W. Brown.
157. The Mother Lode system of California, by Adolph Knopf.
158–A. The occurrence and origin of analcite and meerschaum beds in the Green River formation of Utah, Colorado, and Wyoming, by W. H. Bradley.

BULLETINS

775. Geology and lignite resources of the Marmarth field, southwestern North Dakota, by C. J. Hares.
788. Topographic instructions of the United States Geological Survey.
794. "Red Beds" and associated formations in New Mexico, with an outline of the geology of the State, by N. H. Darton.
797–B. The Skwentna region, Alaska, by S. R. Capps.
797–C. Preliminary report on the Sheenjek River district, Alaska, by J. B. Mertie, jr.
797–D. Surveys in northwestern Alaska in 1926, by P. S. Smith.
797–E. Aerial photographic surveys in southeastern Alaska, by R. H. Sargent and F. H. Moffit.
797–F. Geology and mineral resources of the Aniakchak district, Alaska, by R. S. Knappen.
798. Geology of the Muddy Mountains, Nev., with a section through the Virgin Range to the Grand Wash Cliffs, Ariz., by C. R. Longwell.
801. Geology and water resources of the Edgeley and La Moure quadrangles, N. Dak., by H. A. Hard.
802. Bibliography of North American geology, 1925 and 1926, by J. M. Nickles.
803. Geography, geology, and mineral resources of the Portneuf quadrangle, Idaho, by G. R. Mansfield.
804. Geology and coal and oil resources of the Hanna and Carbon Basins, Carbon County, Wyo., by C. E. Dobbin, C. F. Bowen, and H. W. Hoots.
805. Contributions to economic geology (short papers and preliminary reports), 1928, Part I, Metals and nonmetals except fuels.
805–A. Platinum and black sand in Washington, by J. T. Pardee.
805–B. Deposits of vermiculite and other minerals in the Rainy Creek district, near Libby, Mont., by J. T. Pardee and E. S. Larsen.
806–A. The Pumpkin Buttes coal field, Wyo., by C. H. Wegeman, R. W. Howell, and C. E. Dobbin.
806–B. The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Mont., by A. A. Baker.
806–C. Geology and oil and gas prospects of part of the San Rafael Swell, Utah, by James Gilluly.
806–D. Geology of the Rock Creek oil field and adjacent areas, Carbon and Albany Counties, Wyo., by C. E. Dobbin, H. W. Hoots, C. H. Dane, and E. T. Hancock
806–E. Thrust faulting and oil possibilities in the plains adjacent to the Highwood Mountains, Mont., by Frank Reeves.
807. Geology of Hyder and vicinity, southeastern Alaska, with a reconnaissance of Chickamin River, by A. F. Buddington.
810–A. Mineral industry of Alaska in 1927 and administrative report, by P. S. Smith [with selected list of Geological Survey publications on Alaska].

WATER-SUPPLY PAPERS

540. Ground water in the New Haven area, Conn., by J. S. Brown.
571. Surface water supply of the United States, 1923, Part XI, Pacific slope slope basins in California.
581. Surface water supply of the United States, 1924, Part I, North Atlantic slope drainage basins.
582. Surface water supply of the United States, 1924, Part II, South Atlantic slope and eastern Gulf of Mexico basins.
586. Surface water supply of the United States, 1924, Part VI, Missouri River Basin.
588. Surface water supply of the United States, 1924, Part VIII, Western Gulf of Mexico basins.
589. Surface water supply of the United States, 1924, Part IX, Colorado River Basin.
590. Surface water supply of the United States, 1924, Part X, The Great Basin.
591. Surface water supply of the United States, 1924, Part XI, Pacific slope basins in California.
593. Surface water supply of the United States, 1924, Part XII, North Pacific slope drainage basins: B, Snake River Basin.
594. Surface water supply of the United States, Part XII, North Pacific slope drainage basins: C, Lower Columbia River Basin and Pacific slope drainage basins in Oregon.
595. Surface water supply of Hawaii, July 1, 1923, to June 30, 1924.
596. Contributions to the hydrology of the United States, 1927.
597–A. Geology of reservoir and dam sites, with a report on the Owyhee irrigation project, Oreg., by Kirk Bryan.
597–B. A study of ground water in the Pomperaug Basin, Conn., with special reference to intake and discharge, by O. E. Meinzer and N. D. Stearns.
597–C. Problems of the soft-water supply of the Dakota sandstone, with special reference to the conditions at Canton, S. Dak., by O. E. Meinzer.
597–D. Geology and water resources of the upper McKenzie Valley, Oreg., by H. T. Stearns.
597–E. Surface water supply of the Sacramento River Basin, Calif., 1895–1927, by H. D. McGlashan.
611. Surface water supply of the United States, 1925, Part XI, Pacific slope basins in California.
612. Surface water supply of the United States, 1925, Part XII, North Pacific slope drainage basins: A, Pacific basins in Washington and upper Columbia River Basin.
636–A. Quality of water of the Colorado River in 1926–1928, by C. S. Howard.

GEOLOGIC ATLAS

Geologic map of New Mexico.

TOPOGRAPHIC AND OTHER MAPS

[The figures in parentheses indicate limiting parallels and meridians of the areas covered]

Alabama:
Samantha (33° 15′–33° 30′; 87° 30′–87° 45′).
Arizona:
Buck Mountains (34° 30′–34° 45′; 114°–114° 15′).
Fortuna (32° 30′–32° 45′; 114° 15′–114° 30′).
Mohawk (32° 30′–32° 45′; 113° 45′–114°).
Norton (32° 45′–33°; 113° 45′–114°).
Wellton (32° 30′–32° 45′; 114°–114° 15′).
Arizona–California:
Laguna (32° 45′–33°; 114° 15′–114° 30′).
Arkansas:
State, scale 1:500,000.
California (see also Arizona–California):
Corcoran (36°–36° 7′ 30″; 119° 30′–119° 37′ 30″).
Eden Valley (39° 30′–39° 45′; 123°–123° 15′).
Glendale (34° 6′–34° 12′; 118° 12′–118° 18′).
Guernsey (36° 7′ 30″–36° 15′: 119° 37′ 30″–119° 45′).

Lassen Volcanic National Park (40° 25′–40° 35′; 121° 15′–121° 35′).
Lindsay (36° 7′ 30″–36° 15′; 119°–119° 7′ 30″).
San Pedro Hills (33° 42′–33° 48′; 118° 18′–118° 26′).
Tipton (36°–36° 7′ 30″; 119° 15′–119° 22′ 30″).
Waukena (36° 7′ 30″–36° 15′; 119° 30′–119° 37′ 30″).
Westhaven (36° 7′ 30″–36° 15′; 119° 52′ 30″–120°).
Woodville (36°–36° 7′ 30″; 119° 7′ 30″–119° 15′).
Yosemite National Park (37° 30′–38° 15′ 30″; 119°–120°).

Colorado:
Highmore (39° 30′–39° 45′; 108° 15′–108° 30′).

District of Columbia–Maryland–Virginia:
Washington and vicinity (38° 45′–39° 5′; 76° 52′ 30″–77° 15′).

Georgia. (See South Carolina–Georgia.)

Hawaii:
Haleakala (20° 35′–20° 45′; 156°–156° 15′).
Honaunau (19° 15′–19° 30′; 155° 45′–155° 57′ 30″).
Hoopuloa (19°–19° 15′; 155° 45′–155° 57′ 30″).
Kahoolawe (20° 30′–20° 45′; 156° 30′–156° 42′ 30″).
Keahole (19° 37′ 30″–19° 52′ 30″; 156°–156° 12′ 30″).
Koolau (20° 45′–20° 57′ 30″; 156°–156° 15′).
Mauna Loa (19° 15′–19° 30′; 155° 30′–155° 45′).
Niihau (21° 46′–22° 2′; 160° 2′–160° 15′).

Idaho:
Craters of the Moon National Monument (43° 16′–43° 30′; 113° 25′–113° 36′).
State, scale 1:500,000.

Illinois (see also Kentucky–Illinois):
Brighton (39°–39° 15′; 90°–90° 15′).
Chicago Loop (41° 52′ 30″–42°; 87° 37′ 30″–87° 45′).
Evanston (42°–42° 7′ 30″; 87° 37′ 30″–87° 45′).
Tinley Park (41° 30′–41° 37′ 30″; 87° 45′–87° 52′ 30″).

Illinois–Indiana:
Jackson Park (41° 45′–41° 52′ 30″; 87° 30′–87° 37′ 30″).

Indiana. (See Illinois–Indiana.)

Iowa:
Albia (41°–41° 15′; 92° 45′–93°).

Kansas–Nebraska:
Southwestern Nebraska and western Kansas (37°–41°; 100°–109°; land classification).

Kentucky. (See Tennessee–Kentucky, Virginia–Kentucky, West Virginia–Kentucky, West Virginia–Virginia–Kentucky.)

Kentucky–Illinois:
Smithland (37°–37° 15′; 88° 15′–88° 30′).

Maine:
Dead River (45°–45° 15′; 70°–70° 15′).
Dixfield (44° 30′–44° 45′; 70° 15′–70° 30′).

Maryland. (See District of Columbia–Maryland–Virginia.)

Michigan:
Laingsburg (42° 45′–43°; 84° 15′–84° 30′).

Missouri:
Cardareva (37°–37° 15′; 91°–91° 15′).
Des Arc (37° 15′–37° 30′; 90° 30′–90° 45′).

Montana:
Flathead Lake project (48° 3′–48° 13′; 114° 6′–114° 18′).

Nebraska (see also Kansas–Nebraska):
Northwestern Nebraska (41°–43°; 100° 10′–104° 3′; land classification).

New Hampshire:
Hillsboro (43°–43° 15′; 71° 45′–72°).
Mount Kearsarge (43° 15′–43° 30′; 71° 45′–72°).

New Hampshire–Vermont:
Averill (44° 45′ to Canadian boundary; 71° 30′–71° 45′).
Claremont (43° 15′–43° 30′; 72° 15′–72° 30′).

New York (see also Pennsylvania–New York):
Coxsackie (42° 15′–42° 30′; 73° 45′–74°).

North Carolina. (See Virginia–North Carolina.)

North Dakota:
Minot (48°–48° 15′; 101° 15′–101° 30′).

Ohio. (See West Virginia–Ohio.)
Pennsylvania:
Gettysburg (39° 45′–40°; 77°–77° 15′; areal geology).
Gettysburg (economic geology).
Pennsylvania–New York:
Youngsville (41° 45′–42°; 79° 15′–79° 30′).
South Carolina–Georgia:
Warrenville (33° 30′–33° 45′; 81° 45′–82°).
Tennessee:
Decherd (35°–35° 15′; 86°–86° 15′).
Gordonsville (36°–36° 15′; 85° 45′–86°).
Tennessee–Kentucky:
Tompkinsville (36° 30′–36° 45′; 85° 30′–85° 45′).
Texas:
Tankersly (31° 15′–31° 30′; 100° 30′–100° 45′).
Waldrip (31° 15′–31° 30′; 99° 15′–99° 30′).
Wall (31° 15′–31° 30′; 100° 15′–100° 30′).
United States:
Physical divisions.
Utah:
Fort Douglas (40° 30′–41°; 111° 30′–112°).
Gold Hill (40°–40° 15′; 113° 45′–114°).
Vermont. (See New Hampshire–Vermont.)
Virginia (see also District of Columbia–Maryland–Virginia, West Virginia–Kentucky, West Virginia–Virginia–Kentucky):
Covesville (37° 45′–38°; 78° 30′–78° 45′).
Virginia–Kentucky:
Big Stone Gap (36° 45′–37°; 82° 45′–83°).
Virginia–North Carolina:
Critz (36° 30′–36° 45′; 80°–80° 15′).
West Virginia:
Ripley (38° 45′–39°; 81° 30′–81° 45′).
Spencer (38° 45′–39°; 81° 15′–81° 30′).
West Virginia–Kentucky:
Naugatuck (37° 45′–38°; 82° 15′–82° 30′).
West Virginia–Ohio:
Point Pleasant (38° 45′–39°; 82°–82° 15′).
Ravenswood (38° 45′–39°; 81° 45′–82°).
West Virginia–Virginia–Kentucky:
Matewan (37° 30′–37° 45′; 81° 45′–82°).
Wyoming:
Southeastern Wyoming (41°–43°; 104° 3′–107°; land classification).

THE YEAR'S OPERATIONS

The director continued his service as chairman of the advisory committee of the Federal Oil Conservation Board and as chairman of the Naval Oil Reserve Commission. During March to June, as the representative of the Federal Oil Conservation Board, he attended several oil conferences and as the personal representative of the Secretary of the Interior promoted oil conservation in California. This service involved 25,000 miles of travel.

For the purpose of bringing before the public the results of the work of his associates and in connection with his administration of the general work of the Geological Survey, as in other years, he made several addresses and informal talks and contributed articles to the press. These are listed below:

ADDRESSES

Empire builders, Columbia section, American Institute of Mining and Metallurgical Engineers, Spokane, Wash., July 20.
Washington development, Mining Association, Seattle, Wash., July 23.

Brakes for the mineral industry, American Bar Association, Seattle, Wash., July 24.

Our share in the Nation's business, joint meeting of the American Institute of Mining and Metallurgical Engineers and the American Mining Congress, Los Angeles, Calif., September 12.

Open mind and open forum, Petroleum division, American Institute of Mining and Metallurgical Engineers, Tulsa, Okla., October 18.

Address, Tri-State Zinc and Lead Association, Picher, Okla., October 22.

Address, Mid-Continent Oil and Gas Association, Tulsa, Okla., October 24.

Geophysical exploration, radio hearing, Interior Department, Washington, November 15.

Government work in aid of mining, American Institute of Mining and Metallurgical Engineers, New York City, December 20.

Engineering standards for society, address as retiring president, American Institute of Mining and Metallurgical Engineers, New York City, February 20.

Address, American Petroleum Institute, Houston, Tex., March 15.

Address, conference on oil conservation, Colorado Springs, Colo., June 10.

ARTICLES

Natural resources of the United States, 1927, American Journal of Sociology, July.

Conservation of oil, United States Daily, August 13.

National conservation, New York Herald-Tribune, November 18.

Geological Survey's oil studies of great importance to industry, Oil and Gas Journal, January 3.

Radio as a stop-watch for the geophysicist, New York Herald-Tribune, January 27.

Our field fact-finding, National Republic, April.

What the new oil policy means, Nation's Business, May.

Natural resources, 1928, American Journal of Sociology, May.

Secretary Wilbur has full authority for enforcing order, California Oil World, May 8.

California gas law is beneficial, California Oil World, May 15.

Cooperative conservation new policy, California Oil World, May 29.

Self-government in oil, Oil Bulletin, June.

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 and Alaska. In this work 13 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. Considerable geologic work was also done in cooperation with other Government organizations and with nongovernmental scientific associations. Cooperative investigations bearing on oil and gas resources were made in 1 State, on metalliferous deposits in 4 States, on potash in 2 States, and on general geologic problems in 8 States. The investigations in search of potash, carried on in cooperation with the Bureau of Mines, were continued in New Mexico, where four sites for Government core drilling were selected, and in Texas, where drilling at four sites was completed. The cores were studied and selected portions analyzed, and preliminary reports on the economic results were prepared. Volcanologic studies were carried on in California, Alaska, and Hawaii. Numerous paleontologic determinations were made. Investigations of ore deposits, coal, oil shale, and other minerals and studies in glacial geology, stratigraphy, and structure were continued. In the chemical laboratory 5,880 samples of potash salts were examined and a total of 8,910 specimens were analyzed. Study and experimental work on ore deposition and other chemical problems were continued. Further work was done on problems connected with petroleum recovery.

EXPLORATIONS IN ALASKA

The principal explorations conducted by the Geological Survey in Alaska in the field season of 1928 were made in southeastern Alaska, the Copper River region, the Mount Spurr region of the Alaska Range, and the region north of the Tanana River. The work in southeastern Alaska consisted of reconnais-

sance topographic mapping in the Ketchikan district, with the aid of the aerial photographs taken by the Navy Department in 1926, and of a detailed survey of a small tract in the Juneau region for the Forest Service. The work in the Copper River region consisted of the revision of earlier geologic surveys in the Nizina district. The Mount Spurr expedition accomplished the topographic and geologic mapping of 1,000 square miles of new country. In the Tanana region the major geologic features of an area of nearly 4,000 square miles were mapped.

Six field projects were in progress at the end of the fiscal year 1929, including topographic studies in southeastern Alaska, in connection with the airplane photographing expedition of the Navy Department, geologic reconnaissance in the Copper River and Yukon-Tanana regions, and geologic and topographic reconnaissance in the Alaska Range. Some of the work in southeastern Alaska is being done for the Forest Service, which is bearing the cost. Special assistance is being given to the Alaska Railroad in solving problems that arise in its work in which geologic information is useful. The supervision of operations under leases issued by the Government for extracting coal and oil on public lands was continued during the year, a small staff being maintained at two local offices in Alaska for this purpose.

TOPOGRAPHIC MAPPING

The topographic work was done in cooperation with 25 States, county officials in 2 States, the War Department, the Corps of Engineers, and the Colorado Metal Mining Fund, and the area mapped amounted to 17,333 square miles in 29 States, the District of Columbia, and Hawaii. Of this total 12,956 square miles represents new surveys, 4,049 square miles resurveys, and 328 square miles revisions. The total area mapped to June 30, 1929, is 1,327,234 square miles. Nine States and the District of Columbia are now entirely mapped, and the percentages in other States range from 8 to 88.6. Of the total continental United States, exclusive of Alaska, 43.6 per cent has been mapped. River surveys amounting to 838 linear miles were also made. In connection with the topographic work 8,542 miles of spirit levels and 5,068 miles of transit traverse were run and 211 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 base map of California was prepared, and the base map of. Arkansas was revised. A partial culture and drainage map of the Tensas Basin, Louisiana and Arkansas, was compiled for the Mississippi River Commission.

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 $367,929.66. This sum covered work in 35 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 47 States and Hawaii, in which at the end of the year 2,238 gaging stations were being maintained. The work on ground-water resources has been planned to meet the more and more exacting public demand for precise information with increasing need for the water. Investigations relating to ground water and power or reservoir sites were made in 22 States. Research into the principles of hydrology has been continued in order to provide a more secure basis for ground-water investigations. 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 1,037 samples of water and 245 samples of silt. 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.

WORK IN CLASSIFYING AND LEASING PUBLIC LAND

The work of classifying public and Indian lands with respect to mineral content and of supervising mineral operations on such lands was carried on in 21 States and Alaska. The number of cases involving land classification acted

on during the year was 15,428, and the results accomplished include net decreases of 57,006 acres in the area of outstanding coal withdrawals, of 92,140 acres in outstanding petroleum withdrawals, and of 26,261 acres in outstanding phosphate reserves. At the end of the year the total area classified as mineral in character amounted to 36,433,446 acres in 14 States and Alaska and the outstanding mineral withdrawals to 46,639,593 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 515,378 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 245,808 acres in the area included in power reserves, making a total of 6,479,570 acres in 20 States and Alaska, on which about 15,000,000 continuous horsepower can be developed. The net increase in enlarged-homestead designations was 142,493 acres, making a total outstanding of 325,302,286 acres in 14 States, and the net increase in stock-raising homestead designations was 1,141,957 acres, making a total outstanding of 120,236,561 acres in 18 States. There was a net increase of 15,040 acres in public water reserves, and the total outstanding is now 418,431 acres in 12 States. The supervisory work on public lands subject to the mineral leasing laws was increased by the issuance of 101 leases, 2,539 permits, and 13 licenses, covering 4,295,366.98 acres, and decreased by 8,756 cancellations of leases and permits. The production of petroleum on such lands during the year was 22,458,842.62 barrels, of natural gas 22,770,394,110 cubic feet, and of gasoline 47,319,874.32 gallons, on which the royalty, rentals, and bonuses amounted to $3,685,883.35. The production of coal on such lands was 1,022,860.90 tons, of phosphate rock 21,792.06 tons, and of sodium 23,580.99 tons, on which the royalty, rentals, and bonuses amounted to $414,186.11. Supervision over oil and gas operations on naval petroleum reserves was continued, and the production was 8,116,635.98 barrels of petroleum, 7,711,858,000 cubic feet of natural gas, and 24,908,262.82 gallons of gasoline, on which the royalty value was $1,817,464.45. Inspectional, regulatory, and advisory service was rendered in connection with the leasing of mineral deposits on Indian lands in seven States, with a royalty value of approximately $7,500,000, nearly all in Oklahoma.

PUBLICATIONS

The publications of the year consisted of 60 books and pamphlets of the regular series, 76 new or revised maps, 200 reprinted maps, and numerous circulars, lists of publications, etc. The total number of pages in the new book publications was 7,381. In addition to the publications in the regular series, 89 brief reports were issued in mimeographed form as memoranda for the press. The manuscript edited and prepared for printing amounted to 16,601 pages; 2,677 galley proofs and 14,814 page proofs were read and corrected. Indexes were prepared for 31 publications, covering 6,291 pages. The drawings prepared for publications numbered 2,738, and the proofs of illustrations examined 969. The new topographic maps edited and transmitted for engraving numbered 57, and 473 other maps were edited. Map proofs numbering 600 were read. Of new and reprinted maps and folios 759,732 copies were printed. The publications distributed numbered 975,155, of which 8,910 folios and 717,349 maps were sold for $49,289.38.

GEOLOGIC BRANCH

W. C. MENDENHALL, Chief Geologist

ORGANIZATION AND PERSONNEL

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

Paleontology and stratigraphy, T. W. Stanton, geologist, in charge.
Geology of metalliferous deposits, G. F. Loughlin, geologist, in charge.
Geology of areal and nonmetalliferous deposits, G. R. Mansfield, geologist, in charge.
Geology of iron and steel metals, E. F. Burchard, geologist, in charge.
Glacial geology, W. C. Alden, geologist, in charge.

Coastal Plain investigations, L. W. Stephenson, geologist, in charge.
Geology of fuels, H. D. Miser, geologist, in charge.
Volcanology, T. A. Jaggar, jr., volcanologist, in charge.
Petrology, C. S. Ross, geologist, in charge.
Chemistry and physics, George Steiger, chemist, in charge.

The professional force was reduced by 1 retirement, 5 transfers (including 2 topographic engineers), and 1 resignation, and there were 14 appointments (including 1 topographic engineer). With these changes it now includes 106 geologists of various grades, many of whom are not employed continuously, 8 chemists, and 2 physicists. The subprofessional force comprises 6 draftsmen (2 temporary), 7 preparators of fossils (1 temporary), and 1 laboratory mechanic. In the clerical force there were 5 accessions and 9 separations, leaving a total of 27 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	$355,000
Classification of lands	18,000
Volcanologic surveys	21,000
Investigating potash deposits	10,000
Repayments from other Federal departments	7,647
Repayments from State, city, and other cooperating organizations	22,468
	434,115

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

Geologic investigations (economic and scientific)	$323,142
Supervision, administration, services of clerical, technical, and skilled-labor forces, etc	91,191
Hawaiian volcanology	18,526
Unexpended balances	1,256
	434,115

NEED FOR GEOLOGIC RESEARCH

The student of modern civilization, its trends and the reasons that underlie its swift advance, finds it difficult to phrase a plea for the support of research—as difficult as to prove an axiom; to him no plea is needed. Research, resulting in an understanding of natural laws and of man's relation to nature, is the very foundation of modern life. This understanding constitutes perhaps the most essential difference between the brilliant civilizations of the past and those of to-day and contains the soundest basis for expecting that those of to-day will survive, although those of the past have perished. Research has substituted an alliance with nature for war with nature. In art, in philosophy, in literature we may still be the pupils of the past. But in science and its applications we are in a new era. In this field antiquity has nothing to compare with the present.

Science itself has developed with democracy. The release of the human mind from the bondage of ignorance by the Revival of Learning, the spread of education that followed, the destruction of the spirit of feudalism, the recognition of the value and the rights

of the individual are all steps in the process through which the modern state has evolved. This evolution has released and developed the latent intellectual powers of the masses of mankind and enlisted them in the service of further progress. It is in the atmosphere thus created that science has developed. Because self-government, political and intellectual freedom, universal education, and scientific progress are characteristics of the modern state, are interdependent, and advance together, all must be fostered if the advance is to continue. Research, the basis of scientific progress, is no less important than the others. Upon it depends man's mastery of nature, the multiplication of his physical powers, and his release from deadening drudgery, and it is perhaps the greatest of modern stimuli to his intellectual development, through its constant revelation of new facts and new relations and its constant calls upon his powers of constructive imagination.

Among modern States, those that lead in supporting and fostering educational and scientific progress also lead in political and intellectual progress. In such States material prosperity need not be made a matter of direct concern. It is an inevitable by-product of this leadership. It follows scientific and educational progress as surely as day follows night.

Because research in the sciences is thus an integral part of modern human progress, it should be unnecessary to urge support of research by a modern State. That should be and eventually will be recognized as one of its every-day duties to its citizens—as direct a duty and as unnecessary of specific advocacy as national defense or education.

Not only because geology is one of the sciences but also because it is one of those upon which each citizen depends daily and hourly, whether he realizes it or not, its study should have adequate national support. All the metals, the important fuels, the more permanent building materials, the soils are geologic products—parts of the earth's crust. Imagine a world without steel, copper, aluminum, coal, petroleum, concrete. It would be a world without railroads, automobiles, airplanes, telephones, telegraph, electric power and light—in short, without modern communication, transportation, or industry; industrially we would be living in the Middle Ages.

Through force of circumstances, chiefly financial, an undue proportion of the energies of the geologic branch in recent years has been directed into the fields of applied geology. This does not mean that no research work has been done. It means merely that not enough of it has been done. No scientific organization, even though much of its energy must be devoted to the application of science, can continue to function long without continuing the study of principles. Research is to such an organization what fuel is to the engine or food to the body. It is the source of power. If a continuous supply is not maintained, the mechanism runs down. For this reason research has been maintained, along with that work which is commonly denominated practical, because it is directed immediately to supplying an answer to some question of current human need. More coal, or copper, or manganese, or potash, or granite is wanted. Where is it to be found? How accessible is it? What is its quality? Is it suited to the specific need? But none of these questions can

be answered adequately unless there have been years of study quietly conducted before the need arises, to determine where the substances are to be expected, what differences exist in distribution and in quality in different localities, and why.

So geologic research has continued of necessity, as well as of choice, while the practical work has been going forward. Each study of a practical question has been made the vehicle to carry some research into principles. It has yielded its bit of knowledge about heretofore unknown facts and relations. Any thorough study of a problem by trained men will yield such contributions. But too much of the research during the last decade or two has been of this incidental sort. Too little of the work has been specifically planned and directed for the purpose of finding out more about unknown general relations and natural laws. As a consequence of this enforced relative neglect of fundamental work in geology, its capacity to solve the growing volume of practical problems, which are constantly increasing in complexity, is being endangered. The immediate need is to strengthen our foundations, to add to the staff of research workers, to increase the energy available for fundamental work. To apply science to human needs, there must be science to apply. Research can not be neglected in any field of science, geologic or other, without jeopardizing its usefulness.

It is high time that this principle should be publicly recognized and adequate support be forthcoming for those phases of geologic work which, although their application to current problems may not be obvious, constitute the foundations for future usefulness. Secretary Wilbur has recently said, "So close to-day is the link between science and its laboratories and the Government that we can measure the progress of a civilization by its economic capacity to support laboratories and by the quality of the intellects brought into them." Will our civilization meet this test?

WORK IN GEOLOGY BY STATES

ALABAMA

An examination of lands in the Pearson Hills unit and a report thereon was made by C. W. Cooke for the Forest Service. Deposits of iron ore in Jackson, Cullman, Marshall, De Kalb, Etowah, Cherokee, St. Clair, and Calhoun Counties were examined by E. F. Burchard in cooperation with the Alabama Geological Survey. A report on the red iron ores of northeastern Alabama, giving the results of this work, will be published by the State.

ALASKA

The seismograph station at Kodiak was in operation for a part of the year, and a station was established at Dutch Harbor, where the construction of the hut and the installation of the seismograph were in charge of Austin E. Jones.

ARIZONA

Further field paleontologic examinations of the Hermit shale and the Supai formation of the Grand Canyon, determination of the stratigraphic limits of the Redwall and the Cambrian formations in the same section, and a search for remains of pre-Cambrian life in the formations of the Unkar group in the vicinity of Bright Angel Creek were made by David White. A manuscript describing and illustrating the fossil plants of the Hermit shale was transmitted for publication to the Carnegie Institution, which has supported the cost of the field investigations and travel. The Apache group in central

Arizona was examined by Mr. White at a number of points for traces of fossil remains, and the Devonian, Mississippian, and Carboniferous stratigraphy in the region embracing Payson and Jerome was inspected in a review of the stratigraphic work by Prof. A. Stoyanow, of the Arizona State University. A paper on correlation of the Permian of southern Utah, northern Arizona, northwestern New Mexico, and southwestern Colorado was prepared by A. A. Baker and J. B. Reeside, jr., to be published in the Bulletin of the American Association of Petroleum Geologists. A paper on the Cretaceous section in Black Mesa, northeastern Arizona, was submitted by Messrs. Reeside and Baker for publication in the Journal of the Washington Academy of Sciences. On invitation of the Carnegie Institute, N. H. Darton spent several days at the Grand Canyon for the purpose of investigating conditions under which the geologic features might be made of interest to the public. A geologic map of the Grand Canyon was prepared by Mr. Darton and transmitted to the National Park Service for use in the Museum at Yavapai Point. He also prepared a description of the geology of Arizona for publication in the North American volume of Geologie der Erde.

A manganese deposit at Bisbee was examined by D. F. Hewett, in connection with a summary of manganese ore deposits of the United States for which Mr. Hewett is accumulating material. A strontium deposit near Aguila was examined by B. S. Butler, who prepared a brief report describing it as a memorandum for the press. A large deposit of iron ore near the west line of the Fort Apache Indian Reservation was examined and a local map prepared by E. F. Burchard and B. W. Dyer, at the request of the conservation branch. A report on nitrate deposits of the Southwest, prepared by L. F. Noble, contains brief notes on deposits in the Peloncillo Mountains of southeastern Arizona.

ARKANSAS

A tract of land adjacent to the Ouachita National Forest in west-central Arkansas was examined by H. D. Miser at the request of the Forest Service, and a report was prepared and transmitted to that service. Additional stratigraphic and structural studies in parts of the Ouachita Mountains of Oklahoma and Arkansas were made by Mr. Miser, in company with C. L. Cooper, of the Oklahoma Geological Survey, and a paper on the structure of the Ouachita Mountains of Oklahoma and Arkansas was transmitted to the Oklahoma Survey for publication. In informal cooperation with the Arkansas Geological Survey work was contributed by several members of the branch toward the completion of the new geologic map of Arkansas to be issued by the State. The study of the lead and zinc deposits of northern Arkansas was continued by E. T. McKnight in cooperation with the Arkansas Geological Survey. E. O. Ulrich reported on Paleozoic invertebrate fossils from this area. Studies of the Carboniferous invertebrate faunas of the Morrow formation and the Batesville sandstone and of the faunas of the basal Fayetteville shale were continued by G. H. Girty. Pleistocene mollusks were reported on by W. C. Mansfield, and a study of upper Mississippian invertebrates was made by P. V. Roundy. Manganese deposits of the Batesville district were examined by Mr. Miser. A note on the age of the Brownstown marl of Arkansas was submitted by L. W. Stephenson for publication in the Bulletin of the American Association of Petroleum Geologists.

Publication: Professional Papers 154–B and 154–F. (See p. 3.)

CALIFORNIA

Studies of the Engels-Walker copper belt, in Plumas County, were completed by Adolph Knopf, who is now preparing the report on this investigation. Recent developments in the Allegheny mining district were studied by H. G. Ferguson, who completed the revision of his report on that district. A paper on the gold-quartz veins of the Allegheny district, by Mr. Ferguson and R. W. Gannett, was presented at the meeting of the American Institute of Mining and Metallurgical Engineers in New York in February and published by that organization as Technical Paper 211.

Manganese deposits in Plumas, San Joaquin, and San Luis Obispo Counties were examined by D. F. Hewett in connection with a summary of manganese ore deposits of the United States. F. E. Matthes completed the final revision of his report on the Yosemite Valley, to be published as a professional paper,

and revised the descriptive text for the back of the Yosemite Valley topographic map. He also prepared a short paper entitled "Multiple Glaciation in the Sierra Nevada," which was published in Science, July 10, 1929. A report on the geology of the eastern part of the Santa Monica Mountains and adjacent areas, Los Angeles County, was completed by H. W. Hoots, to be published in "Shorter contributions to general geology." Papers on the age of the Modelo formation of the Santa Monica Mountains and on warm-water faunas of the so-called Pliocene of San Pedro were presented by W. P. Woodring at the meeting of the Cordilleran section of the Geological Society of America, and abstracts were published in the proceedings of the meeting.

The report on the Elk Hills oil field is being revised by Mr. Woodring, P. V. Roundy, and H. R. Farnsworth.

Studies of the San Andreas rift in the Cajon Pass area were continued by L. F. Noble, who made much progress on his report on the rift zone. Mr. Noble also completed and submitted his report on nitrate deposits of southeastern California. A paper by W. T. Schaller on borate minerals from the Kramer district, Mohave Desert, was approved for publication as Professional Paper 158–I. An area covered by the Mount Diablo overthrust in the Mount Diablo, Concord, Byron, and Napa quadrangles was inspected by G. R. Mansfield in company with B. L. Clark and C. E. Weaver in connection with reports in preparation by Messrs. Clark and Weaver. Mr. Mansfield also examined diatomite deposits on the Pit River, northeastern Shasta County. The Lassen Volcano Observatory, one of the stations maintained for the studies of volcanology, has been conducted by R. H. Finch. A paper on the quartz basalt eruptions of Cinder Cone, Lassen Volcanic National Park, was prepared by Mr. Finch and C. A. Anderson for publication either by the University of California or in the American Journal of Science.

Publications: Professional Papers 154–E, 157. (See p. 3.)

COLORADO

Cooperative geologic work with the State of Colorado and the Colorado Metal Mining Fund in a study of the mining geology of the State was continued under the immediate supervision of B. S. Butler. Mr. Butler, assisted by Q. D. Singewald, spent most of the field season in a detailed study of the Alma district and vicinity, on the east slope of the Mosquito Range. With W. S. Burbank he completed a paper on the electrode potential of some elements of hypogene mineral deposits, which was published by the American Institute of Mining and Metallurgical Engineers. Mr. Butler also completed a preliminary paper on the relation of ore deposits in the Rocky Mountains to the Colorado Plateau, to be published by the Colorado Scientific Society. A detailed study of the west slope of the Mosquito Range in areas adjoining the Leadville district on the south was begun by C. H. Behre, who has transmitted a brief paper showing certain results of interest to the mining industry, to be published by the Colorado Scientific Society. A paper on edge facies of mineralization at Leadville was presented by Mr. Behre before the Ohio Academy of Science, and an abstract of this paper will be published in the Ohio Journal of Science. G. F. Loughlin spent a few days in Cripple Creek visiting mines that were not accessible during previous visits. Work in the Bonanza district was completed by Mr. Burbank, and he then began a resurvey of the Ouray district. A preliminary report on the Bonanza mining district has been issued as a press memorandum, and the complete report will be transmitted during the summer of 1929. Mr. Burbank has also prepared a short paper for the benefit of mining interests showing the position of ore horizons in sedimentary rocks in the Ouray district. Work in the Breckenridge district was completed by T. S. Lovering, who continued structural and stratigraphic studies in the mineralized belt of the Front Range from Breckenridge northeastward. His work thus far has covered about four 15-minute quadrangles in considerable detail and includes related reconnaissance in adjoining areas. His report on the Breckenridge district will probably be transmitted in the summer or fall of 1929; his paper on the geologic history of the Front Range was completed, and a report on the Montezuma quadrangle is well under way. In the Washington office M. N. Short continued his microscopic studies of ores from the several districts, Edwin Kirk determined Ordovician invertebrate fossils for Messers. Behre and Burbank, and J. B. Reeside, jr., reported on Cretaceous invertebrate fossils from central Colorado for Mr. Lovering. A report on recent mining developments in the Creede dis-

trict, by E. S. Larsen, was completed and transmitted for publication as Bulletin 811–B. A comprehensive report on the volcanic and other rocks of the entire San Juan region of southwestern Colorado is being prepared by Mr. Larsen, for whom map data on the Ignacio and Red Mesa quadrangles were assembled by J. B. Reeside, jr. A paper on the physiography and Quaternary geology of the San Juan Mountains, by W. W. Atwood and K. F. Mather, has been transmitted for publication as a professional paper. Quarries and drifts made by oil-shale companies near Rifle and DeBeque were examined by David White, who collected specimens for research investigations. A report on the origin and microfossils of the oil shale of the Green River formation of Colorado and Utah was completed by W. H. Bradley and transmitted for publication as a professional paper, and a paper on the varves and climate of the Green River epoch, by Mr. Bradley, will be published as Professional Paper 158–E. A report on the geology and coal resources of the Book Cliffs field, Garfield and Mesa Counties, was completed by C. E. Erdmann, and progress was made by M. R. Campbell on his report on the coal resources, structure, and stratigraphy of the eastern Yampa coal field. Mr. Lovering examined the Granby anticline, in Grand County, and prepared and transmitted for publication in Contributions to Economic Geology a report on this investigation. A granite quarry near Salida was examined by G. F. Loughlin. A paper on correlation of the Permian of southern Utah, northern Arizona, northwestern New Mexico, and southwestern Colorado was prepared by A. A. Baker and J. B. Reeside, jr., for publication in the Bulletin of the American Association of Petroleum Geologists. Carboniferous invertebrates were studied by G. H. Girty, who spent a short time in field work in the State.

Publications: Professional Papers 154–G, 154–J, 158–A. (See p. 3.)

CONNECTICUT

In connection with studies in the southern Taconic area, which included detailed areal mapping in the Clove quadrangle, New York, Mrs. E. B. Knopf did occasional reconnaissance mapping in the Cornwall and New Milford quadrangles.

FLORIDA

The report on the geology of Florida, with accompanying geologic map of the State, by C. W. Cooke and Stuart Mossom, prepared in cooperation with the Florida Geological Survey, has been published by the State. Mr. Cooke presented a paper on the geology of Florida at the December meeting of the Geological Society of America, and an abstract of the paper was published in the bulletin of that society. A cooperative report on the Miocene gastropods and scaphopods of the Choctawhatchee marl of northwestern Florida was completed by W. C. Mansfield and transmitted to the Florida Geological Survey for publication. Mr. Mansfield also has in preparation a report on the pelecypods of the Choctawhatchee marl. Localities in Walton County reported to contain fluorspar deposits were examined by E. F. Burchard.

GEORGIA

A field study of the Tertiary formations of the Coastal Plain of Georgia was made by C. W. Cooke for the purpose of establishing closer correlations with the adjacent States and of obtaining data for a revised geologic map of the State.

HAWAII

From the headquarters of the section of volcanology at Hawaiian Volcano Observatory, Hawaii National Park, T. A. Jaggar, jr., directed the work of the Hawaiian, Lassen (Calif.), and Alaskan stations. In the Hawaiian Islands the work consisted of observations of Halemaumau, including mapping of changes, the operation of a seismograph on the edge of the pit, and measurement of rim fissures; the operation of seismographs at Mauna Loa, at Kilauea Station, and at Uwekahuna, on the west summit of Kilauea Mountain; measurements of seismograms and preparation of seismologic reports; recording of tide data from Hilo and Honolulu gages; and designing, building, and repairing seismographs and other instruments. Cooperation with the Hawaiian Volcano Research Association was continued in the publication of the Weekly

Volcano Letter and the Monthly Bulletin, in inspection and direction of the sesimograph stations at Hilo and Kealakekua and temperature bore holes, in collaborative experimental projects, and in the direction of research associates.

IDAHO

Continued field studies of the geology, geography, and mineral resources of southeastern Idaho were carried on in the Ammon quadrangle by G. R. Mansfield, assisted by W. B. Lang, who also reviewed some details in mapping in the Paradise Valley quadrangle and made a trip to the Continental Divide west of Spencer and to the Snake River Plains in company with H. T. Stearns to study problems of overthrusting and rhyolitic extrusion. A report on the geography, geology, and mineral resources of the Portneuf quadrangle, by Mr. Mansfield, was published as Bulletin 803. A paper on the Blackfoot Mountains was prepared by Mr. Mansfield for presentation to the Geological Society of Washington. A reconnaissance study of the glacial geology and physiography of parts of Bonner, Kootenai, Fremont, and Teton Counties was made by W. C. Alden, and the results will be incorporated in a report on the glacial geology and physiography of western Montana, eastern Washington, and northern Idaho. In continuation of his studies of the ore deposits of south-central Idaho, C. P. Ross did geologic mapping and examined mines of the Bayhorse quadrangle and made a trip to the Wood River district to review recent developments. Mr. Ross completed a report on the geology and mines of the Casto quadrangle and a paper on the history of mining in central Idaho. He has in preparation reports on the Bayhorse quadrangle and on south-central Idaho as a whole. A paper entitled "A Resurrected Fossil Forest in Idaho" was prepared by Mr. Ross for publication in the Idaho School of Mines Quarterly. A paper on early Pleistocene glaciation in central Idaho was prepared and transmitted by Mr. Ross for publication as Professional Paper 158–G, and a section on the gold resources of Idaho was submitted by Mr. Ross in preliminary form for inclusion in a report on gold resources of the United States to be presented at the meeting of the International Geological Congress at Pretoria, South Africa, in August, 1929. Fresh-water Tertiary mollusks were identified by W. C. Mansfield, and Silurian and Ordovician invertebrates were examined by Edwin Kirk. Carboniferous invertebrates were studied by G. H. Girty. Work was continued on a report by D. F. Hewett on the Mineral Hill section of the Wood River district. The cooperative report on the geology and silver ore deposits of the Pend Oreille district, by Edward Sampson, was transmitted for publication by the Idaho Bureau of Mines and Geology. A paper on contact metamorphism of the rocks of the Pend Oreille district, by J. L. Gillson, was submitted for publication as Professional Paper 158–F. C. H. Behre, jr., prepared a report on Tertiary volcanic tuffs and sandstones used as building stones in the upper Salmon River Valley for publication in Contributions to Economic Geology.

ILLINOIS

The geologic mapping of the Hardin and Brussels quadrangles, a cooperative project with the Illinois Geological Survey, was continued by W. W. Rubey, who made some progress in the preparation of the report on these quadrangles. G. R. Mansfield made a brief inspection trip through this area with Mr. Rubey. Supposed Pleistocene plants from the area were reported on by E. W. Berry, and Ordovican and Silurian invertebrates were studied and reported on by E. O. Ulrich. Field examinations of sections of Pottsville age and collections of fossil plants for monographic study were made by David White, in cooperation with the Geological Survey of Illinois. The projected report is planned for publication by the State. A geologic folio on the Equality and Shawneetown quadrangles was revised by Charles Butts. The study of the Carboniferous invertebrates of the Ste. Genevieve and Okaw formations was continued by G. H. Girty.

INDIANA

A report on Indiana oolitic limestone and the relation of its natural features to its commercial grading was revised by G. F. Loughlin and transmitted for publication as Bulletin 811–C. This work was undertaken in 1917 by agreement with the Director of the Bureau of Standards and the Supervising Architect. An abstract of the paper was read before the American Institute of Mining and Metallurgical Engineers in New York, February, 1929.

IOWA

An article on the Loveland loess, discussion of a paper by G. F. Kay, was prepared by Frank Leverett for publication in Science.

KANSAS

A cooperative report on the geology of Cowley County, with special reference to the occurrence of oil and gas, by N. W. Bass, was transmitted to the Geological Survey of Kansas for publication. Pennsylvanian and Carboniferous invertebrates and Carboniferous microfossils were studied by P. V. Roundy, and collections of fossil plants, vertebrate skulls, and invertebrates at Baldwin were inspected by David White.

KENTUCKY

A geologic folio on the Equality and Shawneetown quadrangles, lying partly in Kentucky, was revised by Charles Butts.

LOUISIANA

Lands in the Kisatchie and Vernon areas were examined by C. W. Cooke at the request of the Forest Service, to which a report was made. Revision of the oil and gas map of Louisiana was undertaken by G. B. Richardson, who made a field trip to obtain additional data. Well cores in the offices of oil companies at Shreveport were studied by W. P. Popenoe.

MARYLAND

Work in field and office was continued by Miss A. I. Jonas, in connection with the report on Frederick County and revision of the report on Baltimore County, for publication by the Maryland Geological Survey in informal cooperation with the United States Geological Survey. Field work was done in Frederick County and the eastern part of Washington County by G. W. Stose in cooperation with the Maryland Geological Survey, which is to publish reports on these counties.

MASSACHUSETTS

The structural relations of Greylock Mountain and adjoining areas in the Taconic quadrangle were studied by L. M. Prindle, and special localities in the Berlin and Greylock quadrangles were visited by Mr. Prindle in company with G. R. Mansfield. Mr. Prindle extended these studies to the Pittsfield quadrangle. Progress was made by Mr. Prindle on his report covering these investigations.

MISSISSIPPI

Lands in the Homochitto and Pearson Hills area were examined by C. W. Cooke for the Forest Service, to which a report was made. Cuttings from an oil prospecting well near Amory were studied by L. W. Stephenson and Charles Butts. A small collection of fossil plants from the Mississippian formation of northeastern Mississippi was examined by David White. W. P. Popenoe visited the offices of oil companies at Meridian and Jackson to study well cores as an aid in general studies of stratigraphy and correlation.

MISSOURI

The Missouri-Arkansas field conferences of the Kansas Geological Survey at Cape Girardeau and Ste. Genevieve were attended by W. W. Rubey, who also conferred with other geologists on Mississippian problems near the Hardin and Brussels quadrangles. The Lafayette gravel of St. Louis County formed the subject of a conference by Mr. Rubey with E. D. Shipton, and Mr. Rubey also conferred with the State geologist of Illinois regarding the Pleistocene near Winfield. The lead and zinc mines of the Joplin region were visited by E. T. McKnight. Carboniferous invertebrates were studied in the field and office by G. H. Girty, early Paleozoic invertebrates by E. O. Ulrich, and Carboniferous microfossils by P. V. Roundy.

MONTANA

The mapping of the lignite resources of McCone and Dawson Counties, with stratigraphic, structural, and physiographic studies, was continued in 1928 by A. J. Collier and C. E. Erdmann and in 1929 by Mr. Collier, assisted by M. N. Bramlette, M. P. Billings, H. E. Thomas, and Frank S. Parker. Progress on a report on the investigations of 1928 was made by Mr. Collier. Field studies and mapping of the Ashland coal field of Powder River County and adjacent parts of Rosebud and Custer Counties were completed by a party under the direction of N. W. Bass, who completed a report on the geology of the field. A detailed examination of the Lance, Lebo, and Fort Union coals in parts of Rosebud and Custer Counties along Tongue River, a northward extension of Mr. Bass's work of 1928, was begun by A. A. Baker, assisted by William G. Pierce and R. W. Brown. In connection with the revision of a report on the geology of the Crow Indian Reservation, W. T. Thom, jr., spent a few days in checking the areal geology and rock correlations in parts of that reservation. In cooperation with the city of Helena, the study of the mining districts in the greater Helena mining region, begun two years ago, was broadened to include a large area south of Helena and an area in the Belt Mountains between York and Confederate Gulches. The work in the York-Confederate Gulch area was carried on by J. T. Pardee, assisted by Russell Gibson, and that in the area south of Helena, near Winston and Deer Lodge, by F. C. Schrader. A preliminary report on the metalliferous deposits in the York-Confederate Gulch area, by Mr. Pardee, has been issued as a memorandum for the press, and a preliminary report on the metalliferous deposits in the Winston-Deer Lodge area, by Mr. Schrader, will be issued shortly in similar form. An investigation of the mining districts of the Libby quadrangle was begun by Mr. Gibson under the general supervision of Mr. Pardee. Deposits of manganese ore at Philipsburg, Canyon Ferry, and Deer Lodge were examined by Mr. Pardee, who is preparing a short report on manganese reserves at Philipsburg and has in preparation a paper on late Tertiary and Quaternary faults in southwestern Montana. Reconnaissance field studies of the glacial geology and physiography of western Montana were extended by W. C. Alden to parts of Lincoln, Flathead, Missoula, Ravalli, Beaverhead, and Madison Counties and Glacier National Park. The report on glacial geology and physiography of eastern Montana was revised by Mr. Alden, who also made progress on a report on physiography and glacial geology of western Montana, northern Idaho, and eastern Washington and a report on Glacier National Park. A report on the geology of the Big Snowy Mountains was completed by Frank Reeves, for publication in Shorter Contributions to General Geology. Devonian invertebrates from an oil well in Montana were reported on by Edwin Kirk for the Montana Bureau of Mines. Carboniferous invertebrates were studied by G. H. Girty, and Cretaceous invertebrates by J. B. Reeside, jr., and T. W. Stanton. A stratigraphic section and well log measured in Blaine County and submitted by C. L. Thompson were studied by Mr. Reeside.

Publications: Bulletins 805–B, 806–B, and 806–E. (See p. 3.)

NEBRASKA

Carboniferous invertebrates were studied by G. H. Girty.

NEVADA

Studies in the Ivanpah quadrangle were continued by D. F. Hewett and in the Tonopah and Hawthorne quadrangles by H. G. Ferguson, who also began investigations in the Lowry Peak quadrangle and a study of the geology and ore deposits of the Silver Peak quadrangle. Progress was made on the reports on the geology and ore deposits of the Tonopah and Hawthorne quadrangles by Mr. Ferguson, of the Carson Sink by F. C. Schrader, and of the Ivanpah quadrangle by Mr. Hewett. The report on the geology and ore deposits of the Goodsprings quadrangle by Mr. Hewett has been transmitted for publication as a professional paper, and a paper on the mining districts of Nevada by Mr. Ferguson was completed and published in Economic Geology, March-April, 1929. Two brief papers on petrography of the Pioche district were submitted by J. L. Gillson for publication as Professional Paper 158–D. A study of rock alteration in Nevada was made by G. F. Loughlin and Mr. Hewett, and examinations in the Ely, Hamilton, and Eureka districts were made by Mr. Hewett in connection with his study of dolomitization. A manganese mine east of

Las Vegas was examined by Mr. Hewett. Field studies of the Carboniferous formations of the Eureka district and the Las Vegas quadrangle were continued by G. H. Girty in cooperation with Mr. Ferguson and C. R. Longwell. Office studies of the collections of Carboniferous invertebrates were made by Mr. Girty and P. V. Roundy. A small collection of upper Paleozoic plants obtained by Messrs. Girty and Ferguson was examined by David White. Stratigraphic studies of the Cambrian, Ordovician, Silurian, and Devonian formations were made in the vicinity of Eureka, in the White Pine district, and in the Lowry Peak quadrangle, by Edwin Kirk, in cooperation with Mr. Ferguson, and office studies of collections of Ordovician and Devonian invertebrates were made by Mr. Kirk. Middle Triassic ammonites were identified by T. W. Stanton for the National Museum.

Publication: Bulletin 798. (See p. 3.)

NEW HAMPSHIRE

A visit to the White Mountains to determine the upper limits of the Wisconsin ice sheet was made by Frank Leverett in company with Dr. Ernst Antevs.

NEW JERSEY

Results of studies of the pre-Wisconsin glacial and associated deposits in New Jersey, in which the New Jersey Geological Survey cooperated, will be embodied in a paper by Frank Leverett to be published by the Pennsylvania Topographic and Geologic Survey. Fossil material from the Shiloh marl was collected and studied by W. C. Mansfield, in connection with his general studies of the Miocene formations of the Atlantic Coastal Plain.

NEW MEXICO

The search for potash was continued in the Permian salt basin of southeastern New Mexico and western Texas. W. B. Lang was assisted in the field office at Roswell, N. Mex., by J. W. Vanderwilt during the first part of the year and by R. K. Bailey later. Mr. Lang kept in close touch with drilling operations in this area and so far as possible obtained samples for potash testing from all wells being drilled in the area. He also obtained for study by the Geological Survey portions of cores from special tests for potash made in Eddy County by two private companies. Four sites in Eddy, Lea, and Chaves Counties were recommended for Government potash tests to be made during the next fiscal year under the supervision of the Bureau of Mines. Mr. Vanderwilt made logs of wells being drilled in southeastern New Mexico and began a structure map of that area showing the top of the salt series. Mr. Bailey's time was devoted chiefly to the logging of samples and the making of potash tests. A press notice entitled "Potash Struck by Three More Government Tests in Texas," which included information relative to potash findings in wells drilled for oil in New Mexico, was prepared by G. R. Mansfield. A paper on Government potash exploration in Texas and New Mexico was prepared by Messrs. Mansfield and Lang, presented at the meeting of the American Institute of Mining and Metallurgical Engineers in New York in February, and published by the Institute as Technical Publication 212. A paper on the mineralogy of the potash field of New Mexico and Texas was presented by W. T. Schaller at the same meeting. Studies in the Jemez Mountains were completed by C. S. Ross and E. S. Larsen, and some progress was made on the report on the igneous geology of the area. G. F. Loughlin visited the Magdalena mining district with members of the New Mexico Bureau of Mines and Geology and supplied them with a geologic map and other data for a report on the geology and ore deposits of the district. Geologic mapping and study of the ore deposits of the Santa Rita quadrangle were resumed by A. C. Spencer, who revised topographic mapping where necessary and continued preparation of his report on the district. Upper Cretaceous invertebrates from this quadrangle were identified by T. W. Stanton. Structural and stratigraphic studies of the coal-bearing and associated formations on the south side of the San Juan Basin in northeastern McKinley County and northwestern Sandoval County were continued by C. H. Dane and party, and the manuscript of a report on the geology and coal resources of this region, by Mr. Dane, is in progress. Field work in northwestern New Mexico, northeast of Gallup, for the purpose of mapping the coals of the Mesaverde formation, was begun by J. D. Sears and party in the

spring of 1929. The work will consist of an extension northeast and east of the work of Mr. Sears in the Gallup district in 1919–20 and will eventually connect on the east with the work of the party in charge of Mr. Dane in 1928. A reconnaissance of a part of northern New Mexico was made by A. A. Baker and J. B. Reeside, jr., in connection with Utah studies, and a paper on correlation of the Permian of southern Utah, northern Arizona, northwestern New Mexico, and southwestern Colorado, by Messrs. Baker and Reeside, was transmitted for publication in the Bulletin of the American Association of Petroleum Geologists. Preparation of a paper on the fauna of the Lake Valley limestone was continued by G. H. Girty, who also continued in field and office his studies of other Carboniferous invertebrates. Land shells, probably of Pleistocene age, from northeastern New Mexico were identified by W. C. Mansfield. Manganese deposits near Deming, Santa Rita, Silver City, Lordsburg, and Rodeo were examined by D. F. Hewett. The report on the nitrate deposits of the Southwest by L. F. Noble includes a description of nitrate claims in the Animas Valley, N. Mex. N. H. Darton prepared a chapter on the geology of New Mexico for publication in the volume on North America of Geologie der Erde.

Publications: Geologic map of New Mexico, on a scale of 1:500,000; Bulletin 794. (See p. 3.)

NEW YORK

The study of structural relations in the Taconic quadrangle, which includes the Berlin and Hoosick quadrangles in New York, was continued by L. M. Prindle, and an inspection trip by Mr. Prindle and G. R. Mansfield extended into the Cambridge quadrangle. In the office Mr. Prindle continued work on geologic maps and text of the report on this area. Areal mapping of parts of the Clove, Millbrook, and Poughkeepsie quadrangles was continued by Mrs. E. B. Knopf, who made petrographic and other studies pertaining to the proposed report on this area. Primary structural features of igneous bodies in the Adirondack Mountains near Lake Placid were studied by James Gilluly in cooperation with Prof. Robert Balk, a specialist on the subject. The upper limit of Wisconsin glaciation in the Catskill Mountains was studied by Frank Leverett, assisted by Ernst Antevs, in company with George H. Chadwick. Stratigraphic sections in eastern New York were studied by E. O. Ulrich with members of the New York State Survey.

NORTH CAROLINA

A field examination of the upper Miocene deposits of North Carolina was continued by W. C. Mansfield, and the material collected was studied in the office. Mr. Mansfield also prepared a paper on some deep wells near the Atlantic coast in Virginia and the Carolinas for publication in the Proceedings of the Geological Society of Washington.

NORTH DAKOTA

Cretaceous invertebrates were identified by J. B. Reeside, jr., for the North Dakota Historical Society at the request of the National Museum. The results of Mr. Reeside's studies of cuttings from the Glenfield well, eastern North Dakota, were published in a memorandum for the press.

Publications: Bulletins 775, 801. (See p. 3.)

OHIO

Preparation of a report on the glacial geology, physiography, and drainage history of the upper Ohio Valley, embracing parts of Ohio, West Virginia, and western Pennsylvania, for publication as a professional paper, was continued by Frank Leverett.

OKLAHOMA

Work on a report on the lead and zinc deposits of the Picher and Miami areas, in the Wyandotte quadrangle, was continued by C. E. Siebenthal. Carboniferous invertebrates were studied by G. H. Girty, who also continued preparation of his reports on the faunas of the Morrow, Moorfield, and Glenn formations. Carboniferous microfossils were studied by P. V. Roundy. Ordovician and older Paleozic formations were studied by E. O. Ulrich, in cooperation with

C. H. Decker, of the Oklahoma Geological Survey. A paper entitled "Revised Classification of Formations in the Arbuckle and Wichita Uplifts in Oklahoma" was prepared by Mr. Ulrich for presentation at the meeting of the Geological Society of America, and a paper entitled "Large Size of Caney Boulders" was presented at the meeting of the Paleontological Society of America. Deep-well drillings (Ordovician) were reported on by R. D. Mesler. A report on the structure of the Ouachita Mountains in Oklahoma and Arkansas was completed by H. D. Miser and transmitted to the Oklahoma Geological Survey for publication. Sales of Osage leases at Pawhuska on September 27 and December 11 were attended by P. V. Roundy, who, at the request of the Indian Service, acted as an adviser concerning bids. The new map of oil and gas fields of Oklahoma, which was revised by G. B. Richardson, has been issued on a scale of 8 miles to the inch.

Publication: Professional Paper 154–F. (See p. 3.)

OREGON

Fresh-water fossils were reported on by W. C. Mansfield, and Miocene fossil plants were studied by E. W. Berry. Upper Triassic pelecypods from eastern Oregon were identified by T. W. Stanton for James Gilluly, and Tertiary mollusks were identified by Mr. Mansfield for Bruce Clark. A preliminary reconnaissance of the geology of the eastern copper belt of Oregon was begun by Mr. Gilluly, preparatory to more detailed studies on the mineral deposits of Oregon to be undertaken in cooperation with the State Mining Board.

PENNSYLVANIA

The studies on the glacial geology of Pennsylvania carried on in cooperation with the Pennsylvania Topographic and Geologic Survey were continued by Frank Leverett, and progress was made on his reports on the glacial geology of the Susquehanna drainage basin and the glacial deposits of eastern Pennsylvania. These reports will be published by the State. A report by Mr. Leverett on the glacial geology, physiography, and drainage history of the upper Ohio Valley, embracing parts of western Pennsylvania, will be issued by the United States Geological Survey as a professional paper. M. R. Campbell continued his cooperative study of the physiographic problems in eastern Pennsylvania, making a special study of river gravel. Other cooperative projects include field and office studies of the geology and mineral resources of the Middletown, York, and Hanover quadrangles, by Anna I. Jonas and G. W. Stose, Miss Jonas working for the State survey. Mr. Stose made field investigations of the Martinsburg-Medina contact for the Pennsylvania survey and continued work on the geologic map of Pennsylvania being compiled by the State survey. Field work in the Butler and Zelienople quadrangles was practically completed by G. B. Richardson, who also made progress on his report on the geology and mineral resources of these quadrangles and completed a report on the geology, coal, oil, and gas resources of the New Kensington quadrangle. Work on the detailed report on the geology of the Tyrone quadrangle was continued by Charles Butts, who collected and studied fossils from the Bradford oil sand in McKean County and reported on collections from Crawford County. Carboniferous invertebrates were studied by G. H. Girty. E. O. Ulrich collected Ordovician fossils and carried on field studies in Perry and Lancaster Counties.

SOUTH CAROLINA

Preparation of a report on the geology of the Coastal Plain of South Carolina was resumed by C. W. Cooke. A paper on some deep wells near the Atlantic coast in Virginia and the Carolinas was prepared by W. C. Mansfield for publication in the Proceedings of the Geological Society of Washington. Miocene invertebrate fossils were collected and studied by Mr. Mansfield in connection with his general studies of the Miocene of the Atlantic Coastal Plain.

TENNESSEE

The stratigraphy of the zinc deposits at and near Mascot was studied by E. O. Ulrich and Charles Butts, and other stratigraphic examinations were made in cooperation with the Tennessee Geological Survey. Mr. Ulrich made a preliminary study of fossils from the Ottosee formation in Grainger County.

TEXAS

W. B. Lang continued to collect samples from wells being drilled for oil in the salt basin of western Texas and southeastern New Mexico. Four Government tests in Crane, Glasscock, Reagan, and Winkler Counties were completed during the year, and a press notice giving the important potash findings in the ninth and tenth tests, in Regan and Glasscock Counties, completed during the year, and the eighth test, in Crockett County, completed the previous year, was prepared by G. R. Mansfield and published under the title "Potash Struck by Three More Government Tests in Texas." During the three years of Government exploration for potash, under the act approved June 25, 1926, 9 Government tests have been completed in Texas and 3 in New Mexico, and reports were made by the Geological Survey on 10 of these tests. A paper on Government potash exploration in Texas and New Mexico, prepared by Messrs. Mansfield and Lang, was presented at the meeting of the American Institute of Mining and Metallurgical Engineers in New York in February and published by the Institute as Technical Publication 212. At the same meeting a paper on the mineralogy of the potash field of New Mexico and Texas was presented by W. T. Schaller. Examinations of the Cliffside dome, in Potter County, were made by E. M. Spieker at the request of the Bureau of Mines, and a confidential report with detailed subsurface and surface maps was prepared and transmitted to that bureau. Data for the revised geologic map of Texas, being compiled as a cooperative project with the Texas Bureau of Economic Geology, were obtained by N. H. Darton during field work in central and western Texas, and examinations in the Marathon Basin were made by Philip King for the same purpose. In the office Mr. Darton prepared these data for inclusion in the map. Permission was granted to Mr. Darton to publish in the Bulletin of the Geological Society of America a brief notice on the discovery of Devonian rocks north of El Paso. Supplemental field work on the Woodbine, Eagle Ford, and related formations was done by L. W. Stephenson in connection with his studies of the Upper Cretaceous formations of Texas, and he continued preparation of his report on these formations and of his cooperative monograph on the fossils of the Navarro formation of Texas to be published by the Texas Bureau of Economic Geology. Mr. Stephenson also prepared a paper on unconformities in the Upper Cretaceous series of Texas for the meeting of the American Association of Petroleum Geologists in Fort Worth, and a paper on a new *Ostrea* and a new *Exogyra* from the Austin chalk, for publication in the Proceedings of the United States National Museum. Several months was spent in field work in Atascosa, Frio, La Salle, Zavalla, and Dimmit Counties by Miss Julia Gardner in connection with the revision of Alexander Deussen's report on the ground waters of the Coastal Plain of Texas between the Brazos River and the Rio Grande, in cooperation with S. S. Nye, of the water-resources branch. Miss Gardner traced the nonvolcanic clays of Live Oak and McMullen Counties to correlate them with the clays in the area to the south covered by A. C. Trowbridge's report on the Tertiary and Quaternary geology of the lower Rio Grande region. The results of her investigations will be incorporated in Mr. Trowbridge's report, which will be issued as a bulletin. Miss Gardner continued field and office studies of the stratigraphy and paleontology of the Eocene and later Tertiary formations of Texas, to assist in the revision of the geologic map of the State, and completed her field studies of the Midway formation of Texas, a cooperative project with the Texas Bureau of Economic Geology. Her monograph on the fauna of the Midway formation is practically completed and will be transmitted to the State for publication. A reconnaissance study of Mesozoic stratigraphy and paleontology in western Texas was continued by T. W. Stanton, and a brief informal paper on the Del Rio and Buda formations in western Texas was given by him at the meeting of the Society of Economic Paleontologists and Mineralogists in Fort Worth. Progress on the report on the salt-dome cap rock was made by M. I. Goldman. Carboniferous invertebrates were studied in field and office by G. H. Girty, Eocene fossils by C. W. Cooke, and fossil plants by E. W. Berry. Devonian invetebrates were reported on by Edwin Kirk for Mr. Darton, and Comanche invertebrates were studied by Mr. Stanton. Cretaceous well cuttings and Carboniferous micro-fossils were examined by P. V. Roundy. Cretaceous fossils were collected and studied by J. B. Reeside, jr. Well cores in northeastern Texas were examined for fossils by W. P. Popenoe.

Publication: Professional Paper 154–F. (See p. 3.)

UTAH

A report on the geology and ore deposits of the Gold Hill quadrangle, by T. B. Nolan, and one on the geology and ore deposits of the Stockton and Fairfield quadrangles, by James Gilluly, have been completed. A section on the general geology of the Cottonwood-American Fork district is being prepared by F. C. Calkins for incorporation in the report on the ore deposits. A paper entitled "Possible Desert-Basin Integration in Utah" was prepared by Mr. Gilluly for publication in the Journal of Geology. Examinations in the Tintic district were made by D. F. Hewett in connection with his study of dolomitization. Field studies of the stratigraphy and structure in southern San Juan County were continued by A. A. Baker and party, and a map of the Monument Valley region was prepared by Mr. Baker. In connection with this work J. B. Reeside, jr., and Mr. Baker made stratigraphic studies of late Paleozoic and early Mesozoic rocks in southeastern Utah. A paper on correlation of the Permian of southern Utah, northern Arizona, northwestern New Mexico, and southwestern Colorado was prepared by Messrs. Baker and Reeside for publication in the Bulletin of the American Association of Petroleum Geologists. Detailed investigations of the stratigraphy and structure of southeastern Utah between the Colorado and Dolores Rivers in Grand County was begun by C. H. Dane and party. Quarries and drifts made by oil-shale companies near Watson and Ute Switch were examined by David White, who collected specimens in connection with his research investigation of oil shales. Proposed dam sites in the Fort Douglas Indian Reservation were examined by Messrs. Hewett and Loughlin at the request of the War Department, and reports were submitted to the Quartermaster General. A semidetailed reconnaissance of the western part of the Wasatch Plateau, including a study of the stratigraphy, structure, and coals, was begun by E. M. Spieker, assisted by A. J. Eardley, primarily for purposes of land classification. A report on bituminous sandstone near Vernal was completed by Mr. Spieker for publication in Contributions to Economic Geology, and progress was made on his paper on the Wasatch coal field. Studies of the Wasatch, Green River, and Bridger formations in the vicinity of Burch Fork were continued by W. H. Bradley in connection with his studies of oil shale in the Green River Basin, and a paper on the origin and microfossils of the oil shale of the Green River formation of Colorado and Utah was completed by Mr. Bradley. A paper on the varves and climate of the Green River epoch, by Mr. Bradley, will be published as Professional Paper 158–E. An alunite deposit near Marysvale was examined by G. F. Loughlin, and a report was prepared and transmitted to the conservation branch. Progress was made on the general report on the stratigraphy of the Book Cliffs, by D. J. Fisher. Carboniferous invertebrates were identified by G. H. Girty, Upper Cretaceous invertebrates by T. W. Stanton, and Eocene land and fresh-water fossils by W. C. Mansfield.

Publications: Professional Paper 154–G, 154–J; Bulletin 806–C. (See p. 3.)

VERMONT

Field investigations in the Taconic quadrangle, which includes the Bennington quadrangle and small parts of the Hoosick and Greylock quadrangles in Vermont, and the preparation of a report on the area, were continued by L. M. Prindle. In connection with these studies Mr. Prindle, accompanied by G. R. Mansfield, visited several localities in the Cambridge quadrangle.

VIRGINIA

In cooperation with the Virginia Geological Survey areal and stratigraphic surveys in the southern Appalachian Valley were continued by Charles Butts and in the Piedmont region by G. W. Stose and Anna I. Jonas, in connection with the preparation of the new geologic map of Virginia, which was issued during the year by the State. Outcrops in the southwestern part of the Appalachian Valley were investigated by Mr. Butts, in company with E. O. Ulrich, to determine ages. A brief review of the work of C. R. L. Odor, of the Virginia Geological Survey, at the south end of Massanutten Mountain, was made by Mr. Butts, who studied Paleozoic invertebrates from Massanutten Mountain for Mr. Odor. Studies of the warm springs in the Shenandoah Valley and in the mountain valleys in Alleghany, Bath, and Highland Counties, in cooperation with the Virginia Geological Survey, were concluded by Frank

Reeves, who completed his report on the investigations and transmitted it to the State Survey for publication. Paleozoic invertebrate fossils from the Warm Springs area were reported on by Mr. Ulrich. Late Tertiary and Quaternary deposits were examined by W. C. Mansfield, who prepared papers on the revision of the Chesapeake group of Virginia and the Chesapeake Miocene basin of sedimentation as expressed in the new geologic map of Virginia for presentation at the annual meeting of the Geological Society of America, and a paper on some deep wells near the Atlantic coast in Virginia and the Carolinas for the Geological Society of Washington. A landslide near Arlington was examined by C. P. Ross. Geologic conditions at the District of Columbia Reformatory at Lorton, Va., were examined by T. B. Nolan. A belt of kyanite in the region around Farmville was investigated by Miss Jonas for the State Geological Survey, which has in preparation a report on the kyanite of Virginia. Office studies of the iron industry of Virginia were carried on by E. F. Burchard, and a brief statement concerning iron ore along the lines of the Chesapeake & Ohio Railway in western Virginia was transmitted to the Virginia Geological Survey for publication by the railroad company. Permission was given to E. P. Henderson to publish an article on gearksutite from Virginia in the American Mineralogist.

WASHINGTON

A reconnaissance study of the glacial geology and physiography of eastern Washington, including parts of Spokane, Lincoln, Adams, Columbia, Douglas, Franklin, Grant, Stevens, and Whitman Counties, was made by W. C. Alden, and the results will be incorporated in a report on the glacial geology and physiography of western Montana, eastern Washington, and northern Idaho. Deposits of diatomaceous earth in Kittitas, Yakima, and Grant Counties were examined by J. T. Pardee. Fossil plants from the Grand Coulee were studied by E. W. Berry.

Publications: Professional Paper 154–H, Bulletin 805–A. (See p. 3.)

WEST VIRGINIA

A report on the glacial geology, physiography, and drainage history of the upper Ohio Valley, embracing parts of West Virginia, is in preparation by Frank Leverett for publication as a professional paper. A paper on the need for research touching the natural resources of West Virginia was delivered by David White at the inauguration of the new president of the University of West Virginia.

WISCONSIN

Pre-Cambrian faunas were studied by E. O. Ulrich.

WYOMING

Examinations of the Green River, Wasatch, and Bridger formations in the Green River Basin, southwestern Wyoming, in connection with studies of oil shale, were continued by W. H. Bradley, who prepared a geologic map and compiled other data relative to a report on this work. An examination of the geology of the Alcova and Seminoe dam sites, in central Wyoming, was made by Mr. Bradley for the Bureau of Reclamation. A paper on the Rawlins, Shirley, and Seminoe iron-ore deposits of Carbon County was completed by T. S. Lovering for publication as Bulletin 811–D, and a memorandum for the press giving advance information on these deposits was prepared. Upper Cretaceous invertebrates from Rock River were reported on by T. W. Stanton and from the Aspen shale near Kemmerer by J. B. Reeside, jr., and Mr. Stanton. E. W. Berry revised his papers on the flora of the Frontier formation and the flora of the so-called Bridger of the Wind River Basin. Preparation of a general report on the Black Hills rim was continued by W. W. Rubey, whose report on lithologic studies of fine-grained Upper Cretaceous sedimentary rocks of the Black Hills region was approved for publication in Shorter Contributions to General Geology. A reconnaissance of the physiography and glacial geology of Gros Ventre Valley and Jackson Hole was made by W. C. Alden, who continued preparation of his report on the glacial geology and physiography of Wyoming.

Publications: Professional Papers 154–G, 154–J, 158–A; Bulletins 804, 806–A, 806–D. (See p. 3.)

APPALACHIAN TROUGH

In continuation of his study of the Devonian and lower Mississippian floras of the Appalachian trough, David White examined collections from Pennsylvania, West Virginia, Virginia, Tennessee, Kentucky, and Ohio.

MISSISSIPPI VALLEY

A preliminary study of physiographic features of the Mississippi Valley, from Wisconsin to the Gulf of Mexico, and of the lower valleys of the Missouri, Illinois, Ohio, Tennessee, St. Francis, White, Arkansas, and Red Rivers was made by F. E. Matthes for the purpose of planning a systematic investigation of the regimen, deposits, and geologic history of these rivers.

CANAL ZONE

A preliminary geologic study of the Madden Dam project, Alhajuela, Canal Zone, was made by James Gilluly at the request of the Governor of the Panama Canal, and a report was prepared and transmitted through the Washington office of the canal. Further examinations being recommended by Mr. Gilluly and desired by the Panama Canal officials, Frank Reeves and C. P. Ross were assigned to the task. The results of their examinations were given to the Panama Canal officials, and a report on the geology of the region has been submitted for publication as a bulletin.

PORTO RICO

The El Guineo and Matrullos dam sites were examined by T. B. Nolan at the request of the Governor of Porto Rico, and a report on these sites was transmitted through the Bureau of Insular Affairs.

GENERAL INVESTIGATIONS

Work covering broad fields of geologic research or areas not confined to individual States is in progress by many of the geologists and paleontologists. The following papers giving the results of some of these studies were submitted for publication as professional papers of the United States Geological Survey or through unofficial channels.

Lower Triassic ammonoids of North America, by J. P. Smith. Professional paper.

The flora of the Frontier formation, by E. W. Berry. Professional Paper 158–H.

Gold reserves of the United States, by G. F. Loughlin and others, prepared for the Fifteenth International Geological Congress, held in South Africa, summer of 1929. An abstract of this paper was presented to the section of mining geology, American Institute of Mining and Metallurgical Engineers.

Cycles in metal production, by D. F. Hewett. Published as part of program of committee on production control, American Institute of Mining and Metallurgical Engineers.

Review of manganese reserves, by D. F. Hewett. For subcommittee on manganese of the American Institute of Mining and Metallurgical Engineers.

Determination of anisotropism in metallic minerals, by Edward Sampson. Economic Geology.

Fluorspar in the Western States, by E. F. Burchard. Prepared for a joint committee on international control of minerals of the American Institute of Mining and Metallurgical Engineers.

Alabandite in the Southwestern States, by D. F. Hewett. Economic Geology.

The properties and associated minerals of gillespite, by W. T. Schaller. American Mineralogist.

Progress in the study of clay minerals, by C. S. Ross, E. T. Wherry, and P. F. Kerr. Proceedings of the Seventh Colloidal Symposium.

Is chromite always a magnetic product? by C. S. Ross. Economic Geology.

Carbon ratios and oil gravities in the Rocky Mountain region in the United States, by C. E. Dobbin. Bulletin of the American Association of Petroleum Geologists.

Cultures of algae oolites, by W. H. Bradley. American Journal of Science.

Neue Beobachtungen über Algen als Urmaterialien der Bogheadkollen und -Schiefer, by W. H. Bradley. Centralblatt für Mineralogie, Geologie und Palaeontologie.

The fuels of the future, by M. R. Campbell. Given before the Eastern States Blast Furnace & Coke Oven Association at Pittsburgh.

Some factors for consideration in an appraisal of the oil possibilities of the United States, by David White. Presented at the Second International Conference on Bituminous Coal, at Pittsburgh.

The Atlantic and Gulf Coastal Plain, by L. W. Stephenson, C. W. Cooke, and Julia Gardner. For volume on North America in Geologie der Erde.

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

Pleistocene glaciation of the Northern Hemisphere, by Frank Leverett. Presented at the meeting of Section E, American Association for the Advancement of Science, in New York; published in the bulletin of the association.

Mitrospira, a new Ordovician gastropod genus, by Edwin Kirk. Proceedings of the United States National Museum.

The status of the genus *Mariacrinus* Hall, by Edwin Kirk. Proceedings of the United States National Museum.

The Ordovician, Silurian, and Devonian of Alaska, by Edwin Kirk. Abstract to be published in Bulletin of the Geological Society of America.

Pagecrinus, a new crinoid genus from the American Devonian, by Edwin Kirk. Proceedings of the United States National Museum.

Known species of *Telephus*, *Glaphurus*, and *Glaphurina* and ages of beds containing them, by E. O. Ulrich. Proceedings of the United States National Museum.

Criteria in distinguishing fossil faunas of the Arctic region from those developed in other seas, by E. O. Ulrich. Presented at the annual meeting of the Paleontological Society of America.

Triassic and Jurassic of the Arctic region, by T. W. Stanton. Abstract in Bulletin of the Geological Society of America.

Cretaceous of the Arctic and subarctic regions, by J. B. Reeside, jr. Abstract in Bulletin of the Geological Society of America.

New Carboniferous invertebrates (I), by G. H. Girty. Journal of the Washington Academy of Sciences.

Late geological deformation of the Appalachian Piedmont as determined by river gravels, by M. R. Campbell. Proceedings of the National Academy of Science.

The geomorphic value of river gravel, by M. R. Campbell. Bulletin of the Geological Society of America.

The river system: a study in the use of technical geographic terms, by M. R. Campbell. Journal of Geography.

Rainfalls accompanying explosive eruptions of volcanoes, by R. H. Finch.

Memorial to Joseph Silas Diller, by A. J. Collier. Bulletin of the Geological Society of America.

Thomas Chrowder Chamberlin's contributions to glacial geology, by W. C. Alden. Journal of Geology.

Incompleted projects on which work was accomplished comprise a report on the copper deposits of the southern Appalachian region, by C. S. Ross and M. N. Short; a report on the geology of the Great Basin, by D. F. Hewett; studies of Appalachian oil fields by G. B. Richardson; a report on antimony deposits of the world, by F. C. Schrader; investigations of salt-dome cap rock, by M. I. Goldman; studies of the stratigraphy and paleontology of the Appalachian Valley and of the Upper Cambrian trilobites, by E. O. Ulrich; a report on early Paleozoic cephalopods, by Mr. Ulrich and A. F. Foerste; investigations of the Cretaceous formations of the Western Interior province, by J. B. Reeside, jr., including papers on pelecypods of the Eagle sandstone and related formations, ammonites of

the Greenhorn limestone, new species of scaphites, and a chapter on the geology of the Rocky Mountains and northern plateau region for Geologie der Erde; studies of Devono-Carboniferous faunas, by G. H. Girty; studies of Paleozoic ostracode genera and a paper on some species of *Paraparchites*, by P. V. Roundy; studies of the Eocene Foraminifera of the Atlantic Coastal Plain, by J. A. Cushman; research on microchemical methods of ore identification and on certain nickel ores, by M. N. Short; studies on the selenium content of zinc sulphides, by C. E. Siebenthal and R. C. Wells, and on granite for acid towers, by G. F. Loughlin; investigations in connection with the tectonics committee of the National Research Council, by G. R. Mansfield; and earthquake studies, by Arthur Keith.

WORK IN CHEMISTRY

The work in chemistry was carried on by eight chemists. One chemist, R. K. Bailey, was transferred in August to Roswell, N. Mex., where he collects potash cores and samples and makes qualitative tests.

During the year 8,910 specimens were analyzed.

The study and experimental work on ore deposition was continued with gratifying results by R. C. Wells. This research included dolomitization, the origin and replacement of minerals, and similar phenomena. Mr. Wells also started an investigation including laboratory experiments on the diffusion of gases through rocks and other slightly permeable materials with a view to explaining the separation and movement of gases through rock formations and their concentration in specific localities. He also made a study and tests of methods for determining small quantities of selenium and for the separation of rare-earth metals.

Short researches on a hydrous phosphate from Virginia, phillipsite in manganese ore from Nevada, spadaite from Utah, hydrozincite from Nevada, ammonium borate from Italy, and the properties of minerals associated with gillespite were made by W. T. Schaller. Besides preparing the manuscripts credited to him in the list of papers given below, Mr. Schaller read the following papers before scientific societies:

Crystallography of quartz pseudomorphs after glauberite.
Ludwigite group.
Ending of chemical adjectives in describing isomorphous minerals.
Halite-anhydrite intergrowths.
Serendibite from New York.
Mineralogy of the cores from the New Mexico-Texas potash field.

Additional laboratory work was done on the chemical disintegration of Indiana limestone and the composition of its insoluble residue by George Steiger. Mr. Steiger also made a study with laboratory experiments on the permeability of granite and prepared for the committee on sedimentation of the National Research Council a bibliography of chemical works published during the year having a bearing on the problem of sedimentation.

Exhaustive experiments in perfecting a method for determining small quantities of selenium were made by E. T. Erickson. It is now possible to identify definitely as small a quantity of this metal as 1 part in 500,000.

A series of dehydration tests on certain clays in a study on the rôle of water in the clay minerals were made by J. G. Fairchild in cooperation with C. S. Ross.

In the search for potash 11 cores from wells drilled especially in the interest of this project were received in the Washington laboratory and studied in detail. In addition 5,880 samples of cuttings, which were taken from 56 different wells being drilled for oil, were assayed or otherwise tested for their potash content. Three of the cores came from wells drilled in Crockett, Reagan, and Glasscock Counties, Tex., under the auspices of the Bureau of Mines, with funds appropriated by Congress for the investigation of potash deposits. Numerous beds of salts were encountered that were sufficiently high in their potash content but rather thin to be of economic interest. Excellent showings were made by seven cores taken from wells drilled by private interests in a field in Eddy County, N. Mex. Seventeen wells have been drilled in developing this field, each of which gave good showings for potash-rich salts, but two of those drilled this year deserve special mention. Both wells are in the western part of the field, about a mile apart. The first well pierced seven beds, each over 2 feet in thickness, composed of salts showing a potash content of more than 10 per cent. The second well pierced four beds thicker than 2 feet each, composed of salts containing more than 12 per cent of potash.

The following papers were completed during the year:

Steiger, George, Indiana oolitic limestone [part of U. S. Geol. Survey Bull. 811–C].

——— Investigations of chemistry that have a bearing on problems of sedimentation [to appear in annual report of committee on sedimentation, National Research Council].

Schaller, W. T., Borate minerals from the Kramer district, Calif.: U. S. Geol. Survey Prof. Paper 158–I (in press).

——— The properties and associated minerals of gillespite [to appear in Am. Mineralogist].

Erickson, E. T., The determination of small quantities of selenium in ores [to appear in Washington Acad. Sci. Jour.].

Fairchild, J. G., Base exchange in artificial autunites [to appear in Am. Mineralogist].

Henderson, E. P., Gearksutite from Hot Springs, Va. [to appear in Am. Mineralogist].

WORK IN PHYSICS

Field observations of deep earth temperatures were made by C. E. Van Orstrand from March 26 to September 12, 1928, and in June, 1929, in Alabama, Kansas, Texas, Oklahoma, California, Montana, and Wyoming. Some of the observations were made in cooperation with the American Petroleum Institute. Apart from administrative duties, Mr. Van Orstrand devoted his time in the office to the preparation of scientific papers and the review of observations of deep earth temperatures submitted by three research associates of the American Petroleum Institute, working in Texas, Oklahoma, and California.

The investigation of the association of water and petroleum with silica and various silicates and with alumina and hydrous ferric oxide was continued by P. G. Nutting, who has applied his results in studies of filtering earths, oil sands, and the formation of asphalt

beds. The theory of cohesive pressures in adsorbed films has been further developed and applied. Methods of determining the permeability of oil sands and other rocks have been studied and the results applied to field problems, such as dam seepage and petroleum recovery. Among the papers published that on deformation and temperature gives new formulas for calculating the heat developed by compression in rocks.

The following papers were completed during the year:

Nutting, P. G., Some geological consequences of the selective adsorption of water and hydrocarbons by silica and silicates: Econ. Geology, vol. 23, pp. 773–777, 1928.

——— Deformation and temperature: Washington Acad. Sci. Jour., vol. 19, pp. 109–115, 1929.

——— Petroleum and the filtering earths: Washington Acad. Sci. Jour., vol. 18, pp. 409–414, 1928.

——— Petroleum recovery by the soda process—III: Oil and Gas Jour., Oct. 18, 1928, p. 146.

——— Internal pressures in adsorbed films [to appear in Washington Acad. Sci. Jour.].

Van Orstrand, C. E., Geothermal surveys in the United States: United States Daily, Feb. 15, 1929.

——— On the detection of inhomogeneities in the crust of the earth by means of deviations in the isogeothermal surfaces [to be published by the National Research Council].

ALASKAN BRANCH

PHILIP S. SMITH, Chief Alaskan Geologist

ORGANIZATION AND PERSONNEL

The organization of the Alaskan branch remains unchanged at the end of the year. The force comprises the chief Alaskan geologist, 3 geologists, 1 supervising mining engineer, 2 topographic engineers, 1 coal-mining assistant, 1 draftsman, and 3 clerks.

FUNDS

The funds used by the Geological Survey in its Alaskan work are provided in two items in the general act making appropriations for the Interior Department. One of these items reads, "for continuation of the investigation of the mineral resources of Alaska * * *." In the act for the fiscal year 1929 the amount was $64,500, which was later increased $3,000 through the provisions of the deficiency act to take care of salary advances made under the Welch Act. In the similar act for 1930 the amount appropriated was $67,500. Each of these appropriations was made available immediately on the passage of the act in which it was contained. The other item is an allotment made from the appropriation "for the enforcement of the provisions of the acts of October 20, 1914, October 2, 1917, February 25, 1920, and March 4, 1921, and other acts relating to the mining and recovery of minerals on Indian and public lands and naval petroleum reserves * * *." Allotments under this item are available only during the fiscal year specified. In the fiscal year 1928 an allotment of $14,500 was made for work of this kind in Alaska; in 1929,

$10,000. The two types of work indicated will be described for convenience as the work on mineral resources and the leasing work.

WORK ON MINERAL RESOURCES

PRINCIPAL RESULTS OF THE YEAR

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

The Skwentna region, by S. R. Capps (Bulletin 797–B).

Preliminary report on the Sheenjek River district, by J. B. Mertie, jr. (Bulletin 797–C).

Surveys in northwestern Alaska in 1926, by Philip S. Smith (Bulletin 797–D).

Aerial photographic surveys in southeastern Alaska, by R. H. Sargent and F. H. Moffit (Bulletin 797–E).

Geology and mineral resources of the Aniakchak district, by R. S. Knappen (Bulletin 797–F).

Mineral industry of Alaska in 1927, by Philip S. Smith (Bulletin 810–A).

Administrative report, 1927–28, by Philip S. Smith (Bulletin 810–A).

Geology of Hyder and vicinity, southeastern Alaska, with a reconnaissance of Chickamin River, by A. F. Buddington (Bulletin 807).

Five reports have been completed by their authors and approved for editing or printing, as follows:

Notes on the upper Nizina River, by F. H. Moffit (Bulletin 810–D).

Administrative report, 1928–29, by Philip S. Smith (Bulletin 813–A).

The Chakachatna-Stony region, by S. R. Capps (Bulletin 813–B).

Mining in the Fortymile district, by J. B. Mertie, jr., (Bulletin 813–C).

A geologic reconnaissance of the Fortymile-Tanana district, by J. B. Mertie, jr.

The following reports are in press:

The Upper Cretaceous floras of Alaska, by Arthur Hollick, with a description of the Upper Cretaceous plant-bearing beds by G. C. Martin (Professional Paper 159).

Geology and mineral deposits of southeastern Alaska, by A. F. Buddington and Theodore Chapin (Bulletin 800).

The Chandalar-Sheenjek region, by J. B. Mertie, jr. (Bulletin 810–B).

The Mount Spurr region, by S. R. Capps (Bulletin 810–C).

Geography and geology of northwestern Alaska, by Philip S. Smith and J. B. Mertie, jr. (Bulletin 815).

Geology of the Eagle-Circle district, by J. B. Mertie, jr. (Bulletin 816).

Six other reports are in preparation but have not approached near enough to completion to warrant any definite statement as to the time of publication.

Practically all the completed reports are accompanied by maps, the base of which has been made principally from surveys conducted by the topographers of the Alaskan branch. The following maps have been published:

Drainage map of part of the Hyder-Ketchikan region, southeastern Alaska, compiled under direction of R. H. Sargent; mainly from aerial photographs made by the Navy Department at the request of the Geological Survey; scale, 1:250,000. Published in Bulletin 797–E.

Topographic map of the Hyder district (new ed.), by R. M. Wilson; scale, 1:62,500. Published in Bulletin 807.

Topographic map of the Pavlof region, Alaska Peninsula; scale, 1:250,000; by C. P. McKinley, for the National Geographic Society's Pavlof Volcano Expedition. Issued in a free preliminary photolithographic edition.

The maps listed below were completed during the year under the direction of R. H. Sargent and submitted for publication:

Topographic map of Valdez and vicinity, by J. W. Bagley and C. E. Giffin; scale, 1:62,500. To be published as a sale map. The base of this map is largely the Port Valdez map, now out of print, but it covers a somewhat larger area, has been revised and brought up to date, and includes the results of hitherto unpublished surveys.

Topographic map of Revillagigedo Island, southeastern Alaska, by R. H. Sargent; scale, 1:125,000. The topography of this map is from surveys made in 1928 by the usual ground methods, but the drainage features are taken from the Hyder-Ketchikan map, which was compiled from aerial photographs. To be issued as a free preliminary photolithographic edition.

Progress was also made in the compilation of a topographic map of the Mount Spurr region, scale, 1:250,000, from recent surveys.

The base map of Alaska on a scale of 1:5,000,000 was brought up to date, and considerable work was done toward the revision of the map on a scale of 1:2,500,000.

Besides the official reports, several articles were prepared by the scientific and technical members of the Alaskan branch for publication in outside journals, and 10 or more public lectures were given regarding the general work of the branch or some of its special features. Most of these were prepared unofficially but represent excellent by-products of the regular work and serve to reach special audiences not readily reached by the regular official publications. Among these articles may be mentioned the following:

Gold reserves of Alaska, by Philip S. Smith, for presentation at the International Geological Congress in South Africa, 1929.

Geology and geography of Alaska, by Philip S. Smith, for publication in "Geology of North America," included in "Geologie der Erde" in process of compilation.

The pre-Cambrian of interior Alaska, by J. B. Mertie, jr., delivered before the Geological Society of Washington.

Notes on geographic features of Alaska, by R. H. Sargent, delivered at the meeting of the Association of American Geographers in New York.

Field work of the Geological Survey in 1928, by F. H. Moffit, for publication in Alaska newspapers.

Our northern frontier territory, by Philip S. Smith, delivered before the Service Club of the Signal Corps, U. S. A.

PROJECTS IN PROGRESS DURING THE SEASON OF 1928

Some of the results that the Geological Survey has accomplished in its Alaska work may be expressed in terms of the area covered. The areas reported in the following table are based on the field season and not on the fiscal year, and therefore no account is taken of the work that was started during the field season of 1929 but remained uncompleted at the end of the fiscal year. This procedure has been adopted in part because most of the parties at work during the field season of 1929 are out of communication and so can not yet report the extent of the work they have accomplished, but in part it has been adopted because the field season is a more practicable unit of measurement.

Areas surveyed by Geological Survey in Alaska, 1898–1928, in square miles

Field season	Geologic surveys			Topographic surveys		
	Exploratory (scale 1:500,000 or smaller)	Reconnaissance (scale 1:250,000)	Detailed (scale 1:62,500 or larger)	Exploratory (scale 1:500,000 or smaller)	Reconnaissance (scale 1:250,000)	Detailed (scale 1:62,500 or larger)
1898-1927	75,150	169,305	4,277	55,630	204,565	4,066
1928		5,450			[a] 3,965	
	75,150	[b] 174,305	4,277	55,630	208,530	4,066
Percentage surveyed of total area of Alaska	43.3			45.8		

[a] Includes 2,000 square miles mapped by National Geographic Society Pavlof Expedition on Geological Survey standards.
[b] 450 square miles surveyed prior to 1928 deducted because of resurvey during 1928.

In this table only the net areas surveyed are listed in the appropriate column, though of course most of the areas that have been surveyed geologically have also been surveyed topographically. It is by no means unusual that areas surveyed hastily are resurveyed later with more precision. If the areas thus revised were not excluded from the totals the same area would be counted twice. It is for this reason that an area of 450 square miles which was reexamined geologically in 1928 has been deducted from the total in the column of reconnaissance geologic surveys. The necessity for resurveying some areas in more detail is generally due to the need of covering a large tract rapidly at first. As development takes place in certain parts of that large tract more accurate and detailed work may be required to furnish the desirable information. This policy is well illustrated by the procedure adopted in surveying the Seward Peninsula placer camps. Within two or three months after the return of the Federal geologist from this field during the height of the first stampede to Nome a rough exploratory map and a report on the environs of Nome were published by the Geological Survey. During the next field season reconnaissance surveys of the entire region within 100 miles of Nome were made, and later these were succeeded by detailed mapping and reports of the smaller tracts in the vicinity of the richest camps.

The scale most commonly adopted for Alaska surveys is 1:250,000, in which 4 miles on the ground is represented by an inch on the map, with a contour interval of 200 feet. This scale is adequate for most general purposes, and the surveys can be made expeditiously and cheaply. It is obvious, however, that such a scale can not effectively show detailed features of topography or geology, and yet many of these are of prime importance in their relations to the mineral resources of the region. Therefore, although more than two-fifths of the Territory has been mapped on reconnaissance or exploratory standards, there is constant demand for more detailed work, and this demand will become more and more insistent as the Territory develops. Even for the reconnaissance type of mapping there still remains about 200,000 square miles of unsurveyed territory that holds promise of containing mineral deposits of value. At the present rate it will be many decades before even the reconnaissance mapping of the prospective mineral areas can be completed, and the

requisite detailed mapping of the most promising tracts must be postponed far into the future or must supplant the equally pressing reconnaissance work unless more funds are made available.

The surveys in 1928 tabulated above were made in the Ketchikan and Juneau districts of southeastern Alaska, the Chitina-Nizina district of the Copper River region, the vicinity of Mount Spurr in the Alaska Range, and a tract lying north of the Tanana River and west of the international boundary. The work in the Ketchikan district was reconnaissance topographic mapping conducted by R. H. Sargent. Ores of various metals have long been known to occur here, and some of them have been worked more or less successfully. Owing to the easy accessibility of most parts of the district to ocean transportation, many of the costs of development will probably be low, and the general geologic conditions are such as to encourage search for deposits of commercial extent. Although the principal object of this mapping was to furnish a topographic base that would serve for the mineral investigations, it has met an immediate need of those concerned with the development of the timber, pulp, and water-power resources of this district. This project is of special technical interest because the topographer made use of the first of the drainage maps compiled from the aerial photographs taken for the Geological Survey by the Navy Department in 1926. The use of these aerial pictures proved highly advantageous in facilitating the work of the topographer in this region of high relief and almost impenetrable timber cover. As the photographs taken by the naval expedition cover nearly 10,000 square miles of southeastern Alaska, this project is the forerunner of similar surveys that will be carried on in this region as rapidly as funds and personnel permit.

The surveys in the Juneau region were made by R. K. Lynt, a topographer of the Geological Survey, who was temporarily assigned to duty with a party of the Forest Service. This work was especially desired by the Forest Service in connection with its activities in developing the paper-pulp industry in southeastern Alaska, and although the Geological Survey would doubtless have mapped that area in the course of its regular mineral investigations, the immediate needs of the Forest Service were so urgent that that organization bore the entire cost, and the resulting map was turned over to it. The work has not been included in the table of areas surveyed, nor in the table of expenditures. It covered a small tract on the west coast of Admiralty Island and was done with the accuracy required for publication on a scale of 1:62,500. The tract is exceedingly difficult to survey, and the map covered an area of only a few score square miles.

The work in the Nizina district of the Copper River region consisted principally of the revision of earlier geologic surveys and the critical study of some of the places where different interpretations that have been advanced could be tested. This work was done by F. H. Moffit, who with a small pack train and camp assistant traversed much of the known copper-bearing region north of the Chitina River and greatly refined the broad determinations of the geology resulting from earlier more hurried expeditions. The more precise knowledge of the stratigraphy and geologic history thus obtained is essential in directing the search for valuable deposits in this important mineralized region. Mr. Moffit also spent some time at the large copper mines near Kennecott and at the placer gold camps on Dan and Chititu Creeks and visited most of the places in the district where prospecting has recently been in progress.

In the vicinity of Mount Spurr, in the Alaska Range west of Anchorage, a combined geologic and topographic party in charge of S. R. Capps, geologist, with Gerald FitzGerald as topographer, carried on extensive surveys by means of a pack-train expedition. The geologist, topographer, and recorder were carried by airplane to the point where the surveys were to be started, and the trip from Anchorage consumed one hour and twenty minutes, whereas the pack train that was sent overland from the west shore of Cook Inlet took over 20 days to make the trip. It is evident that in a region like the Alaska Range, where the working season is limited to less than 100 days, this great saving in time is of paramount importance. Moreover, the saving in food and salaries almost, if not quite, makes this means of transportation cheaper than tramping on foot across the country. The geologic and geographic results of this work are of great interest and significance. The party traversed with pack train a pass across the Alaska Range leading on the west side to streams flowing into the Stony River, one of the large southern tributaries of the Kuskokwim River,

and mapped a tract of 1,000 square miles that has hithereto remained a blank on all authoritative maps of the Territory.

A triangular area in the vicinity of the international boundary north of the Tanana River and extending more than 100 miles to the west, south of the gold placer camps of the Fortymile district, had been covered by a reconnaissance topographic map some years ago, but until the season of 1928 it had not been possible to map the area geologically. In that season J. B. Mertie, jr., with a small pack train and two camp assistants, left Eagle to carry on reconnaissance geologic surveys. A serious injury to one of the camp assistants before reaching the field necessitated the return of the party to Eagle to get medical attention. The loss of the assistant still further hampered the party, which had been undermanned even before the accident, but in spite of this Mr. Mertie pushed ahead with only one camp hand and was successful in mapping the major geologic features of an area of nearly 4,000 square miles. The geologic features observed seem to indicate that at a number of places the conditions are favorable for the occurrence of gold lodes, and that where concentration has been effective placer deposits may be sought with considerable assurance of success.

The only other field work that was done during the season of 1928 by a member of the staff having headquarters in Washington was the customary broad survey of recent developments in the mining industry as a whole, with special visits to some of the more active mining camps or those that had not been recently visited by members of the Geological Survey. This work was done by the chief Alaskan geologist and included visits to the Ketchikan, Juneau, Kennecott, Fairbanks, Tenderfoot, Hot Springs, and other districts. A general familiarity with the mining industry such as may be gained by a rapid survey of this type is regarded as essential in keeping track of recent developments and in laying out plans for future work so that they will fit the needs of the mining industry.

The Geological Survey maintains in Alaska two district offices, one at Juneau and one at Anchorage. The main duties of the personnel attached to these offices relate to mineral leasing, but about two-fifths of the time of B. D. Stewart, who is in direct charge of the local offices, was allotted to general investigations of mineral resources, including both office duties and visits to various parts of the Territory as conditions warrant. Mr. Stewart's long familiarity with mining matters throughout the Territory and his availability for consultation at Juneau have made his advice much sought by many of the Federal and Territorial agencies in Alaska, including the Alaska Railroad, the Forest Service, the governor, and members of the Territorial legislature, as well as by many of the individual operators and prospectors. The Alaska offices also act as local distributing points for publications of the Geological Survey and assist in furnishing the main office at Washington with information on many phases of the mineral industry in the Territory.

A field project that strictly does not properly belong to the work of this branch, as it was financed by a non-Federal organization and was performed by members of the Geological Survey who belong to other branches, was the National Geographic Society's Pavlof Expedition to the Alaska Peninsula, which was in charge of T. A. Jaggar, jr., volcanologist, with C. P. McKinley as topographer. Through the courtesy of the National Geographic Society the excellent topographic field sheets that resulted from this survey were made available without expense to the Geological Survey, which has issued the resulting map in a preliminary edition that is in every respect comparable to the standards used for its own maps. The area covered by this map has been included in the table on page 32. This adds one more to the already long list of notable contributions which the National Geographic Society has made to Alaskan exploration.

In addition to these distinctly field projects the Alaskan branch each year compiles and issues statements regarding the production of mineral commodities in the Territory.

Each of the field projects involves considerable office work in examining and testing the specimens collected, preparing the illustrations and maps, and writing the reports. In all the office work on the technical reports the members of the Alaskan branch have received much assistance and valuable advice from their associates in other branches of the Geological Survey. T. W. Stanton, G. H. Girty, J. B. Reeside, jr., Edwin Kirk, David White, and E. W. Berry, paleontologists, have examined and reported on the fossils collected in the field surveys. The map editors have been especially helpful in critically scrutinizing

the Alaskan topographic maps that were in course of preparation to see that they conform so far as practicable to the best Geological Survey standards.

PROJECTS FOR THE SEASON OF 1929

The six projects that were approved for the season of 1929 had been under way for only a short time at the end of the fiscal year, and most of the parties are out of touch with ordinary means of communication, so that no specific details are available regarding the work accomplished. The principal objects of these projects are topographic studies in connection with the airplane photographing expedition of the Navy Department in the northern part of southeastern Alaska; geologic reconnaissance surveys in the Alaska Range in the vicinity of Mentasta Pass and Chistochina, at the head of the Copper River Basin; a combined geologic and topographic reconnaissance survey of an unexplored tract of the Alaska Range northwest of Lake Clark, in southwestern Alaska; a geologic reconnaissance of the White and Crazy Mountains, in the north-central part of the tract between the Yukon and Tanana Rivers, central Alaska; investigations of mineral properties in the vicinity of the Alaska Railroad; and the usual general inspectional trip.

The projected work in southeastern Alaska is essentially a part of the undertaking by the Navy Department to photograph from airplanes a large tract, including Baranof and Chichagof Islands and contiguous territory. This work is a continuation of similar work done in 1926, when about 10,000 square miles of the southern part of southeastern Alaska was photographed and the resulting films were turned over to the Geological Survey for working up into drainage maps. The value of the pictures was at once apparent, and subsequently the Forest Service, feeling the urgent need of similar pictures for the northern part of this region, entered into an agreement whereby the work should be resumed by the Navy during the season of 1929. Under this agreement most of the extra expense of the photographic work is borne by the Forest Service, the Geological Survey contributing only $2,000 and the services of R. H. Sargent, topographer, who serves as technical adviser to see that the resulting films are suitable for cartographic use. It is expected that as a result of this work many thousand new films will be obtained and that with these, together with those already in hand from the earlier expedition, it will be practicable to compile drainage maps of almost all the hitherto unmapped portions of southeastern Alaska. The task of taking off the cartographic data from these views is laborious, and the funds for this work at the disposal of the Geological Survey are so small that unless they are materially increased these valuable data can not be worked up into maps in the near future. The former success of the Navy in this work and the whole-hearted enthusiasm with which its personnel have engaged in the new project give every assurance of its successful completion. The resulting maps will be of service not only to the Geological Survey in its mineral investigations but to everyone having an interest in the development of any of the natural resources of this region. The topography of southeastern Alaska gives a very severe test of the application of methods of photographic surveying, because the relief of the country is so strong that distortion of scale is especially great. Furthermore, the atmospheric conditions are bad, with a great amount of clouds and rain and the intricate interspersal of land and water areas. Aerial photographic methods, however, have many advantages over ground methods in this region, because of the difficulty of traversing on foot the high ridges, precipitous ledges, and almost impenetrable jungle of forest and brush-clad slopes.

The geologic reconnaissance in the Alaska Range, at the head of the Copper River, is being conducted by F. H. Moffit, accompanied by a small pack train and two camp assistants. The country adjacent to Mentasta Pass has long been known to be mineralized, affording evidence of the presence of gold and lead and some indications of the presence of copper. Development work is in progress in this district on prospects of lode gold and lead. Productive gold placers have long been worked in the Slate Creek district, which lies along the western margin of the area to be surveyed. The region as a whole lies across the axis of the Alaska Range, and the surveys are expected to yield information as to the relation of the metamorphic rocks on the north side of the range to the Paleozoic and Mesozoic sediments on the south. A part of the area was mapped both topographically and geologically by hasty reconnaissance methods in 1902, but the results of the geologic investigations were never published. It is especially desirable now to revise and extend that

mapping in the light of the present knowledge of the stratigraphy and the renewed interest that is being taken in the mineral deposits in this general region.

The combined geologic and topographic surveys to be made in the Alaska Range region north and west of Lake Clark are in charge of S. R. Capps, geologist, with Gerald FitzGerald, topographer. These surveys started from the previously surveyed region adjacent to Lake Clark and will extend northward as far as time and other conditions permit, possibly tying in with the surveys made during the field season of 1928 in the valley of the Stony River, a tributary of the Kuskokwim. The surveys should fill in some of the gap that now exists between the work that has been done in the northern and central parts of the Alaska Range and that done to the south. The region holds promise of containing deposits of valuable minerals, but it is practically unexplored, and this possibility can be stated now only as a surmise. In fact, the absence of authoritative information regarding it makes its exploration especially desirable at this time.

The work in the Yukon-Tanana region will be principally a geologic reconnaissance and revision of the older mapping of parts of the country adjacent to the White Mountains and the extension of the surveys northward to the Yukon Flats and eastward to the Crazy Mountains. The work is in charge of J. B. Mertie, jr., accompanied by a pack train and two camp assistants. The party will have the opportunity of visiting some of the old placer camps, especially those near Circle, and will collect information regarding the progress of mining and prospecting in those places. This work is part of the general revision that Mr. Mertie has been carrying on for a number of years in the Fairbanks and Circle districts. The results of this critical study, when completed, should be of much significance in determining the general geologic history of the region and in throwing light on the conditions under which the mineralization was effected and consequently giving clues to the places where further prospecting is most likely to be successful.

Early in 1929 O. F. Ohlson, in charge of the Alaska Railroad, broached the question of organizing a geologic staff as part of the railroad personnel, to assist the railroad in its search for tonnage and in solving problems that arose in its work that required this special type of information. The Geological Survey agreed to make available to the railroad the services of an engineer or geologist for about four months a year and to meet so far as possible any requests for areal work that might be submitted by the railroad officials. This arrangement was started in the season of 1929, and at the end of the fiscal year the results were not yet sufficient to afford adequate measure of its success. It is proposed that in the main the needs of the railroad for an engineer or geologist shall be taken care of by members of the staff attached to the local offices at Anchorage and Juneau. If necessary, additional assistance will be given by the chief Alaskan geologist or such other members of the field force as may be in the general neighborhood of the railroad. The successful operation of the railroad as a means of developing Alaska is of most vital concern to the entire mining industry, and the Geological Survey in its relation to that industry feels keenly concerned with making this cooperation effective.

The general work on mineral resources done by B. D. Stewart from the Alaska offices, in addition to that called for by the arrangement with the Alaska Railroad, will be similar to that of the season of 1928. It will consist in such general field studies as time and other conditions permit, the maintenance of office records, the answering of inquiries, and the holding of such conferences as may be required.

The only other field work that the Geological Survey proposes to do in Alaska in 1929 is the customary broad survey of recent developments in the mining industry as a whole, with special visits to some of the more active camps and to some of those that have not been visited recently by members of the Geological Survey. This work will be done by the chief Alaskan geologist, who will reach Alaska late in July and spend the rest of the season on the projects.

EXPENDITURES

The funds used for the work of the Geological Survey on Alaska's mineral resources during the field season of 1928 were made available through the Interior Department appropriation acts for the fiscal

years 1928 and 1929. For a large part of the time the two appropriations were running concurrently. All the expenditures have been properly accounted for under the usual system of bookkeeping, but the analysis from that standpoint gives only an imperfect picture of the real conduct of the work. In the following statement an attempt has been made to summarize the expenditures under a number of major heads, so as to show the principal objects for which the funds appropriated during the fiscal year 1929 were expended.

Expenditures from funds appropriated for investigation of mineral resources of Alaska for the fiscal year 1929

Projects for the season of 1928	$13,566
Projects for the season of 1929	11,350
Administrative salaries	3,150
All other technical and professional salaries	28,167
All other clerical and drafting salaries	7,667
Office maintenance and expenses	3,251
Balance	349
	67,500

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

The expenditures for the projects of 1928 amounted to $13,566, which includes $7,938 for geologic and general investigations and $5,628 for topographic work. These figures are based on the assumption that in combined geologic and topographic parties the expenses are divided equally between the two types of work. A similar analysis shows that expenditures from funds for the fiscal year 1929 amounted to $11,350, of which $6,675 was for geologic work and $4,675 for topographic work. Of the total allotted to field projects for both seasons about 58 per cent was allotted to geologic or related general work and 42 per cent to topographic work.

The item for administrative salaries in the foregoing table includes only those salaries that are directly related to general administration and does not include charges for administration such as each party chief is called on to perform with regard to the party in his charge. During the fiscal year the chief Alaskan geologist was in the field until early in October and was on leave from April 3 throughout the rest of that year. During his absence the general administration of the branch was carried on by S. R. Capps until he left in May to undertake field work in the Alaska Range region. During part of May and all of June Miss L. M. Graves served for the chief of the branch. Part of Mr. Stewart's salary has been included in this item, as the local administration of the Alaska offices is in his charge. The low cost of administration is due principally to the fact that the administrative officers are engaged also in technical projects, which therefore have their proportional charge of their salaries. This makes for low cost of administration but les-

sens the amount of time available for real directive handling of many of the affairs of the branch and would not be at all practicable except with a branch whose personnel has long been familiar with the work to be done and is well qualified to solve for itself many of the problems that arise.

The item for clerical and drafting salaries for the Washington office covers part of the salary of the chief clerk, a junior clerk, and a draftsman, and the services for a little more than three months of a stenographer. In addition the item includes part of the salary of a clerk in the Anchorage office. Approximately three-fourths of the time of the junior clerk in the Washington office is devoted to the canvass and compilation of data regarding the production of minerals and work related thereto, which is practically a technical project. The draftsman is engaged in all kinds of map preparation, especially in the finer kinds of work required where photolithographic methods are to be used for reproducing the original copy. The present clerical and drafting personnel is entirely too small to handle the volume of business that passes through the office. Curtailments in appropriations have been met by curtailments in the clerical force, so as to make as much money as possible available for the field projects. This procedure is having an injurious effect on the work as a whole and should not much longer be continued.

The item for office maintenance and expenses includes all the miscellaneous expenses incident to the general conduct of the work that are not directly part of a definite project. By far the heaviest charges entering into this item during the fiscal year were those for new instruments, amounting to $1,742 and including a transit and equipment, a telescopic alidade to replace instruments that have been long in service and are now worn out, a photographic printer especially designed for airplane films, and a special stereoscopic apparatus necessary for handling the airplane views when being used for map compilation. The amount thus spent represents in fact a replacement that will not be necessary again for some years, unless the scope of the work is expanded. The next largest item of expense under this heading covers photographic and related work, which amounted to about $800. Nearly 40 per cent of this total represents the cost of preparing a preliminary edition of the Pavlof map which was made available to the Geological Survey by the National Geographic Society, and 15 per cent was for work on the drainage map prepared from airplane pictures of part of southeastern Alaska. The cost of all the other supplies and equipment for the branch was considerably less than 1 per cent of the total appropriation. This amount is rather less than can be consistently maintained.

In the following tables the cost of the salaries charged against each project is only approximately accurate, for the whole time of a geologist or topographer assigned to a project is charged against that project, whereas much of his time at the office is required for miscellaneous duties. The columns of salaries, except as specifically noted, do not include administrative or clerical salaries, and the columns of expenses do not include items charged to office maintenance or expense. For these reasons, as well as because two different appropriation years are tabulated together, the total given in the last column does not equal, even approximately, the total given in the table on page 37 for a single fiscal year.

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

Region or work	Appropriation for 1928		Appropriation for 1929		Total
	Expenses	Salaries	Expenses	Salaries	
Southeastern Alaska [a]	$1,900	$765	$3,278	$3,333	$9,276
Copper River region	660	765	2,408	4,167	8,000
Alaska Range	2,600	1,445	4,700	7,200	15,945
Yukon-Tanana region	2,400	700	2,089	4,000	9,189
General investigations			986		4,519
Statistical studies				[b] 2,200	2,200
Alaska offices			105	[c] 2,563	2,668
	7,560	3,675	13,566	26,996	51,797

[a] Does not include $1,925 transferred to Geological Survey from Forest Service for detailed topographic mapping.
[b] Includes $1,515 clerical salaries.
[c] Includes $1,000 for administrative salary and $480 for clerical salary.

Approximate cost and distribution of work by geographic divisions for the season of 1929

Region or work	Appropriation for 1929		Appropriation for 1930		Total
	Expenses	Salaries	Expenses	Salaries	
Southeastern Alaska	[a] $2,350	$833	$600	$4,167	$7,950
Copper River region	1,800	833	3,000	4,167	9,800
Alaska Range	4,650	1,533	3,585	7,670	17,438
Yukon-Tanana region	2,550	800	3,150	4,000	11,500
General investigations			1,000	2,400	3,400
Statistical studies				[b] 2,272	2,272
Alaska offices			1,837	[c] 2,563	4,400
	11,350	3,999	13,172	27,239	56,760

[a] Includes $2,000 transferred to Navy Department for aerial photography.
[b] Includes $1,215 for clerical services.
[c] Includes $1,000 for administrative salary and $480 for clerical salary.

LEASING WORK

Part of the activities of the Alaskan branch are related to the proper conduct of mining work on the public mineral lands that have been leased to private individuals or corporations. Funds for this work throughout the United States are provided in a general item contained in the Interior Department appropriation act, and the amounts allotted for the different districts, including Alaska, are determined by the relative needs of each. For the fiscal year 1929 the allotment for Alaska leasing work was $10,000. This was nominally somewhat less than heretofore but in reality was exactly the equivalent of the $14,500 alotted in 1928, because certain work that was paid for out of the allotment in 1928 was in 1929 carried in the appropriation for the work on mineral resources.

In order that the policies and practices that have been developed by the leasing unit of the conservation branch for handling the much larger volume of similar work in the States should be maintained in Alaska and at the same time the specialized knowledge of Alaskan affairs possessed by the Alaskan branch should be utilized, the general conduct of the leasing work in Alaska is in a measure shared between the two branches, the office work in Washington being done

principally by the conservation branch and the field work by the Alaskan branch. The field work is done by the engineers assigned to the Alaska local offices, under the immediate charge of B. D. Stewart, supervising engineer, who has headquarters at Juneau, and J. J. Corey, coal-mining engineer, at Anchorage. The use of the same personnel and facilities for both the leasing work and the work on mineral resources makes it extremely difficult to distinguish accurately between the two. The point of real importance, however, is that by this plan duplication of activities is avoided, costs are lowered, and the technical facilities are focused on the main problem, which is the development of the Territory's mineral resources. At present about three-fifths of Mr. Stewart's time, all of Mr. Corey's time, and two-thirds of the time of the clerk is considered to be devoted to the leasing work. The charges for the maintenance of the local office are shared between the leasing and mineral-resources work on ratios of about 2 to 1. In the fiscal year 1929 the allotment for field expenses was approximately $1,400, an amount that is inordinately low and that proved adequate only because the Alaska Railroad has extended to the limit its services in facilitating the movement of the engineers.

The primary purpose of the leasing work is to supervise the operations under the coal and oil leases or permits that have been granted by the Government and to advise and consult with the proper authorities, both Federal officers and private applicants, regarding lands that may be under consideration for lease or permit. Practically all the coal mining and much of the oil prospecting in Alaska is done on public lands by private individuals or companies under leases or permits issued by the Secretary of the Interior. The interest of the Government in these lands requires not only that these grants shall be a source of revenue to the Nation, but that proper methods of extracting the minerals shall be employed, thus preventing waste or damage to the property, and that the lives, health, and welfare of those engaged in the work shall be properly safeguarded. Practically all the producing coal mines that have been opened in the Territory are in the region adjacent to the Alaska Railroad. The Government has therefore an especial interest in their successful operation. For this reason the Federal engineers have given intensive study to the problems confronting these mines, to be of as much assistance as possible to the operators, by giving them competent technical advice and aiding them in making their ventures successful. Among the points to which special attention has been given are the installation and maintenance of safe and efficient mining and hoisting equipment, adequate ventilation, the reduction of explosion and blasting hazards, and the providing of adequate pillars in advance of all mining operations. This service is appreciated by the operators, and the relations between them and the engineers are extremely cordial and friendly, with no hint of the antagonism that sometimes exists between inspector and inspected.

At present drilling for oil is being done under Government permit at only one point in Alaska, and consequently little of the time of the engineers is spent in the supervision of oil developments. There are, however, many tracts of public land in Alaska that appear to hold promise of containing oil, and hundreds of prospecting permits

for oil have been issued by the Government throughout the length and breadth of the Territory. If the staff were larger it would be good practice for the engineers to check up on these permits occasionally by field visits. Under present conditions it is necessary to rely mostly on local unofficial reports, especially as these indicate no active oil prospecting in progress. In this connection it should be pointed out that the number of engineers needed to look after the Government's mineral lands in Alaska is not comparable with the number required in certain of the States. Neither is the need to be measured by the revenues received by the Government, nor by the number of leases or permits outstanding. In Alaska the open season is so short, the distances so great, and the means of transportation so slow and infrequent that either a proportionately much larger force must be maintained or supervision in the more remote parts must be reduced merely to a gesture.

TOPOGRAPHIC BRANCH

C. H. BIRDSEYE, Chief Topographic Engineer

ORGANIZATION AND PERSONNEL

The organization of the topographic branch at the end of the year is shown below.

Atlantic division, Glenn S. Smith, division engineer, in charge.
Central division, W. H. Herron, division engineer, in charge.
Pacific division, T. G. Gerdine, division engineer, in charge.
Section of inspection and editing, W. M. Beaman, topographic engineer, in charge.
Section of computing, G. W. Hawkins, geodetic engineer, acting in charge.
Section of photographic mapping, J. H. Wheat, topographic engineer, in charge.
Section of cartography, A. F. Hassan, cartographic engineer, in charge.
Map information office, J. H. Wheat, topographic engineer, in charge.

The technical force comprises the chief topographic engineer, 3 senior topographic engineers in charge of divisions, 25 topographic engineers, 2 geodetic engineers, 1 cartographic engineer, 139 associate, assistant, and junior topographic, geodetic, or cartographic engineers, and 84 engineering field aides and draftsmen of various grades, a total of 255. The clerical force comprises 14 clerks.

EXPENDITURES

Appropriations and expenditures for topographic surveys for the fiscal year ended June 30, 1929

State or project	Appropriation for topographic surveys	Repayments for work performed for other Federal units	Total Federal funds	State cooperative funds	Total funds
Topographic surveys, 1929	$505,000.00	$133,002.13	$638,002.13	$476,527.34	$1,114,529.47
Great Smoky National Park, 1928 and 1929	62,050.84		62,050.84		62,050.84
Great Smoky National Park, 1929 and 1930	60,000.00		60,000.00		60,000.00
Shenandoah National Park, 1928 and 1929	32,437.54		32,437.54		32,437.54
Shenandoah National Park, 1929 and 1930	45,000.00		45,000.00		45,000.00
Waterways treaty, 1928 and 1929	10,000.00		10,000.00		10,000.00
Waterways treaty, 1929	11,800.00		11,800.00		11,800.00
Deficiency act	20,000.00		20,000.00		20,000.00

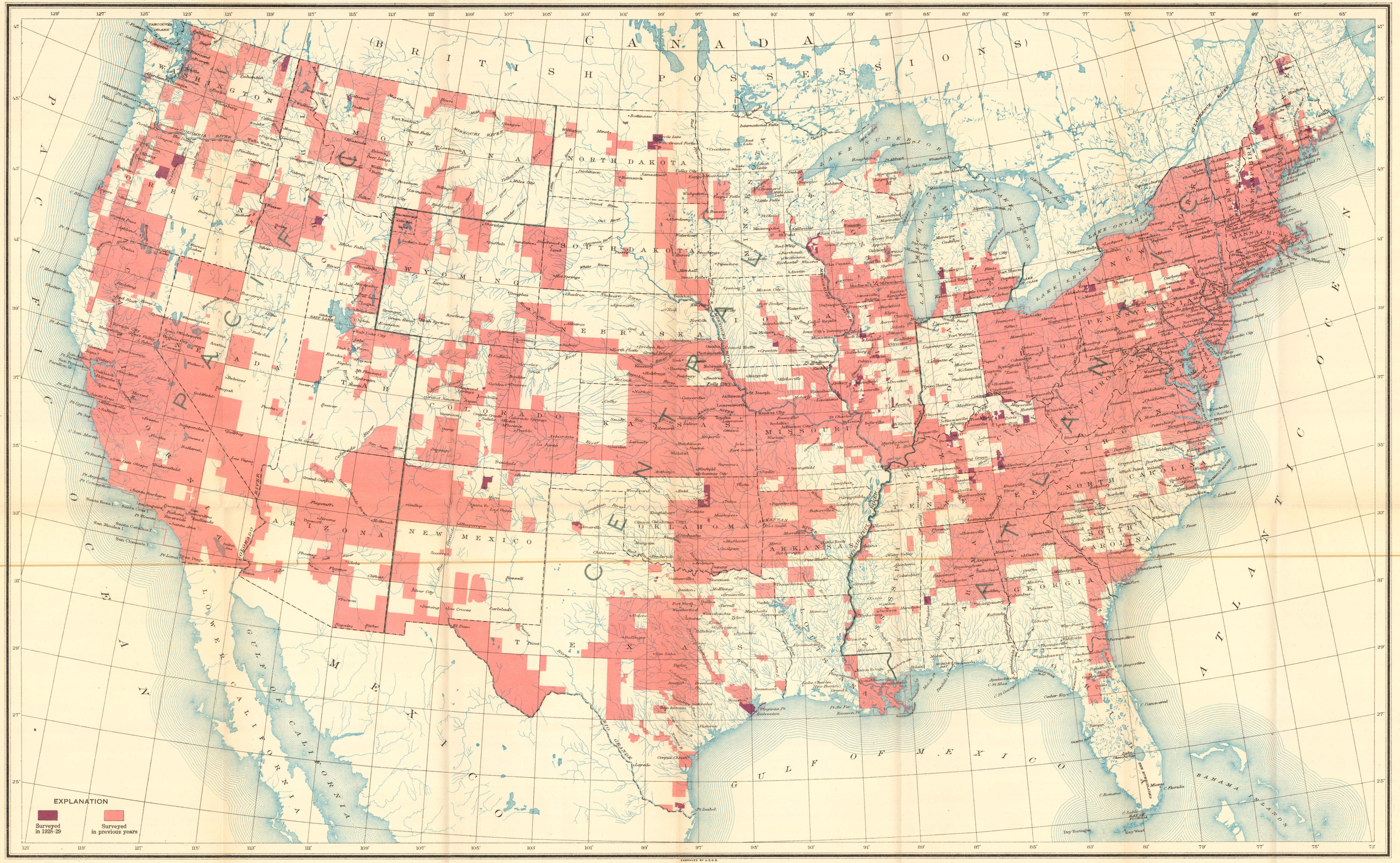
Appropriations and expenditures for topographic surveys for the fiscal year ended June 30, 1929—Continued

State or project	Appropriation for topographic surveys	Repayments for work performed for other Federal units	Total Federal funds	State cooperative funds	Total funds
Welch Act	$34,000.00		$34,000.00		$34,000.00
Total funds available	780,288.38	$133,002.13	913,290.51	$476,527.34	1,389,817.85
Expenditures:					
Alabama	12,091.46		12,091.46	10,000.00	22,091.46
Arizona	8,278.05		8,278.05		8,278.05
Arkansas	1,565.76		1,565.76	1,500.00	3,065.76
California	37,485.01	1,432.31	38,917.32	56,911.99	95,829.31
Colorado	7,194.95		7,194.95	2,000.00	9,194.95
Connecticut	3,468.97		3,468.97	4,988.27	8,457.24
Hawaii	27,562.63		27,562.63	24,887.55	52,450.18
Idaho	28,009.71		28,009.71		28,009.71
Illinois	46,378.05	27,199.88	73,577.93	40,015.77	113,593.70
Iowa	1,133.04		1,133.04	1,997.48	3,130.52
Kentucky	93,486.85	8,525.09	102,011.94	66,145.32	168,157.26
Maine	29,823.77	13,498.65	43,322.42	33,934.56	77,256.98
Michigan	14,629.53		14,629.53	15,053.54	29,683.07
Mississippi		48,962.70	48,962.70		48,962.70
Missouri	7,486.62		7,486.62	6,288.32	13,774.94
Montana	2,769.02		2,769.02	15,626.92	18,395.94
Nevada	32.05	4,797.42	4,829.47		4,829.47
New Hampshire	14,736.03		14,736.03	33,677.90	48,413.93
New Mexico	13,868.86		13,868.86	12,726.85	26,595.71
New York	6,098.81		6,098.81	10,424.50	16,523.31
North Dakota	8,694.39		8,694.39	12,965.09	21,659.48
Oklahoma	16,690.31		16,690.31	15,566.73	32,257.04
Oregon	11,345.82		11,345.82	1,735.17	13,080.99
Pennsylvania	15,211.13		15,211.13	22,456.46	37,677.59
Tennessee	72,920.44		72,920.44	14,000.00	86,920.44
Texas	36,418.51	4,531.63	40,950.14	33,867.41	74,817.55
Utah	7,421.02		7,421.02	329.44	7,750.46
Vermont	13,925.03	4,029.51	17,954.54	8,184.73	26,139.27
Virginia	68,795.74	3,012.03	71,807.77	12,020.04	83,827.81
Washington	8,618.73		8,618.73	3,367.98	11,986.71
West Virginia	203.78		203.78		203.78
Wisconsin	13,431.98	6,329.47	19,761.45	15,855.32	35,616.77
Wyoming	708.68		708.68		708.68
Books for library	157.39		157.39		157.39
Computing	[a] 4,207.53		4,207.53		4,207.53
Contingent	11,176.74		11,176.74		11,176.74
Field distribution offices	600.00		600.00		600.00
Instruments (field)	[a] 8,137.10		8,137.10		8,137.10
Stationery (field)	[a] 225.00		225.00		225.00
Inspection and editing	[a] 8,887.42		8,887.42		8,887.42
Map information	3,496.36		3,496.36		3,496.36
One-millionth maps	7,747.64		7,747.64		7,747.64
Miscellaneous repay		10,683.44	10,683.44		10,683.44
Office salaries	[a] 8,742.64		8,742.64		8,742.64
Photographic mapping	[a] 3,939.81		3,939.81		3,939.81
Relief maps	3.85		3.85		3.85
Total expenditures [b]	687,806.21	133,002.13	820,808.34	476,527.34	1,297,335.68
Unexpended balance [c]	92,482.17		92,482.17		92,482.17
	780,288.38	133,002.13	913,290.51	476,527.34	1,389,817.85

[a] Represents 37.5 per cent of total cost; balance of 62.5 per cent included in charges for State cooperation.
[b] $452,541.39 expended on State cooperation.
[c] Includes $57,945.84 Great Smoky and $33,924.78 Shenandoah Park funds available during fiscal year 1930.

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, the computation and adjustment of the results of control field work, and the preparation of partial culture and drainage basins from aerial photographs. A base map of California was prepared, and the base map of Arkansas was revised. A partial



AREAS COVERED BY TOPOGRAPHIC SURVEYS MADE BY UNITED STATES GEOLOGICAL SURVEY PRIOR TO JULY 1, 1929

AND TERRITORY COVERED BY DIVISIONS OF TOPOGRAPHIC BRANCH

Scale 1/7000000

100 50 25 0 50 100 200 300 STATUTE MILES

ENGRAVED BY U.S.G.S.

culture and drainage base map of the Tensas Basin, Louisiana and Arkansas, was compiled for the Mississippi River Commission. Cooperation with the Air Corps, United States Army, was continued whereby aerial photographs were furnished for use in topographic mapping. (See also p. 80, "Inspection and editing of topographic maps.")

SUMMARY OF RESULTS

The condition of topographic surveys to June 30, 1929, is shown on Plate 1. The status of topographic surveys is further shown in the following table:

New topographic surveys of the United States, July 1, 1928, to June 30, 1929, 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, 1929 (square miles)	Percentage of total area of State mapped to June 30, 1929	River surveys, scale 1 : 20,000 (linear miles)	Spirit levels (miles)	Transit traverse (miles)	Triangulation stations occupied
		12,000	20,000	24,000	31,680	62,500	125,000	Revision	Resurvey	New survey						
Alabama	20					457			206	251	21,491	41.3		65	34	
Arizona	100						480		480		58,398	51.3		92		
Arkansas	10										21,730	40.7	16	239		
California	5, 20, 25			294	568			46	816		125,921	79.5		963		100
Colorado	25, 50	20		14		17			34	17	55,547	53.4		3		
Connecticut											4,965	100.0			232	
Delaware											2,370	100.0				
District of Columbia											70	100.0				
Florida											4,716	8.0				
Georgia											24,835	41.9				
Idaho	2,100	61					300		61	300	30,746	36.7		8		
Illinois	5, 10, 20					1,330			143	1,187	31,700	55.9	124	548	1,151	
Indiana	5, 20					3				3	3,668	10.1	114	219	170	
Iowa	20					144				144	13,167	23.5				
Kansas											64,159	78.1				
Kentucky	20					2,004				2,004	25,236	62.2	172	790	1,067	
Louisiana											8,823	18.2				
Maine	20					1,071				1,071	14,406	43.6		354	43	36
Maryland											12,327	100.0				
Massachusetts											8,266	100.0				
Michigan	5, 10, 20					546				546	13,484	23.3		356		
Minnesota											7,354	8.7				
Mississippi	2, 5, 10, 20					104				104	3,985	8.5	196	486	313	
Missouri	20					228			228		43,083	62.1		193	280	
Montana	2, 5	57								57	41,891	28.5		88		5
Nebraska											27,117	35.0				
Nevada	2, 5	[a] 5		13					18		44,642	40.3		18		4
New Hampshire	20					864				864	8,021	85.9		268	23	2
New Jersey											8,224	100.0				
New Mexico	20, 25, 50, 100			33			1,318	33	913	405	41,915	34.2		387		9
New York	20					229			229		49,204	100.0		83		
North Carolina	20				79	6			79	6	19,040	36.3		281	247	15
North Dakota	20					887				887	13,076	18.5		224		
Ohio											41,040	100.0				
Oklahoma	10, 20					1,073		249		824	41,208	58.8	12			
Oregon	100						1,112			1,112	31,762	32.8		135		
Pennsylvania	20					896			22	874	35,763	79.3		259	257	
Rhode Island											1,248	100.0				
South Carolina											13,737	44.3				

South Dakota											19,243	24.8				
Tennessee	20				90	379			316	153	23,380	55.6		497	349	14
Texas	1, 5, 10				737	15				752	87,367	32.9		517	559	
Utah	50				6					6	19,103	22.5		114		11
Vermont	10, 20					128				128	7,495	78.4	[b] 204	232		
Virginia	20				244	305			504	45	37,749	88.6		745	343	
Washington	100						440			440	35,374	51.2		61		
West Virginia											24,170	100.0				
Wisconsin	10, 20					510				510	18,349	32.7		295		
Wyoming											30,374	31.0				
Total continental United States (exclusive of Alaska)		143		354	1,724	11,196	3,650	328	4,049	12,690	1,320,939	43.6	838	8,520	5,068	196
Hawaii	10.50		[c] 266			266				266	6,295	97.6		22		15

[a] Mapped on scale of 1:4,800.
[b] 200 miles mapped on scale of 1:24,000; 3 miles on 1:1,200; 1 mile on 1:2,400.
[c] Advance sheet editions in 10-foot contours; final publication in 50-foot contours and on a scale of 1:62,500.

FIELD SURVEYS

Alabama.—In cooperation with the State geologist of Alabama the survey of the Epes quadrangle was completed and the resurvey of the Searles quadrangle was completed and that of the Cottondale quadrangle (previously surveyed on a smaller scale) was continued.

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

Arkansas.—In cooperation with the United States Army district engineer, Vicksburg, Miss., the survey of the Ouachita River from Arkadelphia to Fairview was completed.

California.—In cooperation with the State engineer of California the resurvey of the Rosedale, Fairfax School, Rio Bravo, Buttonwillow, Coles Levee, No. 69, and Gosford quadrangles was completed, and that of the Bena, Stevens, No. 68, No. 70, Treves, Waits, Millux, and Treadwell quadrangles was begun (areas previously surveyed on a smaller scale). In cooperation with the county surveyor of Los Angeles County the resurvey of the Dry Canyon, Las Flores, Vejor, Zelzah, Newhall, Solstice Canyon, Chatsworth, Pico, Arroyo Sequ.s, and Russell Valley quadrangles was completed; that of the Sylmar quadrangle was continued; that of the Dume Point and Del Valle quadrangles was begun (areas previously surveyed on a smaller scale); and the culture was revised on the previously surveyed parts of the Dry Canyon and Zelzah quadrangles.

Colorado.—In cooperation with the Colorado Metal Mining Fund the resurvey of the Ouray mining district, the Mosquito Range mining region, and the Telluride mining district was continued. At the request of the Forest Service the survey of the Mount Powell No. 4 quadrangle was begun.

Connecticut.—In cooperation with the attorney general of Connecticut the culture and drainage of the Broad Brook, Cromwell, East Hampton, Glastonbury, Mittineague, Manchester, Long Meadow, Rocky Hill, Windsor, and Windsor Locks quadrangles (previously surveyed on a smaller scale) was partly revised by means of aerial photography.

Hawaii.—In cooperation with the commissioner of public lands of the Territory of Hawaii the survey of the Schofield, Mokapu, Waianae, Kaneohe, and Koko Head quadrangles was completed, that of the Wahiawa quadrangle was continued, and that of the Laie, Kaena, Kaaawa, Kaipapau, Kahana, and Haleiwa quadrangle was begun.

Idaho.—At the request of the geologic branch the survey of the Bayhorse quadrangle was continued. At the request of the State Department the survey of the Kootenai River was completed.

Illinois.—In cooperation with the Department of Registration and Education of Illinois, Geological Survey, the survey of the Mackinaw, Chandlerville, Meredosia, Barry, Hannibal, Thebes, Wickliffe, and Mound City quadrangles and the Salem-Mount Vernon and Shelbyville-Altamont highway projects were completed, that of the Arenzville and Hettick quadrangles was continued, and that of the Keokuk, Fort Madison, Annawan, Virginia, Prophetstown, Rose Hill, Decatur, and Effingham quadrangles and Mulberry Grove project was begun. The resurvey of the Geneva quadrangle was continued. In cooperation with the United States Army district engineer, Chicago, the survey of the Kankakee River from Wilmington to the Indiana State line, of the Sangamon River from Chandlerville to Mahomet, and of Salt Creek from the mouth to Rankin Bridge was completed.

Indiana.—In cooperation with the United States Army district engineer, Chicago, the survey of the Kankakee River from Brems to the Illinois State line, of the Whitewater River from Connersville to the Ohio State line, and of the East Fork of the Whitewater River from Brownsville to the mouth was completed. The survey of the La Grange quadrangle was completed.

Iowa.—In cooperation with the Geological Survey of Iowa the survey of the Indianola quadrangle was completed.

Kentucky.—In cooperation with the State geologist of Kentucky the survey of the Burnside, Hardinsburg, Eddyville, Pleasureville, Morehead, Barthell, Higginsport, Felicity, Red Boiling Springs, Corydon, Lawrenceburg, Lafayette, La Center, Adolphus, and Cannelton quadrangles and the Blue Lick Battleground was completed and that of the Cynthiana, Somerset, Falls of Rough, Sadieville, and Sunnybrook quadrangles was begun. In cooperation with the United States Army district engineer, Cincinnati, the survey of the Licking River from the mouth to Cave Run was completed.

Maine.—In cooperation with the Public Utilities Commission of Maine the survey of the Stratton, Spencer, Winterville, and Eagle Lake quadrangles was completed, that of the Great Pond quadrangle was continued, and that of the Beddington, Winchell, Caribou, and Brooks quadrangles was begun. In cooperation with the War Department the survey of the Chain Lakes and Skinner quadrangles was completed.

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

Michigan.—In cooperation with the Department of Conservation of Michigan, Geological Survey, the survey of the Fennville quadrangle was completed, that of the Fletcher quadrangle was continued, and that of the Muskegon, Holland, Twin Lake, and Shepherd quadrangles was begun.

Mississippi.—In cooperation with the United States Army district engineer, Vicksburg, Miss., the survey of the Yazoo River from Yazoo City to Greenwood, of the Tallahatchie River from Greenwood to the Tallahatchie County line, of the Yalobusha River from Holcomb to Sabougla Creek, of the Skuna River from the mouth to the Calhoun County line, of the Coldwater River from Coldwater to Miller, and of the Little Tallahatchie River from Batesville to Abbeville was completed.

Missouri.—In cooperation with the State geologist of Missouri the resurvey of the McCredie quadrangle was completed and that of the Mexico No. 3 quadrangle was begun (areas previously surveyed on a smaller scale).

Montana.—At the request of the geologic branch the survey of the Libby quadrangle was continued. In cooperation with the State engineer of Montana the survey of the Flathead Lake project was completed.

Nevada.—At the request of the Navy Department the resurvey of a part of the Hawthorne quadrangle was completed.

New Hampshire.—In cooperation with the Highway Department of New Hampshire the survey of the Rumney, Plymouth, and Wonalancet quadrangles was completed and that of the Sugar Hill, Franconia, Partridge Pond, and Thetford quadrangles was begun.

New Mexico.—In cooperation with the State engineer of New Mexico the survey of the Talpa quadrangle was completed and the resurvey of the Kirtland quadrangle was completed and that of the Crozier, Talpa, Shiprock, and Stony Butte quadrangles was begun (areas previously surveyed on a smaller scale). At the request of the geologic branch the revision of the Santa Rita quadrangle was completed.

New York.—In cooperation with the Department of Public Works of New York the resurvey of the Amsterdam quadrangle was completed and the resurvey of the Ramapo, Schunemunk, and Kinderhook quadrangles was begun.

North Carolina.—The survey of the tentative boundary of the proposed Great Smoky Mountains National Park was begun, and that of the Stuart quadrangle was completed.

North Dakota.—In cooperation with the State engineer of North Dakota the survey of the Devils Lake, Tokio, Oberon, Grahams Island, and Flora quadrangles was completed and that of the Upham quadrangle was begun.

Oklahoma.—In cooperation with the State Highway Commission of Oklahoma the survey of the Yale, Skedee, Stroud, Fairfax, and Ripley quadrangles and the cultural revision of previous work on the Drumright and Stroud quadrangles was completed.

Oklahoma-Texas.—In cooperation with the United States Army district engineer, Vicksburg, Miss., the survey of the Red River in the vicinity of Ryan, Okla., was completed.

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

Pennsylvania.—In cooperation with the Department of Internal Affairs of Pennsylvania, Topographic and Geologic Survey, the survey of the Ariel, Snowshoe, and Corry quadrangles was completed and that of the Clearfield, Penfield, Union City, and Karthaus quadrangles and a resurvey of the Tyrone quadrangle was begun.

Tennessee.—In cooperation with the State geologist of Tennessee the survey of the Monoville quadrangle and the resurvey of the Nashville special quad-

rangle (previously surveyed on a smaller scale) was completed. The survey of the tentative boundary of the proposed Great Smoky Mountains National Park was begun.

Texas.—In cooperation with the county commissioners of Cameron County the survey of the Lyford No. 4, Harlingen No. 1, and Harlingen No. 2 quadrangles was completed and that of the Fernando No. 3, Fernando No. 4, Mercedes No. 1, and Harlingen No. 3 quadrangles was begun. In cooperation with the county commissioners of Galveston County the survey of the Seabrook, Trinity Bay, Genoa, Algoa No. 1, Algoa No. 2, Algoa No. 3, Algoa No. 4, Galveston No. 2, Galveston No. 3, and San Luis Pass No. 1 quadrangles was completed and the survey of the High Island No. 3, Round Point No. 3, Round Point No. 4, Patton No. 1, Patton No. 2, Patton No. 3, Galveston No. 1, Galveston No. 4, Lake Como No. 2, San Luis Pass No. 4, and Smith Point No. 4 quadrangles and the southeastern parts of the Galveston No. 3, San Luis Pass No. 1, and Trinity Bay quadrangles was completed by means of aerial photography. In cooperation with the Board of Water Engineers of Texas the survey of the Archer City 3–a and Archer City 4–b quadrangles was begun. At the request of the Bureau of Mines the survey of the Cliffside structure area was completed.

Utah.—At the request of the National Park Service the survey of the Zion National Park was begun.

Vermont.—In cooperation with the State geologist of Vermont the survey of the Townshend and Ludlow quadrangles was begun. In cooperation with the Vermont Flood Control Commission the survey of parts of the Passumpsic, Moose, and White Rivers and the North Branch of the Winooski River, the Stevens Branch, and Bolton Falls and vicinity was completed. In cooperation with the United States Army district engineer, New York, the survey of parts of the Winooski, Kingsbury, and Lamoille Rivers was completed.

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

Washington.—In cooperation with the Department of Conservation and Development of Washington the survey of the Colville quadrangle was continued.

Wisconsin.—In cooperation with the Geological and Natural History Survey of Wisconsin the survey of the Alma and Minneiska quadrangles was completed, that of the Mondovi and Montana quadrangles was continued, and the culture and drainage of the Three Lakes quadrangle were compiled from aerial photographs. In cooperation with the United States Army district engineer, St. Paul, and the Geological and Natural History Survey of Wisconsin the survey of the Durand quadrangle was continued and that of the Wabasha, Arkansaw, Chippewa Falls, Elk Mound, and Menomonie quadrangles was begun.

WATER-RESOURCES BRANCH

N. C. GROVER, Chief Hydraulic Engineer

ORGANIZATION AND PERSONNEL

The work of the water-resources branch has been administered through the year by the following units:

Division of surface waters, John C. Hoyt, hydraulic engineer, in charge.
Division of ground water, O. E. Meinzer, geologist, in charge.
Division of quality of water, W. D. Collins, chemist, in charge.
Division of power resources, A. H. Horton, hydraulic engineer, in charge.

The technical force at the end of the year comprises the chief hydraulic engineer, 1 principal hydraulic engineer, 29 senior hydraulic engineers, 10 hydraulic engineers, 117 associate, assistant, and junior engineers; 3 senior geologists, 7 associate, assistant and junior geologists; 1 senior chemist, 5 associate, assistant, and junior chemists—a total of 174. The clerical force comprises 31 clerks. The changes in personnel during the year show a net increase of 51.

FUNDS

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

Gaging streams	$270,500.00
Transfers from Federal agencies	157,210.00
Repayments by Federal agencies	217,178.00
Funds furnished by States and other non-Federal governmental agencies	367,929.66
Funds furnished by permittees and licensees of the Federal Power Commission	31,251.00

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.

Alabama		$2,925.37
Arizona		18,127.03
Arkansas		6,400.16
California:		
State	$32,505.54	
Municipal	20,643.18	
		53,148.72
Colorado		496.53
Connecticut		6,040.58
Florida		210.00
Hawaii:		
Territory	29,507.29	
Municipal	5,418.56	
		34,925.85
Idaho		17,562.93
Illinois		3,926.38
Kansas		3,254.37
Kentucky		100.00
Maine		5,265.59
Maryland		922.84
Massachusetts		4,222.82
Minnesota		372.48
Missouri		8,929.14
Montana		13,128.08
Nevada		672.66
New Hampshire		1,592.46
New Jersey		11,702.15
New Mexico		4,126.20
New York		18,219.22
North Carolina:		
State	10,462.24	
Municipal	5,638.70	
		16,100.94
Ohio		23,865.33
Oregon:		
State	5,311.32	
Municipal	1,399.98	
		6,711.30
Pennsylvania		3,032.93
Tennessee		19,559.65

Texas		$30,707.50
Utah		6,042.02
Vermont		8,003.58
Virginia		17,575.48
Washington:		
State	$4,084.19	
Municipal	1,031.85	
		5,116.04
West Virginia		395.05
Wisconsin		6,484.79
Wyoming		8,063.49
		367,929.66

Bureau of Reclamation.—The measurement of streams that are to furnish water to reclamation projects was continued in cooperation with the Bureau of Reclamation on the Black Canyon project and on the lower Colorado River. A supplemental study has been begun for the Bureau of Reclamation of the change of conditions at the Avalon Dam of the Carlsbad irrigation project in New Mexico.

Indian Service.—Stream gaging was continued for the Indian Service in the Colville, Western Shoshone, and Walker River Reservations and on the Gila and San Carlos Rivers. Examinations were made of available sources of ground-water supplies for the Haskell Institute in Kansas, for the White Earth Indian Agency and School in Minesota, for Tesuque Pueblo in New Mexico, and for the Standing Rock Indian Agency and School in North Dakota.

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

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

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

Department of State.—Stream gaging and investigations concerning water utilization and flood-control problems have been continued on the Rio Grande on the Mexican boundary and on numerous streams on and near the Canadian boundary from the Lake of the Woods westward. Notable centers of activity on the Canadian boundary have been the Roseau River in Minnesota, the St. Mary and Milk Rivers in Montana, and the Kootenai River in Idaho. Some of these operations on the Canadian boundary are being conducted jointly with Dominion officials because of the common interest of the two countries therein, and negotiations are in progress for extending the scope of such operations. The cost of this work is being met by funds transferred to the Geological Survey by the Department of State.

Corps of Engineers, United States Army.—During the fiscal year stream gaging has been in progress in cooperation with the Corps of Engineers in connection with flood control and with studies and reports to be made under House Document 308 of the Sixty-ninth Congress, first session. This cooperation has been arranged with the district engineers of the Army at Boston, Providence, New York, Philadelphia, Washington, Norfolk, Huntington, Wilmington, Chat-

tanooga, Nashville, Florence, Montgomery, Mobile, Galveston, Jacksonville, Vicksburg, Louisville, Cincinnati, St. Paul, Kansas City, Seattle, Portland, and San Francisco and includes about 520 gaging stations. The cost of this work is met by transfers from the funds of the Corps of Engineers.

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

PUBLICATIONS

The publications of the year prepared by the water-resources branch comprised 15 reports and 6 separate chapters. (See p. 4.) At the end of the year 19 other reports were in press, and 16 were awaiting funds for publication.

CHARACTER AND METHOD OF WORK

The study of surface waters, which consists primarily of the measurement of the flow of streams, has been conducted in 47 States and Hawaii at selected gaging stations at which the volume of water carried by the streams is measured and records of stage and other data, from which the daily flow of the stream is computed, are collected. At the end of the year 2,238 gaging stations were being maintained; 257 stations were discontinued and 665 new stations established during the year. Records for about 96 additional stations were received, ready for publication, from Government bureaus and private persons, and a number of Government and State organizations and individuals cooperated in the maintenance of the regular gaging stations.

The division of ground water investigates the waters that lie below the surface; their occurrence, quantity, quality, and head; their recovery through wells and springs; and their utilization for domestic, industrial, irrigation, and public supplies and as watering places for livestock and desert travelers. Each year surveys are made of selected areas where problems of water supply are urgent, and the results are generally published in water-supply papers that include maps showing the ground-water conditions. The investigations relating to the chemical composition of the water are made in cooperation with the division of quality of water. Projects involving large expenditures for drilling wells to develop water supplies are considered each year by the several departments of the United States Government, and the ground-water division is called upon to furnish information and advice on many of these projects. During the

fiscal year about 45 investigations relating to ground water and reservoir sites were in progress, and work was conducted in 24 States. The demands of the public for precise information in regard to ground-water resources are becoming more and more exacting with increasing need for the water. In recent years considerable research into the principles of ground-water hydrology has been undertaken in the division in order to provide a more secure basis for ground-water investigations.

A series of papers on methods of estimating ground-water supplies was presented at the New York meeting of the Society of Economic Geologists in December, 1928, as follows: Outline of available methods, by O. E. Meinzer; Methods based on transpiration of plants, by W. N. White; Methods applicable to artesian basins, by D. G. Thompson. O. E. Meinzer, Kirk Bryan, and H. T. Stearns presented papers in a symposium on the geology of reservoir and dam sites at the meeting of the American Institute of Mining and Metallurgical Engineers in New York in February, 1929. Abstracts of papers relating to ground-water hydrology were prepared for the Annotated Bibliography of Economic Geology and for foreign abstract journals.

A. G. Fiedler was assigned, with headquarters at Minneapolis, to undertake a comprehensive study of well-drilling methods and to cooperate with the several State associations of water-well drillers. He took part in the annual meetings of seven of these State associations and assisted in the organization of a national association.

The work on quality of water involved the examination of 1,037 samples of water with reference to their dissolved mineral matter and 245 samples of silt taken in connection with the study of the silt carried by streams. The samples analyzed included some for nearly all the studies of ground water in the different States as noted below. Results for an additional year were added to manuscripts previously prepared by C. S. Howard on dissolved matter and suspended matter in the Colorado River. The report on dissolved matter for 1926–1928 was issued as Water-Supply Paper 636–A.

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, 1929, 1,720 companies, operating 3,795 power plants with a total capacity of generators of 29,630,000 kilowatts, were on the list of companies requested to submit reports of the operation of their power plants. Plants whose output is less than 10,000 kilowatt-hours a month are not included. Reports are received from plants representing over 95 per cent of the capacity of all plants listed. The output of plants not reporting is estimated.

Annual production of electricity by public-utility power plants in the United States, 1919–1928

Year	Total		Water power			Fuel power		
	Kilowatt-hours	Change from preceding year	Kilowatt-hours	Per cent of total	Change from preceding year	Kilowatt-hours	Per cent of total	Change from preceding year
		Per cent			*Per cent*			*Per cent*
1919	38,921,000,000		14,606,000,000	37.5		24,315,000,000	62.5	
1920	43,555,000,000	+11.9	16,150,000,000	37.1	+10.6	27,405,000,000	62.9	+12.7
1921	40,975,000,000	−5.9	14,970,000,000	36.5	−7.3	26,005,000,000	63.5	−5.1
1922	47,654,000,000	+16.3	17,207,000,000	36.1	+14.9	30,447,000,000	63.9	+17.1
1923	55,665,000,000	+16.8	19,343,000,000	34.8	+12.4	36,322,000,000	65.2	+19.3
1924	59,014,000,000	+6.0	19,969,000,000	33.8	+3.2	39,044,000,000	66.2	+7.5
1925	65,870,000,000	+11.6	22,356,000,000	33.9	+11.9	43,514,000,000	66.1	+11.4
1926	73,791,000,000	+12.0	26,189,000,000	35.5	+17.1	47,602,000,000	64.5	+9.4
1927	80,205,000,000	+8.7	29,875,000,000	37.2	+14.1	50,330,000,000	62.8	+5.7
1928	87,850,000,000	+9.5	34,696,000,000	39.5	+16.1	53,154,000,000	60.5	+5.6

Annual consumption of fuel in the production of electricity by public-utility power plants in the United States, 1919–1928

Year	Coal		Fuel oil		Gas	
	Short tons	Change from preceding year	Barrels	Change from preceding year	M cubic feet	Change from preceding year
		Per cent		*Per cent*		*Per cent*
1919	35,100,000		11,050,000		21,406,000	
1920	37,124,000	+5.8	13,123,000	+18.8	24,702,000	+15.4
1921	31,585,000	−14.9	12,045,000	−8.2	23,722,000	−4.0
1922	34,179,000	+8.2	13,197,000	+9.6	27,172,000	+14.5
1923	38,966,000	+14.0	14,684,000	+11.3	31,483,000	+15.9
1924	37,556,000	−3.6	16,630,000	+13.3	48,443,000	+53.9
1925	40,222,000	+7.1	10,246,000	−38.4	46,521,000	−4.0
1926	41,311,000	+2.7	9,399,000	−8.3	53,207,000	+14.4
1927	41,888,000	+1.4	6,782,000	−27.8	62,919,000	+18.3
1928	41,350,000	−1.3	7,158,000	+5.5	77,326,000	+22.9

The remarkable improvement each year in the utilization of fuel in the generation of electricity by public-utility companies continues, as indicated in the following table:

Average consumption of coal[a] per kilowatt-hour by public-utility power plants in the United States, 1919–1928

Year	Pounds	Per cent of rate in 1919	Year	Pounds	Per cent of rate in 1919
1919	3.2	100	1924	2.2	69
1920	3.0	94	1925	2.1	66
1921	2.7	84	1926	1.95	61
1922	2.5	78	1927	1.84	57
1923	2.4	75	1928	1.76	55

[a] Oil and gas included as equivalent coal.

If there had been no improvement in the utilization of fuel subsequent to 1919 about 180,000,000 tons more of coal would have been consumed in generating electricity from 1920 to 1928. The produc-

tion of electricity by the use of water power continues to show a greater proportional increase over that produced by the use of fuel, notwithstanding the increase in efficiency of fuel-burning plants.

A report of the amount of developed water power in the United States on January 1, 1929, was released February 8, 1929, and the final report of the annual production of electricity by public-utility power plants in 1928 was released May 27, 1929.

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 two field offices, one of which was discontinued early in the year. It has consisted of the examination of streams, including the location and survey of power and reservoir sites and of neighboring lands to determine their value for power or irrigation, and the preparation of reports, either for office use or for publication, on the power value of streams.

WORK OF THE YEAR BY STATES

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

Gaging stations and cooperating parties for the year ended June 30, 1929

State or Territory	Geological Survey alone	Bureau of Reclamation	Forest Service	Indian Service	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					23			2		7	2	30	11	2	215	2
Arizona		1		3				49			4	49	9	3	1,459	45
Arkansas					4	4		11		11	10	20	9	1	142	5
California			20	1	5		5	232	72	95	196	234	25	16	3,180	341
Colorado		2			12			14	3	6	5	32	15	14	240	11
Connecticut					3			5		3	1	10	8		124	
Delaware																
Florida					6					8	5	9	4	2	65	26
Georgia					13					8	1	20	12		98	17
Idaho		6	8		9	2	38	104	5	200	90	282	131	120	2,317	98
Illinois					7	2		34	1	2	12	34			100	
Indiana					13			10		1	11	13	7	1	90	
Iowa					4	1			1		1	5	5		34	1
Kansas					21	4		25		2	6	46	46		216	4
Kentucky					22					9	8	23	3	1	112	18
Louisiana					4							4	4		34	
Maine					13			18		8	14	25	9	1	169	
Maryland	2				5				5			12	3		67	
Massachusetts								20		1	1	20	1		136	
Michigan									1	1		2	1		10	
Minnesota					22		12	6		4		44	31		183	1
Mississippi					11							11	15	4	174	3
Missouri					13	6		63		24	30	76	26	8	494	3
Montana		2			32		32	34		12		112	41	6	530	20
Nebraska					1							14	14		160	
Nevada				1				15		7	8	15			19	
New Hampshire					7			15		12	12	22	4	1	82	
New Jersey						1		41	9	6	16	41	2		219	15
New Mexico							1					1	1		98	
New York					9			90	2	49	60	90	10	3	583	2
North Carolina					23			67	21	18	61	68	21	4	406	22
North Dakota					8							8	4		33	
Ohio					6	3		99	14	5	28	99	4	3	542	9
Oklahoma					1					2		3	1		25	
Oregon			1		30	7		84	9	37	84	84	28	38	440	75
Pennsylvania					5			3		5	3	10	8		85	6
Rhode Island					1							1	1		5	2
South Carolina					1					5		6	1	2	34	1
South Dakota					18							18	17		132	3
Tennessee					57	4		60		10	71	60	1		389	27
Texas					1	11	17	94	14	9	34	112	11	4	1,760	96
Utah	1	3					1	53	1	16	21	54	2	4	163	8

Gaging stations and cooperating parties for the year ended June 30, 1929—Continued

State or Territory	Geological Survey alone	Bureau of Reclamation	Forest Service	Indian Service	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
Vermont					3			13		13	7	22	15		118	
Virginia					5			63	6	13	19	68	12	2	186	151
Washington			1	4	44		4	95	20	39	94	113	50	3	598	91
West Virginia					29			2	1	9		41	20		191	20
Wisconsin					3			37		11	13	38	2	2	176	7
Wyoming		5		4	14	1	7	30		3	6	58	17	4	236	30
Hawaii								79	7	27	34	79	3	8	433	348
	3	19	30	13	521	46	117	1,567	192	698	968	2,238	665	257	17,302	1,508

Alabama.—A systematic survey of the ground-water resources of Alabama was undertaken in cooperation with the State Geological Survey. Field work was done in 11 counties by W. D. Johnston, jr., who prepared reports on these counties. Gaging stations were established on the Tuscumbia and Huntsville Springs.

Arizona.—In connection with the supervision of investigational work and construction under permits and licenses of the Federal Power Commission, examination is in progress for the commission of several minor projects to develop power on the Colorado River and its tributaries.

Arkansas.—In cooperation with the Arkansas State Geological Survey, a study of the source and quantity of the ground-water supply used for irrigation of rice in the area about Stuttgart was undertaken by D. G. Thompson.

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 25 years. Work was continued, with financial support by the East Bay Municipal Utility District, on an investigation of the ground water in the alluvial fan of the Mokelumne River, by H. T. Stearns, T. W. Robinson, and G. H. Taylor. A manuscript report giving the records of wells, ground-water levels, pumpage, and irrigation areas was released by filing it in the public library at Lodi. A manuscript report was prepared on the power classification of lands in the Cow and Clover Creek Basins, for office use.

Colorado.—A report on the upper Colorado River and its utilization, by Robert Follansbee, is in press as Water-Supply Paper 617.

Idaho.—The study of ground-water conditions in the Snake River Basin and their relation to large springs and stream flow was continued by H. T. Stearns, Lynn Crandall, W. G. Stewart, and J. L. Saunders. A paper on the Craters of the Moon National Monument, by Mr. Stearns, published as Bulletin 13 of the Idaho Bureau of Mines and Geology, was a by-product of the investigations in the Snake River Basin. It contains 57 pages, a sketch map, and 20 page plates consisting of views of the monument. A report on ground water for irrigation in the Raft River Valley, by Mr. Stearns, was released to the public in manuscript form. A brief examination and report were made by Messrs. Meinzer and Stearns on the Joy reservoir site, on the South Fork of the Boise River. The ground-water work in Idaho is conducted in cooperation with the Idaho Department of Reclamation and the Idaho Bureau of Mines and Geology.

Illinois.—A. G. Fiedler attended the annual meeting of the Illinois State Association of Water-Well Drillers and presented a paper on cementing methods used in well construction.

Iowa.—A. G. Fiedler cooperated with the State geologist of Iowa in the organization of a State well-drillers' association.

Kansas.—An examination of the prospects of obtaining a water supply from wells for the Haskell Institute, Lawrence, Kans., was made by W. N. White, and a report thereon was submitted to the Indian Service.

Kentucky.—A brief examination of ground-water conditions in the vicinity of Madisonville, Ky., was made by W. D. Johnston, jr.

Maryland.—An examination was made by S. S. Nye of the available supply of ground water at the District of Columbia training school at Laurel, Md.

Michigan.—A. G. Fiedler cooperated with the State geologist of Michigan in the organization of a State well drillers' association.

Minnesota.—A branch office was established in Minneapolis in charge of A. G. Fiedler, who undertook a thorough study of well-drilling methods in Minnesota and other States and cooperated with the several State associations of water-well drillers. An examination of the available sources of water supply for the White Earth Indian Agency and School was made by H. E. Simpson, who prepared a report on the subject that was transmitted to the Indian Service.

Montana.—The study of ground-water levels in an area north of Flathead Lake, Mont., in relation to fluctations in the lake level was continued by A. H. Tuttle, and a preliminary report thereon was transmitted to the Federal Power Commission. Work was continued on the geology and ground-water resources of Big Horn County by W. T. Thom, jr., and G. M. Hall.

Nebraska.—A. G. Fiedler cooperated with the Nebraska State Geological Survey in the organization of a State well drillers' association.

New Jersey.—A report entitled "Ground-Water Supplies of the Atlantic City Region," by D. G. Thompson, was published by the New Jersey Department of Conservation and Development as Bulletin 30. It contains 134 pages, 7 plates, and 23 text figures. Similar reports on the ground-water supplies in the

vicinity of Asbury Park and in the Camden region were completed by Mr. Thompson and transmitted to the Department of Conservataion and Development for publication. A report on the ground-water supplies of the Passaic River Valley was also nearly completed. Measurements on numerous observation wells were continued by H. C. Barksdale, of the Department of Conservation and Development. Determinations of chloride are being made regularly on samples from several wells in and near Atlantic City.

New Mexico.—Investigation of the ground-water resources of different parts of New Mexico was continued in cooperation with the State engineer. The following reports, prepared by the United States Geological Survey, were published in the eighth biennial report of the State engineer:

Fiedler, A. G., and Nye, S. S., Ground-water investigation of the Roswell artesian basin, pp. 81–107, 5 plates.

Fiedler, A. G., Report on a reconnaissance of the ground-water area of the Mimbres Valley, Luna County, pp. 159–171.

Nye, S. S., Geology of the Cactus Flat reservoir site for the Hope Community, pp. 179–188, 1 plate.

Bryan, Kirk, State of New Mexico Middle Rio Grande Conservancy District, Geology of the State Line dam site, pp. 253–258.

The final report on the geology and ground-water resources of a part of Sandoval County, by B. C. Renick, was transmitted for publication as a water-supply paper. Preparation of the final report on the Roswell artesian basin was continued by Mr. Nye. An intensive investigation of the ground-water supply of the Mimbres Valley was undertaken by W. N. White. A more detailed study of the project for raising the Avalon dam of the Carlsbad irrigation project was undertaken by Mr. Bryan. Mr. Bryan also made a brief study of the feasibility of developing a water supply for irrigation from artesian wells at Tesuque Pueblo, and prepared a report thereon for the Indian Service.

North Dakota.—An investigation of the available sources of water supply at the Standing Rock Indian Agency and School, at Fort Yates, N. Dak., was made by Prof. H. E. Simpson, and a report thereon was submitted to the Indian Service. A. G. Fiedler cooperated in the educational work of the State well drillers' association.

Oregon.—Arrangements were made with the Director of the Oregon Agricultural Experiment Station for cooperation in the investigation of the ground-water resources of the State. An investigation of the ground water available for irrigation in the Willamette Valley was undertaken by A. M. Piper, who also made brief examinations of ground-water conditions in Baker and Harney Valleys and prepared a report on Baker Valley which was transmitted to the Oregon Agricultural Experiment Station. A report on the water-power resources of the Umpqua River and tributaries, by B. E. Jones and H. T. Stearns, was prepared and is in press as Water-Supply Paper 636–F.

Pennsylvania.—The systematic survey of the ground-water resources of Pennsylvania was continued in cooperation with the State Topographic and Geologic Survey. A report by A. M. Piper on six counties in the southwestern part of the State, including the industrial district of Pittsburgh, was transmitted for publication by the State. A similar report by G. M. Hall on fifteen counties in the southeastern part of the State, including the industrial district of Philadelphia, was practically completed. Progress was made by R. M. Leggette on a survey of fourteen counties in the northwestern part of the State.

South Carolina.—Work was continued by C. W. Cooke, of the geologic branch, on the ground-water conditions of the Coastal Plain of South Carolina.

Tennessee.—Work was continued on the systematic survey of the ground-water resources of Tennessee in cooperation with the State geologist. A. M. Piper prepared a report on the springs in 12 counties in north-central Tennessee, which was released in manuscript form. He also made progress on his final report on this area. Eleven counties in the southwestern part of the State were surveyed by F. G. Wells, who gave special attention to the conditions at Memphis. Reports were prepared on the counties covered, and also a special report on the water supply of Memphis. Field work was started in the northwestern part of the State.

Texas.—Progress was made by S. S. Nye on a report on the ground water in 12 counties in the Nueces area of the Texas Coastal Plain. An investigation of the Red Bluff reservoir site on the Pecos River was undertaken by Kirk Bryan.

Utah.—The report on the ground-water supply in the Escalante Valley, Utah, by W. N. White, was nearly completed. Some work was done by Ralf

R. Woolley in revising his report on Green River and its utilization, which is in press as Water-Supply Paper 618. Examinations were made of the power value of lands in the Provo and Sevier River Basins and along Big Brush and Little Brush Creeks. Engineering advice and assistance were given to the Department of Justice in connection with a suit of the United States against the State of Utah involving the Colorado, Green, and San Juan Rivers.

Virginia.—Investigation of the thermal and cold springs of Virginia was continued in cooperation with the State Commission on Conservation and Development. A report was practically completed for publication by the State, with descriptions of 566 springs and partial analyses of 425. Water-stage recorders were operated on the ebbing and flowing spring near Broadway and on the observation well in Arlington County. In cooperation with the State Commission on Conservation and Development a survey of the chemical character of surface water of the State was started April 1, 1929. Daily samples will be collected for a year at 16 gaging stations. Analyses will be made of 10-day composites.

Washington.—Field work and the preparation of reports have been continued to the end of the year on river surveys and power investigations of streams draining the Olympic Range.

Wisconsin.—A. G. Fiedler cooperated in the educational work of the State well drillers' association.

Wyoming.—An ebbing and flowing spring near Afton, Wyo., was examined by O. E. Meinzer and H. T. Stearns, and a water-stage recorder was installed over it.

CONSERVATION BRANCH

HERMAN STABLER, Chief

ORGANIZATION AND PERSONNEL

The work of the conservation branch, comprising the classification of public lands with respect to mineral, water-power, and agricultural value and the technical supervision of mineral and power development on such lands and of mineral development on Indian lands increased materially during the fiscal year 1929. It was directed through four administrative divisions, as follows:

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

Personnel changes during the fiscal year include 15 separations (9 resignations, 2 deaths, and 4 transfers) and 17 additions. On June 30, 1929, the personnel of the branch, both office and field, numbered 141, consisting of 5 geologists, 8 hydraulic engineers, 9 mining engineers, 40 petroleum engineers, 8 agricultural classifiers, 1 chemist, 1 attorney, 15 accountants and draftsmen, and 54 clerical employees.

FUNDS

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

Classification of lands	$191,500
Supervision of leasing operations, public lands	246,000
Supervision of leasing operations, Indian lands	70,000
Supervision of naval-reserve operations	43,000
Plugging abandoned wells	40,000
Federal Power Commission	4,000
	594,500

Diminished by the special appropriation for plugging abandoned wells, this aggregate is $5,292, or about 1 per cent, greater than the

corresponding total in 1928. Diminished further by $32,500 appropriated for salary increases required by the act of May 28, 1928 (45 Stat. 776), this aggregate is $27,792, or 5 per cent, less than in 1928.

CORRESPONDENCE

During the year 29,873 letter requests for information or technical reports were received in the Washington office of the branch, together with 38,025 additional pieces of miscellaneous correspondence for filing or for transmission to the appropriate field office. Within the same period 24,168 letters were answered and 23,346 additional pieces of miscellaneous correspondence were sent out.

SUMMARY OF LAND-CLASSIFICATION CASES

The activities of the conservation branch with respect to land classification include the preparation of reports in response to requests for data or action on specific cases, the preparation of orders of withdrawal and restoration of lands not involved in specific requests, and the promulgation of broad areal classifications. The following table summarizes activity with respect to requests for data or action on specific cases. The terms "gain" and "loss" signify, respectively, decrease and increase in the number of cases pending. In consequence of strenuous effort and the voluntary overtime work of an efficient personnel the number of cases pending was less by 1,137, or 25 per cent, at the end of the year than at its beginning.

General summary of cases involving land classification

Class of cases	Record for fiscal year 1929						Record since receipt of first case	
	Pending July 1, 1928	Received during fiscal year	Total	Acted on during fiscal year	Pending June 30, 1929	Gain or loss during fiscal year	Received	Acted on
General Land Office requests:								
General	344	922	1,266	966	300	+44	-------	-------
Time extensions	41	636	677	671	6	+35	2,313	2,307
Oil development	1,607	3,253	4,860	4,843	17	+1,590	16,111	16,094
Applications for classification as to mineral:								
General	1	0	1	1	0	+1	10	10
Coal	3	5	8	5	3	-------	782	779
Oil	98	632	730	474	256	−158	7,338	7,082
Phosphate	0	1	1	1	0	-------	38	38
Applications for mineral permits	383	3,748	4,131	4,093	38	+345	52,505	52,467
Applications for mineral leases	12	102	114	102	12	-------	1,332	1,320
Applications for patent, potassium	1	0	1	1	0	+1	124	124
Federal Power Commission cases:								
Preliminary permits	10	9	19	8	11	−1	78	67
Licenses	0	1	1	1	0	-------	25	25
Determinations under sec. 24	8	29	37	35	2	+6	227	225
Applications for reclassification as to water resources	18	48	66	43	23	−5	759	736
Applications for rights of way	31	155	186	151	35	−4	6,224	6,189
Irrigation project reports	4	2	6	6	0	+4	911	911
Applications under enlarged-homestead acts	214	397	611	345	266	−52	56,809	56,543
Applications under stock-raising homestead acts	1,704	4,277	5,981	3,640	2,341	−637	126,217	123,876
Applications under ground-water reclamation act	8	57	65	26	39	−31	935	896
Indian Office requests for information	0	6	6	6	0	-------	9,511	9,511
Cases in national forests	1	11	12	10	2	−1	335	333
	4,488	14,291	18,779	15,428	3,351	+1,137	-------	-------

SUMMARY OF FIELD OPERATIONS BY STATES

Alaska.—Expended $10,000 through the Alaskan branch for supervision of 9 leases, 3 licenses, and 13 prospecting permits for coal and 1,025 prospecting permits for oil and gas. Coal produced, 107,971.62 tons; accrued rent and royalty, $13,162.60.

Alabama.—Investigated the status of oil and gas prospecting operations throughout the State. Supervised 1 coal lease and 2 oil and gas prospecting permits. Coal produced, 109,832 tons; accrued rent and royalty, $10,983.20.

Arizona.—Examined 61 tracts for agricultural classification. Supervised 5 coal prospecting permits, 3 sodium permits, 6 potassium permits, and 439 oil and gas permits involving public land. Investigated and reported on the value of 2 iron-ore deposits, 7 radium-ore leases, and 4 coal mines involving lands in 5 Indian reservations.

Arkansas.—Supervised 2 prospecting permits for coal and 15 for oil and gas.

California.—Examined 83 tracts for agricultural classification. Investigated the oil-shale resources of 1 tract in Santa Barbara County and the sodium resources of parts of 2 townships in southeastern Kern County. Investigated the power resources of the Cow Creek Basin, in Shasta County. Supervised on public land 130 leases and 1,301 prospecting permits for oil and gas, 4 leases for potassium, 6 prospecting permits for coal, 5 for sodium, and 1 for potassium. Oil produced, 5,790,220 barrels; natural gas, 1,208,043,000 cubic feet; natural-gas gasoline, 8,199,734 gallons; coal, 36 tons; sodium borate, 7,154.47 tons; sodium carbonate, 15,752 tons. Total rent and royalty accrued, $677,743.16. Supervised on naval petroleum reserves 27 leases for oil and gas and completed a detailed investigation of subsurface conditions in Reserve No. 1 (Elk Hills). Oil produced, 8,116,636 barrels; natural gas, 7,711,858,000 cubic feet; natural-gas gasoline, 24,908,263 gallons. Total rent and royalty accrued, $1,817,464.45.

Colorado.—Examined 119 tracts for agricultural classification and made regional studies of agricultural utility precedent to areal classification in the western part of the State. Examined 1 tract in Jackson County and 2 tracts in Grand County for oil and gas classification and 1 tract in Las Animas County for coal classification. Examined and mapped geologic structure in the Garcia field, Las Animas County, and in the Skull Creek district, Routt County. Supervised on public land 12 leases and 1,749 prospecting permits for oil and gas, 77 leases, 5 licenses, and 36 prospecting permits for coal, and 1 prospecting permit for potassium. Oil produced, 962,170 barrels; natural gas, 64,360,000 cubic feet; natural-gas gasoline, 73,522 gallons; coal, 490,446.22 tons. Total rent and royalty accrued, $106,832.87. Supervised on tribal lands of the Ute Indians 7 leases for oil and gas, and inspected for the Indian Service 1 coal mine on the Southern Ute Reservation.

Idaho.—Examined 68 tracts for agricultural classification. Supervised 269 oil and gas prospecting permits, 9 coal permits, 2 sodium permits, and 2 phosphate leases. Coal produced, 466.65 tons; phosphate rock, 22,612 tons. Total rent and royalty accrued, $2,385.14.

Kansas.—Supervised 1 prospecting permit for oil and gas.

Louisiana.—Investigated the status of oil and gas prospecting and development throughout the State. Supervised 10 leases and 21 prospecting permits for oil and gas. Oil produced, 7,823.12 barrels; natural gas, 759,719,000 cubic feet; natural-gas gasoline, 54,248.60 gallons. Total rent and royalty accrued, $3,874.99.

Michigan.—Supervised 1 prospecting permit for oil and gas.

Mississippi.—Investigated the status of oil and gas prospecting throughout the State.

Montana.—Examined 88 tracts for agricultural classification. Began a broad areal investigation of the stratigraphy and structure of parts of Toole, Teton, Chouteau, and Cascade Counties. Continued through the geologic branch detailed examinations in McCone, Richland, Dawson, Rosebud, Custer, and Powder River Counties for coal classification. Supervised on public land 58 leases and 1,387 prospecting permits for oil and gas; 50 leases, 10 licenses, and 12 prospecting permits for coal. Oil produced, 617,051 barrels; natural gas, 1,082,999,000 cubic feet; coal, 299,813.84 tons. Total rent and royalty accrued, $110,554.70. Supervised on Indian land 117 leases for oil and gas.

Nebraska.—Examined 3 tracts for agricultural classification and made regional investigations in the western part of the State to provide basis for broad areal classification as to agricultural utility. Supervised 3 prospecting permits for oil and gas.

Nevada.—Examined 27 tracts for agricultural classification and made regional investigations of agricultural utility precedent to grazing classification in the northeastern part of the State. Supervised 219 prospecting permits for oil and gas, 5 prospecting permits for coal, 1 lease and 6 prospecting permits for sodium, and 1 lease for phosphate. Sodium sulphate produced, 674.43 tons; phosphate rock, 45.45 tons. Total rent and royalty accrued, $1,480.

New Mexico.—Examined 10 tracts for agricultural classification. Continued through the geologic branch detailed examinations in McKinley and Sandoval Counties for coal classification. Supervised on public land 8 leases and 3,601 prospecting permits for oil and gas, 16 leases and 64 prospecting permits for coal, 81 prospecting permits for potassium, and 5 prospecting permits for sodium. Oil produced, 158,202 barrels; natural gas, 253,924,000 cubic feet; natural-gas gasoline, 3,792 gallons; coal, 84,441.64 tons. Total rent and royalty accrued, $50,978.45. Supervised on Indian land 57 oil and gas leases and made technical investigation and report on 1 coal-mining operation in each of the Northern Navajo, Eastern Navajo, and Zuni Reservations.

North Dakota.—Examined 7 tracts for agricultural classification. Supervised 51 leases, 2 licenses, and 3 prospecting permits for coal and 26 prospecting permits for oil and gas. Coal produced, 462,285.16 tons. Total rent and royalty accrued, $24,763.89.

Oklahoma.—Continued in cooperation with the Oklahoma Geological Survey detailed geologic examination of the coal resources of the Stigler-Muskogee district in Haskell and Muskogee Counties, begun in 1927. Supervised on public land 17 leases for oil and gas involving land in the bed of the Red River, Tillman County, and 69 prospecting permits for oil and gas. Oil produced, 465,086.76 barrels; natural-gas gasoline, 1,528,001.92 gallons. Total rent and royalty accrued, $114,160.27. Supervised on Indian lands 10,531 leases for oil and gas involving 920,608 acres, 5,651 producing wells, and a combined rental and royalty value of $5,985,882.34; on segregated Choctaw and Chickasaw lands, 68 leases for coal involving 62,129 acres, a production of 560,979 tons of coal, and a royalty value of $50,934.59, and 1 lease for asphalt; on allotted restricted lands of Cherokee, Choctaw, and Creek Indians, 63 leases for coal involving a production of 80,101 tons and a royalty value of $11,236.70, 3 leases for volcanic ash, and 1 for lead and zinc involving production with a royalty value of $447.44; and on restricted Quapaw lands, 50 departmental leases for lead and zinc involving 6,284 acres, a production of 186,423 tons of concentrates, and a royalty value of $848,219.49.

Oregon.—Examined 42 tracts for agricultural classification. Investigated the coal resources of John Day Valley between Dayville and John Day, Grant County. Investigated the power resources of the Middle Fork of the Willamette, Santiam, Clackamas, Imnaha, and Wenaha Rivers. Supervised 30 prospecting permits for oil and gas, 2 leases and 3 prospecting permits for coal, 1 lease for oil shale, and 1 prospecting permit for potassium. Coal produced, 3,234.47 tons. Accrued rent and royalty, $1,187.10.

South Dakota.—Examined 9 tracts for agricultural classification. Supervised 46 prospecting permits for oil and gas and 1 lease for coal. Coal produced, 342.45 tons; accrued rent and royalty, $80.

Utah.—Examined 113 tracts for agricultural classification. Examined parts of 2 townships in Cache County for phosphate classification and 1 tract in the Marysvale district for potash. Continued through the geologic branch investigations of the areal geology and structure of southern San Juan County and of the coal resources of eastern San Pete County. Investigated the physical characteristics and power resources of parts of the Green and Colorado Rivers. Published and distributed a map showing coal mines and coal occurrence in parts of Carbon and Emery Counties. Supervised on public land 6 leases and 1,913 prospecting permits for oil and gas; 43 leases, 1 license, and 28 prospecting permits for coal; 11 prospecting permits for potassium; and 3 prospecting permits for sodium. Oil produced, 2,953 barrels; natural gas, 1,004,659,000 cubic feet; coal, 580,100.78 tons. Total rent and royalty accrued, $112,271.36. Supervised 1 lease for oil and gas involving land in the Navajo Indian Reservation.

Washington.—Examined 3 tracts for agricultural classification. Investigated power resources of the Hoh, Bogachiel, Queets, Nespelem, and Sanpoil Rivers. Supervised 28 prospecting permits for oil and gas and 17 for coal.

Wyoming.—Examined 156 tracts for agricultural classification and made regional investigations of agricultural utility precedent to areal classification

in the southwestern part of the State. Mapped the areal and structural geology of the Big Sand Draw gas field, Fremont County, and published a structure-contour map of the field. Investigated structural conditions affecting one tract in Niobrara County and one in Weston County. Collected representative samples of shale formations in Wyoming for ceramic experimentation. Remapped basal coal from Fort Steele westward and southward to the Colorado boundary to conform with certain township resurveys. Supervised on public lands 329 leases and 3,298 prospecting permits for oil and gas; 35 leases, 2 licenses, and 18 prospecting permits for coal; and 1 prospecting permit each for potassium and sodium. Oil produced, 14,455,335 barrels; natural gas, 18,396,690,000 cubic feet; natural-gas gasoline, 37,460,576 gallons; coal, 1,022,860.90 tons. Total rent and royalty accrued, $2,862,763.66. Supervised 74 leases for oil and gas involving tribal and allotted lands of the Shoshone Indians. Made periodic inspection and pressure test of wells shut in on Naval Petroleum Reserve No. 3 (Teapot dome).

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 relative to mineral classifications, orders of withdrawal, modification, and restoration. The results of these field investigations take the form 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, Indian land, and naval oil reserves.

Classification phases of division activity were substantially increased by departmental order 349 on May 14, 1929, requiring a report by the Geological Survey to the General Land Office on the prospective value for oil and gas of public lands involved in certain types of nonmineral entries and filings in Alabama, Kansas, Louisiana, Michigan, Mississippi, Nebraska, and Wyoming and in specified counties of Arkansas, California, Colorado, Florida, Idaho, Michigan, Montana, New Mexico, North Dakota, Oregon, South Dakota, Utah, and Washington, as a basis for the reservation or waiver of the Government's title to deposits of those minerals. To the end of the fiscal year 425 requests for reports of this type had been received.

Little progress was made in 1929 in classifying the vast areas of public land that are still embraced in mineral withdrawals. The results accomplished include, however, net decreases of 57,006 acres in the total area of outstanding coal withdrawals, of 92,140 acres in the total area of outstanding petroleum withdrawals, and of 26,261 acres in the total area of outstanding phosphate reserves.

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

Summary of outstanding mineral withdrawals and classifications, June 30, 1929, in acres

State	Coal		Oil		Oil shale		Phosphate		Potash
	Withdrawn	Classified as coal land	Withdrawn	Classified as oil land	Withdrawn	Classified as oil-shale land	Withdrawn	Classified as phosphate land	Withdrawn
Alaska		56,993							
Arizona	139,415		356						
Arkansas		61,160							
California	17,603	8,720	1,178,392						90,357
Colorado	4,142,233	3,082,272	218,997		64,560	952,239			
Florida							67,076	120	
Idaho	4,761	4,603					391,532	268,299	
Louisiana			466,990	4,233					
Montana	7,863,941	[a]8,563,862	1,350,426	67,651			279,944	3,833	
Nevada	83,673				123				39,422
New Mexico	5,084,069	570,372							9,282,160
North Dakota	5,954,364	11,178,286	84,894						
Oregon	4,361	18,887							
South Dakota		250,093							
Utah	3,636,541	1,267,697	1,341,264		91,464	2,703,755	277,344	2,937	
Washington	691,801	141,444							
Wyoming	2,260,604	[b]6,740,594	541,777			460,103	989,149	25,293	
	29,883,366	31,944,983	5,183,096	71,884	156,147	4,116,097	2,005,045	300,482	9,411,939

[a] Includes 3,151 acres of coal land reserved for use of the United States (coal reserve No. 1).
[b] Includes 2,078 acres of coal land reserved for use of the United States (coal reserve No. 2).

The functions of this division in connection with administration of the mineral leasing laws, fully described in earlier reports, continued unchanged with respect to coal, phosphate, oil-shale, potassium, and sodium filings throughout the year and with respect to oil and gas filings until March 12, 1929, when a change of administrative policy necessitated material change in their nature. Subsequent to that date they were generally restricted, as far as oil and gas cases, outside Alaska, were concerned, to the preparation of technical reports on the status of drilling operations initiated or completed on permit holdings, or on the geologic structure affecting them, that had been held for cancellation or were involved in pending applications for extension of time, reinstatement, or assignment, and to the appraisal of geologic showings submitted in support of such applications. To July 1, 1929, a total of 543 reports of this type had been submitted to the "departmental committee to pass on claims in connection with oil and gas permits" pursuant to departmental order 337, of March 16, 1929, outlining procedure under the Federal oil-conservation policy announced by President Hoover March 12, 1929. Prior to that date 4,450 reports on drilling status were rendered to the General Land Office in furtherance of its campaign begun in 1928 to cancel oil and gas prospecting permits the terms of which had had no bona fide compliance.

The following table summarizes the year's work to the extent that it involved technical reports on original applications for permit or lease rights on public lands. Except for a few cases involving land in Alaska, the recorded action on oil and gas prospecting permit applications antedated March 12, 1929.

Applications received, acted on, and pending under the mineral leasing acts, fiscal year 1929

Mineral	Prospecting permits			Leases		
	Received	Acted on	Pending	Received	Acted on	Pending
Oil and gas	3,945	3,932	13			
Coal	116	104	12	99	89	10
Phosphate				2	1	1
Sodium	35	30	5	7	6	1
Potassium	35	27	8	5	5	
Oil shale				1	1	
	4,131	4,093	38	114	102	12

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

Middle Red River, Okla.; 418 acres (additional 196 acres); promulgated October 18, 1928.

Big Sand Draw, Wyo.; 4,830 acres (diminished 2,563 acres); promulgated August 24, 1928.

The net area included in outstanding definitions of the "known geological structure" of producing oil and gas fields on June 30, 1929, was 515,378 acres in California, Colorado, Montana, New Mexico, Oklahoma, Utah, and Wyoming.

Geologic field work required in the solution of the problems of the division is performed in part by summer detail of Washington employees, in part by a division geologist with permanent headquarters in Denver, Colo., and in part by the geologic branch at the expense of the conservation branch. The work accomplished in 1929 is included in the branch summary of field operations by States beginning on page 61.

POWER DIVISION

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

In order that this information may be made substantially complete, areas not thoroughly surveyed are designated for examination by the topographic and water-resources branches of the Geological Survey. The field projects undertaken during the year to obtain information for power classification, including plan and profile surveys, power-site and reservoir-site investigations, and geologic studies of dam sites, are included in the branch summary of field operations by States (pp. 61–63).

The information obtained in the field is indexed and incorporated in an inventory of water resources which, when complete, will enable the Geological Survey to give competent advice on short notice as to the manner in which each tract of public land having value for power can best be used in connection with the development of water power and as to the relation of such use to other possible uses of the tract. Copies of many of the reports on the power possibilities of the streams examined have been placed in the district offices of the Geological Survey for public inspection, and notices of the availability of the reports have been sent to the press.

The work of the division is briefly summarized in the accompanying tables showing power-site reserves and outstanding water-resources withdrawals and classifications and in the general summary.

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 1928. The total installation of the reporting companies is 3,244,000 kilowatts, of which 2,415,000 kilowatts is installed at hydraulic plants. The total energy generated was 8,987,000,000 kilowatt-hours, of which more than 8,051,000,000 kilowatt-hours was generated by water power. The energy generated by steam has increased 366,000,000 kilowatt-hours, and that generated by water power 505,000,000 kilowatt-hours, making a total increase of 871,000,000 kilowatt-hours.

Power output of permittees and grantees, 1916–1928

Calendar year	Kilowatt-hours	Increase or decrease		Calendar year	Kilowatt-hours	Increase or decrease	
		Kilowatt-hours	Per cent			Kilowatt-hours	Per cent
1916	1,200,000,000			1923	5,910,000,000	+963,000,000	+19
1917	2,000,000,000	+800,000,000	+67	1924	6,100,000,000	+164,000,000	+3
1918	3,200,000,000	+1,200,000,000	+60	1925	6,930,000,000	+830,000,000	+14
1919	3,100,000,000	−100,000,000	−3	1926	7,800,000,000	+870,000,000	+13
1920	4,300,000,000	+1,100,000,000	+35	1927	8,116,000,000	+316,000,000	+4
1921	3,725,000,000	−475,000,000	−11	1928	8,987,000,000	+871,000,000	+11
1922	4,947,000,000	+1,222,000,000	+33				

Power-site reserves, in acres

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

State	Reserved prior to July 1, 1928	Eliminated prior to July 1, 1928	Reserves outstanding prior to July 1, 1928	Reserved during fiscal year	Eliminated during fiscal year	Reserves outstanding June 30, 1929
Alabama	2,377		2,377			2,377
Alaska	247,066	520	246,546	35,861		282,407
Arizona	1,282,976	124,012	1,158,964	13,380	15	1,172,329
Arkansas	29,671	360	29,311			29,311
California	1,368,036	30,243	1,337,793	68,839	3,037	1,403,595
Colorado	537,520	77,020	460,500	20,100	5,210	475,390
Florida	1,131		1,131			1,131
Idaho	605,642	191,534	414,108	5,061		419,169
Michigan	1,240		1,240			1,240
Minnesota	19,062	532	18,530			18,530
Mississippi	3		3			3
Montana	304,489	96,379	208,110	1,378	280	209,208
Nebraska	761		761			761
Nevada	301,196	480	300,716	58,019		358,735
New Mexico	270,878	10,511	260,367	49	732	259,684
Oregon	769,204	123,963	645,241	16,063	19,521	641,783
South Dakota	636		636			636
Utah	771,933	126,518	645,415	7,436	3,720	649,131
Washington	398,015	53,835	344,180	51,849	52	395,977
Wisconsin	1,866	226	1,640	40		1,680
Wyoming	232,477	76,284	156,193	300		156,493
	7,146,179	912,417	6,233,762	278,375	32,567	6,479,570

Summary of outstanding water-resources withdrawals and classifications, June 30, 1929, in acres

State	Power reserves					Reservoir withdrawals	Public water reserves
	Withdrawals	Classifications	Designations [a]	Miscellaneous	Total		
Alabama	120	1,735		522	2,377		
Alaska	93,415	105,425		83,567	282,407		
Arizona	386,244	50,082	528,237	207,766	1,172,329	23,040	19,425
Arkansas	21,994	1,590		5,727	29,311		
California	285,055	359,219		759,321	1,403,595	1,160	199,506
Colorado	225,463	193,989		55,938	475,390	1,728	7,540
Florida				1,131	1,131		
Idaho	206,272	195,364		17,533	419,169		14,345
Michigan	1,240				1,240		
Minnesota	12,309			6,221	18,530		
Mississippi				3	3		
Montana	130,337	53,862		25,009	209,208	9,080	9,017
Nebraska	761				761		
Nevada	27,492	85,866		245,377	358,735		12,101
New Mexico	116,474	49	143,161		259,684		11,001
North Dakota						1,569	
Oregon	355,272	194,280	15,250	76,981	641,783	10,619	25,941
South Dakota				636	636		240
Utah	438,655	176,204		34,272	649,131	80	35,970
Washington	97,034	226,775		72,168	395,977	35,943	920
Wisconsin				1,680	1,680		
Wyoming	79,953	35,407		41,133	156,493	1,714	82,425
	2,478,090	1,679,847	686,648	1,634,985	6,479,570	84,933	418,431

[a] Designated and not otherwise withdrawn.

AGRICULTURAL DIVISION

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

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

The number of cases received and acted on during the fiscal year by the agricultural division is shown in the general summary of cases (p. 60). It increased about 22 per cent above the number received in 1928 and resulted in an arrearage 37 per cent greater at the end of 1929 than at the end of 1928.

In the field broad areal studies were continued in the Colorado Basin region in northwestern Colorado and southwestern Wyoming.

The series of five maps showing the agricultural utility of the central Great Plains was completed and published, together with brief texts discussing the agricultural characteristics of three of the areas. Text for the other two maps was partly completed. Revision of a text for the series of eight similar maps relating to the northern Great Plains prepared in cooperation with the Department of Agriculture was also completed.

During the fiscal year the area designated under the Nevada ground water reclamation act as a result of the work of the division was increased 24,080 acres, to a total of 1,643,295 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 entryman required: Act of Feb. 19, 1909 (35 Stat, 639), applicable to Arizona, Colorado, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming; act of June 17, 1910 (36 Stat. 531), applicable to Idaho; act of June 13, 1912 (37 Stat. 132) applicable to California, North Dakota; act of Mar. 3, 1915 (38 Stat. 953), applicable to Kansas; act of Mar. 4, 1915 (38 Stat. 1163), applicable to South Dakota. Areas classified as arid, nonirrigable, and lacking domestic water supply, residence by entryman not required: Act of Feb. 19, 1909 (35 Stat. 639), applicable to Utah; act of June 17, 1910 (36 Stat. 531), applicable to Idaho]

State	Designations prior to July 1, 1928	Cancellations prior to July 1, 1928	Designations outstanding prior to July 1, 1928	Designations during fiscal year	Cancellations during fiscal year	Designations outstanding June 30, 1929
Arizona	31, 502, 584	5, 870, 874	25, 631, 710	30, 120	13, 440	25, 648, 390
California	13, 333, 226	240, 453	13, 092, 773	48, 207		13, 140, 980
Colorado	33, 810, 627	195, 508	33, 615, 119	162, 165	920	33, 776, 364
Idaho:						
Total	13, 754, 190	461, 365	13, 292, 825	2, 126		13, 294, 951
Nonresidence	573, 227	4, 233	568, 994			568, 994
Kansas	651, 364		651, 364			651, 364
Montana	53, 485, 650	245, 728	53, 239, 922	2, 011		53, 241, 933
Nevada	50, 168, 165	3, 580, 717	46, 587, 448	50, 379		46, 637, 827
New Mexico	43, 837, 357	227, 732	43, 609, 625	11, 650	160	43, 621, 115
North Dakota	12, 280, 704	3, 848	12, 276, 856			12, 276, 856
Oregon	21, 282, 311	989, 902	20, 292, 409			20, 292, 409
South Dakota	16, 340, 761	348, 170	15, 992, 591	2, 080		15, 994, 671
Utah:						
Total	11, 654, 776	701, 484	10, 953, 292	93, 294	344, 833	10, 701, 753
Nonresidence	1, 650, 911	81, 880	1, 569, 031		344, 833	1, 224, 198
Washington	6, 660, 452	251, 842	6, 408, 610			6, 408, 610
Wyoming	29, 677, 292	162, 043	29, 515, 249	99, 814		29, 615, 063
	338, 439, 459	13, 279, 666	325, 159, 793	501, 846	359, 353	325, 302, 286

Summary of stock-raising homestead designations, in acres

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

State	Designations prior to July 1, 1928	Cancellations prior to July 1, 1928	Designations outstanding prior to July 1, 1928	Designations during fiscal year	Cancellations during fiscal year	Designations outstanding June 30, 1929
Arizona	14, 056, 666	887, 580	13, 169. 086	98, 207		13, 267, 293
Arkansas	1, 120		1, 120			1, 120
California	7, 965, 904	3, 400	7, 962, 504	64, 471		8, 026, 975
Colorado	8, 647, 578	18, 920	8, 628, 658	224, 484	920	8, 852, 222
Florida	480	480				
Idaho	5, 545, 291	1, 854	5, 543, 437	51, 719		5, 595, 156
Kansas	115, 139		115, 139	640		115, 779
Michigan	3, 491		3, 491			3, 491
Montana	15, 487, 123	17, 081	15, 470, 042	127, 252		15, 597, 294
Nebraska	202, 184		202, 184	3, 977		206, 161
Nevada	586, 089	3, 120	582, 969	10, 537		593, 506
New Mexico	31, 363, 953	636	31, 363, 317	144, 213		31, 507, 530
North Dakota	383, 700		383, 700			383, 700
Oklahoma	83, 610		83, 610	1, 308		84, 918
Oregon	6, 355, 378	3, 128	6, 352, 250	29, 068		6, 381, 318
South Dakota	6, 510, 048	550	6, 509, 498	9, 498		6, 518, 996
Utah	1, 796, 149	7, 800	1, 788, 349	142, 173		1, 930, 522
Washington	694, 686	1, 174	693, 512			693, 512
Wyoming	20, 278, 111	6, 373	20, 271, 738	236, 130	800	20, 507, 068
	120, 076, 700	952, 096	119, 124, 604	1, 143, 677	1, 720	120, 266, 561

By blanket order of withdrawal creating public water reserve No. 107, which received Executive approval April 17, 1926, every smallest legal subdivision of the public-land surveys which is vacant unappropriated public land and contains a spring or water hole and all land within a quarter of a mile of every spring or water hole located on unsurveyed public land was reserved for public use and in aid of pending legislation. This order obviated the necessity for future withdrawals of specific tracts containing springs or water

holes valuable for stock watering but requires a determination by the division with respect to all entries of public land, whether or not any of the subdivisions involved are in fact affected by it. On the basis of such determination orders of interpretation are issued from time to time listing by legal subdivisions of the public-land survey any tracts found to contain a water supply affected by the order. New withdrawals of this type are made to reserve lands along streams and are also made from time to time for special public purposes. The extent of outstanding reserves of this type and of current action affecting them is shown in the following table:

Public water reserves, in acres

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

State	Reserved prior to July 1, 1928	Eliminated prior to July 1, 1928	Reserves outstanding July 1, 1928	Reserved during fiscal year	Eliminated during fiscal year	Reserves outstanding June 30, 1929
Arizona	21,782	1,632	20,150		725	19,425
California	205,924	7,138	198,786	720		199,506
Colorado	5,220	360	4,860	2,680		7,540
Idaho	14,315	410	13,905	440		14,345
Montana	10,009	1,152	8,857	240	80	9,017
Nevada	14,426	3,250	11,176	925		12,101
New Mexico	10,491	520	9,881	1,120		11,001
Oregon	22,549	1,288	21,261	4,680		25,941
South Dakota	240		240			240
Utah	41,526	7,596	33,930	2,040		35,970
Washington	920		920			920
Wyoming	92,845	13,420	79,425	3,640	640	82,425
	440,157	36,766	403,391	16,485	1,445	418,431

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 coal, oil and gas, zinc, iron, silver-lead, and radium ores, asbestos, asphalt, and volcanic ash 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 activities, under the direction of responsible engineers who have full authority to represent the Government within their jurisdiction and to enforce compliance with the law and regulations under which operations are conducted.

ACTIVITIES ON THE PUBLIC DOMAIN

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

	Number	Acres		Number	Acres
Leases:			Permits:		
Oil and gas	62	26,595.77	Oil and gas	2,416	4,093,743.20
Coal	39	6,511.04	Coal	83	91,090.46
Licenses:			Potassium	32	63,905.63
Coal	13	426.29	Sodium	8	13,094.59

During the same period supervisory work was decreased by the cancellation of 17 coal leases, 4 coal-prospecting permits, 26 potassium-prospecting permits, 1 sodium-prospecting permit, 8 oil and gas leases, and 8,700 oil and gas prospecting permits—a total of 8,756 cancellations, compared with the total of 7,827 for the fiscal year 1928.

The following table shows the total number of leases, licenses, and permits involving public land in effect at the end of the fiscal year:

Mineral leases, licenses, and permits on the public domain and naval petroleum reserves under supervision of the Geological Survey June 30, 1929

State	Coal						Oil and gas	
	Leases		Permits		Licenses		Leases (number)	Permits (number)
	Number	Acres	Number	Acres	Number	Acres		
Alaska	9	11,307.28	13	22,548.84	3	30.00	------	1,025
Alabama	1	1,840.00	------	------	------	------	------	2
Arizona	------	------	5	11,520.00	------	------	------	439
Arkansas	------	------	2	2,199.88	------	------	------	15
California	------	------	6	6,511.17	------	------	[a]157	1,301
Colorado	77	12,252.60	36	22,542.90	5	200.00	12	1,749
Idaho	------	------	9	11,697.17	------	------	------	269
Kansas	------	------	------	------	------	------	------	1
Louisiana	------	------	------	------	------	------	10	[b]21
Montana	50	6,168.17	12	7,840.00	10	396.29	58	1,387
Nebraska	------	------	------	------	------	------	------	3
Nevada	------	------	5	7,821.88	------	------	------	219
New Mexico	16	10,310.28	64	101,121.53	------	------	8	3,601
North Dakota	51	6,176.86	3	360.46	2	80.00	------	26
Oklahoma	------	------	------	------	------	------	------	60
Red River	------	------	------	------	------	------	17	9
Oregon	2	1,895.24	3	760.00	------	------	------	30
South Dakota	1	79.04	------	------	------	------	------	46
Utah	43	33,281.47	28	27,594.47	1	80.00	6	1,913
Washington	------	------	17	13,742.33	------	------	------	28
Wyoming	35	14,718.98	18	17,694.30	2	80.00	329	3,298
	285	98,029.92	221	253,954.93	23	866.29	597	15,442

State	Sodium				Potash			
	Leases		Permits		Leases		Permits	
	Number	Acres	Number	Acres	Number	Acres	Number	Acres
Arizona	------	------	3	5,200.00	------	------	[c]1	2,400.00
Do	------	------	------	------	------	------	5	9,040.00
California	------	------	5	5,995.96	4	7,783.80	[c]1	2,559.58
Colorado	------	------	------	------	------	------	1	2,538.67
Idaho	------	------	2	3,254.11	------	------	------	------
Nevada	1	1,440.00	6	11,075.63	------	------	------	------
New Mexico	------	------	5	12,480.00	------	------	[c]7	16,400.00
Do	------	------	------	------	------	------	74	169,704.30
Oregon	------	------	------	------	------	------	1	2,560.00
Utah	------	------	------	------	------	------	[c]9	16,518.68
Do	------	------	3	3,840.00	------	------	2	3,361.33
Wyoming	------	------	1	1,245.00	------	------	1	1,760.00
	1	1,440.00	25	43,090.70	4	7,783.80	102	226,842.56

[a] Includes 15 leases on naval petroleum reserves 1 and 2 under the act of Feb. 25, 1920, and 12 on naval petroleum reserves 1 and 2 under the act of June 4, 1920.

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

[c] Under the act of Oct. 2, 1917.

Also Idaho, 2 phosphate leases, 1,700 acres; Nevada, 1 phosphate lease, 160 acres; Oregon, 1 oil-shale lease, 2,680 acres. Total leases, 891; licenses, 23; permits 15,790; grand total, 16,704.

Since October 20, 1914, the date of approval of the Alaska coal-land leasing act (38 Stat. 741), the Secretary of the Interior has issued a total of 653 leases and 34,672 prospecting permits for oil and gas; 357 leases, 149 licenses, and 1,102 prospecting permits for coal; 18 leases and 680 prospecting permits for potassium; 1 lease and 88 prospecting permits for sodium; 2 leases for oil shale; and 3 leases for phosphate.

PRODUCTION

Compared with 1928, mineral production from public lands in the fiscal year 1929 increased as follows: Coal, 161,583 tons, or 5 per cent; natural gas, 3,848,368,110 cubic feet, or 20 per cent; natural-gas gasoline, 7,621,581 gallons, or 19 per cent; sodium minerals, 7,453 tons, or 46 per cent. In the same period decrease was recorded in the production of petroleum to the extent of 911,707 barrels, or 4 per cent; and of phosphate rock to the extent of 1,668 tons, or 8 per cent. Prospecting for potassium was continued in Eddy County, N. Mex., where 9 prospect holes were drilled by permittees to an aggregate depth of 12,470 feet. No potassium salts were produced from public land in 1929.

Important sources of oil and gas production discovered or actively developed during the year in areas containing relatively large holdings of public land include the Kettleman Hills field, Kings County, Calif.; the Jal district, Lea County, N. Mex.; and the Hiawatha district, Sweetwater County, Wyo. Phosphate production was also begun in Nevada from a cave deposit of guano in White Pine County.

Statistics of mineral production under Federal leases, licenses, and prospecting permits are summarized in the following tables:

Petroleum, natural gas, and natural-gas gasoline produced from public lands

Total

Fiscal year	Petroleum	Natural gas	Gasoline
	Barrels	*M cubic feet*	*Gallons*
1921–1925	118, 333, 954. 01	60, 298, 796. 00	63, 997, 718. 97
1926	29, 712, 876. 16	18, 535, 880. 50	35, 910, 791. 54
1927	25, 648, 101. 43	17, 723, 410. 03	40, 104, 404. 57
1928	23, 370, 549. 38	18, 922, 026. 00	39, 698, 292. 82
1929	22, 458, 842. 62	22, 770, 394. 11	47, 319, 874. 32
	219, 524, 323. 60	138, 250, 506. 64	227, 031, 082. 22

1929, by States

California	5, 790, 220. 07	1, 208, 043. 11	8, 199, 733. 80
Colorado	962, 170. 29	64, 360. 00	73, 522. 00
Louisiana	7, 823. 92	759, 719. 00	54, 248. 60
Montana	617, 051. 45	1, 082, 999. 00	
New Mexico	178, 202. 44	253, 924. 00	3, 792. 00
Oklahoma	465, 086. 76		1, 528, 001. 92
Utah	2, 953. 13	1, 004, 659. 00	
Wyoming	14, 455, 334. 56	18, 396, 690. 00	37, 460, 576. 00

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

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

State	1912–1925	1926	1927	1928	1929	Total
Alaska	455, 497. 43	98, 144. 74	93, 416. 14	106, 382. 66	107, 971 62	861, 412. 59
Alabama		10, 056. 00	22, 854. 00	43, 523. 00	109, 832. 00	186, 265. 00
California			3. 00	3. 00	36. 00	42. 00
Colorado	2, 028, 940. 29	353, 433. 61	448, 552. 09	439, 650. 40	490, 446. 22	3, 761, 022. 61
Idaho					466. 65	466. 65
Montana	252, 973. 58	198, 602. 15	278, 896. 48	278, 886. 33	299, 813. 84	1, 309, 172. 38
Nevada				91. 15		91. 15
New Mexico	74, 427. 26	37, 461. 86	85, 905. 31	74, 462. 82	84, 441. 64	356, 698. 89
North Dakota	453, 695. 38	163, 533. 79	215, 540. 12	404, 456. 71	462, 285. 16	1, 699, 511. 16
Oregon	688. 97	628. 88	423. 58	1, 280. 03	3, 234. 47	6, 255. 93
South Dakota	1, 842. 63	1, 074. 00	531. 11	422. 68	342. 45	4, 212. 87
Utah	487, 303. 62	172, 433. 36	282, 564. 80	432, 707. 96	580, 100. 78	1, 955, 110. 52
Washington	164, 280. 43	16, 910. 29	20, 974. 32	33, 723. 99		245, 889. 03
Wyoming	4, 465, 885. 23	962, 490. 51	1, 053, 037. 36	1, 184, 657. 65	1, 022, 860. 90	8, 688, 931. 65
	8, 385, 534. 82	2, 014, 769. 19	2, 512, 698. 31	3, 000, 248. 38	3, 161, 831. 73	19, 075, 082. 43

Sodium salts produced from public lands, in tons, by fiscal years

State	1921–1925	1926	1927	1928	1929	Total
California	3, 145. 30	430. 09	5, 911. 35	15, 377. 99	22, 906. 47	47, 771. 20
Nevada	248. 25	233. 53	302. 53	750. 00	674. 43	2, 208. 74
	3, 393. 55	663. 62	6, 213. 88	16, 127. 99	23, 580. 90	49, 979. 94

Phosphate produced from public lands, in tons, by fiscal years

State	1921–1925	1926	1927	1928	1929	Total
Idaho	6, 132. 44	343. 20	23, 854. 61	23, 459. 95	21, 746. 61	75, 536. 81
Nevada					45. 45	45. 45
	6, 132. 44	343. 20	23, 854. 61	23, 459. 95	21, 792. 06	75, 582. 26

Productive leases, permits, and licenses, fiscal year 1929

	Coal		Potash	Sodium	Phosphate	Oil and gas
	Shipping	Wagon				
Alaska	4	1				
Alabama	1					
California		1	2			69
Colorado	15	49				12
Idaho	0	3			1	
Louisiana						7
Montana	2	65				50
Nevada				1	1	
New Mexico	6	10				28
North Dakota	7	56				
Oklahoma						17
Oregon		2				
South Dakota		1				
Utah	17	16				8
Washington						
Wyoming	13	26				304
	65	230	2	1	2	495

ROYALTY, RENT, AND BONUSES

The following tables summarize accrued income from all mineral leases, licenses, and prospecting permits under the various leasing acts applicable to the public lands:

Royalties, rentals, and bonuses accrued from all mineral operations on public lands, by fiscal years

State	1912–1925	1926	1927	1928	1929	Total
Alabama	$86,380.00	$1,005.60	$2,285.40	$4,352.30	$10,983.20	$105,006.50
Alaska	35,142.42	9,227.63	11,327.50	19,495.19	13,162.60	88,355.34
California	4,676,746.55	1,259,912.83	966,228.53	1,356,050.49	677,743.16	8,936,681.56
Colorado	216,853.81	124,725.20	115,573.21	102,702.44	106,832.87	666,687.53
Idaho	1,111.38	695.00	2,549.41	2,529.85	2,385.14	9,270.78
Louisiana	1,508.59	1,670.12	15,993.32	3,829.21	10,723.06	33,724.30
Montana	891,278.79	355,254.89	172,765.63	107,964.87	110,554.70	1,637,818.88
Nevada	301.07	2,160.00	1,440.00	1,462.79	1,480.00	6,843.86
New Mexico	13,883.64	14,278.88	20,894.59	25,331.39	50,978.45	125,366.95
North Dakota	29,144.79	12,320.50	15,379.14	30,138.88	24,763.89	111,747.20
Oklahoma		45,813.28	182,829.59	147,974.25	114,160.27	490,777.39
Oregon	952.15	972.80	1,048.00	948.00	1,187.10	5,108.05
South Dakota	399.60	227.34	40.86	43.32	80.00	791.12
Utah	138,932.03	87,282.79	71,864.60	79,144.70	112,271.36	489,495.48
Washington	22,215.91	1,721.04	3,096.57	3,495.22		30,528.74
Wyoming	31,206,133.17	6,862,754.84	4,760,870.88	2,909,905.61	2,862,763.66	48,602,428.16
	37,320,983.90	8,780,022.74	6,344,187.23	4,795,368.51	4,100,069.46	61,340,631.84

Royalty and bonuses accrued from oil and gas operations on public lands

Total

Fiscal year	Royalty			Bonuses	Total
	Petroleum	Natural gas	Gasoline		
1921–1925	$32,938,494.47	$398,543.30	$251,197.70	$2,768,085.14	$36,356,320.61
1926	7,951,665.52	93,508.29	154,265.43	250,503.94	8,449,943.18
1927	5,741,485.97	91,796.54	173,172.59	3,980.00	6,010,435.10
1928	3,519,810.55	108,570.86	107,070.00	672,500.00	4,407,951.41
1929	3,437,477.58	125,013.01	116,254.69	7,138.07	3,685,883.35
	53,588,934.09	817,432.00	801,960.41	3,702,207.15	58,910,533.65

1929, by States

California	$642,073.06	$6,030.46	$17,641.31		$665,744.83
Colorado	45,702.15	1,484.14	96.27		47,282.56
Louisiana	1,606.07	2,022.43	246.49	$6,848.07	10,723.06
Montana	73,677.27	3,911.40			77,588.67
New Mexico	30,022.84	6,943.49	125.54		37,091.87
Oklahoma	107,752.03		6,408.24		114,160.27
Utah	305.84	6,071.62			6,377.46
Wyoming	2,536,338.32	98,549.47	91,736.04	290.00	2,726,914.63

Rent, royalty, and bonuses accrued from mining operations on public lands

	Coal	Sodium	Phosphate	Potash	Bonuses	Total
1929						
Alabama	$10,983.20					$10,983.20
Alaska	13,162.60					13,162.60
California	9.00			$11,989.33		11,998.33
Colorado	59,250.31				$300.00	59,550.31
Idaho	116.66		$2,268.48			2,385.14
Montana	32,966.03					32,966.03
Nevada		$1,440.00	40.00			1,480.00
New Mexico	13,886.58					13,886.58
North Dakota	24,579.89				184.00	24,763.89
Oregon	1,187.10					1,187.10
South Dakota	80.00					80.00
Utah	105,893.90					105,893.90
Wyoming	135,849.03					135,849.03
	397,964.30	1,440.00	2,308.48	11,989.33	484.00	414,186.11
SUMMARY						
1912–1925	790,408.19	301.07	1,111.38	24,458.65	148,384.00	964,663.29
1926	319,626.78	2,160.00	695.00	6,031.78	1,566.00	330,079.56
1927	322,308.12	1,440.00	2,549.41	6,217.60	1,237.00	333,752.13
1928	372,949.85	1,440.00	2,529.85	9,402.40	1,095.00	387,417.10
1929	397,964.30	1,440.00	2,308.48	11,989.33	484.00	414,186.11
	2,203,257.24	6,781.07	9,194.12	58,099.76	152,766.00	2,430,098.19

ACTIVITIES ON NAVAL PETROLEUM RESERVES

On March 17, 1927, by Executive order, the administration of all naval petroleum reserves was vested in the Department of the Navy. Pursuant to a cooperative agreement engineering supervision was continued by the Geological Survey under the direction of the Secretary of the Navy.

Statistics of the production of petroleum, natural gas, and natural-gas gasoline from naval petroleum reserves are summarized as follows:

Royalty accrued from naval petroleum reserves

By States

State	Petroleum	Natural gas	Gasoline	Total
California:				
1921–1925	$10,127,293.96	$287,996.12	$231,447.70	$10,646,737.78
1926	3,187,461.22	100,089.27	151,296.95	3,438,847.44
1927	3,094,331.59	90,475.99	163,760.36	3,348,567.94
1928	1,909,711.11	125,866.88	162,834.08	2,198,412.07
1929	1,583,072.32	82,685.76	151,706.37	1,817,464.45
	19,901,870.20	687,114.02	861,045.46	21,450,029.68
Wyoming:				
1923–1927	763,114.40	44,765.64	7,104.55	814,984.59
1928	24,169.70	7,952.86	1,840.76	33,963.32
1929				
	787,284.10	52,718.50	8,945.31	848,947.91

Total

1921–1925	$10,685,660.38	$298,874.65	$231,485.45	$11,216,020.48
1926	3,310,658.54	114,247.75	152,480.36	3,577,386.65
1927	3,175,882.25	110,204.62	169,643.75	3,455,730.62
1928	1,933,880.81	133,819.74	164,674.84	2,232,375.39
1929	1,583,072.32	82,685.76	151,706.37	1,817,464.45
	20,689,154.30	739,832.52	869,990.77	22,298,977.59

Petroleum, natural gas, and gasoline produced from naval reserves

By States

	Petroleum	Natural gas	Gasoline
California:	*Barrels*	*M cubic feet*	*Gallons*
1921–1925	37, 882, 945. 09	35, 544, 349. 81	34, 508, 751. 07
1926	12, 234, 702. 16	12, 917, 255. 09	19, 851, 282. 68
1927	12, 368, 315. 70	12, 328, 208. 69	24, 052, 402. 12
1928	9, 690, 573. 93	9, 077, 966. 68	24, 797, 263. 61
1929	8, 116, 635. 98	7, 711, 858. 00	24, 908, 262. 82
	80, 293, 172. 86	77, 579, 638. 27	128, 117. 962. 30
Wyoming:			
1923–1925	2, 523, 213. 05	950, 520. 00	7, 829. 00
1926	520, 680. 00	1, 458, 032. 00	291, 852. 00
1927	357, 049. 32	1, 958, 463. 00	1, 441, 036. 00
1928	149, 285. 26	795, 854. 00	743, 179. 00
	3, 550, 227. 63	5, 162, 869. 00	2, 483, 896. 00

Total

1921–1925	40, 406, 158. 14	36, 494, 869. 81	34, 516, 580. 07
1926	12, 755, 382. 16	14, 375, 287. 09	20, 143, 134. 68
1927	12, 725, 365. 02	14, 286, 671. 69	25, 493, 438. 12
1928	9, 839, 859. 19	9, 873, 820. 68	25, 540, 442. 61
1929	8, 116, 635. 98	7, 711, 858. 00	24, 908, 262. 82
	83, 843, 400. 49	82, 742, 507. 27	130, 601, 858. 30

Production from naval petroleum reserve No. 3, in Wyoming, was definitely suspended in January, 1928. Supervision on this reserve for the present is confined to observation of gas pressure and consultation with the Navy Department.

ACTIVITIES ON INDIAN LANDS

On behalf of the Indian Service, the mineral-leasing division exercises technical supervision over all oil and gas operations, except in the Osage Reservation, Okla., and over all mining operations on tribal and allotted Indian lands and on Indian reservations set aside by Executive order. For the performance of these functions field offices are maintained at Muskogee, Okmulgee, Tulsa, Oklahoma City, Shawnee, Miami, and McAlester, Okla.; Farmington, N. Mex.; and Thermopolis, Wyo., and additional service is provided from other field offices of the conservation branch as needed.

The supervision of oil and gas activities in Oklahoma, exclusive of the Osage Reservation, includes 10,531 leases, covering 920,608.25 acres, on which there are 5,651 producing oil and gas wells, summarized by jurisdiction or Indian agencies as follows:

Oil and gas leases in Oklahoma exclusive of the Osage Reservation

Agency	Leases			Wells		Total royalty and rentals
	Non-producing	Producing	Total	Producing	Being drilled	
Five Civilized Tribes:						
Cherokee		387				
Choctaw		62				
Creek	7,022	626	8,239	5,416	85	
Chickasaw		18				
Seminole		124				
	7,022	1,217	8,239	5,416	85	$5,646,586.52
Kiowa Indian Agency:						
Kiowa	162	0	162	0	0	
Comanche	309	19	328	23	1	
Apache	9	6	15	16	0	
Wichita	38	0	38	0	0	
Caddo	131	0	131	0	0	
	649	25	674	39	1	150,540.30
Pawnee Indian Agency:						
Ponca	195	14	209	58	0	
Otoe	232	2	234	2	1	
Tonkawa	21	0	21	0	0	
Pawnee	201	20	221	56	1	
Kaw	49	4	53	33	0	
	698	40	738	149	2	224,580.61
Shawnee Indian Agency:						
Iowa	30	0	30	0	0	
Kickapoo	84	0	84	0	0	
Pottawatomie	67	6	73	23	3	
Sac and Fox	176	9	185	24	1	
Shawnee	212	0	212	0	0	
	569	15	584	47	4	278,148.23
Cheyenne and Arapaho Indian Agency	296	0	296	0	0	92,095.33
Grand total	9,234	1,297	10,531	5,651	92	6,391,950.99

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

Oil and gas leases on Indian lands outside Oklahoma

State and tribe	Being tested	Producing	Nonproducing	Under supervision
Colorado:				
Ute tribal	5	3	4	7
Montana:				
Blackfeet tribal	1	0	3	3
Blackfeet allotted	0	0	[a] 10	[a] 10
Crow tribal	4	1	6	7
Crow allotted	9	2	95	97
New Mexico:				
Navajo tribal	3	3	9	12
Navajo, Executive order	2	0	2	2
Navajo allotted	0	0	43	43
Utah:				
Navajo, Executive order	1	0	1	1
Wyoming:				
Shoshone tribal	1	13	48	61
Shoshone allotted	3	8	5	13
	29	30	226	256

[a] Awaiting final execution.

Coal.—Supervision of coal-mining operations in 1929 included in Oklahoma 14 producing and 49 inactive leaseholds involving lands of Cherokee, Choctaw, and Creek Indians, which produced 80,101 tons of coal having a royalty and rental value of $11,684.14, and 36 productive and 32 inactive leaseholds involving segregated Choctaw and Chickasaw lands, which produced 560,979 tons of coal having a royalty value of $50,934.59. In Colorado it included 38 leases, 2 licenses, and 8 prospecting permits involving ceded lands of the Ute Indians, from which the rent and royalty, aggregating $11,516.63, was credited to the tribe, and 1 tribal lease involving land in the Southern Ute Reservation. Periodic inspection was made of operations at 2 coal mines each on the Southern Navajo and Western Navajo Reservations in Arizona; 1 coal mine each on the Northern Navajo, Eastern Navajo, and Zuni Reservations in New Mexico; and 1 leasehold involving land in the Uintah and Ouray Reservation in Utah.

In cooperation with the Oklahoma Geological Survey, the geologic examination of the coal resources of the Stigler-Muskogee district, Oklahoma, begun in 1927, was continued.

Lead and zinc.—Supervision of lead and zinc mining operations involved 50 departmental leases for 6,284 acres of restricted lands of the Quapaw Indians in Oklahoma. Production from these leaseholds aggregates 14.2 per cent of the zinc and 3.9 per cent of the lead mined in the United States. The royalty for the fiscal year, $848,219.49, was 9.63 per cent of the sale value of the ore mined. Zinc and lead were first mined on the Quapaw Reservation in 1902 in the old Lincolnville field; in 1907 the Commerce field was opened, and in 1914 the Picher field was discovered. Production has increased greatly since 1917 and now represents about 62 per cent of the total value of the lead and zinc produced in the Tri-State district. One lead and zinc lease under supervision on restricted Cherokee lands in Oklahoma was unproductive in 1928.

Miscellaneous minerals.—Inspectional and advisory service was provided in 1928 in connection with existing or proposed operations involving 2 iron-ore deposits on the Fort Apache Reservation and 2 asbestos mines on the San Carlos Reservation, Ariz.; 7 radium-ore leaseholds on the Northern Navajo Reservation, Ariz.; 3 volcanic-ash leaseholds on restricted lands of the Five Civilized Tribes, Oklahoma; and 1 marl and 3 metalliferous leaseholds on the Pyramid Lake Reservation, Nev.

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 its oil and gas technologic investigations; with the Bureau of Reclamation in reporting on the plant and coal mine at Williston, N. Dak.; with the National Research Council on the conservation of the scientific results of drilling and the improvement of drilling methods and equipment; with the Alaska Railroad in maintaining the Eska coal mine in condition for production; and with the General Land Office

and Bureau of Mines in extinguishing fires in coal deposits on the public domain.

In cooperation with the technical committee on the scientific classification of coals of the American Society for Testing Materials, the Bureau of Mines, and the fuel research laboratories of the Mines Branch, Department of Mines, Canada, many samples of subbituminous and low-rank bituminous coals were collected by the mining engineers of the Denver, Billings, and Salt Lake City offices. These samples were submitted to the Bureau of Mines, where slacking tests and analyses were made.

STATE BENEFITS AND COST OF SUPERVISION

Leases and permits involving publicly owned mineral deposits have been issued in 21 of the States and Alaska. Such States receive under the act of February 25, 1920, directly, without expense to themselves, 37.5 per cent of all royalties, rentals, and bonuses derived from leases and permits within their respective boundaries and participate likewise in the benefits resulting from the expenditure of an additional 52.5 per cent of the funds, by the Bureau of Reclamation. Only 10 per cent of this money is retained in the Treasury of the United States.

Alaska, however, receives all net profits from the operation of Government mines as well as all royalties and rentals received from leasing operations. This money is deposited in a special fund and applied to the reimbursement of the Federal Government for the construction of railroads in that territory.

Since the inception of the mineral leasing acts a total of $61,340,631.84 has accrued from royalty, rent, and bonuses. More than 99.5 per cent of this amount has been paid into the United States Treasury. Twenty States and Alaska have benefited thereby without expense to themselves.

Preliminary estimates indicate that the cost of the supervisory work of the mineral leasing division averaged less than 3 per cent of the aggregate income from the leases on public and Indian lands in the fiscal year 1929. This indicates a slight increase in supervisory cost compared with 1928, chargeable principally to the decline in the total value of the minerals produced.

WORK ON PUBLICATIONS

TEXTS

BERNARD H. LANE, Editor

During the year 16,601 pages of manuscript were edited and prepared for printing by the section of texts, and 2,677 galley proofs and 14,814 page proofs were read and corrected. Indexes were prepared for 31 publications, covering 6,291 pages. Copy and proof or stencils for 1,262 pages of multigraph and mimeograph matter were read. At the end of the fiscal year four persons were employed in this section.

ILLUSTRATIONS

C. A. WECKERLY, Chief Illustrator

The number of drawings and photographs prepared by the section of illustrations was 2,738, including 253 maps, 864 sections and diagrams, 512 photographs, and 1,109 paleontologic drawings; 181 miscellaneous jobs were also done by the section. The illustrations transmitted to accompany 36 reports numbered 819, to be reproduced by chromolithography, photolithography, half-tone, and zinc etching. The number of proofs received and examined was 969. At the end of the year material for illustrating 20 reports was in hand. The section consists of eight employees.

GEOLOGIC EDITING AND DRAFTING OF MAPS AND ILLUSTRATIONS

GEORGE W. STOSE, Editor of Geologic Maps

The geologic map of New Mexico was completed as a folio during the year. The Fairfield-Gettysburg (Pa.) folio was nearly completed, all but its structure maps having been printed. The maps and sections of the Coatesville-West Chester (Pa.) and Gaffney-Kings Mountain (S. C.-N. C.) folios reached stone proof. The maps of the Somerset-Windber (Pa.) and Montevallo-Columbiana (Ala.) folios were engraved. The maps of the Boston (Mass.) folio were approved for engraving. The Hollidaysburg-Huntingdon (Pa.) folio was prepared for engraving.

Maps and illustrations for 29 reports other than folios were edited for geology in the section, and 60 geologic maps and illustrations for 17 reports were drawn for geologists of the geologic branch. Material progress was made on the compilation of the geologic map of the United States. The geologic map of Virginia, compiled in the section in cooperation with the Virginia Geological Survey, was published during the year. The geologic map of Florida was edited and published for the Florida Geological Survey. The geologic map of Arkansas was edited and prepared for printing for the Arkansas Geological Survey, and the map reached color proof. The geologic map of Kentucky was edited and prepared for printing for the Kentucky Geological Survey, and the map was engraved. The compilation of the geologic map of Pennsylvania for the Pennsylvania Topographic and Geologic Survey was completed.

INSPECTION AND EDITING OF TOPOGRAPHIC MAPS

W. M. BEAMAN, Chief

During the year 57 new topographic maps were edited and transmitted for engraving, 164 published topographic maps, 9 State maps, and 11 State index circulars were edited for reprint, and 289 maps were edited as illustrations for Geological Survey reports—a total of 530 maps edited. First, second, combined, and woodland proofs of engravings for new topographic maps and reprints numbering 432 and proofs of maps reproduced by photolithography in one to three colors numbering 168 were read. At the end of the year 109 new topographic maps were in progress of engraving and printing and 154 new topographic maps and projects were in preparation for submission for reproduction.

DISTRIBUTION

R. C. SHELSE, Chief

A total of 334 publications, comprising 59 new books and pamphlets, 1 new geologic folio, 76 new or revised topographic and other maps, and 200 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 128,231 books and pamphlets, 5,140 geologic folios, and 758,542 topographic and other maps, a grand total of 891,913.

The division distributed 129,478 books and pamphlets, 9,826 geologic folios, and 835,851 maps, a grand total of 975,155, of which 8,910 geologic folios and 717,349 maps were sold. The sum received and deposited in the Treasury as the result of sales of publications was $49,289.38, including $45,050.14 for topographic and geologic maps and $4,239.24 for geologic folios. In addition to this $2,823.54 was repaid by other establishments of the Federal Government at whose request maps or folios were furnished. The total receipts, therefore, were $52,112.92.

The division received and answered 89,167 letters.

ENGRAVING AND PRINTING

S. J. KUBEL, Chief Engraver

During the fiscal year 67 new topographic maps were engraved and printed, including 7 revised maps. Two fractional sheets for Trempealeau County, Wis., were also engraved but not printed. Seven new maps were photolithographed and printed, and extra copies of 2 geologic maps from folios were printed, making a total of 76 new maps printed and delivered. Corrections were engraved on the plates of 164 maps. Reprint editions of 190 engraved topographic maps and 10 photolithographed State and other maps were printed and delivered. In addition, 52 new topographic maps had been engraved and were in press June 30, and the engraving of 16 other new topographic maps was nearly completed. Of new and reprinted maps, 261 different editions, amounting to 754,592 copies, were delivered. One new geologic folio was printed, its edition amounting to 5,140 copies. Extra geologic sheets of folios numbering 690 copies were also delivered.

OTHER GOVERNMENT MAP PRINTING

A large amount of work was done for the Government Printing Office, the office of the Secretary of the Interior, the Bureau of Reclamation, Bureau of Education, General Land Office, National Park Service, Office of Indian Affairs, Alaska Railroad, Bureau of Pensions, St. Elizabeths Hospital, Bureau of Public Roads, Bureau of Agricultural Economics, Bureau of Plant Industry, Forest Service, Bureau of Biological Survey, Bureau of Entomology, Weather Bureau, Plant Quarantine and Control Administration, Bureau of Standards, Bureau of Lighthouses, Bureau of Foreign and Domestic Commerce, Bureau of Mines, Bureau of Fisheries, Federal Radio Commission, Department of Labor, Department of State, War Department, Post Office Department, Treasury Department, Department of

Agriculture, Department of Commerce, Interstate Commerce Commission, Federal Power Commission, National Capital Park and Planning Commission, Commission of Fine Arts, International Boundary Commission, International Exposition (Seville, Spain), Smithsonian Institution, Bureau of the Public Health Service, Office of the Chief of Engineers, United States Marine Corps, Federal Board for Vocational Education, United States Veterans' Bureau, Architect of the Capitol, Washington Suburban Sanitary District, Library of Congress, Philadelphia Regional Planning Federation, Purdue University, and the States of New Hampshire, Georgia, New Mexico, Florida, Virginia, North Carolina, Tennessee, Texas, and Delaware. This work done for other branches of the Government and State governments included many reprints, and the charges for it amounted to about $135,000, for which the appropriation for engraving and printing geologic and topographic maps was reimbursed.

Transfer impressions numbering 400 were made during the year, including 200 furnished to contracting lithographic printers on requisition of the Government Printing Office, 5 furnished to other branches of the Government, 72 furnished to State surveys, and 123 furnished to private firms. The amount turned over to miscellaneous receipts was $633.15.

Of contract and miscellaneous work of all kinds, 2,611,671 copies were printed. Including topographic maps and geologic folios, a grand total of 3,372,093 copies were printed and delivered.

PHOTOGRAPHIC LABORATORY

The output of the photographic laboratory consisted of 11,103 negatives (4,215 wet, of which 3,408 were for photolithographs), 60 paper, 1,807 dry, and 5,021 field negatives), 645 lantern slides, 25,931 prints (4,085 maps and diagrams and 21,846 photographs for illustrations), 3,052 zinc plates, 201 zinc etchings, 47 celluloid prints, 99 lantern slides colored, 1 transparency colored, 24 prints colored, and 1,600 prints mounted.

ADMINISTRATION

JULIAN D. SEARS, Administrative Geologist

JOHN J. MADIGAN, Chief Clerk

The administrative geologist assists the director in all phases of general administration, performs special tasks assigned to him by the director from time to time, serves as acting director in the director's absence, and has special supervision over the section of illustrations.

The chief clerk, in addition to performing the duties usually pertaining to that office, serves as budget officer and exercises administrative supervision over the division of engraving and printing, the division of distribution, the section of correspondence and records, the section of accounts, the library, and the division of field equipment.

CORRESPONDENCE AND RECORDS

C. A. KING, Chief

The work of the section of correspondence and records was of the same general character as during the fiscal year 1928.

Mails, files, and records.—During the year 101,299 pieces of mail, of which 1,864 were registered, were opened and referred. In addition 160,162 letters were received direct by the other divisions, making a total of 261,461, a decrease of 6 per cent compared with 1928. Of the letters opened in this section 20,173 contained $49,614.94 remitted for Geological Survey publications. In addition $2,085.97 was received as direct office cash sales, making a total of $51,700.91. The number of ordinary letters mailed through the section was 62,351; of registered letters and packages, 952. In addition, 163,226 pieces of mail were sent out direct from other divisions. The total number of outgoing pieces of mail for the Geological Survey was 225,574.

Freight and express.—During the year 3,474 pieces of freight and express were handled, 1,798 outgoing and 1,676 incoming.

Personnel.—The roll of Secretary's appointees numbered 997 at the end of the fiscal year, 120 more than at the end of 1928. The total number of changes in personnel was 536, which included 252 appointments, 132 separations, and 152 miscellaneous changes.

During the calendar year 1927, 16,303 days of annual leave and 3,138 days of sick leave were granted, being 68 per cent of the amount of annual leave which could have been taken and 13 per cent of the sick leave it would have been possible to grant. In addition, 6,601 days of leave without pay and furloughs were granted.

LIBRARY

J. L. V. McCORD, Librarian

The year's accessions to the library comprised 13,271 books, pamphlets, and periodicals and 747 maps. The recorded loans were 6,391 books and 186 maps, in addition to those used by the 7,488 readers who consulted the library in person. The catalogue was increased by the addition of 7,616 cards. Title entries to the number of 422 were furnished to the Library of Congress for printing, the proof reading of which involved 121 galleys. Correspondence handled included 2,124 letters received and 2,063 letters sent. Letters and other writings in foreign languages to the number of 142 were translated for other divisions of the Geological Survey. Volumes to the number of 1,080 were collated and prepared for binding, and 573 newly bound volumes were labeled, plated, and shelf listed. Numerous loans were made to libraries both in Washington and in other places, and a considerable volume of reference work was done in the usual course of the library's service to specialists and students, both those in the Geological Survey and others. Work on the bibliography of North American geology has continued.

ACCOUNTS

C. K. FRANCIS, Chief

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, transferred to, and expended by the United States Geological Survey pertaining to the fiscal year ended June 30, 1929 [a]

	Funds available				Expenditures			
	Amount of appropriation	Repayments on account of work performed		Total	Disbursements	Outstanding liabilities	Total	Balance
		Made	To be made					
APPROPRIATIONS								
Salaries	$135,500.00			$135,500.00	$134,889.86		$134,889.86	$610.14
Topographic surveys	559,000.00	$318,482.45	$55,208.49	932,690.94	917,637.93	$13,141.36	930,779.29	1,911.65
Geologic surveys	355,000.00	25,401.31	3,565.98	383,967.29	375,506.20	7,662.70	383,168.90	798.39
Volcanologic surveys	21,000.00			21,000.00	18,954.65	1,750.88	20,705.53	294.47
Alaskan mineral resources	67,500.00	161.12		67,661.12	57,390.64	9,765.20	67,155.84	505.28
Gaging streams	270,500.00	413,051.77	25,299.39	708,851.16	693,551.82	12,294.25	705,846.07	3,005.09
Classification of lands	191,500.00	1,283.44	75.35	192,858.79	185,236.37	5,526.98	190,763.35	2,095.44
Geologic and topographic maps of the United States	110,000.00	110,708.27	23,627.48	244,335.75	227,140.54	15,939.63	243,080.17	1,255.58
Preparation of illustrations	26,480.00	60.43		26,540.43	26,101.87	2.88	26,104.75	435.68
Mineral leasing	246,000.00	1,593.83		247,593.83	240,090.41	4,665.89	244,756.30	2,837.53
Great Smoky Mountains National Park in North Carolina and Tennessee, 1928–29	65,000.00	53.32		65,053.32	64,860.98	181.43	65,042.41	10.91
Shenandoah National Park in Virginia, 1928–29	35,000.00	2,851.16		37,851.16	37,827.88	18.53	37,846.41	4.75
U. S. Geological Survey, 1927–1929 (mineral leasing)	20,000.00			20,000.00		14,850.00	14,850.00	5,150.00
U. S. Geological Survey, 1926–1929 (oil, gas, and oil shale)	20,000.00			20,000.00	574.70	10,175.00	10,749.70	9,250.30
Shenandoah National Park in Virginia, 1929–30	11,075.22			11,075.22	11,030.08	45.14	11,075.22	
Great Smoky Mountains National Park in North Carolina and Tennessee, 1929–30	2,054.16	6,072.80		8,126.96	7,435.97	690.99	8,126.96	
	[b] 2,135,609.38	879,719.90	107,776.69	3,123,105.97	2,998,229.90	96,710.86	3,094,940.76	28,165.21
TRANSFERS								
Engineering, Bureau of Engineering (Navy Department, act Mar. 7, 1928), 1929	43,000.00			43,000.00	42,445.47		42,445.47	554.53
Federal Power Commission (act Mar. 7, 1928), 1929	4,500.00			4,500.00	4,381.91	66.76	4,448.67	51.33
Flood control, Mississippi River and tributaries (War Department, act Mar. 7, 1928)	29,240.00	400.00	342.42	29,982.42	23,965.56	4,057.51	28,023.07	1,959.35
Helium plants, Bureau of Mines (Commerce Department, act Mar. 7, 1928), 1929	2,300.00	266.66		2,566.66	2,470.66	35.56	2,506.22	60.44
Investigating potash deposits, Bureau of Mines (Commerce Department, act Feb. 15, 1928), 1929	10,000.00			10,000.00	9,887.83	110.55	9,998.38	1.62
Maintenance and improvement of existing river and harbor works (War Department, act Mar. 7, 1928)	57,080.00		38.20	57,118.20	32,964.87	6,868.45	39,833.32	17,284.88
Salaries and expenses, Forest Service (Agriculture Department, act Mar. 7, 1928), 1929	1,121.63			1,121.63	1,121.63		1,121.63	
Southern Appalachian National Park (act May 21, 1920), 1926–27	2,000.00			2,000.00	2,000.00		2,000.00	

Supervising mining operations on leased Indian lands (act Mar. 7, 1928), 1929	60,000.00	3,114.63		63,114.63	62,957.69	156.94	63,114.63	
Supervising mining operations on leased Indian lands (act Mar. 4, 1929), 1929	10,000.00	3.00		10,003.00	9,646.08	356.92	10,003.00	
Water boundary, United States and Mexico (State Department, act Feb. 15, 1928), 1929	18,440.00	36.07		18,476.07	18,384.53	76.46	18,460.99	15.08
Waterways treaty, United States and Great Britain (State department, act Feb. 15, 1928), 1928–29	61,971.11	1,426.91	161.54	63,559.56	62,663.96	885.39	63,549.35	10.21
Waterways treaty, United States and Great Britain (State Department, act Mar. 4, 1929), 1929	11,800.00		22.89	11,822.89	7,066.68	2,204.24	9,270.92	2,551.97
	2,447,062.12	884,967.17	108,341.74	3,440,371.03	3,278,186.77	111,529.64	3,389,716.41	50,654.62

[a] In addition to these appropriations an item of $120,000 for printing and binding for the Geological Survey was contained in the appropriation act, but the account was not kept in the Geological Survey. There was also an allotment of $14,765.10 for miscellaneous supplies from the appropriation for contingent expenses of the Interior Department.

[b] This subtotal includes $146,400 supplemental appropriation on account of the act of May 28, 1928, and $20,000 for standard topographic surveys for expenditure in cooperation with States or municipalities, appropriated in the second deficiency act, fiscal year 1929, approved Mar. 4, 1929.

Classification of expenditures by the United States Geological Survey pertaining to the fiscal year ended June 30, 1929

Object of expenditure	Geological Survey salaries	Topographic surveys	Geologic surveys	Volcanologic surveys	Alaskan mineral resources	Gaging streams	Classification of lands	Geologic and topographic maps of the United States	Preparation of illustrations	Mineral leasing	Total
Personal services	$134,889.86	$725,200.72	$326,817.65	$17,686.61	$49,805.42	$536,716.89	$149,493.26	$194,725.21	$25,427.17	$280,886.83	$2,441,649.62
Stationery and office supplies		11,309.69	978.07	158.06	116.21	2,969.28	272.76	28,259.38		2,588.01	46,651.46
Scientific and educational supplies		247.13	1,299.67	12.72	17.00	156.74	214.15			108.34	2,055.75
Sundry supplies		5,574.16	865.11	188.43	372.07	3,171.12	234.55	6,549.17	3.02	727.16	17,684.79
Subsistence and care of animals and storage and care of vehicles		1,793.01	695.51			33.00	81.33			26.00	2,628.85
Telegraph service		1,006.36	238.03	7.53	35.65	918.69	61.13	1.56	.25	738.74	3,007.94
Telephone service		240.39	103.70	19.90	9.70	1,080.55	58.55			2,527.92	4,040.71
Other communication service		26.90		.45		20.25				142.30	189.90
Travel expenses		113,164.73	27,037.96	271.82	8,084.30	93,838.67	15,352.26		2.88	19,577.52	277,330.14
Attendance at meetings		96.96	825.10		38.61	300.68	23.78				1,285.13
Hire, maintenance, operation, and repair of horse-drawn and motor-propelled passenger-carrying vehicles		962.95	2,854.44	328.26		12,998.39	5,758.66			20,019.21	42,921.91
Transportation of things		48,008.15	7,173.91	163.41	3,774.14	20,790.53	3,631.84	140.77	1.04	1,785.24	85,469.03
Lithographing, engraving, and engrossing		10,795.69	527.31		332.11	957.35	1,809.95		256.13	201.43	14,879.97
Stenographic work, typewriting, and duplicating work, etc. (job work)						81.00	2.00			.25	83.25
Photographing and making photographs and prints		3,245.95	3,122.26	66.48	2,094.30	1,059.14	1,250.81	129.69	379.83	497.71	11,846.17
Heat, light, power, water, and electricity		8.33	81.29	32.00	20.08					4,378.33	4,520.03
Rents		153.60	4.00			2,752.20				7,886.94	10,796.74
Repairs and alterations		303.93	859.02	57.60	24.15	1,531.55	215.34	728.40		28,111.90	31,831.89
Special and miscellaneous current expenses		30,294.25	1,141.83		194.87	1,097.14	167.75	341.17		1,512.51	34,749.52
Purchase of passenger-carrying vehicles			1,149.30	538.00		6,856.68	3,417.00			5,030.40	16,991.38
Furniture, furnishings, and fixtures		1,430.16	215.10		592.59	3,247.11	632.23	1,105.88		3,526.60	10,749.67
Educational and scientific equipment		40,678.68	11,187.19	662.21	1,844.32	66,257.69	2,877.94	1,594.59	6.11	1,627.80	126,736.53
Livestock		125.80					90.00				215.80
Other equipment		39,708.60	6,333.47	512.05	203.49	73,300.94	3,518.49	9,396.44		789.31	133,762.79
Miscellaneous transfers and adjustments		20,494.15	2,163.58		718.46	39,296.80	1,599.57	107.91	28.32	3,228.65	67,637.44
	134,889.86	1,054,870.29	395,673.50	20,705.53	68,277.47	869,432.39	190,763.35	243,080.17	26,104.75	385,919.10	3,389,716.41

GEORGE OTIS SMITH, *Director.*

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