

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, 1932*

UNITED STATES DEPARTMENT OF THE INTERIOR

RAY LYMAN WILBUR, *Secretary*

GEOLOGICAL SURVEY

WALTER CURRAN MENDENHALL, *Director*

FIFTY-THIRD ANNUAL REPORT

OF THE

DIRECTOR OF
THE GEOLOGICAL SURVEY

TO THE

SECRETARY OF THE INTERIOR

FOR THE

FISCAL YEAR ENDED JUNE 30, 1932



UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1932

Directors of the Geological Survey

CLARENCE KING, 1879-1881

JOHN WESLEY POWELL, 1881-1894

CHARLES DOOLITTLE WALCOTT, 1894-1907

GEORGE OTIS SMITH, 1907-1936

WALTER CURRAN MENDENHALL, 1931-

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ANNUAL REPORT
OF THE
DIRECTOR OF THE GEOLOGICAL SURVEY

W. C. MENDENHALL, *Director*

DEPARTMENT OF THE INTERIOR,
GEOLOGICAL SURVEY,
October 15, 1932.

SIR: The appropriations made directly for the work of the Geological Survey for the fiscal year 1932 included 12 items, amounting to \$3,141,740. In addition \$12,573.23 for miscellaneous supplies was allotted from appropriations for the Interior Department.

A detailed statement of the amounts appropriated and expended is given at the end of the report. The balance on July 31 was \$206,411.98, of which \$150,000 continued available for expenditure in the fiscal year 1933.

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 \$5,115,087.50.

PUBLICATIONS OF THE YEAR

The following publications were issued during the fiscal year 1932:

ANNUAL REPORT

Fifty-second Annual Report of the Director of the Geological Survey.

PROFESSIONAL PAPERS

162. Geology and ore deposits of the Goodsprings quadrangle, Nev., by D. F. Hewett.
163. The significance of geologic conditions in Naval Petroleum Reserve No. 3, Wyo., by W. T. Thom, jr., and E. M. Spieker, with a section on the waters of the Salt Creek-Teapot Dome uplift, by Herman Stabler.
164. The Kaiparowits region, a geographic and geologic reconnaissance of parts of Utah and Arizona, by H. E. Gregory and R. C. Moore.
165. Shorter contributions to general geology, 1930; W. C. Mendenhall, chief geologist.
- 165-C. Geology of the eastern part of the Santa Monica Mountains, Los Angeles County, Calif., by H. W. Hoots.
168. Origin and microfossils of the oil shale of the Green River formation of Colorado and Utah, by W. H. Bradley.
169. Geology and ore deposits of the Bonanza mining district, Colorado, by W. S. Burbank, with a section on history and production, by C. W. Henderson.
- 170-A. Glaciation in Alaska, by S. R. Capps.

- 170-B. The Upper Cretaceous ammonite genus *Barroisiceras* in the United States, by J. B. Reeside, jr.
 170-C. A Miocene flora from Grand Coulee, Wash., by E. W. Berry.
 170-D. Pliocene fossils from limestone in southern Florida, by W. C. Mansfield.
 172. Gold quartz veins of the Allegheny district, Calif., by H. G. Ferguson and R. W. Gannett.

BULLETINS

818. Geology and mineral resources of the Cleveland district, Ohio, by H. P. Cushing, Frank Leverett, and F. R. Van Horn.
 824. Mineral resources of Alaska, report on progress of investigations in 1929, by P. S. Smith and others.
 824-B. The Slana district, upper Copper River region, Alaska, by F. H. Moffit.
 824-C. The Lake Clark-Mulchatna region, Alaska, by S. R. Capps.
 824-D. Mining in the Circle district, Alaska, by J. B. Mertie, jr.
 824-E. The occurrence of gypsum at Iyookeen Cove, Chichagof Island, Alaska, by B. D. Stewart.
 827. A geologic reconnaissance of the Dennison Fork district, Alaska, by J. B. Mertie, jr.
 828. Geology and mineral resources of the Quakertown-Doylestown district, Pennsylvania and New Jersey, by F. Bascom, E. T. Wherry, G. W. Stose, and A. I. Jonas.
 829. Geology and coal, oil, and gas resources of the New Kensington quadrangle, Pennsylvania, by G. B. Richardson.
 830-A. Copper deposits near Keating, Oreg., by James Gilluly.
 831-A. The Jackson gas field, Hinds and Rankin Counties, Miss., by W. H. Monroe.
 832. The crystal cavities of the New Jersey zeolite region, by W. T. Schaller.
 833. Mineralogy of drill cores from the potash field of New Mexico and Texas, by W. T. Schaller and E. P. Henderson.
 834. Bibliography of North American geology, 1929 and 1930, by J. M. Nickles.
 836-A. Mineral industry of Alaska in 1930 and Administrative report, by P. S. Smith.
 836-B. Notes on the geography and geology of Lituya Bay, Alaska, by J. B. Mertie, jr.
 836-C. Surface water supply of southeastern Alaska, 1909-1930, by F. F. Henshaw.
 838. Nitrate deposits of the United States, by G. R. Mansfield and Leona Boardman.

WATER-SUPPLY PAPERS

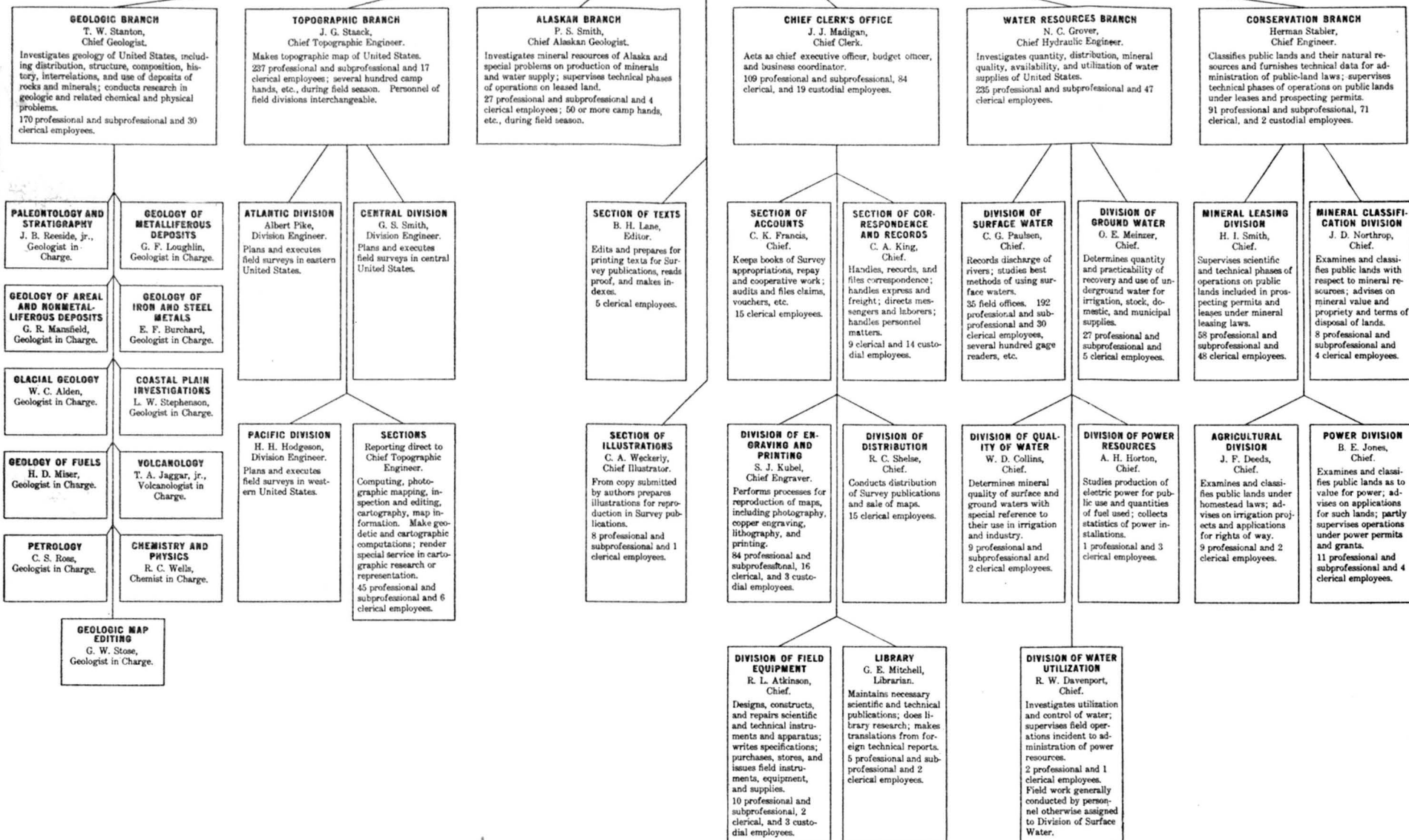
637. Contributions to the hydrology of the United States, 1930; N. C. Grover, chief hydraulic engineer.
 637-D. Geology and water resources of the middle Deschutes River Basin, Oregon, by H. T. Stearns.
 638-A. A preliminary report on the artesian water supply of Memphis, Tenn., by F. G. Wells.
 638-B. Water-power resources of the Rogue River drainage basin, Oregon, by B. E. Jones, Warren Oakey, and H. T. Stearns.
 638-C. Outline of methods for estimating ground-water supplies, by O. E. Meinzer.
 638-D. Quality of water of the Colorado River in 1928-1930, by C. S. Howard.

Papers on surface water supply of the United States as follows:

642. 1927, Part 2, South Atlantic slope and eastern Gulf of Mexico basins.
 651. 1927, Part 11, Pacific slope basins in California.
 652. 1927, Part 12, North Pacific slope drainage basins: A, Pacific slope basins in Washington and upper Columbia River Basin.
 653. 1927, Part 12, North Pacific slope drainage basins: B, Snake River Basin.
 654. 1927, Part 12, North Pacific slope drainage basins: C, Pacific slope basins in Oregon and lower Columbia River Basin.
 661. 1928, Part 1, North Atlantic slope drainage basins.
 662. 1928, Part 2, South Atlantic slope and eastern Gulf of Mexico basins.
 663. 1928, Part 3, Ohio River basin.
 664. 1928, Part 4, St. Lawrence River Basin.

**DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY**

DIRECTOR
W. C. Mendenhall
Directs scientific investigations of Geological Survey and makes its activities available to the public.
ADMINISTRATIVE GEOLOGIST
Julian D. Sears
Acts as scientific, technical, and administrative assistant of Director and at times serves as acting Director during his absence. Conducts investigations in special fields of geologic work.



ORGANIZATION JUNE 30, 1932

665. 1928, Part 5, Hudson Bay and upper Mississippi River Basins.
666. 1928, Part 6, Missouri River Basin.
667. 1928, Part 7, Lower Mississippi River Basin.
668. 1928, Part 8, Western Gulf of Mexico basins.
669. 1928, Part 9, Colorado River Basin.
670. 1928, Part 10, The Great Basin.
671. 1928, Part 11, Pacific slope basins in California.
672. 1928, Part 12, North Pacific slope drainage basins: A, Pacific slope basins in Washington and upper Columbia River Basin.
673. 1928, Part 12, North Pacific slope drainage basins: B, Snake River Basin.
674. 1928, Part 12, North Pacific slope drainage basins: C, Pacific slope basins in Oregon and lower Columbia River Basin.
675. Hawaii, July 1, 1927, to June 30, 1928.
681. 1929, Part 1, North Atlantic slope drainage basins.
682. 1929, Part 2, South Atlantic slope and eastern Gulf of Mexico basins.
683. 1929, Part 3, Ohio River Basin.
684. 1929, Part 4, St. Lawrence River Basin.
685. 1929, Part 5, Hudson Bay and upper Mississippi River basins.
686. 1929, Part 6, Missouri River Basin.
687. 1929, Part 7, Lower Mississippi River Basin.
688. 1929, Part 8, Western Gulf of Mexico basins.
689. 1929, Part 9, Colorado River Basin.
690. 1929, Part 10, The Great Basin.
691. 1929, Part 11, Pacific slope basins in California.
692. 1929, Part 12, North Pacific slope drainage basins: A, Pacific slope basins in Washington and upper Columbia River Basin.
693. 1929, Part 12, North Pacific slope drainage basins: B, Snake River Basin.
694. 1929, Part 12, North Pacific slope drainage basins: C, Pacific slope basins in Oregon and lower Columbia River Basin.
696. 1930, Part 1, North Atlantic slope drainage basins.
699. 1930, Part 4, St. Lawrence River Basin.
701. 1930, Part 6, Missouri River Basin.
702. 1930, Part 7, Lower Mississippi River Basin.
703. 1930, Part 8, Western Gulf of Mexico basins.
704. 1930, Part 9, Colorado River Basin.
705. 1930, Part 10, The Great Basin.
706. 1930, Part 11, Pacific slope basins in California.
707. 1930, Part 12, North Pacific slope drainage basins: A, Pacific slope basins in Washington and upper Columbia River Basin.
708. 1930, Part 12, North Pacific slope drainage basins: B, Snake River Basin.

GEOLOGIC FOLIO

222. Gaffney-Kings Mountain, S. C.-N. C., by Arthur Keith and D. B. Sterrett.

TOPOGRAPHIC AND OTHER MAPS

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

Alabama:

Eutaw (32° 45'-33°; 87° 45'-88°).

Alaska:

Lower Matanuska Valley (61° 39'-61° 53'; 147° 55'-149° 10').

Alaska, scale 1 inch=39.5 miles.

California:

Arroyo Sequit (34°-34° 6'; 118° 54'-119°).

Buttonwillow (35° 22' 30''-35° 30'; 119° 22' 30''-119° 30').

Deepwell Ranch (35° 37' 30''-35° 45'; 119°-119° 7' 30'').

Delta Farms (36° 15'-36° 22' 30''; 120° 7' 30''-120° 15').

East Elk Hills (35° 15'-35° 22' 30''; 119° 22' 30''-119° 30').

Edison (35° 15'-35° 22' 30''; 118° 45'-118° 52' 30'').

Goose Lake (35° 30'-35° 37' 30''; 119° 30'-119° 37' 30'').

Gosford (35° 15'-35° 22' 30''; 119°-119° 7' 30'').

Humphreys (34° 24'-34° 30'; 118° 24'-118° 30').

Las Flores (34°-34° 6'; 118° 36'-118° 42').

Mouth of Cantua Creek (36° 22' 30''-36° 30'; 120° 15'-120° 22' 30'').

Rio Bravo (35° 22' 30''-35° 30'; 119° 15'-119° 22' 30'').

California—Continued.

Russell Valley (34° 6'–34° 12'; 118° 48'–118° 54').
 Seminole (34° 6'–34° 12'; 118° 42'–118° 48').
 Towne Oil Station (36° 22' 30''–36° 30'; 120° 7' 30''–120° 15').
 West Elk Hills (35° 15'–35° 22' 30''; 119° 30'–119° 37' 30'').
 West of Lethent (36° 15'–36° 22' 30''; 120°–120° 7' 30'').
 Wheatville (36° 22' 30''–36° 30'; 120°–120° 7' 30'').

Hawaii:

Hilo (19° 30'–19° 45'; 155°–155° 15').
 Waikii (19° 45'–20°; 155° 30'–155° 45').

Idaho:

Bayhorse (44°–44° 30'; 114°–114° 30').
 Salmon River, plan and profile, scale 1 inch=½ mile.

Idaho-Wyoming:

Snake River, plan and profile, scale 1 inch=½ mile except on Sheet D.

Illinois (see also Kentucky-Illinois):

Arenzville (39° 45'–40°; 90° 15'–90° 30').
 Barry (39° 30'–39° 45'; 91°–91° 15').
 Brussels (38° 45'–39°; 90° 30'–90° 45').
 Edwardsville (38° 45'–39°; 89° 45'–90°).
 Hannibal (39° 30'–39° 45'; 91° 15'–91° 30').
 Mackinaw (40° 30'–40° 45'; 89° 15'–89° 30').
 Manio (40° 15'–40° 30'; 89° 45'–90°).
 Meredosia (39° 45'–40°; 90° 30'–90° 45').

Indiana (see Kentucky-Indiana).

Indiana-Kentucky-Ohio:

Lawrenceburg (39°–39° 15'; 84° 45'–85°).

Iowa:

Indianola (41° 15'–41° 30'; 93° 30'–93° 45').

Kentucky (see also Indiana-Kentucky-Ohio; Ohio-Kentucky; and Tennessee-Kentucky).

Adolphus (36° 30'–36° 45'; 86° 15'–86° 30').
 Big Clifty (37° 30'–37° 45'; 86°–86° 15').
 Burnside (36° 45'–37°; 84° 30'–84° 45').
 Corydon (38°–38° 15'; 86°–86° 15').
 Eddyville (37°–37° 15'; 88°–88° 15').
 Fordsville (37° 30'–37° 45'; 86° 30'–86° 45').
 Hardinsburg (37° 45'–38°; 86° 15'–86° 30').
 Lafayette (36° 30'–36° 45'; 86°–86° 15').
 New Castle (38° 15'–38° 30'; 85°–85° 15').

Kentucky-Illinois:

La Center (37°–37° 15'; 88° 45'–89°).

Kentucky-Indiana:

La Grange (38° 15'–38° 30'; 85° 15'–85° 30').

Maine:

Caribou (46° 45'–47°; 68°–68° 15').
 Eagle Lake (47°–47° 15'; 68° 30'–68° 45').
 Great Pond (44° 45'–45°; 68° 15'–68° 30').
 Portage (46° 45'–47°; 68° 15'–68° 30').
 Robbinston (45°–45° 15'; 67°–67° 15').
 Skinner (45° 30'–45° 45'; 70° 30'–70° 45').
 Spencer (45° 15'–45° 30'; 70° 15'–70° 30').

Maryland (see Virginia-Maryland).

Michigan:

Bangor (42° 15'–42° 30'; 86°–86° 15').
 Holland (42° 45'–43°; 86°–86° 15').

Missouri:

Fulton (38° 45'–39°; 91° 45'–92°).
 Mexico (39°–39° 15'; 91° 45'–92°).

Montana:

National Bison Range (47° 17' 30''–47° 22' 30''; 114° 10'–114° 17' 30'').

New Hampshire:

Franconia (44°–44° 15'; 71° 30'–71° 45').
 Littleton (44° 15'–44° 30'; 71° 45'–72°).
 Mount Chocorua (43° 45'–44°; 71° 15'–71° 30').
 Plymouth (43° 45'–44°; 71° 30'–71° 45').
 Rumney (43° 45'–44°; 71° 45'–72°).

New Hampshire-Vermont:

Mascoma ($43^{\circ} 30' - 43^{\circ} 45'$; $72^{\circ} - 72^{\circ} 15'$).

New Mexico:

Kirtland ($36^{\circ} 15' - 36^{\circ} 45'$; $108^{\circ} 15' - 108^{\circ} 45'$).Magdalena district ($34^{\circ} 3' 15'' - 34^{\circ} 9' 30''$; $107^{\circ} 10' 45'' - 107^{\circ} 13' 30''$).

New York (see also Pennsylvania-New York).

Amsterdam ($42^{\circ} 45' - 43^{\circ}$; $74^{\circ} - 74^{\circ} 15'$).

North Carolina (see Virginia-North Carolina).

North Dakota:

Flora ($47^{\circ} 45' - 48^{\circ}$; $99^{\circ} 15' - 99^{\circ} 30'$).Grahams Island ($48^{\circ} - 48^{\circ} 15'$; $99^{\circ} - 99^{\circ} 15'$).Oberon ($47^{\circ} 45' - 48^{\circ}$; $99^{\circ} - 99^{\circ} 15'$).Tokyo ($47^{\circ} 45' - 48^{\circ}$; $98^{\circ} 45' - 99^{\circ}$).

Ohio (see Indiana-Kentucky-Ohio).

Ohio-Kentucky:

Felicity ($38^{\circ} 45' - 39^{\circ}$; $84^{\circ} - 84^{\circ} 15'$).Higginsport ($38^{\circ} 45' - 39^{\circ}$; $83^{\circ} 45' - 84^{\circ}$).

Oklahoma:

Drumright ($35^{\circ} 45' - 36^{\circ}$; $96^{\circ} 30' - 96^{\circ} 45'$).Fairfax ($36^{\circ} 30' - 36^{\circ} 45'$; $96^{\circ} 30' - 96^{\circ} 45'$).Ripley ($36^{\circ} - 36^{\circ} 15'$; $96^{\circ} 45' - 97^{\circ}$).Skedee ($36^{\circ} 15' - 36^{\circ} 30'$; $96^{\circ} 30' - 96^{\circ} 45'$).Stroud ($35^{\circ} 30' - 35^{\circ} 45'$; $96^{\circ} 30' - 96^{\circ} 45'$).Yale ($36^{\circ} - 36^{\circ} 15'$; $96^{\circ} 30' - 96^{\circ} 45'$).

Oregon:

Madras ($44^{\circ} 30' - 45^{\circ}$; $121^{\circ} - 121^{\circ} 30'$).Three Sisters ($44^{\circ} - 44^{\circ} 30'$; $121^{\circ} 30' - 122^{\circ}$).

Pennsylvania:

Clearville ($39^{\circ} 45' - 40^{\circ}$; $78^{\circ} 15' - 78^{\circ} 30'$).Eagles Mere ($41^{\circ} 15' - 41^{\circ} 30'$; $76^{\circ} 30' - 76^{\circ} 45'$).Hyndman ($39^{\circ} 45' - 40^{\circ}$; $78^{\circ} 30' - 78^{\circ} 45'$).Karthaus ($41^{\circ} - 41^{\circ} 15'$; $78^{\circ} - 78^{\circ} 15'$).Snow Shoe ($41^{\circ} - 41^{\circ} 15'$; $77^{\circ} 45' - 78^{\circ}$).Townville ($41^{\circ} 30' - 41^{\circ} 45'$; $79^{\circ} 45' - 80^{\circ}$).

Pennsylvania-New York:

Corry ($41^{\circ} 45' - 42^{\circ}$; $79^{\circ} 30' - 79^{\circ} 45'$).Union City ($41^{\circ} 45' - 42^{\circ}$; $79^{\circ} 45' - 80^{\circ}$).

Standard symbols adopted by the Board of Surveys and Maps, United States of America. Chart, 22 by 33 inches.

Tennessee-Kentucky:

Red Boiling Springs ($36^{\circ} 30' - 36^{\circ} 45'$; $85^{\circ} 45' - 86^{\circ}$).

Texas:

Archer City ($33^{\circ} 30' - 33^{\circ} 45'$; $98^{\circ} 30' - 98^{\circ} 45'$).Aspermont ($33^{\circ} - 33^{\circ} 15'$; $100^{\circ} - 100^{\circ} 15'$).Beaumont ($30^{\circ} - 30^{\circ} 15'$; $94^{\circ} - 94^{\circ} 15'$).Bend ($31^{\circ} - 31^{\circ} 15'$; $98^{\circ} 30' - 98^{\circ} 45'$).Camp Springs ($32^{\circ} 45' - 33^{\circ}$; $100^{\circ} 30' - 100^{\circ} 45'$).Dennis ($32^{\circ} 30' - 32^{\circ} 45'$; $97^{\circ} 45' - 98^{\circ}$).Dundee ($33^{\circ} 30' - 33^{\circ} 45'$; $98^{\circ} 45' - 99^{\circ}$).Elm Mott ($31^{\circ} 30' - 31^{\circ} 45'$; $97^{\circ} - 97^{\circ} 15'$).Iola ($30^{\circ} 45' - 31^{\circ}$; $96^{\circ} - 96^{\circ} 15'$).Junction ($30^{\circ} 15' - 30^{\circ} 30'$; $99^{\circ} 45' - 100^{\circ}$).McGregor ($31^{\circ} 15' - 31^{\circ} 30'$; $97^{\circ} 15' - 97^{\circ} 30'$).Manning ($31^{\circ} - 31^{\circ} 15'$; $94^{\circ} 30' - 94^{\circ} 45'$).Morgan ($32^{\circ} - 32^{\circ} 15'$; $97^{\circ} 30' - 97^{\circ} 45'$).Mullin ($31^{\circ} 30' - 31^{\circ} 45'$; $98^{\circ} 30' - 98^{\circ} 45'$).Orange ($30^{\circ} - 30^{\circ} 15'$; $93^{\circ} 30' - 93^{\circ} 45'$).Orla ($31^{\circ} 45' - 32^{\circ}$; $103^{\circ} 45' - 104^{\circ}$).Paint Rock ($31^{\circ} 30' - 31^{\circ} 45'$; $99^{\circ} 45' - 100^{\circ}$).Rotan ($32^{\circ} 45' - 33^{\circ}$; $100^{\circ} 15' - 100^{\circ} 30'$).Rule ($33^{\circ} - 33^{\circ} 15'$; $99^{\circ} 45' - 100^{\circ}$).Springtown ($32^{\circ} 45' - 33^{\circ}$; $97^{\circ} 30' - 97^{\circ} 45'$).Stacy ($31^{\circ} 15' - 31^{\circ} 30'$; $99^{\circ} 30' - 99^{\circ} 45'$).Terry ($30^{\circ} - 30^{\circ} 15'$; $93^{\circ} 45' - 94^{\circ}$).Tow ($30^{\circ} 45' - 31^{\circ}$; $98^{\circ} 15' - 98^{\circ} 30'$).Valley Mills ($31^{\circ} 30' - 31^{\circ} 45'$; $97^{\circ} 15' - 97^{\circ} 30'$).Valley Wells ($28^{\circ} 15' - 28^{\circ} 30'$; $99^{\circ} 30' - 99^{\circ} 45'$).

Texas—Continued.

Vivian (34°-34° 15'; 99° 45'-100°).
 Voss (31° 30'-31° 45'; 99° 30'-99° 45').
 Whitney (31° 45'-32°; 97° 15'-97° 30').
 Zavalla (31°-31° 15'; 94° 15'-94° 30').

United States:

United States, scale 1 inch=40 miles.

Vermont (See New Hampshire-Vermont).

Virginia:

Colonial National Monument, Yorktown Battlefield (37° 11' 33''-37° 15' 14''; 76° 29'-76° 33').

Virginia-Maryland:

Wakefield (38°-38° 15'; 76° 45'-77°).

Virginia-North Carolina:

Stuart (36° 30'-36° 45'; 80° 15'-80° 30').

West Virginia:

Bald Knob (37° 45'-38°; 81° 30'-81° 45').
 Beckley (37° 45'-38°; 81°-81° 15').
 Eccles (37° 45'-38°; 81° 15'-81° 30').
 Fayetteville (38°-38° 15'; 81°-81° 15').
 Flattop (37° 30'-37° 45'; 81°-81° 15').
 Madison (38°-38° 15'; 81° 45'-82°).
 Montgomery (38°-38° 15'; 81° 15'-81° 30').
 Peytona (38°-38° 15'; 81° 30'-81° 45').

Wisconsin:

Alma (44° 15'-44° 30'; 91° 45'-92°).
 Cochrane (44°-44° 15'; 91° 45'-92°).
 Durand (44° 30'-44° 45'; 91° 45'-92°).
 Ferryville (43° 15'-43° 30'; 91°-91° 15').
 Gilmanton (44° 15'-44° 30'; 91° 30'-91° 45').
 Mondovi (44° 30'-44° 45'; 91° 30'-91° 45').
 Prairie du Chien (43°-43° 15'; 91°-91° 15').
 Wabasha (44° 15'-44° 30'; 92°-92° 15').

Wyoming (see Idaho-Wyoming).

THE YEAR'S OPERATIONS

Among the outstanding publications of the year are Professional Paper 163, on the significance of geologic conditions in Naval Petroleum Reserve No. 3 (Teapot Dome); Professional Paper 164, giving the results of a geographic and geologic reconnaissance of the Kaiparowits region, a large, little-known area in Utah and Arizona; Professional Paper 169, on the geology and ore deposits of the Bonanza mining district, Colorado; Professional Paper 172, on the gold quartz veins of the Alleghany district, California; Bulletin 833, on the mineralogy of drill cores from the potash field of New Mexico and Texas; and Water-Supply Paper 638-C, an outline of methods for estimating ground-water supplies.

A summary of the year's operations is given below.

GEOLOGIC WORK

The geologic work of the year was varied and widely distributed. It included economic and general studies of many mining districts in Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, and Oregon; of lead and zinc deposits in Virginia; of iron ores in Alabama and the Lake Superior district; of coal fields in Montana, New Mexico, Oklahoma, and Utah; of oil fields and prospective oil and gas areas in California, Colorado, Mississippi, and Utah. Much of this work was carried on in cooperation with State surveys and other organizations.

The field work incident to the drilling of the last four wells of the 5-year potash exploration program was completed at the end of the year, but much laboratory and office work must still be done before all the stratigraphic and economic results of the investigation can be made available.

Areal mapping and stratigraphic, structural, and general geologic investigations were carried on in many areas in the Appalachian region, the Coastal Plain, and other parts of the country. Geologic work was done in 43 States in addition to the work of the volcanologic section in Hawaii, Alaska, and California.

EXPLORATIONS IN ALASKA

The work of the Geological Survey in Alaska, begun more than 30 years ago, is still in large part pioneer service under frontier conditions, though airplanes are being used for transportation to some of the remote camps. In the field season of 1931 eight field projects resulted in the geologic mapping of 5,976 square miles, of which 1,986 square miles represented revision on a larger scale of earlier surveys, and the topographic mapping of 5,680 square miles, of which 1,037 square miles represented revision. The Bureau of Mines cooperated in one of these projects. Of the total area of Alaska, 44.4 per cent has now been covered by geologic surveys and 47.3 per cent by topographic surveys. The broad survey of recent mining developments, the collection of mining statistics, and the supervision of operations under coal and oil leases on Government lands were continued. Progress in compiling drainage maps from the Navy Department aerial photographs added more than 1,000 square miles to the areas thus covered.

At the beginning of the fiscal year work had been started on 7 field projects chargeable to funds appropriated directly to the Geological Survey and 10 field projects undertaken under a special appropriation to the Alaska Railroad to discover resources that may contribute to railroad tonnage, funds being transferred to the Geological Survey for this purpose. The railroad projects included examinations in one coal area, five gold districts, and three areas where the lodes consist mainly of mixed sulphides and a general investigation of non-metalliferous deposits throughout the railroad belt. Cooperation in this work was furnished by the Bureau of Mines and the Alaska Road Commission.

Under the special appropriation to the Alaska Railroad contracts were let, in the spring of 1932, for core drilling in both the Moose Creek and Chickaloon coal areas to determine the areal extent and quality of coal in undeveloped portions of those fields. This work was carried out under direction of the Geological Survey.

TOPOGRAPHIC MAPPING

The topographic maps prepared as an essential base for detailed geologic mapping have proved to have hundreds of other uses, and the general realization of their value is shown in the increasing funds made available by States and other Federal units for cooperation in this work. The State cooperative funds during the year amounted to \$382,804.06 and were furnished by 15 States and 2 counties. Cooperation was furnished by the War Department in eight States, and by the Department of Justice in one State. The area mapped during the year amounted to 25,893 square miles, and the total area now mapped is 1,375,644 square miles. Ten States, the District of Columbia, and Hawaii are completely mapped, and the percentages in the other States range from 8 in Florida to 88.9 in Virginia. Of the continental United States, exclusive of Alaska, 45.2 per cent has been mapped. Office mapping from aerial photographs, by stereophotogrammetric methods, was completed for the Zion National Park and nearly completed for the Bryce Canyon National Park, both in Utah. An experimental project with a new 5-lens camera used at high altitudes, undertaken in cooperation with the Air Corps, United States Army, promises to reduce the amount of control needed. Maps were compiled and other illustrations assembled for publication in the George Washington Atlas.

INVESTIGATIONS OF WATER RESOURCES

The work on water resources consists primarily of the collection of facts in regard to the quantity, quality, availability, and utilization of water. The widespread interest in the availability of water for many uses has led to a persistent and increasing demand for reliable data that would serve as a basis for safe and sane developments. The work is done largely in cooperation with other Government organizations, 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 \$548,337.64. This sum covered work in 40 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 48 States, the District of Columbia, and Hawaii, in which at the end of the year 2,791 gaging stations were being maintained. In this work 39 of the States cooperated. Investigations relating to ground water or power and reservoir sites were made in 25 States, 15 of which cooperated, and in Hawaii. Research into the principles of hydrology and cooperation with well drillers' associations have been continued. In the hydrologic laboratory 283 samples of water-bearing material were analyzed. The work on quality of water involved the examination of 1,025 samples of water. Studies of the dissolved and suspended matter in the Colorado River and its tributaries were continued. The investigations of power resources included the preparation of monthly and annual reports on the production of electricity and consumption of fuel by public-utility power plants, a report on the developed water power of the United States, and compilations of the stocks of coal held by electric public-utility power plants.

Studies of water utilization and flood control were continued and included investigations relating to the apportionment of water on international streams. Special field work was done in connection with 130 projects of the Federal Power Commission.

WORK IN CLASSIFYING AND LEASING PUBLIC LANDS

The classification of public lands with respect to their 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 were continued in 21 States and Alaska. The number of cases involving land classification acted on during the year was 12,913, and the results accomplished include net decreases of 816,873 acres in outstanding withdrawals for coal, of 54,100 acres in areas classified as oil-shale land, and of 115,293 acres in outstanding withdrawals for phosphate, and net increases of 508,480 acres in areas classified as coal and of 1,737 acres in areas classified as phosphate. At the end of the year the total area classified as mineral in character amounted to 36,889,563 acres in 14 States and Alaska, and the outstanding mineral withdrawals to 45,434,202 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 843,106 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 40,712 acres in the area included in power reserves, making a total of 6,577,185 acres in 21 States and Alaska, on which about 15,000,000 continuous horsepower can be developed. The net decrease in enlarged-homestead designations was 3,135,666 acres, making a total outstanding of 314,348,866 acres in 14 States, and the net increase in stock-raising homestead designations was 817,868 acres, making a total outstanding of 123,596,586 acres in 19 States. There was a net increase of 9,483 acres in public water reserves, and the total outstanding is now 447,836 acres in 12 States and Alaska. The supervisory work on public lands subject to the mineral leasing laws was increased by the issuance of 89 leases, 46 licenses, and 237 permits, covering 408,744.75 acres, and decreased by 1,304 cancellations and expirations of leases, permits, and licenses. The production of petroleum on such lands during the year was 26,454,217.11 barrels, of natural gas 50,876,816,000 cubic feet, and of gasoline 97,937,827.90 gallons, on which the royalty, rentals, and bonuses amounted to \$3,097,682.87. The production of coal on such lands was 2,880,448 tons, of phosphate rock 33,099 tons, of potash 45,967 tons, and of sodium salts 32,895 tons, on which the accrued royalty, rentals, and bonuses amounted to \$403,787.65. Supervision over oil and gas operations on naval petroleum reserves was continued, and the total production was 3,919,625.61 barrels of petroleum, 4,442,014,000 cubic feet of natural gas, and 18,539,144 gallons of gasoline, on which the royalty value was \$690,188.27. Inspectional, regulatory, and advisory service was rendered in connection with the leasing of mineral deposits on Indian lands in eight States. In general the demands for engineering advice and assistance are increasing as the supervisory duties under the leasing laws are more clearly defined and enlarged, and as the competence and impartiality of the supervisors become more widely known.

PUBLICATIONS

The publications of the year consisted of 82 books and pamphlets of the regular series, 141 new or revised maps, 378 reprinted maps, and numerous circulars, lists of publications, etc. The numbers of books and maps issued showed increases from 1931 ranging from 74 to 97 per cent. The total number of pages in the new book publications was 11,238, an increase of 30 per cent. In addition to the publications in the regular series, 71 brief reports, a few of them accompanied by maps, were issued in mimeographed form as memoranda for the press. The publications distributed numbered 893,438, of which 3,877 folios and 547,746 maps were sold for \$34,737.32.

GEOLOGIC BRANCH

T. W. STANTON, Chief Geologist

ORGANIZATION AND PERSONNEL

The administration of the geologic branch continued during the year to be conducted through 11 sections, as follows:

- Paleontology and stratigraphy, J. B. Reeside, jr., 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, R. C. Wells, chemist, in charge.
- Geologic map editing, G. W. Stose, geologist, in charge.

Timothy W. Stanton was acting chief geologist until February 1, 1932, when he became chief geologist, and J. B. Reeside, jr., was made geologist in charge of the section of paleontology and stratigraphy.

At the end of the year the professional force included 132 geologists of various grades, many of whom are not employed continuously, 1 associate engineer, 9 chemists, and 3 physicists. The sub-professional force comprises 7 draftsmen (2 temporary), 1 chief scientific aid, 10 scientific aids (1 temporary), and 2 scientific helpers. The clerical force includes 28 clerks and 1 skilled laborer. The total number of employees in the branch is 194, and the changes during the year resulted in a net decrease of 5.

With the end of the fiscal year, under the provisions of the retirement section of the Federal economy act, the Geological Survey loses three well-known geologists who have to their credit many years of faithful and effective service.

Marius Robinson Campbell joined the Survey as a geologic aid in 1889 and has served continuously since then. The larger part of this time was given to the geology of coal fields, first in the Appalachian region, where he prepared several folios for the Geologic Atlas, and later in the Mississippi Valley and Rocky Mountain regions, and for some years with general supervision of all the work on the geology of fuels. He has also made valuable contributions to the classification of coal and to geomorphic studies in the Appalachian region as well as in the Rocky Mountain States.

Frank Charles Schrader began his work for the Geological Survey in 1896 and spent five years in exploratory geologic work in Alaska

in the pioneer days, soon after gold mining became active there. His further activities included areal mapping in Kansas, reconnaissance of coal fields in Colorado and Wyoming, and, during the last 25 years, the examination of metal-mining districts in Arizona, Idaho, Montana, Nevada, and Wyoming.

Edward Oscar Ulrich was recognized as an authority on the geology of the Mississippi Valley region when he joined the Survey in 1899. In his special fields of the Paleozoic stratigraphy, paleontology, and paleogeography he has won eminent distinction throughout the world. As chief adviser and arbiter on questions of Paleozoic stratigraphy and correlation, his services have been and are still frequently sought by the State geologists of many States, including Maryland, Virginia, Tennessee, Michigan, Wisconsin, Illinois, Missouri, and Oklahoma.

ALLOTMENTS AND EXPENDITURES

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

| | |
|--|------------|
| Geologic surveys..... | \$400, 000 |
| Research in geologic science..... | 100, 000 |
| Volcanologic surveys..... | 35, 000 |
| Classification of lands..... | 20, 000 |
| Repayments from other Federal departments..... | 1, 046 |
| Repayments from State and other cooperating organizations..... | 26, 006 |
| | <hr/> |
| | 582, 052 |

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

| | |
|--|------------|
| Geologic investigations (economic and scientific, including volcanologic)..... | \$472, 348 |
| Supervision, administration, services of clerical, technical, and skilled-labor forces, etc..... | 107, 854 |
| Unexpended balances..... | 1, 850 |
| | <hr/> |
| | 582, 052 |

WORK OF THE GEOLOGIC BRANCH

The work of the geologic branch is divided between fundamental geology and applied geology—between the development of the general principles and the discovery of the fundamental facts on which the science of geology is based and the application of those facts and principles in the discovery and investigation of the mineral resources of the country.

The purpose of its studies and surveys is to determine, as accurately as possible, the reserve supplies of coal, petroleum, and other minerals on the public domain; to aid the great metal-mining industry by making more comprehensive studies of mineralized districts and of the geologic history of the larger regions in which they lie than can ordinarily be made by individuals or mining companies, and thus to discover guiding principles of ore deposition that may lead to the finding of new sources of supply; to study the deposits of iron, manganese, chrome, and other raw materials necessary for the manufacture of steel; to continue the search for and investigation of possible further supplies of minerals of which the domestic supply

is still inadequate; to make fundamental contributions to the geology of mineral fuels by investigating the source rocks of petroleum and the structure and constitution of coals; to work out the geomorphic development and the glacial history of the country; to determine the details of stratigraphy, structure, and lithology of the sedimentary rocks and the chemical and mineral composition of igneous rocks; to describe and locate the successive fossil faunas and floras as essential elements in detailed studies of stratigraphy and correlation; to make available to the public trustworthy descriptions and explanations of the more remarkable natural features of the country; to keep accurate records of volcanic activity, earthquakes, and other earth movements; and in general to make the Geological Survey an efficient clearing house for full and accurate information on the geology and mineral resources of the country.

Cooperation in certain phases of geologic work with several of the States was continued throughout the year. Special mention should be made of the study of metal-mining districts in Colorado which has been actively prosecuted for several years. Similar cooperative work has been carried on in Idaho, Nevada, and New Mexico. The lead and zinc deposits of Virginia and the general geology of the valley of Virginia have been studied in cooperation with the State geological survey. The investigation of the mining districts and mineral resources of Oregon was continued with the aid of an unexpended balance of State funds previously appropriated. The geologic map of Texas, now in process of publication, was completed in cooperation with the State bureau of economic geology.

Research work was continued along varied lines of study in petrology, mineralogy, paleontology, stratigraphy, and mineralogy. The principal new projects undertaken deal with the source rocks of petroleum, the structure and constitution of coal, and the systematic study of diatoms.

The varied character of the work of the branch is exhibited in some detail under the heading "Work in geology by States."

INTERNATIONAL GEOLOGICAL CONGRESS

Guidebooks for the excursions of the International Geological Congress to be held in Washington in July, 1933, have been prepared by members of the Geological Survey and other geologists. Most of the guidebooks contain contributions by several authors and are detailed below under "Work in geology by States."

GEOLOGIC MAP OF THE UNITED STATES

The compilation of the geologic map of the United States was completed. (See p. 84.)

POTASH INVESTIGATIONS

FINAL DRILLING AND ANALYSES

Although the beginning of the fiscal year 1932 officially marked the end of the 5-year period of potash investigations carried on jointly by the Geological Survey and the Bureau of Mines under the act approved June 25, 1926 (44 Stat. 768), the final drilling contract remained in force until November, 1932, when the last test well

was completed. Under this contract three test wells were drilled in the fiscal year 1932. These were No. 21, in Lea County, N. Mex.; No. 22, in Eddy County, N. Mex.; and No. 24, in Grand County, Utah. No. 23, in Eddy County, N. Mex., the first well to be drilled under this contract, was completed shortly before the end of the fiscal year 1931, and the work of studying and analyzing the cores from it fell chiefly in the fiscal year 1932.

In addition to the material from Government test wells, core samples were also received from eight test wells drilled by the Potash Co. of America and one by the United States Potash Co. on Government land. Cores from seven of these wells were studied and analyzed within the fiscal year. Meanwhile the chemical and mineralogic study of cuttings from oil wells was continued, and 18 wells were recognized as furnishing in their cuttings definite evidence of the presence of sylvite, carnallite, or langbeinite, which are commercially more desirable potash-bearing minerals than polyhalite, which is the most abundant and widely distributed potash-bearing mineral thus far found in the Permian basin of Texas and New Mexico.

This study has shown that cuttings from an oil well, if carefully taken and if studied by a competent petrologist, may be expected to reveal the presence of any beds of sylvite or carnallite rich enough to have possible commercial value that the well may have penetrated. These minerals are so soluble that it has hitherto seemed improbable that they could be preserved in well cuttings in sufficient amounts to provide any reliable basis for prospecting. Now, it should be possible to reduce the costs of prospecting for potash by using the churn drill for preliminary exploration and reserving the core drill for checking the most favorable localities.

Three press statements were issued during the year giving the results of chemical and mineralogical tests of the cores from test wells 19 to 24 and summarizing the general results of the whole drilling program. Of these wells, Nos. 19, 20, and 21 were drilled in Lea County and Nos. 22 and 23 in Eddy County, N. Mex., and No. 24 in Grand County, Utah.

GENERAL RESULTS OF GOVERNMENT CORE TESTS

In all 24 core tests have been made—13 in New Mexico, 10 in Texas, and 1 in Utah. As an indirect result of this core-drilling program and of the 15 years of preliminary exploration, chiefly by the Geological Survey, whereby the oil companies and the public generally became "potash conscious," private companies have drilled 42 additional core test holes—2 in Midland County, Tex., and 40 in Eddy County, N. Mex. A shaft has been sunk by the United States Potash Co. in Eddy County about 18 miles northeast of Carlsbad, and shipments of untreated potash salts containing 25 to 30 per cent of K_2O have been made regularly by the company during the year. Thus a new potash industry has been created on American soil during the depression years 1929–1931.

Of the 24 Government tests 17 have revealed more than 50 intersections of polyhalite beds that are of possible economic interest. These beds range in thickness from 2 to about 10 feet and in potash content from 10 to nearly 15 per cent. Most of the private core tests have also cut comparable beds of polyhalite. Commercial in-

terest in many of these polyhalite beds is no doubt remote. Nevertheless, it should be borne in mind that the viewpoint of the Government toward mineral resources is somewhat different from that of industry. Industry seeks an immediate or early return upon invested capital; the Government must foresee and provide for the future requirements in mineral raw materials. Polyhalite contains magnesium and calcium as well as potash. If certain expected industrial uses for magnesium alloys should be developed the polyhalite beds in New Mexico and Texas should prove abundant sources for this metal, and by-product potash could probably be produced very cheaply.

Twelve of the tests have revealed the presence of sylvite, carnallite, or langbeinite. One of these has disclosed a 5-foot bed of sylvite and halite containing more than 30 per cent of K_2O and comparing favorably in content and thickness with the salts now being mined in Eddy County, together with an overlying 5-foot bed of halite with enough sylvite to yield 8.80 per cent K_2O . Two others have penetrated beds of similar salts but of lower grade that may also be considered of possible though more remote commercial interest.

In addition to core samples, thousands of samples of cuttings from many wells drilled for oil in the Texas-New Mexico field have been studied by the Geological Survey.

The Federal 5-year program of potash exploration, together with events that preceded it, has stimulated private exploration and exploitation of potash salts in the Permian basin of New Mexico and Texas. It has demonstrated the presence of great reserves of polyhalite and of at least one rich body of sylvite in the same general region. By improved methods of study applied to both oil-well cuttings and cores it has outlined a broad area in which the occurrence of sylvite is known and in which further exploration may locate additional commercial bodies of that mineral. It has also eliminated certain areas as being improbable sources of potash.

The potash possibilities in Utah have not been sufficiently tested, but from the known structural conditions and the results thus far obtained the prospects for commercial potash development in that State seem to be less favorable than in New Mexico or Texas.

WORK IN GEOLOGY, BY STATES

ALABAMA

In continuation of studies of the iron ores of Alabama in cooperation with the State geological survey, field work on the brown iron ores of the Russellville district was carried on by E. F. Burchard during the year. Field work on iron ore in the Red Mountain formation in northeastern Alabama has been completed, and it is expected that the report, now nearly complete, will be published by the State. A chapter on the red ores in Greasy Cove has been submitted for publication by the Federal Survey.

The southern Appalachian portion of northeastern Alabama has been mapped by A. I. Jonas and G. W. Stose for incorporation in the revised geologic map of the United States. This region has also been covered by Mr. Stose and Miss Jonas in the guidebook on the southern Appalachian region for the International Geological Congress. The Birmingham district has been described by E. F. Burchard in the guidebook on the mining districts of the Eastern States.

E. O. Ulrich and Josiah Bridge visited some early Paleozoic outcrops in northern Alabama to gather additional data as to the age and distribution of these formations in connection with their monographic study of the faunas of these formations in North America.

Marble quarries at Sylacauga and limestone quarries at Rockwood were examined by G. F. Loughlin, who made a report to the Architect of the Capitol on the availability of marble quarries in Alabama.

An article on revision of physical divisions of northern Alabama was submitted by W. D. Johnston, jr., for publication in *Science*.

ALASKA

As a part of the program of work of the section of volcanology, seismograph stations were maintained at Dutch Harbor and Kodiak. The seismograms from these stations were sent to T. A. Jaggar, jr., in Hawaii, and a record of earthquakes at these places from August, 1927, to December, 1931, with map and diagrams, was compiled by A. E. Jones and published in *Volcano Letter* No. 377. During 1929 and 1930 the Kodiak station recorded two and one-half times as many earthquakes as the Dutch Harbor station, but in 1931 Dutch Harbor reported 37 per cent more than Kodiak. On account of prospective lack of funds the observations at these stations were discontinued in the spring of 1932. The Akutan Crater was examined in the fall of 1931 by R. H. Finch, and in the spring of 1932 he made a trip to the northern slope of Shishaldin Volcano for sketch mapping, photography, and records of the eruption that had begun the preceding January. Mr. Finch prepared an illustrated account of the Akutan Crater accompanied by a contour sketch map of Akutan Island. Notes from the Aleutian Islands were published in the *Volcano Letter*.

ARIZONA

Geologic investigation of the Ajo mining district was begun by James Gilluly in the spring of 1932.

Further field investigations of the manganese deposits near Alamo were made by D. F. Hewett, for inclusion in a paper on the subject, of which B. N. Webber is joint author.

The manuscript of a report on correlation of Jurassic sandstones of southeastern Utah, northeastern Arizona, southwestern Colorado, and northwestern New Mexico, by J. B. Reeside, jr., A. A. Baker, and C. H. Dane, has been completed and submitted for publication as a professional paper.

A guidebook describing the geology, geography, and other interesting features along the route of the Southern Pacific Railroad is being prepared by N. H. Darton.

A paper on Algonkian strata in Arizona by Mr. Darton was submitted for publication in the *Journal of the Washington Academy of Sciences*.

David White continued studies relating to pre-Cambrian plant life in the Grand Canyon.

A guidebook by F. L. Ransome, J. B. Tenney, and Sidney Paige on ore deposits of the Southwest describes the geology and mining districts on the route of an excursion of the International Geological Congress through southern Arizona.

B. S. Butler examined and reported on the Charleston, Porphyry, Christmas, Riverside, and Buttes dam sites for the Indian Service.

A chart giving a tentative correlation of the named geologic units for Arizona, by M. Grace Wilmarth, was issued.

Publication: Professional Paper 164. (See p. 1.)

ARKANSAS

The cooperative report on the lead and zinc deposits of northern Arkansas by E. T. McKnight, which was revised to incorporate additional stratigraphic and mineralogic data, was completed.

Studies of the faunas of the Morrow formation of Arkansas and Oklahoma and the Batesville sandstone of Arkansas and Missouri were continued by G. H. Girty.

Structural and stratigraphic studies in the Ouachita Mountains of Oklahoma and Arkansas were continued by H. D. Miser.

Manganese deposits near Cushman were examined by D. F. Hewett, and the cinnabar deposits in Pike County were examined by Mr. Miser. He made a brief field study of manganese deposits in the Batesville district, and a report on recent developments in this district is in preparation by Messrs. Hewett and Miser.

David White is preparing a report describing the Wedington fossil flora of the Fayetteville shale, of Mississippian age, from northwestern Arkansas, and

a report on the fossil flora of the Jackfork sandstone and Stanley shale of Arkansas and Oklahoma. Collections of the Wedington flora were made near Fayetteville by C. B. Read. For comparative purposes, a study of plant material from the Tesnus, Haymond, and associated formations in western Texas and from the Atoka of eastern Oklahoma was made by Mr. White.

E. O. Ulrich and Josiah Bridge continued the study of fossils from certain formations of early Paleozoic age in connection with the preparation of a report on the early Paleozoic gastropods of North America.

R. D. Mesler collected Ordovician and Silurian fossils near Batesville, St. Joe, Gilbert, Pindall, Western Grove, and Jasper.

A paper on the Arkansas-Oklahoma coal field was presented by T. A. Hendricks at the February meeting of the American Institute of Metal and Mining Engineers and will be published in the proceedings of the institute.

An article on the Foraminifera of the Pecan Gap and Annona chalks, by J. A. Cushman, was submitted for outside publication.

Descriptions of Magnet Cove, Ark., by K. K. Landes, Bryan Parks, and V. E. Scheid, and of the Arkansas bauxite deposits, by G. C. Branner, form parts of the guidebook on the mining districts of the Eastern States.

CALIFORNIA

In continuance of the stratigraphic and petrologic investigations of the siliceous sediments and associated rocks of the Monterey group, geologic sections were measured and collections made in areas in the Coast Ranges between Los Angeles and San Francisco, by M. N. Bramlette and K. E. Lohman. Mr. Bramlette will make petrographic studies for the purpose of interpreting the origin of the siliceous formations, and Mr. Lohman will make a systematic study of the diatoms.

A study of the geology and geomorphology of the southern part of Death Valley and the surrounding country, including portions of the Panamint and Funeral Ranges, a region of unusual scientific and popular interest, is being undertaken by L. F. Noble, assisted temporarily by C. L. Gazin. This study will involve several seasons' field work. During the year field mapping was done in the southern part of the Furnace Creek quadrangle and the northern part of the Avawatz Mountains quadrangle.

Messrs. Noble and Gazin completed field work on the geology of the southern part of the San Andreas rift zone from Palmdale to the Mexican border. A comprehensive report covering the results of detailed studies over several years by Mr. Noble and assistants is in preparation.

In continuation of his scientific study of the southern California batholiths, E. S. Larsen, jr., continued geologic mapping in the San Luis Rey quadrangle. Additional field work will be required to complete this investigation.

The field study of the areal geology and underground structure of the Grass Valley mining district was completed by W. D. Johnston, jr., and the report on the investigation is in progress. A report on chromite deposits in northern California by Mr. Johnston is in preparation. He submitted papers on the geothermal gradient of the Mother Lode belt and the geothermal gradient at Grass Valley for publication in the Journal of the Washington Academy of Sciences and prepared a chapter on mesothermal gold-quartz veins of Grass Valley for the Lindgren volume of the American Institute of Mining and Metallurgical Engineers.

Work on a report on the geology and ore deposits of the Ivanpah quadrangle, by D. F. Hewett, has continued, and some progress has been made by H. G. Ferguson toward the completion of his report on the geology and ore deposits of the Hawthorne and Tonopah quadrangles.

The stratigraphic and structural studies of the Kettleman Hills oil and gas field were continued by W. P. Woodring and Ralph Stewart, and field work on the middle and south domes was completed. R. W. Richards continued his study of the subsurface and economic phases of the oil field, and R. M. Kleinpell examined Foraminifera from wells and outcrops in the hills.

Office work on a report on the geology of the San Pedro Hills was continued by W. P. Woodring, and a paper by him on a Miocene *Haliotis* from the Temblor Range was submitted for outside publication.

In connection with his studies on the source rocks of petroleum, P. D. Trask made examinations and collections in the Santa Fe Springs oil field.

G. B. Richardson completed a map of the oil and gas fields of the State for Survey publication.

Preparation of a report on the geomorphology of the upper San Joaquin Basin was continued by F. E. Matthes.

The north half of the geologic map of the State, which is being compiled in cooperation with the California Division of Mines, was completed and transmitted to the State mineralogist.

N. H. Darton continued work on a guidebook for the Southern Pacific Railroad.

J. B. Reeside, jr., studied Cretaceous ammonites.

A paper by C. H. Crickmay on *Alpheus Hyatt's* unfigured types from the Jurassic of California was submitted for publication in "Shorter contributions to general geology."

The work of the Lassen Volcano Observatory at Mineral, in charge of R. H. Finch, included the operation of the Lassen station and three seismograph stations, two new stations having been started at Loomis Museum and at Mount Harkness. The usual measurements of hot-spring temperatures and seismograph readings were continued. Mr. Finch made an ascent of Mount Lassen, a trip to a crater northwest of Glass Mountain, and an exploration of a slump scarp in Hat Creek, and ran a line of levels across an ancient lava flow. He submitted a descriptive article on slump scarps for publication in a scientific periodical and an article on burnt lava flows for the *American Journal of Science*. A new steam vent was discovered in the forest on the south slope of Diamond Peak, and an article describing this occurrence appeared in the *Volcano Letter*, December 3, 1931. During the summer of 1931 and the spring of 1932 Mr. Finch made trips to Alaska, and in his absence C. A. Huff was in charge and C. A. Anderson was employed for part of the time.

A guidebook on southern California, prepared under the direction of H. S. Gale, contains the following chapters:

Geology of southern California, by H. S. Gale.

Excursion to the San Andreas fault and Cajon Pass, by L. F. Noble.

Asphalt deposits and Quaternary life of Rancho La Brea, by Chester Stock.

General geology of the Los Angeles Basin, by H. W. Hoots.

Oil development in the Los Angeles Basin, by H. W. Hoots.

Section from the Repetto Hills to the Long Beach oil field, by R. D. Reed.

San Pedro Hills, by W. P. Woodring.

General geology of the eastern part of the Santa Monica Mountains, by H. W. Hoots.

Excursion in Los Angeles Basin and Santa Monica Mountains, by H. W. Hoots.

Los Angeles to Santa Barbara, by W. S. W. Kew.

A guidebook on middle California and western Nevada prepared under the direction of O. P. Jenkins contains the following chapters:

The geology of middle California, by A. C. Lawson.

The San Francisco Peninsula, by O. P. Jenkins.

San Francisco Bay, by W. M. Davis.

Berkeley Hills, by B. L. Clark.

Geography and geology of the Sierra Nevada, by F. E. Matthes.

Structure of the Sierra Nevada batholith, by Ernst Cloos.

The Mother Lode system, by Adolph Knopf.

The Tertiary auriferous gravel, by Adolph Knopf.

Itinerary, Yosemite to Mother Lode, by W. W. Bradley.

Up the western slope of the Sierra Nevada by way of the Yosemite Valley, by F. E. Matthes.

Eastern slope of the Sierra Nevada, by Eliot Blackwelder.

Reno and vicinity, by J. C. Jones and V. P. Gianella.

Itinerary, Reno to Pyramid Lake and return, by J. C. Jones.

Itinerary, Reno to Valley Hot Springs and return, by V. P. Gianella.

Publication: Professional Paper 172. (See p. 2.)

COLORADO

Cooperative work with the Geological Survey Board of Colorado and the Metal Mining Fund Board in the study of mining districts of Colorado was curtailed somewhat owing to decrease in available funds. B. S. Butler had general supervision of the cooperative work, and his annual progress report was read before the Colorado Mining Association. In carrying on the cooperative program priority was given to field work necessary for the preparation of a geologic map of the State. The manuscript copy of this map, prepared

mainly by W. S. Burbank and T. S. Lovering, assisted by other members of the Golden office, was exhibited at the annual meeting of the Geological Society of America at Tulsa, Okla., and at the meeting of the Colorado Mining Association at Colorado Springs, after which it was brought to Washington by Mr. Burbank, who superintended its final preparation for the engraver.

A general report on the geology and ore deposits of the State is in preparation, and reconnaissance field trips to get data on the less known districts for this report were made by all members of the force in 1931 and 1932. E. B. Eckel is writing the chapter on mineralogy for the general report.

Mr. Lovering continued his study of the tungsten and gold deposits of the Colorado Front Range and prepared a paper and map showing their relation to faults in the region, which was promptly issued by the Colorado Scientific Society as an aid to prospecting and mine development. A report on the Nederland tungsten district by Mr. Lovering will be prepared for official publication. E. N. Goddard made some progress in his study of the Jamestown district, but he was diverted to assist Mr. Burbank, who continued his studies of districts in the San Juan area. Mr. Goddard also studied the complicated structure in Gunnison County and the Sangre de Cristo Mountains.

E. T. McKnight, assisted by E. B. Eckel, completed the field study of the Rico mining district, and Mr. Eckel wrote a scientific paper entitled "Pisanite from Rico."

C. H. Behre and Q. D. Singewald completed field studies in the Mosquito Range and made substantial progress on their report. J. H. Johnson studied the Permo-Carboniferous stratigraphy of this range. B. S. Butler and J. W. Vanderwilt studied the latest developments at Climax and transmitted their report on that district for publication. Mr. Vanderwilt nearly completed his field work in the Snowmass area and also made a study of vanadium deposits near Rifle.

G. F. Loughlin, after inspecting field parties in Colorado, spent a few days at Cripple Creek studying the latest developments. He presented papers on the Cripple Creek district before the Colorado Scientific Society and the Colorado Mining Association. The following papers resulting from the cooperative work were published or completed by their authors during the year. The papers not otherwise indicated are to be published by the Geological Survey.

Burbank, W. S., The Bonanza mining district. Professional Paper 169.

Johnson, J. H., Paleozoic formations of the Mosquito Range.

Lovering, T. S., Breckenridge mining district.

Butler, B. S., and Vanderwilt, J. W., The Climax molybdenum deposits of Colorado, with a section on history, production, metallurgy, and development by C. W. Henderson.

Behre, C. H., Weston Pass mining district. Colorado Scientific Society.

Behre, C. H., The peripheral facies of ore deposition at Leadville. Geological Society of America.

Behre, C. H., Physiographic history of the upper Arkansas and Eagle Rivers, Colo. Geological Society of America.

Burbank, W. S., and Goddard, E. N., Problems of structure and stratigraphy in the Sangre de Cristo Range, Colo. Geological Society of America.

Burbank, W. S., and Goddard, E. N., Thrust faulting in Huerfano Park. Colorado Scientific Society.

Butler, B. S., and Singewald, Q. D., Report on geology of Mount Lincoln and Russian mine, Park County, Colo. Colorado Scientific Society.

Johnson, J. H., Stratigraphic results of cooperative work in Colorado. Geological Society of America.

Lovering, T. S., and Johnson, J. H., The meaning of unconformities in the stratigraphy of central Colorado. American Association of Petroleum Geologists.

Lovering, T. S., Physiographic history of the Front Range. Colorado Scientific Society.

Lovering, T. S., and Van Tuyl, F. M., A contribution to the Cenozoic history of the Front Range. Geological Society of America.

Singewald, Q. D., Buckskin Gulch stock. Geological Society of America.

Vanderwilt, J. W., Treasury Mountain dome, Gunnison County, Colo. Geological Society of America.

Vanderwilt, J. W., Molybdenum deposits at Climax. American Institute of Mining and Metallurgical Engineers.

Eckel, E. B., Garnet as an amygdale mineral. American Mineralogist.

Semireconnaissance areal geologic mapping of the Tertiary and Upper Cretaceous formations of eastern Colorado, north of the Arkansas River and south of the Platte River, was continued by C. H. Dane and W. G. Pierce during the summer and early fall of 1931. This mapping was accompanied by stratigraphic studies, the collection of invertebrate fossils, and studies of the regional structure of the area, which forms part of the eastern flank of the Denver Basin. In June Messrs. Dane and Pierce made a supplemental review of portions of the area to obtain additional stratigraphic and structural information and fossil plants.

A preliminary paper on the San Juan region of southwestern Colorado by E. S. Larsen and Whitman Cross was transmitted for publication as a bulletin of the Survey. A paper by Mr. Larsen on the deuteric and later alterations of the uncomphagrite of Iron Hill was submitted for publication in the American Mineralogist.

R. W. Brown's paper on the recognizable species of the Green River flora, Utah, Colorado, and Wyoming, will be published in "Shorter contributions to general geology."

M. R. Campbell continued work on his report on the Yampa coal field and supplied additional data for land classification.

The report on the Book Cliffs coal field of western Colorado, by C. E. Erdmann, was submitted for Survey publication.

The Paradox formation of eastern Utah and western Colorado is being studied by C. H. Dane and A. A. Baker.

J. B. Reeside, jr., has in preparation a paper on the fauna of the Greenhorn limestone. Mr. Reeside attended a field conference with local geologists on the Fox Hills-Pierre boundary in northeastern Colorado for the State geologic map.

C. B. Read submitted for publication by the Washington Academy of Sciences a paper on a new *Trichopitys* from the Carboniferous of Colorado.

T. S. Lovering made geologic examinations in the Lost Park drainage basin for the Denver municipal waterworks and prepared a report thereon.

A guidebook on Colorado for the International Geological Congress excursions was prepared under the direction of C. W. Henderson, with the following chapters:

Geography, history, and mineral production of Colorado, by C. W. Henderson.

Life zones, faunas, and floras of Colorado, by Junius Henderson.

Grand Junction to Mesa Verde, by W. S. Burbank; Rico district, by E. T. McKnight.

Minturn to Florissant:

Introduction, by T. S. Lovering.

Battle Mountain mining district, by T. S. Lovering and C. H. Behre, jr.

Leadville mining district, by G. F. Loughlin and C. H. Behre, jr.

The molybdenum deposit at Climax, by J. W. Vanderwilt.

Alma district, by Q. D. Singewald.

Florissant to Colorado Springs; Cripple Creek mining district, by G. F. Loughlin.

Foothill region of north-central Colorado, by Junius Henderson and T. S. Lovering.

Denver to Nederland and Central City:

Introduction, by T. S. Lovering.

Geology of the Golden area, by F. M. Van Tuyl.

Road log, by C. E. Dobbin, T. S. Lovering, and F. M. Van Tuyl.

Ore deposits of Nederland, Central City, and Idaho Springs, by T. S. Lovering.

Fort Collins to Denver, by Junius Henderson and J. H. Johnson.

Publications: Professional Papers 168 and 169. (See p. 1.)

CONNECTICUT

E. B. Knopf extended her studies of the geology of ancient metamorphosed rocks to areas in western Connecticut, western Vermont, and western Massachusetts. She prepared a scientific paper on petrotectonics and petrotectonic methods. Additional contributions were made by Mrs. Knopf to the geology of western Connecticut for the revised geologic map of the United States, and

for the guidebook on eastern New York and western New England for the International Geological Congress.

Work on Pleistocene terraces is mentioned under Massachusetts.

DELAWARE

A study of the terraces of the Coastal Plain of Delaware was made by C. W. Cooke in connection with his general study of Coastal Plain terraces.

DISTRICT OF COLUMBIA

Pleistocene plants recently found in the District of Columbia were described by E. W. Berry in a paper prepared for the Washington Academy of Sciences.

FLORIDA

The cooperative report on the Miocene pelecypods of the Choctawhatchee marl of Florida, by W. C. Mansfield, was completed and transmitted to the Florida Geological Survey for publication, and a paper by Mr. Mansfield on faunal zones in that formation was submitted for publication in a scientific periodical. Mr. Mansfield is continuing his studies of the Tampa limestone of western Florida, a cooperative project with the State survey.

J. A. Cushman, assisted by L. G. Henbest, in cooperation with Gerald M. Ponton, of the Florida Geological Survey, prepared a report on the Foraminifera of the early Miocene for publication by the State.

Julia Gardner completed the revision and transmitted for publication the manuscript of part 1 of Professional Paper 142-F, on the gastropods of the Alum Bluff group of Florida. Part 2 of this report is in preparation.

GEORGIA

Stratigraphic studies of certain early Paleozoic formations in northern Georgia were made by E. O. Ulrich and Josiah Bridge to determine the age and distribution of the formations and to collect fossils in connection with their studies of these formations in North America.

A. I. Jonas and G. W. Stose did field work in the Appalachian Mountain section of northern Georgia in connection with the preparation of the geologic map of the United States and of a guidebook on the southern Appalachian region for the International Geological Congress.

The ore deposits of the Cartersville district have been described by G. W. Crickmay in a guidebook on mining districts of the Eastern States.

HAWAII

The scientific personnel of the section of volcanology at Volcano House, in the Hawaii National Park, comprises T. A. Jaggar, volcanologist in charge; E. G. Wingate, topographic engineer; A. E. Jones, seismologist; and H. A. Powers, geologist. Messrs. Wingate and Jones joined the staff early in the fiscal year.

The Halemaumau pit of Kilauea Volcano was active from December 23 to January 5.

The routine of the year has been as follows: Observation of the Hawaiian volcanoes, including constant observation and measurement of Kilauea and Mauna Loa; operation of seven seismographs and measurements of seismograms; issuance of the Volcano Letter (weekly to May 22, monthly thereafter); reporting Hilo tide data in cooperation with the Coast and Geodetic Survey; reporting Kilauea weather data in cooperation with the Weather Bureau; designing and building instruments for observing and registering volcanic and earthquake activities, including 10 shock recorders of new design and a clinoscope; building and operating three tilt cellars; field mapping and laboratory studies of volcanic geology in Hawaii; and local level and triangulation surveys.

Mr. Jaggar prepared a report on volcano events in 1931 for the American Geophysical Union and a paper on the eruption cycles in Hawaii for Thrumm's Annual (Honolulu), 1932, and published in the Volcano Letter articles on the progress of Hawaiian volcano research.

R. M. Wilson completed a manuscript on ground surface displacements at Kilauea, dealing with the results of his leveling and triangulation before and after the steam-blast eruption of Kilauea in 1924.

Four new permanent triangulation points as a base net for Halemaumau observations and three temporary points on the rim of the pit for map control were established by Mr. Wingate, and work was begun on a 1,000-foot contour map of the ocean floor around the entire Hawaiian ridge.

Mr. Powers spent some time completing detailed mapping of the lava flows of Hualailai Volcano and in petrographic laboratory studies and office work on a report covering these studies. He made reconnaissance trips to Mokuaweoweo Crater on Mauna Loa and to Kohala and Mauna Kea volcanoes for collection of specimens, studied the Kilauea ash beds, and made observations during the activity of Halemaumau. He prepared jointly with J. C. Ripperton and W. D. Goto a paper entitled "Survey of the physical features that affect the agriculture of the Kona District of Hawaii," which was published as Bulletin 66 of the Hawaii Agricultural Experiment Station.

A. E. Jones constructed a seismologic laboratory at the observatory and devised apparatus for regular determination of the physical constants of the seismographs. Records of local and distant earthquakes and other seismic movements were continuously kept up to date. Reports and graphs were prepared and published showing seismicity at Kilauea for the last two and one-half years. A special study was made of nine well-recorded local quakes on Hawaii. An expedition was made to the southern Kohala District to select locations for shock recorders and seismographs. The work of Mr. Jones in seismology has resulted in improved methods of operating all instruments and in securing more accurate results as well as bringing the records up to date and gradually measuring the seismograms of past years—work which has been at a standstill for some time.

The Hawaiian Volcano Research Association has continued cooperation in the work of the observatory. Articles on the work in Hawaii by members of the section have appeared during the year in the Volcano Letter, issued by this association.

IDAHO

Investigations of certain mining districts and mineralized areas in Idaho are being made by members of the Geological Survey in cooperation with the Idaho Bureau of Mines and Geology. Field work is now in progress in the Buffalo Hump and Elk City districts, by P. J. Shenon and J. C. Reed, with assistants from the State bureau. This work, which was begun in 1931 by Mr. Shenon, is expected to be completed this year. Work in the Yellow Pine and Thunder Mountain regions, begun in 1931 by A. L. Anderson and D. C. Livingston, is being continued by L. W. Currier and party, and a resurvey and detailed investigation of the geology and mineral resources of the Boise Basin region is being made by a party in charge of Mr. Anderson. A paper by Mr. Anderson on the genesis of mica pegmatites of Latah County was approved for publication in *Economic Geology*.

C. P. Ross has in hand for Survey publication reports on the geology and ore deposits of the Bayhorse quadrangle and some ore deposits in the Boise Basin and a professional paper on south-central Idaho. His report on the geology and ore deposits of the Casto quadrangle was completed for Survey publication. He prepared a chapter on the igneous geology of Idaho for the Lindgren volume of the American Institute of Mining and Metallurgical Engineers, a paper on the geology and ore deposits of the Thunder Mountain district for outside publication, and a contribution on geology of the Snake River Basin, with reference to hydrology, for inclusion in *Water-Supply Paper 657*.

Edward Sampson made some progress on his report on the Pend Oreille district.

G. R. Mansfield continued work on his report on the geology of the Paradise Valley and Ammon quadrangles. He prepared a paper on further developments in the geology of southeastern Idaho for presentation before the Geological Society of Washington and a paper on the Rocky Mountain phosphate field for the Lindgren volume.

Some progress was made by W. C. Alden on his report on glacial geology and physiography of northern Idaho.

A paper on Miocene plants from Idaho, by E. W. Berry, will be published in "Shorter contributions to general geology."

R. W. Brown and C. B. Read began the preparation of a paper on species of *Tempuskyia* from the Cretaceous and Upper Jurassic of Idaho. Mr. Brown has in preparation a paper on a Miocene florule from Salmon.

The Cabinet Gorge dam site was examined and reported on by J. T. Pardee for the Bureau of Reclamation.

Work in the Afton quadrangle is noted under Wyoming.

ILLINOIS

The report on the geology of the Hardin and Brussels quadrangles, by W. W. Rubey, prepared in cooperation with the Illinois Geological Survey, was completed and transmitted for State publication.

A paper on the fluorspar deposits of southern Illinois, by E. S. Bastin, is included in the guidebook on mining districts of the Eastern States. A paper on the Quaternary period in the Mississippi River Basin, by W. C. Alden, and an annotated guide across Illinois, by M. M. Leighton and G. E. Ekblaw, are included in the guidebook on glacial geology of the Central States prepared under the direction of Mr. Alden.

INDIANA

A report on two new crinoid genera from the Devonian and Silurian of Indiana is in preparation by Edwin Kirk.

G. H. Girty is preparing a report on the gastropods of the Spergen limestone, and P. V. Roundy a paper on *Persparchites* from the Spergen limestone.

The Indiana oolitic limestone district is described by G. F. Loughlin in the guidebook on mining districts of the Eastern States.

IOWA

A study of the Kinderhook fauna is in progress by G. H. Girty and J. S. Williams.

An annotated guide of eastern Iowa, by G. F. Kay, is included in the guidebook on glacial geology of the Central States.

KANSAS

Field investigation, including structural mapping of the Shoestring sand bodies and subsurface study of oil pools in Greenwood and adjacent portions of Butler and Lyon Counties, was carried on by N. W. Bass, in cooperation with the Kansas Geological Survey.

C. B. Read made a study of the Wellington shale of Permian age in the vicinity of Elmo and collected fossil plants from the Elmo limestone.

R. C. Moore continued assembling data for the revised geologic map of Kansas.

J. B. Reeside, jr., studied Hydrozoa from the Niobrara chalk, and P. V. Roundy continued his study of microfossils from the Carboniferous of Kansas.

A guidebook on the Pennsylvanian of the northern mid-continent region (Kansas, Oklahoma, and Texas) was prepared by Raymond C. Moore.

LOUISIANA

Studies of salt-dome cap rock and preparation of the report were continued by M. I. Goldman. Mr. Goldman submitted for publication in "Shorter contributions to general geology" a paper on the origin of the anhydrite cap rock of American salt domes.

The route of the Southern Pacific Railroad in Louisiana is being described by N. H. Darton for a geologic guidebook.

MAINE

Arthur Keith did additional field work and compiled data for the revision of the geology of Maine for the geologic map of the United States and presented a paper on the geology of Maine at the Tulsa meeting of the Geological Society of America.

MARYLAND

Field work on the geology of Washington County, a cooperative project with the Geological Survey of Maryland, was continued by G. W. Stose.

R. W. Brown and C. B. Read are preparing a paper on the *Tempskya* from the Cretaceous and Upper Jurassic of Maryland to be embodied in a general report on this subject.

The coastal terraces of Maryland are being studied by C. W. Cooke.

A guidebook on the Chesapeake Bay region, Maryland and Virginia, was prepared by L. W. Stephenson, C. W. Cooke, and W. C. Mansfield, and a guidebook on southern Maryland by Mr. Cooke. The guidebook on southern Pennsylvania and Maryland, by G. W. Stose, A. I. Jonas, and G. H. Ashley, includes a description of the geology on the route from Washington to Harrisburg and the route from Washington to Baltimore and York.

MASSACHUSETTS

L. M. Prindle reviewed in the field portions of the geology of the Taconic quadrangle in connection with his detailed report on this area. He was accompanied by E. B. Knopf on some of these field trips for the purpose of gathering data for the revision of the geology of western Massachusetts for the geologic map of the United States. A joint paper on the geology of the Taconic quadrangle, covering the area between the Hudson River and the Green Mountains, by Mr. Prindle and Mrs. Knopf, was approved for publication in the *American Journal of Science*. A guidebook on eastern New York and western New England, by C. R. Longwell and others, includes sections on the structure, stratigraphy, and metamorphism in the disturbed belt of western Massachusetts.

Pleistocene terraces of the Connecticut River were examined by C. W. Cooke in connection with his studies of shore lines and terraces of the Atlantic coast.

MICHIGAN

Chapters on the Marquette range, by C. O. Swanson; mining on the Marquette range, by F. G. Pardee; geology, exploration, and mining in the Michigan copper district, by T. M. Broderick; the Gogebic range, by W. O. Hotchkiss; and mining in the Gogebic range, by F. G. Pardee, form part of the guidebook on the Lake Superior region prepared under the direction of W. O. Hotchkiss.

Work in the Lake Superior iron-ore district is noted under Minnesota.

MINNESOTA

Andrew Leith, R. J. Lund, and Gordon Atwater spent some time in field work in the Lake Superior iron-ore district for a revision of the correlation of the geologic formations of the Lake Superior region. A revised map and report are in preparation.

D. F. Hewett examined manganese deposits near Ely.

The Lake Superior guidebook prepared for the International Geological Congress includes chapters on Duluth rocks and structure, by F. F. Grout; the Mesabi range, by J. W. Gruner; and the Cuyuna iron-ore district, by Carl Zapffe.

MISSISSIPPI

Field mapping of the areal, structural, and stratigraphic geology of the Jackson, Florence, and Pelahatchee quadrangles was completed by W. H. Monroe, who also did detailed mapping in the Morton quadrangle and in the western edge of the Forest quadrangle and made subsurface structural and stratigraphic studies of the Jackson gas field. Mr. Monroe prepared a paper entitled "Notes on pre-Tertiary rocks in deep borings at Jackson, Miss.," and a brief article on earth cracks in Mississippi, a phenomenon noted by him incident to his field work in the Florence and Jackson quadrangles, for publication by the American Association of Petroleum Geologists.

Brief examinations of deposits of siderite, bauxite, and fuller's earth in Benton and Tippah Counties were made and specimens obtained by Mr. Monroe for D. F. Hewett and E. F. Burchard.

Publication: Bulletin 831-A. (See p. 2.)

MISSOURI

Edwin Kirk is preparing a paper on minute crinoids from the Mississippian formations of Missouri and Oklahoma.

A report on the Kinderhook fauna of Missouri and Iowa is in preparation by J. S. Williams and G. H. Girty. In connection with his studies of the Kinderhook formation, Mr. Williams did field work near Louisiana, Mo. He also, with members of the Missouri Bureau of Geology and Mines, studied the Mississippian formations near Springfield and other localities in the State.

Mr. Williams revised a manuscript on buried and resurrected hills of the central Ozarks, prepared jointly with C. L. Dake, for publication by the American Association of Petroleum Geologists.

E. O. Ulrich and Josiah Bridge made a field study of some early Paleozoic sections with members of the Missouri Bureau of Geology and Mines and studied fossils of the Cotter and Powell formations in connection with their general study of the early Paleozoic gastropods of North America.

Chapters for the guidebook on mining districts of the Eastern States were prepared on the disseminated lead districts of southeastern Missouri, by H. A. Buehler; the iron-ore deposits of Iron Mountain, by M. C. Lake; the iron deposits of Pilot Knob, by Edward Steidtmann; and the tri-State zinc-lead region, by Samuel Weidman.

Study of the Batesville sandstone of Missouri is noted under Arkansas.

MONTANA

Reconnaissance glacial and geomorphic studies of western Montana were continued by W. C. Alden. The results will be included in his report on the glacial geology and geomorphology of western Montana, northern Idaho, and eastern Washington, the preparation of which progressed during the year.

The report on the mining districts of the Greater Helena region, by J. T. Pardee and F. C. Schrader, was completed early in the year and will be published as a bulletin of the Survey.

Mapping of the areal geology and examination of mines and prospects in the Libby quadrangle were continued by Russell Gibson, who also continued office work on his report.

A study of the Pioneer mining district, Powell County, is in progress by J. T. Pardee. He also made brief examinations of the manganese deposits at Philipsburg, the vermiculite deposits near Hamilton, Ravalli County, and phosphate areas in Granite and Powell Counties.

D. F. Hewett reexamined manganese deposits at Butte.

Geologic investigations of the Flathead mine and vicinity, including mine mapping, were made by P. J. Shenon.

A. J. Collier, assisted by M. M. Knechtel and F. S. Parker, continued geologic field studies in the Little Rocky Mountains and made reconnaissance examinations in eastern Montana to gather data for the State geologic map, which is being compiled in cooperation with the Montana Bureau of Mines and Geology. The report on the geology of the Little Rocky Mountains and surrounding plans, by Messrs. Collier and Knechtel, has been practically completed, and office work on their report on the McCone County lignite field was continued.

Detailed mapping of the coal beds, structure, and stratigraphy of a portion of Custer County, primarily for the classification of the lands as to coal, was made by a party in charge of F. S. Parker. This is an extension eastward and northward of similar investigations made in previous years in Custer and Powder River Counties.

The reports on the geology of the Rosebud Creek coal field, Rosebud and Custer Counties, by W. G. Pierce, and on the Richey-Lambert coal field, Richland and Dawson Counties, by F. S. Parker, were nearing completion at the end of the year. Mr. Parker also gave some time in the office to compilation of results of his studies last season in Custer County coal fields, and Mr. Pierce worked on his report on Pleistocene terraces in eastern Montana.

The report on the geology and ground-water resources of Big Horn County and the Crow Indian Reservation, by W. T. Thom, jr., G. M. Hall, and others, was completed for publication as a bulletin of the Survey.

A guidebook on the Butte mining district was prepared by Eugene S. Perry.

Work on the Fort Union and associated formations is noted under North Dakota and on the Rocky Mountain phosphate field under Idaho.

NEVADA

Work in cooperation with the Nevada Bureau of Mines in a study of some of the mining districts of the State was continued. Field work in the Searchlight mining district was carried on by Eugene Callaghan and Harold Thomas; the brucite deposits northeast of Luning were examined by Mr. Callaghan, and a beginning was made in a reconnaissance survey of the Eldorado Canyon district. The report on the geology and ore deposits of the Tonopah mining district, by T. B. Nolan, is well advanced. A report on the Gold Range district is being prepared by H. G. Ferguson, and short papers on several mining districts of eastern Nevada, the field work for which was completed last year,

are being prepared by F. C. Schrader, who also has in preparation a report on mining districts in the Carson Sink region. Mr. Ferguson's report on the geology and ore deposits of the Tybo mining district has been completed and will be submitted to the State for publication. Field work for a resurvey of the Eureka mining district was begun by Mr. Nolan in the early summer of 1932.

Progress has been made on the detailed reports on the geology and ore deposits of the Hawthorne and Tonopah quadrangles, by H. G. Ferguson, and on the geology and ore deposits of the Ivanpah quadrangle and the geology of the Great Basin, by D. F. Hewett.

Edwin Kirk continued office work on his studies of the Eureka quartzite of the Great Basin.

S. W. Muller collected fossil invertebrates and made stratigraphic studies of sections in the Pilot Mountains, Garfield Hills, Gabbs Valley Range, and Eldorado Canyon south of Dayton.

T. B. Nolan examined two dam sites on the Walker River for the Indian Service.

A guidebook covering part of Nevada is noted under California.

Publication: Professional Paper 162. (See p. 1.)

NEW HAMPSHIRE

Field examinations in southern New Hampshire were made by Arthur Keith to aid in drawing geologic boundaries for the geologic map of the United States.

NEW JERSEY

The guidebook on mineral deposits of New Jersey and eastern Pennsylvania, prepared under the direction of C. P. Berkey, contains chapters on zinc deposits near Franklin, N. J., and on the area from Franklin Furnace, N. J., to eastern Pennsylvania, by P. F. Kerr.

M. R. Campbell, in cooperation with Florence Bascom, made several short field trips to New Jersey in connection with studies of gravel deposits under a grant from the National Research Council.

A report on the minerals of Franklin and Sterling Hill, by Charles Palache, was submitted for publication as a professional paper of the Survey.

Publications: Bulletins 828 and 832. (See p. 2.)

NEW MEXICO

Field mapping of the coal beds, stratigraphy, and structure of the portion of the San Juan Basin adjacent to the south and east sides of Mount Taylor, begun in the spring of 1931, was continued by C. B. Hunt and party. In the early summer of 1932 Mr. Hunt made a field study of the structural relations and the igneous rocks of Mount Taylor and the volcanic rocks in the Rio Puerco Valley. He is preparing a report on the geology and fuel resources of the Mount Taylor region and has submitted a short paper entitled "The junction of three orogenic types in northwest New Mexico" for publication in the Journal of the Washington Academy of Sciences.

A report on the geology and fuel resources of a portion of the San Juan Basin extending from Gallup eastward to Mount Taylor was completed by J. D. Sears.

A report on the geology and coal resources of an area in San Juan, McKinley, and Sandoval Counties was completed by C. H. Dane, for Survey publication, and a paper entitled "Notes on Puerco and Torrejon formations, San Juan Basin," was submitted by Mr. Dane for publication in the Journal of the Washington Academy of Sciences.

The report on the geology and mineral resources of the Santa Rita district has been practically completed by A. C. Spencer, with the assistance of Sidney Paige, and progress was made on the report on the geology and ore deposits of the Magdalena district by G. F. Loughlin and A. H. Koschmann. A paper entitled "Dissected sediments in the Magdalena district" was prepared by Mr. Koschmann for publication in the Journal of the Washington Academy of Sciences. S. G. Lasky is preparing a paper on mineralogy, contact metamorphism, and ore deposits of the Magdalena district.

The Central mining district, Grant County, and the Virginia mining district are being studied by Mr. Lasky in cooperation with the New Mexico Bureau of Mines.

W. B. Lang presented a review of petroleum developments in New Mexico in 1931 at the meeting of the American Institute of Mining and Metallurgical Engineers in February, 1932.

G. H. Girty continued his study of the Abo fauna of La Luz Canyon.

D. F. Hewett examined manganese deposits near Deming.

A chart giving a correlation of the named geologic units in New Mexico, by M. Grace Wilmarth, was issued.

G. R. Mansfield discussed the potash field of New Mexico and Texas in a chapter for the Lindgren volume of the American Institute of Mining and Metallurgical Engineers.

Potash investigations in New Mexico are described on pages 11-13.

Several projects covering areas lying partly in New Mexico are noted under Arizona and Texas.

Publication: Bulletin 823. (See p. 2.)

NEW YORK

Edwin Kirk transmitted for unofficial publication a paper entitled "An early estimate of the age of the Niagara Gorge."

Mr. Kirk made field studies of the Middle Devonian of New York and visited several museums in the State in a study of Paleozoic invertebrates. E. O. Ulrich and Josiah Bridge visited Ordovician fossil localities.

E. B. Knopf continued her studies of the geology of the ancient metamorphosed rocks in the Clove and Millbrook quadrangles.

A guidebook on the Paleozoic stratigraphy of New York, prepared under the direction of D. H. Newland, includes the following chapters:

Introduction and outline, by D. H. Newland.

Albany to Binghamton, by Winifred Goldring.

The Finger Lake region, by O. D. von Engeln.

Hornell to East Aurora, by C. A. Hartnagel.

East Aurora to Niagara Falls, by J. T. Sanford.

Niagara Falls and Gorge, by F. B. Taylor.

Niagara Falls to Rochester, by C. A. Hartnagel.

The Rochester region, by H. L. Alling and J. E. Hoffmeister.

Rochester to Utica, by C. A. Hartnagel.

Utica to Albany, by Rudolf Ruedemann.

A guidebook on eastern New York and western New England includes chapters on the stratigraphy and structure of the Hudson Valley and the structure and petrology of the anorthosite and related pre-Cambrian rocks in the Adirondack Mountains.

Work in the Taconic quadrangle is noted under Massachusetts.

NORTH CAROLINA

A. I. Jonas and G. W. Stose did field work in the southern Appalachian region of North Carolina and compiled data on the geology for incorporation in the geologic map of the United States and the guidebook on the southern Appalachian region.

C. S. Ross and Paul F. Kerr submitted an article on the manganese minerals of a vein near Bald Knob, for publication in the American Mineralogist.

Publication: Geologic Folio 222. (See p. 3.)

NORTH DAKOTA

R. W. Brown completed the field study of the Fort Union and associated formations in western North Dakota and adjacent portions of Montana and Wyoming with special reference to the occurrence of the fossil flora. T. W. Stanton was associated with him in the field during the early part of the fiscal year.

A chart giving the correlation of the named geologic units in North and South Dakota was compiled by M. Grace Wilmarth.

OHIO

Taisia Stadnichenko collected coal samples from the Lower Kittanning beds in coal mines in eastern Ohio for study of processes of coal metamorphism.

OKLAHOMA

Geologic mapping of the coal deposits of a part of the southeastern Oklahoma coal field, extending from the McAlester quadrangle to the Arkansas line in Latimer and Le Flore Counties, was carried on by T. A. Hendricks, assisted by C. B. Read. Mr. Hendricks completed his report on the geology and economic resources of the McAlester quadrangle and made progress in the preparation of a report on the Wilburton-Poteau district.

In connection with P. D. Trask's study of organic constituents of sediments from four American oil fields, material from the Burbank field was collected and studied.

G. H. Girty continued office work on his papers on the Morrow fauna and the Moorefield fauna. P. V. Roundy continued his studies of the microfaunas of the Sycamore formation, Caney shale, and Moorefield shale and worked on a paper on Carboniferous microfossils associated with *Chara* from well cores.

H. D. Miser, N. W. Bass, T. A. Hendricks, C. B. Read, and P. B. King attended the Kansas Geological Society field conferences in the Arbuckle and Wichita Mountains, and Messrs. Miser and Trask attended a field excursion of geologists in the Arbuckle and Ouachita Mountains. Mr. Miser prepared a paper on the Oklahoma structural salient of the Ouachita Mountains for the meeting of the Geological Society of America at Tulsa.

Ordovician and early Silurian geologic sections in the Arbuckle and Wichita Mountains were studied by E. O. Ulrich and Josiah Bridge, and fossil material was collected by them in connection with their studies of early Paleozoic gastropods of North America. C. B. Read collected fossil plants from the Woodford chert in the Arbuckle Mountains. Mr. Read is preparing a paper on the fossil flora of the Hartshorne sandstone, of Pennsylvanian age.

P. V. Roundy compiled data for the Indian Service regarding desirable sites for gas wells in the Osage Indian Reservation.

A guidebook on the Pennsylvanian of the northern mid-continent region (Kansas, Oklahoma, and Texas) was prepared by R. C. Moore. A guidebook on the petroleum geology and stratigraphy of Oklahoma and Texas was prepared under the direction of W. E. Wrather.

Work by Edwin Kirk on crinoids is noted under Missouri, and several projects lying partly in Oklahoma are noted under Arkansas.

OREGON

In continuation of the cooperation with the Oregon State Mining Board, field work was done in the mineralized areas of the Cascade Mountains by Eugene Callaghan, and the placer deposits of the western coast of southern Oregon were examined by J. T. Pardee. In eastern Oregon B. N. Moore continued field work on the nonmetallic resources, making examinations of limestone deposits, coal mines, diatomaceous deposits, asbestos, and pumice deposits. His report on these resources is practically completed. Substantial progress has been made on reports covering field work of previous seasons on these cooperative projects, and some of the manuscripts were completed for publication. P. J. Shenon's reports on the Robertson, Humdinger, and Robert E. gold mines and vicinity, southwestern Oregon, which will contain notes on the Chieftain and Continental mines, South Myrtle Creek, by F. G. Wells, and on the geology and ore deposits of the Takilma-Waldo district have been completed and will appear in "Contributions to economic geology." A report on the metalliferous deposits of the Cascade Range in preparation by Eugene Callaghan will include the results of work in the Bohemia and Blue River districts.

Reports on the Oregon gold placers by J. T. Pardee, the quicksilver deposits of southwestern Oregon by F. G. Wells, and the copper deposits in the Squaw Creek and Silver Peak districts and in the Alameda mine by P. J. Shenon are in progress. Mr. Pardee also prepared a report on the geology of dam sites near Troy and Cloverdale for the conservation branch.

The diatoms of eastern Oregon are being studied by K. E. Lohman.

James Gilluly completed his report on the ore deposits of eastern Oregon and a paper on the origin of the albite granite near Sparta, for Survey publication, and a paper with J. C. Reed on the heavy mineral assemblage of some of the plutonic rocks of eastern Oregon, for the American Journal of Science. He continued preparation of a report on the geology of the Baker quadrangle.

F. E. Matthes prepared a revised descriptive text for the reprint of the Crater Lake topographic map.

A guidebook on central Oregon was prepared by R. W. Chaney.

Publication: Bulletin 830-A. (See p. 2.)

PENNSYLVANIA

Work on cooperative projects with the Pennsylvania Topographic and Geologic Survey included completion of the field investigations of the geology of the Hanover and York quadrangles, by G. W. Stose and A. I. Jonas, and

office work on a report to be published as a bulletin of the United States Geological Survey. Additional field work in the New Cumberland quadrangle was done by Mr. Stose, and his portion of the text and the geologic map have been completed and submitted to the State for publication. The results of studies on the general structure of the region of the Hellam Hills, in the Middletown and York quadrangles, by Mr. Stose and Miss Jonas, will be submitted to some scientific periodical.

Revision of the manuscript for the report on the geology of the Bellefonte quadrangle, by E. S. Moore, was completed by Charles Butts for Survey publication, and progress was made by Mr. Butts on his report on the geology and mineral resources of the Tyrone quadrangle.

G. B. Richardson made further field examinations and collected data on oil and gas development in the Butler and Zelienople quadrangles for his detailed report covering these quadrangles, which is nearing completion.

In connection with studies on the effect of progressive metamorphism in the Lower Kittanning coal beds of Pennsylvania, Ohio, and West Virginia, Taisia Stadnichenko collected samples from these beds in coal mines at Clymer, Force, Cadogan, Johnston, and St. Michael.

M. R. Campbell and T. A. Hendricks made a field trip to the anthracite fields of Pennsylvania in connection with their coal-classification studies.

A guidebook on the mineral deposits of New Jersey and eastern Pennsylvania, prepared under the direction of C. P. Berkey, contains the following brief chapters on Pennsylvania:

The Bangor-Pen Argyl slate region, by C. H. Behre, jr.

The Lehigh Portland-cement district, by B. L. Miller.

Bethlehem to Nesquehoning, by B. L. Miller.

The anthracite field of Pennsylvania, by M. R. Campbell.

Anthracite field—Mauch Chunk to Lebanon, by G. H. Ashley.

The Cornwall iron mines, near Lebanon, by W. L. Cumings.

Lebanon to Harrisburg, by W. L. Cumings.

Geology of the Cornwall iron mines, near Lebanon, by G. W. Stose.

A guidebook on southern Pennsylvania and Maryland, by G. W. Stose, A. I. Jonas, and G. H. Ashley, contains a section on Washington to Harrisburg, Juniata River and Cornwall mines.

Publications: Bulletins 828 and 829. (See p. 2.)

SOUTH CAROLINA

C. W. Cooke did field work on the Cretaceous, Eocene, and Pleistocene formations in connection with the preparation of a geologic map to accompany his report on the geology of the Coastal Plain region of South Carolina and continued preparation of the general report on the area.

The guidebook on the southern Appalachian region is noted under Alabama.

SOUTH DAKOTA

A chart giving a correlation of the named geologic units in North and South Dakota, by M. Grace Wilmarth, was issued.

A guidebook on the Black Hills, prepared under the direction of C. C. O'Harra, contains the following papers:

General geology, by C. C. O'Harra.

Western and northern Black Hills, by C. C. O'Harra and J. P. Connolly.

Central Black Hills, by J. P. Connolly.

White River badlands, by G. L. Jepsen.

TENNESSEE

E. O. Ulrich and Josiah Bridge visited certain outcrops of early Paleozoic formations in eastern Tennessee to gather data and fossils for their general study of gastropods of the early Paleozoic formations of North America.

Messrs. Ulrich, Bridge, and Currier visited the zinc-mining areas in northern Tennessee to determine the origin of breccias in zinc areas.

Papers on the Ducktown mining district, by W. H. Emmons, and the Mascot-Jefferson City zinc district, by M. H. Newman, are included in the guidebook on mining districts of the Eastern States.

Work in the southern Appalachian region is noted under Alabama.

TEXAS

L. W. Stephenson collected additional material in the field from the Navarro formation of Texas, including many new species and some new genera, which will necessitate revision of the manuscript for the monograph on the Navarro fossils of Texas that is being prepared in cooperation with the Texas Bureau of Economic Geology.

Julia Gardner continued preparation of the monograph on the Midway fauna of Texas, a cooperative project with the Texas Bureau of Economic Geology, which is about complete and will be published as a bulletin of the University of Texas.

Field work in southern Texas was continued by Miss Gardner in connection with the studies of the Eocene formations of the State. In cooperation with the water-resources branch Miss Gardner studied the Lower Tertiary formations of southern Texas and C. W. Cooke made field studies in the vicinity of Houston.

The geologic map of Texas, which has been compiled by N. H. Darton, L. W. Stephenson, and Julia Gardner in cooperation with the Bureau of Economic Geology of Texas and several oil companies and other geologists, has been so far completed as to be ready for the issuance of a preliminary uncolored edition, as a basis for criticism and revision.

The geology of the Marathon Basin, including the Monument Springs and Marathon quadrangles, will be discussed by P. B. King in a report for Survey publication on which work has been advanced during the year. Mr. King, assisted by J. B. Knight, continued the field study of the geology of the Diablo Plateau area. As a by-product of his investigations in western Texas, Mr. King wrote for unofficial publication the following papers: "Limestone reefs in the Leonard and Hess formations," *American Journal of Science*; "Possible Silurian and Devonian strata in the Van Horn region," *Bulletin of the American Association of Petroleum Geologists*; "Large boulders of the Haymond formation of west Texas," and "Permian limestone reefs in the Van Horn region of Texas," *Bulletin of the Geological Society of America*; and an abstract of a paper on Paleozoic folding in trans-Pecos Texas, for the *American Association of Petroleum Geologists*. The last-mentioned paper will be revised and enlarged for Survey publication.

The manuscript of a report on the geology of the Rio Grande region of Texas, by A. C. Trowbridge, was revised, additional data by L. W. Stephenson and Julia Gardner were included, and the paper was transmitted for publication as a bulletin of the Survey.

The coastal terraces of Texas will be described in a paper which C. W. Cooke is preparing on the coastal terraces of the Atlantic and Gulf States.

In connection with studies of organic constituents of sediments from some American oil fields, P. D. Trask, assisted by W. R. Keyte for the American Petroleum Institute, visited the eastern Texas oil field to procure samples.

A paper by Josiah Bridge and C. L. Dake, entitled "The subdivision and correlation of the Ellenburger limestone" was submitted for publication in the *Bulletin of the Geological Society of America*.

A cooperative investigation including field mapping of the structure of the Cliffside dome and surrounding area in Potter County was made by N. W. Bass for the Bureau of Mines, and the report was completed and sent to that bureau.

A paper by F. S. MacNeil on a new genus of fresh-water mussels from the Catahoula sandstone of Texas was approved for publication in the *Bulletin of the American Association of Petroleum Geologists*.

Study of the Ostracoda of the Marble Falls limestone was continued by P. V. Roundy.

A guidebook on western Texas and the Carlsbad Caverns was written by N. H. Darton, P. B. King, and B. H. Haigh, Mr. Darton having prepared the part relating to the Guadalupe Mountains, Carlsbad Caverns, and El Paso region, and Messrs. King and Haigh the portions on the Marathon and Glass Mountains, Diablo Plateau, and Hueco Mountains. A guidebook on the petroleum geology and stratigraphy of Oklahoma and Texas was prepared under the direction of W. E. Wrather, and one on the Pennsylvanian of the northern mid-continent region by R. C. Moore.

Work on potash is described on pages 11-13, and several projects including work in Texas are noted under Arkansas and Louisiana.

UTAH

A. A. Baker, assisted by D. A. Andrews and party, continued detailed areal and structural mapping in the southern part of the Green River Desert in Emery and Wayne Counties.

Reports for Survey publication on the geology of the Salt Valley anticline and the northwestern flank of the Uncompahgre Plateau, Grand County, by C. H. Dane, and one on the Monument Valley-Navajo region of San Juan County, by A. A. Baker, are nearly completed. Mr. Baker continued office work on his report on the geology of the Green River Desert and the eastern flank of the San Rafael Swell. The report on the geology and oil possibilities of the southeastern part of the Moab district, Grand and San Juan Counties, was completed by Mr. Baker for publication as a bulletin of the Survey.

E. M. Spieker extended his field mapping and study of the coals, stratigraphy, and structure of a portion of the Wasatch Plateau and continued office work on reports in hand covering his investigations of several seasons in this region, which will include a paper on coal resources, a discussion of the glacial geology, and a professional paper on the general geology and mineral resources of the region.

H. E. Gregory did field work in the Colorado Plateau region of southern Utah in connection with gathering material for a guidebook and in furthering his studies on correlation of the geologic formations of this region.

A paper by R. W. Brown on recognizable species of the Green River flora of Colorado, Utah, and Wyoming was completed for inclusion in "Shorter contributions to general geology."

The report on the geology of the portion of the Book Cliffs, Utah, between Sunnyside and the Colorado State line, by D. J. Fisher, was transmitted for publication as a bulletin of the Survey.

The report on the geology and ore deposits of the Gold Hill quadrangle by T. B. Nolan is nearly completed.

Edwin Kirk completed the draft of a paper on the Eureka quartzite of the Great Basin.

Studies of the species of *Tempskya* from the Cretaceous and Upper Jurassic formations are being made by R. W. Brown and C. B. Read.

A guidebook on the Great Salt Lake region, prepared under the direction of J. M. Boutwell, contains the following papers:

Geography, by J. C. Alter.

Geomorphology, by W. M. Davis.

Stratigraphy, by A. A. L. Mathews.

Geologic structure and geologic history, by Paul Billingsley.

Economic geology, by J. M. Boutwell.

Wasatch front, by J. M. Boutwell.

Bingham mining district, by R. N. Hunt.

Stratigraphy in the central Wasatch and western Uinta Mountains, by J. M. Boutwell.

Park City mining district, by J. M. Boutwell.

Cottonwood region, by J. M. Boutwell.

Mount Timpanogos, by M. O. Hayes.

Tintic mining district, by Paul Billingsley and G. W. Crane.

Salt Lake City to Montpelier, Idaho, by G. R. Mansfield.

The dinosaur quarry of eastern Utah, by F. J. Pack.

A guidebook on the Colorado Plateau region was prepared by H. E. Gregory. Correlation of the Jurassic sandstone is noted under Arizona, work in the Bridger Basin under Wyoming, and work in the Rocky Mountain phosphate fields under Idaho. Work on potash in Utah is described on page 12.

Publications: Professional Papers 164 and 168. (See p. 1.)

VERMONT

Arthur Keith contributed corrections and revisions of the geologic boundaries of Vermont for the geologic map of the United States.

A guidebook by C. R. Longwell and others, covering eastern New York and western New England, includes descriptions of geologic features in western Vermont, by Mr. Keith and E. B. Knopf. A paper on the stratigraphy and structure of northwestern Vermont by Mr. Keith was approved for publication by the Washington Academy of Sciences.

Work in the Taconic quadrangle is noted under Massachusetts.

VIRGINIA

The field work in the study of the geology of the southwestern Virginia zinc and lead region carried on by L. W. Currier in cooperation with the Virginia Geological Survey was completed, and the report, which will be published by the State, is about ready for transmittal.

Areal mapping of the Appalachian Valley of Virginia by Charles Butts, a project which has been under way for several years in cooperation with the Virginia Geological Survey, was completed, and the manuscript geologic map was finished by Mr. Butts and transmitted to the State geologist for publication.

Field work in the Abingdon quadrangle is in progress by Mr. Butts in cooperation with the State. This work comprises revision and completion of work started by G. W. Stose several years previously.

E. O. Ulrich and Josiah Bridge made field examinations of outcrops of some early Paleozoic formations to gather data for their general studies of the early Paleozoic gastropods in North America. J. S. Williams made a brief field study of Carboniferous formations in the southern part of the State.

A field study of the titanium deposits was made by C. S. Ross in connection with his work on the southern Appalachian copper deposits.

A guidebook to the Chesapeake Bay region was prepared by L. W. Stephenson, C. W. Cooke, and W. C. Mansfield, and a guidebook to northern Virginia, prepared under the direction of Arthur Bevan, includes the following papers:

Introduction, by Arthur Bevan.

Geomorphology of the Piedmont region, including The composite peneplain of the Virginia Piedmont, by M. R. Campbell, and Itinerary, by Arthur Bevan.

Charlottesville to West Virginia by way of Waynesboro, Staunton, and Monterey, by Charles Butts, including Pre-Cambrian, by A. I. Jonas.

Titanium deposits of the Roseland district, by C. S. Ross.

Talc and soapstone deposits of Virginia, by J. D. Burfoot, jr.

WASHINGTON

Some progress was made by W. C. Alden on the report on the glacial geology and geomorphology of eastern Washington.

A brief examination of the Metaline mining district was made by J. T. Pardee. He also prepared reports for the conservation branch on the geology of dam sites on the South Fork of the Nooksack River and the Queets River and near Ray's Ferry and examined for the water-resources branch ground-water occurrences at the Puget Sound Navy Yard.

E. W. Berry studied fossil plants from the Latah formation of Grand Coulee.

A guidebook on the channeled scabland was prepared by J. H. Bretz.

Publication: Professional Paper 170-C. (See p. 2.)

WEST VIRGINIA

Work on the Lower Kittanning coal beds is noted under Pennsylvania.

WISCONSIN

A guidebook on the glacial geology of the Central States, prepared under the direction of W. C. Alden, contains an annotated guide of southern Wisconsin, by E. F. Bean, F. W. Thwaites, and W. C. Alden. The guidebook on the Lake Superior region, with an introduction by C. K. Leith, contains papers on the Gogebic range, by W. O. Hotchkiss; mining in the Gogebic range, by F. G. Pardee; and Gogebic range to Duluth, by H. R. Aldrich.

Work in the Lake Superior iron-ore region is noted under Minnesota.

WYOMING

The detailed geologic field study of phosphate occurrences in the Afton quadrangle was continued by W. W. Rubey and J. S. Williams, and a conference in the quadrangle was held with G. R. Mansfield. Several more seasons will be required to complete the field work. Paleontologic studies on Ordovician and Devonian fossil collections were made by Edwin Kirk.

Reports for Survey publications are in preparation by W. H. Bradley on the geomorphology of the north flank of the Uinta Mountains and on Tertiary rocks of the Green River Basin.

Samples from wells in and around the Salt Creek oil field were collected by P. D. Trask for study in connection with his work on organic constituents of sediments from four American oil fields.

R. W. Brown completed a paper on fossil plants from the Aspen shale in southwestern Wyoming for publication in the Proceedings of the United States National Museum.

Mr. Brown and C. B. Read collected data on *Tempskya* from the Cretaceous and Upper Jurassic rocks with particular reference to the Wayan and Aspen formations of southwestern Wyoming.

G. R. Mansfield made a geologic examination and prepared a report for the conservation branch on dam sites in the canyon of the South Fork of the Snake River.

A guidebook to the Yellowstone-Beartooth-Big Horn region, prepared under the direction of R. M. Field, contains the following papers:

Introduction, by W. T. Thom, jr.

Stratigraphy, by J. G. Bartram.

Regional structural relations, by W. T. Thom, jr., R. T. Chamberlin, and W. H. Bucher.

Geologic history, by Arthur Bevan, Eliot Blackwelder, N. M. Fenneman, R. M. Field, and W. T. Thom, jr.

Yellowstone National Park, by R. M. Field.

Hot Springs of Yellowstone Park, by E. T. Allen.

Mammoth Hot Springs to Grand Canyon of the Yellowstone, by R. M. Field.

Grand Canyon of the Yellowstone to Roosevelt Lodge, by R. M. Field.

Roosevelt Lodge to east entrance of Yellowstone Park, by R. M. Field.

East entrance of Yellowstone Park to Cody, by W. T. Thom, jr., R. M. Field, R. T. Chamberlin, and W. H. Bucher.

Cody to Red Lodge, by W. T. Thom, jr., R. T. Chamberlin, W. H. Bucher, W. J. Sinclair, and G. L. Jepsen.

Red Lodge area, by N. M. Fenneman, Erling Dorf, W. J. Sinclair, and G. L. Jepsen.

Red Lodge to Beartooth Butte and return, by Arthur Bevan and Erling Dorf.

Red Lodge to Billings by way of Pryor Gap, by W. T. Thom, jr., N. M. Fenneman, R. T. Chamberlin, and W. H. Bucher.

Pryor Gap to Sheridan, by R. T. Chamberlin, W. H. Bucher, and W. T. Thom, jr.

Paleocene and Eocene formations and faunas of the northern part of the Big Horn Basin, by W. J. Sinclair and G. L. Jepsen.

History of petroleum development in the Big Horn Basin region, by W. B. Emery.

Gravity data, by William Bowie.

Other work in Wyoming is noted under Colorado, Idaho, and North Dakota.

MISSISSIPPI VALLEY

Investigation of the geomorphic history of the head of the Mississippi embayment was continued by F. E. Matthes. This included studies of the uplands from the vicinity of Poplar Bluff to Cape Girardeau, Mo., thence south to New Madrid, Mo., and in the vicinity of Reelfoot Lake, Tenn. Mr. Matthes has made progress on his report on diversion of the Mississippi River across Crowleys Ridge.

FOREIGN COUNTRIES

E. O. Ulrich and Josiah Bridge made brief field examinations of fossil localities in eastern Canada in connection with their studies of fossil distribution in North America. C. B. Read prepared a paper on new species of *Dadoxylon* from the Permian of Shensi, China. A paper by C. W. Cooke entitled "Why the Mayan cities of the Peten district, Guatemala, were abandoned" was published in the Journal of the Washington Academy of Sciences. Cooperation with the National Research Council was given by Julia Gardner in a study of Mexican Tertiary fossils. Fossil collections from Bolivia, Brazil, and Puerto Rico were reported upon by Edwin Kirk and J. B. Reeside, jr.

GENERAL STUDIES

Mineralogic, structural, stratigraphic, and paleontologic studies of a general nature or covering broad areas have been carried on during the year by many of the geologists. These include studies on the source rocks of petroleum, by P. D. Trask, in cooperation with the American Petroleum Institute; origin

and constitution of coal and carbonaceous shale, by Taisia Stadnichenko; classification of coals, by David White and M. R. Campbell; copper deposits of the southern Appalachian region, by C. S. Ross; structural relation of lead and zinc deposits in the Appalachian belt, by L. W. Currier; structural geology of the Great Basin, by D. F. Hewett; occurrence of manganese in the United States, by D. F. Hewett; early Paleozoic gastropods, by E. O. Ulrich and Josiah Bridge; early Paleozoic cephalopods, by E. O. Ulrich, A. F. Foerste, and Josiah Bridge; lower Paleozoic stratigraphy of the upper Mississippi Valley, by E. O. Ulrich; Maquoketa fauna of the Mississippi Valley, by E. O. Ulrich and A. F. Foerste; Upper Cretaceous Foraminifera of the Gulf Coastal Plain, by J. A. Cushman and L. G. Henbest; Devonian-Carboniferous faunas, by G. H. Girty; the genus *Productus*, by G. H. Girty and J. S. Williams; the Ostracoda and Carboniferous microfossils, by P. V. Roundy; a new genus of Cycadofilicales, by C. B. Read; *Rototinnula*, a new genus of fossil plants from the upper Paleozoic, by C. B. Read; the Jackson group, by C. W. Cooke; and Pleistocene shore lines by C. W. Cooke. E. F. Burchard compiled data on the fluorspar deposits in the western United States for use by the Bureau of Mines. F. E. Matthes prepared for the National Research Council committee on sedimentation a paper on glacial sediments in the Mississippi Valley.

The following papers giving results of general studies were completed during the year for publication by the Geological Survey:

Cushman, J. A., Upper Eocene Foraminifera of the southeastern United States (professional paper).

Cushman, J. A., and Cahill, E. C., Miocene Foraminifera of the Coastal Plain of the eastern United States (Shorter contributions to general geology).

Howe, M. A., The geologic importance of the lime-secreting algae, with a description of a new travertine-forming organism (Shorter contributions to general geology).

King, P. B., Structural geology of the United States (International Geological Congress guidebook).

Reeside, J. B., Jr., Stratigraphic nomenclature in the United States (International Geological Congress guidebook).

The following papers were completed or published in technical journals:

Anderson, A. L., Notes on the oxidation of jamesonite, sphalerite, and tetrahedrite. *Economic Geology*.

Anderson, A. L., Occurrence of giant hornblende. *Journal of Geology*.

Brown, R. W., A Cretaceous sweet gum. *Botanical Gazette*.

Butler, B. S., Influence of the composition of the replaced rock on the minerals formed in metasomatic replacement associated with ore deposits. *Economic Geology*.

Campbell, M. R., Coal work carried on by the Geological Survey. *United States Daily*.

Cooke, C. W., Tentative correlation of American glacial chronology with the marine time scale. *Journal of the Washington Academy of Sciences*.

Cooke, C. W., The seven coastal terraces in the Southeastern States. *Journal of the Washington Academy of Sciences*.

Gardner, Julia, and Bowles, Edgar, The distribution of the *Venericardia planicosta* group in the American lower Eocene. *Journal of Paleontology*.

Gardner, Julia, and Bowles, Edgar, An inverted hinge in a left valve of the *Venericardia planicosta* group. *Journal of Paleontology*.

Girty, G. H., New Carboniferous invertebrates. *Journal of the Washington Academy of Sciences*.

Goldman, M. I., Discussion of authors' abstracts. *Science*.

Henbest, L. G., The species *Endothyra baileyi* (Hill). *Contributions from the Cushman Laboratory*.

Jonas, A. I., Structure of the metamorphic belt of the southern Appalachians. *American Journal of Science*.

Loughlin, G. F., Nonferrous metal deposits. *United States Daily*.

Lovering, T. S., Field evidence to distinguish overthrust from underthrusting. *Journal of Geology*.

Mansfield, G. R., Remarkable luxuriance of marine vegetation in early geologic time. *Science Service*.

Matthes, F. E., Matthes's studies in the Mississippi Valley (summer of 1932). *Journal of Geography*.

Matthes, F. E., Mountain glaciers and their work. *Home Geographic Monthly*.

Miser, H. D., Geologic studies of petroleum, natural gas, and helium. United States Daily.

Ross, C. S., Clay minerals. American Ceramic Society.

Rubey, W. W., Settling velocities of gravel, sand, and silt particles. American Journal of Science.

Shenon, P. J., Chalcopyrite and pyrrhotite inclusions in sphalerite. American Mineralogist.

Shenon, P. J., A massive sulphide deposit of hydrothermal origin in serpentine. Economic Geology.

Shenon, P. J., A curious occurrence with platinum. Engineering and Mining Journal.

Cushman, J. A., The Foraminifera of the Saratoga chalk. Journal of Paleontology.

Trask, P. D., Origin and environment of source sediments; Summary of work of 1931-32. American Petroleum Institute.

Trask, P. D., Deposition of organic matter in recent sediments. American Association of Petroleum Geologists.

Trask, P. D., Relation of calcium carbonate content of sediments to salinity of the surface water (abstract presented at Tulsa meeting). Geological Society of America.

Williams, J. S., and Rowley, R. R., Unique coloration of two Mississippian brachiopods. Journal of the Washington Academy of Sciences.

Contributions of general scope for the Lindgren volume of the American Institute of Mining and Metallurgical Engineers include the following papers:

Ore deposits as related to stratigraphy, structure, and igneous geology in the western United States, by B. S. Butler.

Manganese in western hydrothermal deposits, by D. F. Hewett and J. T. Pardee.

Mesothermal tungsten deposits of the western United States, by T. S. Lovering.

Pre-Cambrian iron ores, by T. S. Lovering; Mesothermal silver-lead-zinc veins, by E. T. McKnight.

Epithermal precious-metal deposits of the Western States, by T. B. Nolan.

Epithermal quicksilver deposits of the Cordilleran region, by C. P. Ross.

Antimony, by F. C. Schrader.

Molybdenum, by J. W. Vanderwilt.

Publications: Professional Paper 170-B; Bulletin 838. (See p. 2.)

WORK IN PETROLOGY

The work in petrology comprises three distinct phases—the preparation of thin and polished sections of material to be studied under the microscope, the study and identification of rocks and minerals, and the application of petrographic methods to geologic problems.

The grinding laboratory of the section of petrology during the year made 2,501 thin sections, polished 477 specimens, and sawed 77 specimens. Of these about 100 thin sections and 75 polished specimens were of coals, which present unusual difficulties in the production of specimens satisfactory for microscopic study. Over 500 thin sections were of clay, soils, friable sands, and salt, all of which require special technic in preparing.

A large portion of the time of the section of petrology is devoted to the determination of rocks submitted to the Geological Survey by people throughout the country, by oil geologists, and by those interested in mining, and in cooperative work with various States.

J. J. Glass calibrated the materials for 35 sets of index of refraction media for use by geologists, aided in the identification of specimens, and partly completed a detailed study of two pegmatites near Amelia, Va., and of the optical properties of the mineral inesite.

A paper on the manganese minerals of a vein near Bald Knob, N. C., by Clarence S. Ross and Paul F. Kerr, was published in the American Mineralogist.

WORK IN CHEMISTRY AND PHYSICS

The work in chemistry and physics includes tests necessary for the determination of rocks, ores, and minerals collected or received by the Geological Survey, qualitative and quantitative analyses of specimens and samples collected by geologists, and researches relating to problems in geology on which the Geological Survey is engaged.

Work in connection with the special 5-year appropriation for potash investigations is described on pages 11-13. W. T. Schaller has partly prepared a report on the mineralogy of the mine of the United States Potash Co., near Carlsbad, N. Mex. Chemical analyses of potash samples were made by R. K. Bailey, L. T. Richardson, E. T. Erickson, and J. J. Fahey. Some well logs were made by R. K. Bailey in Roswell, N. Mex., and others after he returned to Washington. A few cores were examined petrographically by Mr. Fahey, but most of the petrographic work on potash was done by F. C. Calkins. For several wells Mr. Calkins has edited all available information, consisting of different reports by himself, permittees, chemists, petrographers, and geologists, and combined it into a single report for each well.

Three lines of investigation were carried on by P. G. Nutting—(1) determination of the porosity and permeability of oil sands, (2) thermal dehydration of different minerals, and (3) study of the absorptive power of clays as determining their capacity to bleach or clarify oils. This property of clays seems to indicate distinct differences in their chemical and physical make-up, but it is too soon yet to say exactly what constituents or structures give the clays the properties observed.

C. E. Van Orstrand made temperature tests in deep wells in California, Michigan, Kentucky, and West Virginia. As a result of his discovery several years ago of a variation of temperature with structure in several oil fields, chiefly in Wyoming, the American Petroleum Institute initiated a research on the subject extending over a period of five years. The field work has been completed, and several reports on the subject have been published. In the office Mr. Van Orstrand studied special theoretical problems on the flow of heat in the crust of the earth. He was assisted in this research by H. C. Spicer, who carried out an elaborate series of computations on the flow of heat from dikes and other geologic features.

Identifications of specimens sent in by persons not officially connected with the Survey were made up to October 1, 1931, largely by L. T. Richardson, and after that date by Charles Milton, who also assisted in the chemical analysis of a number of minerals and rocks from different localities. A large number of rock analyses for geologists were made by J. G. Fairchild, assisted by E. T. Erickson, J. J. Fahey, R. E. Stevens, George Steiger, and R. C. Wells. Mr. Fairchild also analyzed several rare minerals, including thorianite from a locality near Easton, Pa., samarskite from South Carolina, pitchblende from Colorado, inesite from Oregon, and siderite from France.

Work with the quartz spectrograph occupied most of George Steiger's time. Technic was further developed so that a fair number of elements could be quickly detected, at least qualitatively. In this way over 150 analyzed samples were tested for beryllium, and the percentages of the six platinum metals in crude platinum ore were estimated. E. T. Erickson made qualitative tests for platinum metals, bromine, boron, and iodine in different ores and salines.

Among the rocks analyzed in the laboratory were 14 lavas and tuffs from Hawaii, 7 greenstones and 16 diatomites from Oregon, 24 dolomites from Colorado, 7 manganese ores from Arkansas, and 14 clays from different localities.

R. E. Stevens made experiments relating to theories of ore genesis and the solution of silicate rocks in water, with special reference to the alkalinity of such solutions. In particular he studied the action of alkali sulphide solutions on pyrite and analyzed an unusual silver and bismuth bearing galena from Leadville.

The age of minerals, as indicated by the lead-uranium ratio, was studied by R. C. Wells, collaborating with the National Research Council committee on the measurement of geologic time. Analyses for this purpose were also made by J. G. Fairchild. J. P. Marble, who had determined the atomic weight of lead in pitchblende from the Great Bear Lake region of Canada at Harvard University, analyzed different samples of the same material in the Geological

Survey laboratory to ascertain if the different deposits of that region have the same or different ages.

J. J. Fahey studied the optical, physical, and chemical properties of serpentines from several localities, collaborating with P. F. Kerr, of Columbia University, who is making X-ray studies of them. He also analyzed apthitalite from New Mexico.

E. T. Erickson determined a number of natural bitumens and familiarized himself with paleobotany, with special reference to possible chemical changes in the alteration of plant tissues in the formation of bitumen, oil, and coal.

Much of Mr. Schaller's time was taken up in consultations with geologists concerning their mineralogic problems. He critically read more than a dozen referred manuscripts and gave eight lectures during the year—one at Spruce Pine, N. C., and most of the others in New York City at Columbia University, the American Institute of Mining and Metallurgical Engineers, and the New York Mineralogical Club. He spent a few days in field work in North Carolina and Virginia. A set of commercial soapstones was studied mineralogically, showing that talc is only a minor constituent. A study of an unknown manganese silicate from Oregon and from Italy showed it to be a new member of the pyroxene group.

During the year 5,814 examinations were made, of which 2,339 were petrographic or microscopic identifications of the potash minerals in cores and well cuttings. The potash work also required 1,187 qualitative tests and 441 quantitative analyses. Identifications of specimens made in the chemical laboratory for persons not connected with the Survey amounted to 1,173. The remaining 460 qualitative tests and 214 quantitative analyses were made chiefly in response to direct requests by geologists and partly in connection with chemical and physical researches relating to methods of analysis and geochemical studies.

The following papers were completed during the year:

- Buddington, A. F., and Fairchild, J. G., Tertiary volcanics of southeastern Alaska. *American Journal of Science*.
- Hess, F. L., and Fahey, J. J., Cesium biotite from South Dakota. *American Mineralogist*.
- Milton, Charles, The occurrence of moissanite in sediments. *Journal of Sedimentary Petrology*.
- Nutting, P. G., Physical and chemical factors in the accumulation and discharge of oil. *American Association of Petroleum Geologists*.
- The bleaching clays. *United States Geological Survey*.
- The solution and colloidal dispersion of minerals in water. *Journal of the Washington Academy of Sciences*.
- The bleaching earths. *Industrial and Engineering Chemistry*.
- Schaller, W. T., Sulvanite from Utah. *American Mineralogist*.
- Refractive indices of bloedite. *American Mineralogist*.
- Schaller, W. T., and Fairchild, J. G., Bavenite from California. *American Mineralogist*.
- Shanon, P. J., and Steiger, George, A curious occurrence of platinum. *Economic Geology*.
- Stevens, R. E., Studies on the alkalinity of some silicate minerals. *United States Geological Survey*.
- The formation of pyrrhotite by the action of alkali sulphide solutions on pyrite. *Economic Geology*.
- Van Orstrand, C. E., The precision analysis of gaseous hydrocarbons and other gases by the heat conduction method. *American Petroleum Institute*.
- Discussion of F. W. Lee's paper on "A comment upon present-day applied geophysics." *American Gas Association*.
- Some recent applications of physics to sedimentation problems. *National Research Council*.
- The correlation of isogeothermal surfaces with the rock strata. *Physics*.
- Wells, R. C., and Stevens, R. E., Further studies of kolm. *Journal of the Washington Academy of Sciences*.

Publications: *Bulls.* 832, 833. (See p. 2.)

*ALASKAN BRANCH**PHILIP S. SMITH, Chief Alaskan Geologist**ORGANIZATION AND PERSONNEL*

The Alaskan branch consisted at the end of the year of the chief Alaskan geologist, 6 geologists, 1 mining engineer, 1 coal-mining assistant, 5 topographic engineers, 1 draftsman, and 4 clerks. In addition, 12 camp hands and other assistants were employed for temporary field service.

SCOPE OF THE WORK

For more than 30 years the Government has been carrying on investigation of the mineral resources of the Territory of Alaska, not only to find out what it owned but also to advise its citizens as to the conditions that were considered favorable for finding deposits of minerals that are of commercial value. This work has been largely carried on through the Alaskan branch of the Geological Survey, and hundreds of reports and maps of the investigations of this unit have been published and made available to all who are interested in the development of the Territory. The work on which these reports are based has taken the geologists and engineers into all parts of the Territory and to all the known important mining camps. Their trails and maps have frequently been the only authoritative guides to many of the remote districts.

The Geological Survey's Alaskan work has two rather distinct phases—one of a general investigational type and the other of a semiadministrative type in connection with the technical supervision of the leases granted by the Government covering coal, oil, or other mineral lands. For convenience of description the work of the first type will be referred to briefly as work on mineral resources and that of the second type as leasing work.

MANUSCRIPTS AND PUBLICATIONS

The principal products of the Alaska work of the Geological Survey are the reports and maps based on original surveys or investigations. During the year 11 such reports and 6 new maps have been issued. (See pp. 1-3.) At the end of the year 28 reports and 8 maps were in different stages of preparation, not including several manuscripts that will require further field work or extensive research before they can be completed. Fifteen short papers were published as press bulletins.

Besides the official reports, several articles were prepared by the scientific and technical members of the branch for publication in outside journals, and 24 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 by-products of the regular work and serve to reach special audiences not readily reached by the official publications.

*WORK ON MINERAL RESOURCES**PROJECTS IN PROGRESS DURING THE SEASON OF 1931*

In addition to the routine duties of administration and of supplying information in answer to hundreds of inquiries received from the public and from other branches of the Government, 11 principal

projects, 8 of which involved field work, were carried on during the season of 1931. The eight projects involving field work were reconnaissance topographic mapping in the vicinity of Wrangell, southeastern Alaska, by R. H. Sargent, assisted by V. S. Seward; mineral investigation in the Taku district, southeastern Alaska, by B. D. Stewart; geographic and geologic investigations in the vicinity of Glacier Bay, southeastern Alaska, by C. W. Wright and H. F. Reid, whose salaries were paid through the generous cooperation of the Bureau of Mines; geologic and mineral-resources investigations in the Alaska Range province, at the head of the Copper River Valley, especially in the vicinity of Suslota Pass, by F. H. Moffit; reconnaissance topographic mapping in the vicinity of Tonsina, in the central part of the valley of the Copper River, by C. F. Fuechsel; a combined topographic and geologic reconnaissance of part of the Nushagak region, southwestern Alaska, by Gerald FitzGerald and P. A. Davison; mineral-resources investigations in the Rampart-Hot Springs district, of the Yukon region, in central Alaska, by J. B. Mertie, jr.; and a general reconnaissance of recent mining developments, particularly in central Alaska, by Philip S. Smith. In the course of the summer the Director of the Geological Survey, who had been a member of several of the pioneer Survey parties in remote parts of Alaska about 30 years before, joined Mr. Smith in going over the work in progress in the Willow Creek, Anthracite Ridge, Matanuska, and Fairbanks districts.

Some of the results of the season's work on the field projects described in the foregoing paragraphs, as well as that done in earlier years, may be expressed in terms of the area covered. In the following table the areas reported 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 1932 but remained uncompleted at the end of the fiscal year 1932, in part because at the end of the fiscal year most of the field parties are out of communication and so can not report how much they have accomplished. The areas credited in the table to 1931 include those surveyed in cooperation with the Alaska Railroad (see pp. 39-42) as well as those surveyed in the course of the regular work on mineral resources.

Areas surveyed by Geological Survey in Alaska, 1898-1931, in square miles

| 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) |
| 1898-1930..... | 75,650 | 176,630 | 4,277 | 55,630 | 213,249 | 4,066 |
| 1931, revision..... | | 1,935 | 51 | | 1,024 | 13 |
| 1931..... | 75,650 | 174,695 | 4,226 | 55,630 | 212,225 | 4,053 |
| | | 5,656 | 320 | | 5,373 | 307 |
| Percentage surveyed of total area of Alaska..... | 75,650 | 180,351 | 4,546 | 55,630 | 217,598 | 4,360 |
| | 44.4 | | | 47.3 | | |

In the table given above only the net areas surveyed are listed in the appropriate columns.

As a result of the photographing expeditions of the Navy Department in 1926 and 1929, the Geological Survey has in its files tens of

thousands of photographs taken specially for map-making purposes. Owing to the lack of funds little more compilation is undertaken at present than is required to furnish the ground parties with bases on which to do their field work. Fortunately, however, the records are permanent, so that ultimately all of this material will be used. A little more than 1,000 square miles of new drainage base was compiled from these photographs during 1931. This covered part of the region north and west of Wrangell, in southeastern Alaska, and was prepared for one of the topographic projects for the season of 1932. The map compilation was in charge of R. H. Sargent, who was assisted by V. S. Seward and J. I. Davidson.

The statistics regarding the output of minerals from Alaska each year are derived from many sources, including other Government organizations, such as the Bureau of Mines, the Bureau of the Mint, and the Customs Service; banks, express companies, and other organizations conducting business in Alaska; the larger Alaska newspapers, as well as certain papers published in the States that feature Alaska matters; and the replies to hundreds of schedules, one of which is sent to each person or company that is known to be engaged in mining in Alaska. The general clerical work on the collection of the statistical data for 1931 was carried on by Mrs. L. N. Eaton, and the material was coordinated and the resulting report prepared by the chief Alaskan geologist.

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 (see p. 42), but a part of their service relates to general investigations of mineral resources. The service of one of the staff at the Anchorage office is confined primarily to studies of deposits that may afford tonnage to the Alaska Railroad. This cooperative work was done by Ralph Tuck, and his salary and expenses were paid from railroad funds. (See p. 41.) Approximately two-fifths of the time of B. D. Stewart, supervising mining engineer, with headquarters in Juneau, is allotted to general investigations of mineral resources, including visits to different parts of the Territory as conditions warrant. The Alaska offices also act as local distributing points for publications of the Geological Survey and assist the main office at Washington by furnishing information on many phases of the mineral industry of the Territory.

PROJECTS FOR THE SEASON OF 1932

Ten projects chargeable to funds appropriated directly to the Geological Survey have been approved for the season of 1932. Seven of these projects involve field work and comprise reconnaissance topographic mapping in the Wrangell district and neighboring parts of southeastern Alaska, by R. H. Sargent, assisted by V. S. Seward; mining studies in the Taku district near Juneau and at other points in southeastern Alaska, by B. D. Stewart; reconnaissance topographic surveys in the mountains at the head of the Copper River Valley and at isolated unmapped tracts adjacent to the Richardson Highway between Valdez and Chistochina, by C. F. Fuechsel; reconnaissance geologic surveys in the Tonsina district, in the west-central part of the valley of the Copper River, by F. H. Moffit; reconnaissance topographic mapping of the northern part of Kodiak Island and adjacent islands in southwestern Alaska, by Gerald FitzGerald;

a geologic reconnaissance of parts of the Aleutian Islands, by S. R. Capps, in connection with an expedition sent by the Navy Department into that region; and the usual general studies of recent mining developments throughout Alaska, by Philip S. Smith.

A project that does not directly require field work for its completion, though it is based primarily on the field work that has been done in the past, is the preparation of a comprehensive report on the large tract of country lying west of the international boundary and included between the Yukon and Tanana Rivers. Ever since the earliest investigations of Alaska's mineral resources by the Geological Survey its parties have traversed parts of this region. To digest the mass of material resulting from these investigations and to bring forth a comprehensive and well-coordinated report that will present the best current interpretation of the complex geologic history of the region is the object of this undertaking. The task has been assigned to J. B. Mertie, jr., who during nine seasons has done field work in different parts of this region.

EXPENDITURES

The following table shows the principal classes of expenditures for which the appropriation for the fiscal year 1931-32 was allotted:

Approximate expenditures from funds appropriated for investigation of mineral resources of Alaska for the fiscal year 1931-32

| | |
|--|---------------|
| Projects for the season of 1931----- | \$22, 190 |
| Projects for the season of 1932----- | 11, 100 |
| Administrative salaries, July 1, 1931, to June 30, 1932----- | 4, 970 |
| All other technical and professional salaries, July 1, 1931, to June 30, 1932----- | 32, 930 |
| All other clerical and drafting salaries, July 1, 1931, to June 30, 1932----- | 8, 710 |
| Office maintenance and expenses----- | 3, 900 |
| Balance and contingent----- | 700 |
| | <hr/> 84, 500 |

Of the \$33,290 allotted to field projects about 45 per cent was allotted to geologic or related general work and 55 per cent to topographic work.

COOPERATIVE WORK WITH THE ALASKA RAILROAD

According to its organic act, the construction of the Alaska Railroad was undertaken not so much to enter the business of common carrier as to develop the Territory. However, the excess of expenses over income was large, and in 1929 Col. O. F. Ohlson, the manager of the railroad, requested aid from the Geological Survey to determine what could be done to stimulate mineral development that might contribute tonnage to the railroad, but with the funds and personnel available only a little work was actually accomplished. In 1930 a senatorial committee visited Alaska with the prime purpose of seeing what could be done to decrease the deficit of the Alaska Railroad, and in 1931 an appropriation of \$250,000 was granted by Congress for the "continuation of the investigation of mineral and other resources of Alaska to ascertain the potential resources available which will affect railroad tonnage." The Geological Survey was asked to submit recommendations as to the areas that appeared desirable to examine under this grant and to direct the technical work through its trained personnel.

PROJECTS IN PROGRESS IN 1931

Ten projects were approved for the season of 1931, embracing examinations in one coal area (Anthracite Ridge field), five gold districts (Fairbanks, Willow Creek, Moose Pass, Girdwood, and Valdez Creek), and three areas where the lodes consist mainly of mixed sulphides (the Eureka area in the Kantishna district, Mount Eielson, and an area near the head of the West Fork of the Chulitna River), and a general investigation of potential nonmetalliferous deposits throughout the railroad belt. All these areas had already been examined by Survey geologists in a manner that was regarded as adequate for reconnaissance standards, and the new work was to be of a much more detailed and intensive character and was directed toward quantitative determination of possible mineral tonnage rather than more general theoretical studies. The direct oversight of all the parties was assigned to S. R. Capps. During part of the season, through the cooperation of the geologic branch, the services of D. F. Hewett were made available as special consultant, and he visited many of the parties working in metalliferous areas and gave valuable advice and suggestions. Through the courtesy of the Bureau of Mines the samples collected by the different parties were analyzed at the laboratories of the bureau in Alaska. Cooperation was also afforded by the Alaska Road Commission.

The following table presents in condensed form information regarding the various projects:

Projects for cooperative work with Alaska Railroad, 1931

| District or area | Principal kind of deposits examined | Types of work | Technical personnel |
|------------------------------|-------------------------------------|--|--|
| Anthracite Ridge..... | Coal field..... | Detailed mineral resources and topography (1:12,000). | R. W. Richards, G. A. Waring, L. O. Newsome. |
| Fairbanks..... | Gold lodes..... | Detailed mineral resources..... | J. M. Hill. |
| Willow Creek..... | do..... | do..... | J. C. Ray. |
| Moose Pass-Hope..... | do..... | do..... | Ralph Tuck. |
| Girdwood..... | do..... | Detailed mineral resources and topography (1:62,500). | W. G. Carson, C. F. Park. |
| Valdez Creek..... | Gold lodes and placers. | Detailed mineral resources and reconnaissance topography. | C. P. Ross. |
| Eureka (Kantishna)... | Gold and mixed sulphides. | Detailed mineral resources and topography (1:62,500). | F. G. Wells, S. C. Kain. |
| Mount Eielson..... | Copper, lead, and zinc. | Detailed mineral resources and topography (1:62,500 and 1:24,000). | S. N. Stoner, J. C. Reed. |
| West Fork of Chulitna River. | Gold and mixed sulphides. | Detailed mineral resources and reconnaissance topography. | C. P. Ross. |
| General..... | Nonmetalliferous deposits. | Reconnaissance mineral resources. | G. A. Waring. |

PROJECTS IN PROGRESS IN 1932

Of all the projects undertaken in the summer of 1931 probably the most general interest centered around the work in the vicinity of Anthracite Ridge. It was undoubtedly the occurrence in this field of a bed of anthracite nearly 40 feet thick that induced the senatorial committee to take an optimistic view as to the probability of discovering mineral tonnage for the railroad, and the large amount of money recommended by the committee was based on the idea of core drilling this field extensively. The investigation in 1931 showed that the geologic information that could be obtained from surface indications is not adequate as a basis for conclusions and that the best way to determine the real value of the field is by drilling. On January 15, 1932, a contract was awarded to put down four holes to an estimated

depth of 2,000 feet each and to recover the core from them. G. A. Waring was designated as the Geological Survey representative to see that the drilling was carried on in accordance with the specifications and to receive and take care of the core as recovered, and P. A. Davison was assigned as assistant. According to the terms of the contract the driller has until December 31, 1932, to complete the work, but it seems probable that if no unusual difficulties arise the work should be finished considerably before that date.

Another drilling project undertaken in 1932 involves the testing of a coal area west of the present developed part of the Moose Creek field, in the Matanuska Valley, where the geologic conditions suggest that the coals may be less shattered and capable of being more cheaply mined than in the developed area. As the region is heavily covered with glacial deposits, the most suitable method of determining the sequence of beds and their structure is by drilling them and recovering cores of the formations penetrated. The contract has been awarded for drilling four holes, each about 1,000 feet deep and the work is to be completed by December 31, 1932. G. A. Waring, assisted by P. A. Davison, will have general oversight of the Government's interest in this work. The Moose Creek field lies within a few miles of existing transportation lines.

Another means of aiding the railroad in its endeavor to stimulate the production of minerals in the territory adjacent to its line has been the assignment of a geologist to the headquarters of the railroad at Anchorage, so that he might be readily available for consultation both by the officials or by others who wished technical information. This duty has been given to Ralph Tuck, who, during the winter of 1931-32 has made trips throughout the extent of the railroad, made several special examinations, completed a report on the Moose Pass-Hope district, and started a comprehensive file listing all the mineral properties adjacent to the railroad. The cooperative plan contemplates that each year the geologist should spend most of the open season in the examination of some prospective mineral-bearing area whose development might contribute tonnage to the railroad. In the season of 1932 an extensive tract along the eastern flanks of the Alaska Range between Ruth and Eldridge Glaciers will be examined by a combined geologic and topographic party in charge of Ralph Tuck and C. P. McKinley.

EXPENDITURES

An analysis of the expenditures made by the Geological Survey in connection with the projects it has carried on in cooperation with the Alaska Railroad would present only a partial picture of the work, because only such amounts as are needed for direct expenditure by the Geological Survey are transferred to its credit.

In general terms the allotments so far made to the Geological Survey for disbursement during the season of 1931 were approximately \$72,000; the expenses of supervision of the drilling and other Geological Survey work in connection with the Anthracite Ridge and Moose Creek projects until December 31, 1932, are estimated at \$13,800; and the field expenses of the reconnaissance geologic and topographic survey, including all office charges for Mr. Tuck's services until December 31, 1932, are estimated at \$7,000. All these estimates provide only for expenses directly incurred in connection with the projects and do not include any charges for general administra-

tion by the Geological Survey nor any indirect charges for overhead expenses in the Washington office, although the projects have thrown a heavy load on the small regular personnel.

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 or may be leased to private individuals or corporations under certain laws. Funds for this work throughout the United States are provided in a general item contained in the Interior Department appropriation act. For the fiscal year 1932 the allotment for Alaska leasing work was \$8,000.

In order that the policies and practices that have been developed by the leasing unit of the conservation branch of the Geological Survey 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.

B. D. Stewart, supervising engineer, who has headquarters at Juneau, is in immediate charge of the field work, assisted by J. J. Corey, coal-mining engineer, at Anchorage.

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 a 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.

During 1931 the operator of one of the two coal mines in the Matanuska district that had furnished a considerable part of the coal used in the operation of the railroad found it financially impracticable to continue operation and decided to close the mine temporarily. This would result in flooding the mine and jeopardizing the whole tract adjacent to the property. The Alaska Railroad on representation of these facts by the Geological Survey entered into an arrangement with the operator whereby the railroad would keep the water pumped out and in return would be allowed to mine enough coal to defray the cost. This work was placed in charge of J. J. Corey, who maintained a small force at the mine throughout the year and mined several thousand tons under this arrangement.

TOPOGRAPHIC BRANCH

J. G. STAACK, Chief Topographic Engineer

ORGANIZATION AND PERSONNEL

At the end of the year the organization of the topographic branch was as follows:

Atlantic division, Albert Pike, division engineer, in charge.

Central division, Glenn S. Smith, division engineer, in charge.

Pacific division, H. H. Hodgeson, division engineer, in charge.

Section of inspection and editing, W. M. Beaman, topographic engineer, in charge.

Section of computing, S. S. Gannett, topographic engineer, 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.

Including the above-named engineers, the technical force comprises 174 topographic, geodetic, or cartographic engineers of different grades and 55 engineering aides and draftsmen—a total of 229. The clerical force numbers 17.

The following members of the topographic branch were retired during the fiscal year 1932:

Asahel B. Searle, a native of Washington, D. C., was educated in private schools and in Columbian College (now George Washington University). He was appointed in the Federal service in 1882 and served as an engineer in topographic surveys in many of the States. During the World War he served as captain in the Engineer Corps. He retired March 31, 1932, after 50 years of service.

Samuel S. Gannett, a native of Maine and an alumnus of Bowdoin College and the Massachusetts Institute of Technology, entered the Government service as an engineer in July, 1882. He made geodetic surveys in many States and several times was appointed by the United States Supreme Court as engineer commissioner for service in the settlement of boundary disputes between States, a task in which he was particularly successful. For several years prior to his retirement June 30, 1932, he was in charge of the section of computing.

Basil Duke, a native of Kentucky, was educated in public and private schools and the University of Kentucky. He entered the Government service in July, 1889, and served as an engineer in the General Land Office and in the Geological Survey and as a captain of engineers during the World War. He was retired March 31, 1932, after nearly 43 years of service.

Charles W. Goodlove was educated in the public schools and Northwood Academy in Ohio, his native State. He entered the Government service in July, 1889, and served as a topographic engineer in many of the States until his retirement March 31, 1932, having served approximately 43 years.

William J. Lloyd, a native of Illinois, was educated in the public schools and the Corcoran Scientific School. He was engaged as a mine surveyor for two years prior to his appointment in the Federal service in May, 1894. Except for periods aggregating about 1½ years, when he was engaged in private work, he served as engineer engaged in topographic surveys until his retirement June 30, 1932, having approximately 36½ years of service to his credit.

EXPENDITURES

As shown in the table which follows, the Geological Survey supplements to a notable extent its own appropriations for topographic mapping with State and other Federal funds for similar purposes. Under this policy of cooperation the topographic work is standardized and its cost reduced. The total expenditures for topographic mapping were \$1,167,159.75.

Appropriations and expenditures for topographic surveys for the fiscal year ended June 30, 1932

| | Appropriation for topographic surveys | Transfers and repayments for work performed for other Federal units | Total Federal funds | State cooperative funds | Total funds |
|------------------------------------|---------------------------------------|---|---------------------|-------------------------|----------------|
| Topographic surveys, 1932----- | \$780,000.00 | \$194,139.05 | \$974,139.05 | \$382,804.06 | \$1,356,943.11 |
| Expenditures: | | | | | |
| Alabama----- | 3,864.20 | | 3,864.20 | 4,022.50 | 7,886.70 |
| Arizona----- | 12,748.49 | 5,490.14 | 18,238.63 | | 18,238.63 |
| Arkansas----- | 10,684.22 | | 10,684.22 | | 10,684.22 |
| California----- | 84,648.31 | | 84,648.31 | 76,611.67 | 161,259.98 |
| Colorado----- | 12,342.88 | | 12,342.88 | 5,562.59 | 17,905.47 |
| Georgia----- | | 317.61 | 317.61 | | 317.61 |
| Hawaii----- | 974.30 | | 974.30 | 1,000.00 | 1,974.30 |
| Idaho----- | 16,042.73 | | 16,042.73 | | 16,042.73 |
| Illinois----- | 52,988.39 | | 52,988.39 | * 39,806.42 | 92,794.81 |
| Iowa----- | 132.33 | 1,446.35 | 1,578.68 | | 1,578.68 |
| Louisiana----- | 36,447.33 | 27,898.13 | 64,345.46 | | 64,345.46 |
| Maine----- | 38,159.71 | 12,956.67 | 51,116.38 | 50,002.64 | 101,119.02 |
| Michigan----- | 27,098.30 | 828.32 | 27,926.62 | 26,410.38 | 54,337.00 |
| Minnesota----- | 7,027.19 | | 7,027.19 | | 7,027.19 |
| Mississippi----- | | 87,821.31 | 87,821.31 | | 87,821.31 |
| Missouri----- | 37,118.69 | 34,340.13 | 71,458.82 | 46,269.72 | 117,728.54 |
| Montana----- | ^b 14,138.21 | | 14,138.21 | 2,874.82 | 17,013.03 |
| Nevada----- | 13,201.05 | | 13,201.05 | 7,285.85 | 20,486.90 |
| New Hampshire----- | 25,592.22 | | 25,592.22 | 9,758.51 | 35,350.73 |
| New Mexico----- | 10,962.76 | | 10,962.76 | 286.00 | 11,248.76 |
| New York----- | * 37,923.61 | | 37,923.61 | 35,611.00 | 73,534.61 |
| Oregon----- | 21,760.61 | | 21,760.61 | 6,111.30 | 27,871.81 |
| Pennsylvania----- | 32,020.80 | | 32,020.80 | 37,322.54 | 69,343.34 |
| Tennessee----- | 8,759.80 | | 8,759.80 | 500.00 | 9,259.80 |
| Texas----- | 2,869.54 | | 2,869.54 | 2,681.54 | 5,551.08 |
| Utah----- | 16,165.29 | | 16,165.29 | | 16,165.29 |
| Vermont----- | 2,636.04 | | 2,636.04 | 5,000.00 | 7,636.04 |
| Virginia----- | 18,788.33 | 1,853.22 | 20,641.55 | 25,000.00 | 45,641.55 |
| Washington----- | 14,177.00 | | 14,177.00 | | 14,177.00 |
| West Virginia----- | 140.44 | | 140.44 | | 140.44 |
| Wisconsin----- | 686.58 | 2,371.30 | 3,057.88 | 686.58 | 3,744.46 |
| Wyoming----- | 16,068.19 | | 16,068.19 | | 16,068.19 |
| Books for library----- | 321.34 | | 321.34 | | 321.34 |
| Field distribution offices----- | 600.00 | | 600.00 | | 600.00 |
| Field instruments, purchase----- | 16,964.02 | | 16,964.02 | | 16,964.02 |
| Map information----- | 3,582.75 | | 3,582.75 | | 3,582.75 |
| One-millionth maps----- | 10,079.45 | | 10,079.45 | | 10,079.45 |
| Computing----- | ^d 4,055.83 | 840.00 | 4,895.83 | | 4,895.83 |
| Inspection and editing----- | ^d 8,937.45 | 911.66 | 9,849.11 | | 9,849.11 |
| Field instruments, repair----- | ^d 3,803.65 | | 3,803.65 | | 3,803.65 |
| Field stationery----- | ^d 268.06 | | 268.06 | | 268.06 |
| Office salaries----- | ^d 9,070.74 | 2,258.31 | 11,329.05 | | 11,329.05 |
| Photographic mapping----- | ^d 2,186.79 | 555.54 | 2,742.33 | | 2,742.33 |
| Contingents----- | ^d 341.12 | | 341.12 | | 341.12 |
| Bureau administration----- | 500.00 | | 500.00 | | 500.00 |
| Miscellaneous repay----- | | 10,157.47 | 10,157.47 | | 10,157.47 |
| Engraving and printing credit----- | * -45,590.00 | | -45,590.00 | | -45,590.00 |
| Refunds and adjustments----- | ^b -1,072.00 | 4,092.89 | 3,020.89 | | 3,020.89 |
| Total expenditures----- | ^f 590,216.64 | 194,139.05 | 784,355.69 | * 382,804.06 | 1,167,159.75 |
| Unexpended balance----- | ^f 189,783.36 | | 189,783.36 | | 189,783.36 |
| Grand total----- | 780,000.00 | 194,139.05 | 974,139.05 | * 382,804.06 | 1,356,943.11 |

* Includes \$697.79 Illinois funds expended for surveys in State parks as a repay project.

^b Includes delayed charge of \$1,072.00 against 1931 funds not reported as an expenditure in 1931.

^c Includes an adjustment of \$1,223.30 between Federal and Monroe County, N. Y., funds for an expenditure erroneously paid and reported as an expenditure from 1931 county funds.

^d Represents 35.74 percent of total cost; balance included in charges for projects undertaken in cooperation with the States.

* Total charges for engraving and printing maps resulting from cooperative surveys in 1932 but not expended.

^f \$359,798.21 expended on State cooperation exclusive of engraving and printing charges.

* Includes \$45,590.00 unexpended credit for engraving and printing maps resulting from cooperative surveys.

GENERAL OFFICE WORK

Office work incidental to the field work consisted in the inking, inspection, and editing of the completed topographic field sheets prior to their submission for reproduction, the computation and adjustment of the results of control field work, and the preparation of culture and drainage bases from aerial photographs for proposed mapping projects. Office mapping from aerial photographs, by stereophotogrammetric methods, was completed for the Zion National Park, Utah, and nearly completed for the Bryce Canyon National Park, Utah. The Air Corps, United States Army, and outside contractors furnished aerial photographs covering approximately 29,500 square miles for use in the topographic mapping program. In cooperation with the Air Corps, an experimental project was undertaken based upon a new 5-lens camera used at high altitudes, which promises to reduce the amount of control needed. Form sketches made from stereoscopic studies of aerial photographs were experimentally used as a supplement to topographic detail in densely wooded areas. A base map of Georgia was completed, and one of Michigan was nearly completed. Maps were prepared for the Office of Indian Affairs, and map projections were constructed for the Bureau of Chemistry and Soils. Maps were compiled and other illustrations were assembled for publication in the George Washington Atlas. A base map of the Appalachian Valley in Virginia was compiled in preparation for geologic mapping. Charts were prepared for congressional use. (See also p. 85, Inspection and editing of topographic maps.)

SUMMARY OF RESULTS

The status of topographic surveys is set forth by States in the following table, which shows that the country as a whole is now 45.2 per cent mapped, the year's increment amounting to 0.6 per cent, representing the largest area covered in a single year by new surveys and resurveys since 1912. New Hampshire has been added to the list of States completely mapped. The increase in the number of surveys requested by other departments and bureaus was continued. The resurveys in large part covered areas previously surveyed on a smaller scale. The revisions were confined chiefly to the cultural features.

New topographic surveys of the United States, July 1, 1931, to June 30, 1932, and total area surveyed in each State

| State | Publication contour interval (feet) | Mapped in fiscal year (square miles) (engraved publication unless otherwise stated) for publication on scale of 1 to — | | | | | | | | Total area mapped in fiscal year (square miles) | | | Total area mapped to June 30, 1932 (square miles) | Percentage of total area of State mapped to June 30, 1932 | River surveys, scale 1:31,680 (linear miles) | Spirit levels (miles) | Transit traverse (miles) | Triangulation stations occupied |
|----------------------|--|--|--------|--------|-----------|--------|--------|---------|---------|---|----------|------------|---|---|--|-----------------------|--------------------------|---------------------------------|
| | | 12,000 or larger | 20,000 | 24,000 | 31,680 | 48,000 | 62,500 | 125,000 | 250,000 | Revision | Resurvey | New survey | | | | | | |
| Alabama | 20 | | | | | | 18 | | | | 18 | | 21,491 | 41.3 | | 137 | | |
| Arizona | 5, 20, 25, 100 | | | | a b 6 | | 182 | 648 | | | 648 | 182 | 59,150 | 51.9 | a 199 | | | 27 |
| Arkansas | 5, 50 | | | | | | 244 | | | | | 244 | 21,974 | 41.2 | | | | |
| California | 5, 25, 50, 100 | | | e 395 | 821 | | 556 | 3,170 | | 474 | 2,879 | 1,589 | 131,047 | 82.8 | | 1,367 | 155 | 27 |
| Colorado | 25, 50 | a d 19 | | a 13 | | | 178 | | | | 32 | 178 | 56,270 | 54.1 | | 58 | | 14 |
| Connecticut | | | | | | | | | | | | | 4,965 | 100.0 | | | | |
| Delaware | | | | | | | | | | | | | 2,370 | 100.0 | | | | |
| District of Columbia | | | | | | | | | | | | | 70 | 100.0 | | | | |
| Florida | | | | | | | | | | | | | 4,718 | 8.0 | | | | |
| Georgia | | | | | | | | | | | | | 24,937 | 42.1 | | | | |
| Idaho | 5, 20, 50, 100 | | | | a b 59 | a 28 | | 768 | | 84 | | 768 | 32,563 | 38.8 | | 174 | | 9 |
| Illinois | 5, 10, 20 | | 89 | | | | 1,772 | | | 35 | 203 | 1,623 | 35,462 | 62.6 | | 566 | | |
| Indiana | | | | | | | | | | | | | 3,668 | 10.1 | | | | |
| Iowa | | | | | | | | | | | | | 13,167 | 23.5 | | | | |
| Kansas | | | | | | | | | | | | | 64,159 | 78.1 | | | | |
| Kentucky | | | | | | | | | | | | | 26,620 | 65.6 | | | | |
| Louisiana | 5 | | | | a * 259 | | 1,098 | | | | | 1,098 | 9,921 | 20.5 | | | 927 | 6 |
| Maine | 20 | | | | | | 1,293 | | | | | 1,293 | 18,967 | 57.4 | | 637 | 165 | 44 |
| Maryland | | | | | | | | | | | | | 12,327 | 100.0 | | | | |
| Massachusetts | | | | | | | | | | | | | 8,266 | 100.0 | | | | |
| Michigan | 2 | (a', a'') | | | a * 2,932 | | | | | | | | 14,069 | 24.3 | | 23 | 661 | |
| Minnesota | 20 | | | | | | 27 | | | | | 27 | 8,040 | 9.5 | | 85 | 85 | |
| Mississippi | 5, 20 | | | | | | 2,186 | | | 403 | 20 | 1,763 | 6,754 | 14.4 | | | | |
| Missouri | 5, 10, 20 | | | | | | 1,973 | | | | 151 | 1,822 | 45,990 | 66.2 | | 1,552 | 1,395 | |
| Montana | 100 | | | | | | | 386 | | 26 | | 360 | 43,088 | 29.3 | | 101 | | 17 |
| Nebraska | | | | | | | | | | | | | 27,117 | 35.0 | | | | |
| Nevada | 25, 100 | | | a 23 | | | | 505 | 3,290 | | 4 | 3,814 | 50,680 | 45.8 | | 584 | | |
| New Hampshire | 20 | | | | | | 456 | | | | 366 | 90 | 9,302 | 100.0 | | 299 | 29 | 12 |
| New Jersey | | | | | | | | | | | | | 8,224 | 100.0 | | | | |
| New Mexico | 25, 100 | | | | | | 325 | 199 | | | | 524 | 42,450 | 34.6 | | | | 25 |
| New York | 5, 10, 20 | | | 365 | | | 60 | | | | 425 | | 49,204 | 100.0 | | 465 | 606 | |
| North Carolina | | | | | | | | | | | | | 19,040 | 36.3 | | | | |
| North Dakota | | | | | | | | | | | | | 13,148 | 18.6 | | | | |
| Ohio | | | | | | | | | | | | | 41,040 | 100.0 | | | | |
| Oklahoma | | | | | | | | | | | | | 41,927 | 59.8 | | | | |
| Oregon | 50, 100 | | | | | | | 1,490 | | | | 1,490 | 36,206 | 37.4 | | 49 | 90 | 31 |
| Pennsylvania | 20 | | | | | | 1,378 | | | 764 | | 614 | 37,839 | 83.9 | | 517 | 1,285 | |
| Rhode Island | | | | | | | | | | | | | 1,248 | 100.0 | | | | |
| South Carolina | | | | | | | | | | | | | 13,737 | 44.3 | | | | |
| South Dakota | | | | | | | | | | | | | 19,243 | 24.8 | | | | |

| | | | | | | | | | | | | | | | | | | |
|---|----------|----|-----------------|-------------------|-------|-----|--------|-------|-------|-------|-------|--------|--------------------|---------------|-----|-------|-------|-----|
| Tennessee | 5.20 | | | | | 84 | | | | 79 | 5 | 23,627 | 56.2 | | 189 | | | |
| Texas | | | | | | 15 | | | | | 184 | 88,284 | 33.2 | | | | | |
| Utah | 50,100 | | | ^a 169 | | 99 | | | | | 99 | 19,527 | 23.0 | | 399 | | 10 | |
| Vermont | 20 | | | | | 609 | | | | | 99 | 7,969 | 83.3 | | 46 | | | |
| Virginia | 10,20 | | ^a 9 | 76 | | | | | | 606 | 88 | 37,897 | 88.9 | | 59 | 278 | | |
| Washington | 100 | | | | | | 406 | | | | 406 | 36,813 | 53.3 | | | | | |
| West Virginia | | | | | | | | | | | | 24,170 | 100.0 | | | | | |
| Wisconsin | 20 | | ^a 20 | | | | | | | 20 | | 19,155 | 34.2 | | | | | |
| Wyoming | 5,25,100 | | | ^{a b} 16 | | | 395 | | | | 395 | 31,309 | 32.0 | | 274 | | 11 | |
| Total continental United States (exclusive of Alaska) | | 19 | 20 | 894 | 4,338 | 28 | 12,553 | 7,967 | 3,290 | 1,786 | 5,451 | 18,656 | 1,369,209 6,435 | 45.2 100.0 | 199 | 7,684 | 5,676 | 233 |
| Hawaii | | | | | | | | | | | | | | | | | | |

^a Lithographic publication only.

^b River survey.

^c Includes 54 square miles for lithographic publication only.

^d Mapped on scale of 1:12,000.

^e Culture and drainage compiled from aerial photographs. Contours not added.

^f 0.32 square mile mapped on scale of 1:4,800.

^g 0.03 square mile mapped on scale of 1:1,200.

^h Includes 137 square miles compiled from aerial photographs by means of stereophotogrammetry.

FIELD SURVEYS

Alabama.—The resurvey of a part of the Adger quadrangle was completed.

Arizona.—At the request of the geologic branch the survey of the Ajo quadrangle was completed. The survey of the Camp Verde quadrangle for the Forest Service was continued. The survey of the Salt River, including parts of the White and Black Rivers and Carrizo Creek, was completed for the conservation branch.

Arkansas.—For the Forest Service the survey of the Treat quadrangle was completed. In cooperation with the United States Army district engineer at Memphis, Tenn., the survey of the Horn Lake quadrangle was completed.

California.—In cooperation with the State engineer of California, the survey of the Dunsmuir, Etna, Hinkley, La Panza, White River No. 2, Harvester, West Camp, Lone Tree Well, No. 57, Lost Hills special, Antelope Plain, Cloud, Santa Ana No. 1, Santa Ana No. 2, Santa Ana No. 3, Anaheim No. 2, Anaheim No. 3, Downey No. 4, and Las Bolsas No. 1 quadrangles was completed and that of the Anaheim No. 1, Anaheim No. 4, Corona 4-c, Corona 4-b, Treadwell, No. 65, Colfax, and Truckee quadrangles was begun. In cooperation with the county surveyor of Los Angeles County, the survey of the Castaic, Red Rover, Redrock Mountain, Warm Spring Canyon, Red Mountain, Whitaker Peak, Oak Flat, La Brun, and Santa Felicia Canyon quadrangles was completed, that of the Bear-trap Canyon quadrangle was continued, and that of the Fairmont, Lake, Palmdale, Hughes Lake, and Mint Canyon quadrangles was begun. A partial revision of the Chatsworth quadrangle was completed. In preparation for geologic mapping the survey of the White River No. 3 quadrangle and the Kramer borate district was completed. At the request of the Forest Service the survey of the Hoaglin quadrangle was continued and that of the Yreka quadrangle was begun. A small area in Yosemite National Park was revised for the National Park Service.

Colorado.—In cooperation with the Colorado Metal Mining Fund and the Colorado Geological Survey Board, the survey of Silverton and vicinity and Jamestown and vicinity was completed. For the Forest Service the survey of the Mount Powell No. 2 quadrangle was begun.

Idaho.—The Bureau of Mines and Geology of Idaho cooperating, the survey of the Gilmore mining district was completed. The survey of the Buffalo Hump quadrangle was completed and that of the Trout Creek quadrangle was begun at the request of the Forest Service. In preparation for geologic mapping, the survey of the Irwin quadrangle was continued. At the request of the National Park Service, the survey of an extension of Yellowstone National Park was begun.

Idaho-Wyoming.—The survey of the Snake River from Pine Creek, Idaho, to Horse Creek, Wyo., with miscellaneous dam sites, was completed for the conservation branch.

Illinois.—The survey of the Geneseo, French Village, and Waterloo No. 1 quadrangles was completed, that of the Virginia, Keithburg, Carthage, Galva, Prophetstown, Orion, Potomac, Jacksonville, and Walnut quadrangles was continued, and that of the Pecatonica, Harvard, Marshall, Lomax, Hoyleton, Oquawka, Hoopeston, Shiloh, and Collinsville quadrangles was begun, and a partial revision of the Winchester quadrangle was completed. This work was done in cooperation with the Department of Registration and Education of Illinois, Geological Survey.

Louisiana.—In cooperation with the United States Army district engineer at New Orleans, the survey of the Covington, Slidell, Ponchatoula, Springfield, and Denham Springs quadrangles was completed. The board of State engineers cooperating, the compilation from aerial photographs of culture and drainage was completed for the Barataria quadrangle, and that of the New Orleans, Cut-Off, Houma, Hahnville, Thibodaux, Lac des Allemands, Gibson, and Schooner Bayou quadrangles was begun.

Maine.—In cooperation with the Public Utilities Commission of Maine, the survey of the Ashland, Saponac, Fish River Lake, Springfield, Stetson, Boyd Lake, and Mooseleuk Mountain quadrangles was completed, that of the Nicasious Lake quadrangle was continued, and that of the Keeobscus Stream and Wabassus Lake quadrangles was begun. In cooperation with the War Department the survey of the Van Buren and Johns Pond quadrangles was completed.

Michigan.—In cooperation with the Department of Conservation of Michigan, Geological Survey, the compilation from aerial photographs of the culture and

drainage was completed for Schoolcraft County, including the Driggs Lake, Manistique, and Manistique River quadrangles and the county parts of the Seney, Blaney, Seul Choix Point, Cooks, Steuben, Uno, Shingleton, Grand Portal, Point Au Sable, Munising, and Grand Marais quadrangles; and was begun for Mackinac County, completing the Gould City, Point Patterson, and Gilchrist quadrangles, the county parts of the Blaney, Epoufette, Seul Choix Point, and Moran quadrangles, and parts of the St. Ignace, Ozark, Rudyard, Pickford, Raber, Bois Blanc, and Beavertail Point quadrangles; for Oceana County, completing the Hart and Little Sable Point quadrangles and the county parts of the Ludington, Fern, and Walkerville quadrangles and parts of the Montague and Twin Lake quadrangles; for Mason County, completing the Big Sable Point quadrangle, the county parts of the Ludington and Fern quadrangles, and parts of the Manistee and Freesoil quadrangles; for Lake County, completing the county part of the Fern quadrangle and parts of the Peacock, Baldwin, Luther, Nirvana, and Freesoil quadrangles; and for Delta County, including the Burnt Bluff, Sturgeon River, Rapid River, Peninsula Point, Brampton, Escanaba, Whitney, and Bark River quadrangles. In cooperation with the Department of Justice the survey of a prison site and grounds near Milan was completed.

Minnesota.—The survey of the Ely quadrangle was begun at the request of the Forest Service.

Mississippi.—In cooperation with the United States Army district engineer at Memphis, Tenn., the survey of the Horn Lake, Crenshaw, Marks, Sledge, Crowder, Clarksdale, and Tutwiler quadrangles was completed, and in cooperation with the United States Army district engineer at Vicksburg the survey of the Greenwood, Schlater, Sumner, Mound Bayou, Cleveland, and Philipp quadrangles was completed.

Missouri.—In cooperation with the United States Army district engineer at Memphis, Tenn., the survey of the Puxico, Zalma, Poplar Bluff, Morley, and Advance quadrangles was completed. The survey of the Pacific quadrangle was continued, and that of the Manchester, Elsey, Bandyville, Clear Springs, Leeper, Upalika, Franks, Drynob, Sleeper, Manes, Plum Valley, Celt, Greenville, Buffalo, Protom, Versailles No. 3, Long Lane, Couch, Summersville, Cedar Grove, Salem, Fordland, Thornfield, Steellville, Topaz, Zanon, Big Piney, Grove Springs, Edgar Springs, Gatewood, and Niangua quadrangles was begun in cooperation with the State geologist of Missouri.

Montana.—The survey of the Trout Creek quadrangle was continued at the request of the Forest Service. For the National Park Service the survey of an extension of Yellowstone National Park was begun.

Nevada.—The survey of the Lovelock quadrangle and the Eureka mining district was completed and that of the Sonoma Range quadrangle was begun in cooperation with the Bureau of Mines of Nevada. The survey of the Halleck quadrangle was completed for the Forest Service.

New Hampshire.—In cooperation with the Highway Department of New Hampshire the survey of the Woodsville, Groton, Lowell, Fitchburg, Haverhill, Lawrence, and Guildhall quadrangles was completed, and that of the Newburyport, Monadnock, and Keene quadrangles was begun.

New Mexico.—For the Forest Service the survey of the Talpa quadrangle was continued and that of the Ute Creek and Questa quadrangles was begun. In preparation for geologic mapping, the survey of the Lordsburg special quadrangle was completed and that of the Lordsburg No. 3 and Lordsburg No. 4 quadrangles was begun.

New York.—The survey of the Ramapo and Rochester East quadrangles was completed and that of the Tarrytown No. 4 quadrangle was begun in cooperation with the Department of Public Works of New York. In cooperation with Monroe County and the Department of Public Works of New York the survey of the Rochester West, Genesee Junction, Mendon Ponds, Ninemile Point, and Rush quadrangles was completed and that of the Brockport Nos. 1, 2, 3, and 4 and Macedon Nos. 2 and 3 quadrangles was begun.

Oregon.—The survey of the Pendleton quadrangle was completed and that of the Medford quadrangle was begun in cooperation with the State engineer of Oregon. In preparation for geologic mapping the survey of the Dayville quadrangle was completed. For the Forest Service, the survey of the Lava Butte quadrangle was completed.

Pennsylvania.—In cooperation with the Department of Internal Affairs of Pennsylvania, Topographic and Geologic Survey, the survey of the Millville,

Laporte, and Trowbridge quadrangles was completed, that of the Susquehanna and Smethport quadrangles was begun, and the cultural revision of the Fayette County part of the Connellsville, Uniontown, Donegal, Confluence, Brownsville, Morgantown, Masontown, Accident, and Bruceton quadrangles was completed.

Tennessee.—The survey of the Sassafras Mountain quadrangle was begun at the request of the Forest Service. In cooperation with the United States Army district engineer at Memphis, the survey of the Horn Lake quadrangle was completed.

Utah.—The survey of Zion National Park was completed and that of Bryce Canyon National Park was begun for the National Park Service. At the request of the geologic branch the survey of the Richfield No. 3 quadrangle was begun.

Vermont.—In cooperation with the State geologist of Vermont the survey of the Mount Cube quadrangle was completed and that of the Littleton quadrangle was begun.

Virginia.—The survey of the Healing Springs, Accomac, and Elkton quadrangles was completed, that of the Timber Ridge, Marion, Mount Rogers, Rural Retreat, Mouth of Wilson, Pearisburg, and Blacksburg quadrangles was continued, and that of the Peterstown and Richmond No. 2 quadrangles was begun, all in cooperation with the Conservation and Development Commission of Virginia, Geological Survey. In cooperation with the War Department and the Fredericksburg and Spotsylvania County Battlefields Memorial Commission, the survey of the Salem Church battlefield and the Chancellorsville battlefield was completed.

Washington.—For the Forest Service the survey of the Mount Constance quadrangle was continued. In preparation for geologic mapping the survey of the Metaline quadrangle was begun.

Wisconsin.—In cooperation with the War Department the survey of Camp Williams was completed.

Wyoming.—The survey of the Jackson quadrangle was completed and that of the Savery Creek quadrangle was begun at the request of the Forest Service. At the request of the geologic branch the survey of the Irwin quadrangle was completed.

WATER-RESOURCES BRANCH

N. C. GROVER, *Chief Hydraulic Engineer*

ORGANIZATION AND PERSONNEL

The water-resources branch, like other branches of the Geological Survey, is primarily an agency of research and investigation. It collects systematically for general public information and use facts in regard to the quantity, quality, and utilization of water. The widespread interest in the availability of water for many uses has led to a persistent and increasing demand for reliable data that would serve as a basis for safe and sane developments. During the year the work of the branch has been administered under the following units:

Division of surface waters, C. G. Paulsen, hydraulic engineer, in charge.

Division of ground water, O. E. Meinzer, geologist, in charge.

Division of quality of water, W. D. Collins, chemist, in charge.

Division of power resources, A. H. Horton, hydraulic engineer, in charge.

Division of water utilization, R. W. Davenport, hydraulic engineer, in charge.

The technical force at the end of the year comprised the chief hydraulic engineer, 31 senior hydraulic engineers, 20 hydraulic engineers, 157 associate, assistant, and junior engineers, 2 engineering field aides, 4 senior geologists, 2 geologists, 10 assistant and junior geologists, 1 senior chemist, 1 chemist, 5 assistant and junior chemists, 3 laboratory assistants and apprentices, 1 illustrator, and 1 computer—a total of 239. The clerical force numbered 46. The changes in personnel during the year show a net increase of seven.

FUNDS

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

| | |
|--|--------------|
| Gaging streams..... | \$711,000.00 |
| Transfers from Federal agencies..... | 200,723.00 |
| Repayments by Federal agencies..... | 6,822.60 |
| Cooperative funds furnished by States and municipalities..... | 548,337.64 |
| Noncooperative funds furnished by State and municipalities..... | 4,996.53 |
| Funds furnished by permittees and licensees of the Federal Power Commission..... | 33,354.93 |
| | <hr/> |
| | 1,505,234.70 |

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..... | \$2,230.97 | Nevada..... | \$1,050.00 |
| Arizona..... | 20,609.65 | New Hampshire..... | 2,714.90 |
| Arkansas..... | 1,422.00 | New Jersey..... | 19,871.93 |
| California: | | New Mexico..... | 17,293.57 |
| State..... | \$52,982.00 | New York: | |
| Municipal..... | 19,587.72 | State..... | \$21,813.86 |
| | <hr/> | Municipal..... | 1,713.51 |
| Connecticut: | | | <hr/> |
| State..... | 6,407.48 | North Carolina..... | 23,527.37 |
| Municipal..... | 850.00 | North Dakota..... | 11,802.25 |
| | <hr/> | Ohio: | 2,305.88 |
| Florida | | State..... | 14,685.95 |
| State..... | 4,499.30 | Municipal..... | 2,930.79 |
| Municipal..... | 2,495.47 | | <hr/> |
| | <hr/> | | 17,616.74 |
| | 6,994.47 | Oregon: | |
| Hawaii..... | 31,394.75 | State..... | 41,375.39 |
| Idaho..... | 17,426.42 | Municipal..... | 545.93 |
| Illinois..... | 7,520.48 | | <hr/> |
| Indiana: | | | 41,921.32 |
| State..... | 4,067.25 | Pennsylvania..... | 23,257.28 |
| Municipal..... | 624.30 | South Carolina: | |
| | <hr/> | State..... | 5,000.00 |
| | 4,691.55 | Municipal..... | 340.15 |
| Kansas..... | 6,096.18 | | <hr/> |
| Kentucky..... | 354.27 | | 5,340.15 |
| Maine..... | 6,997.68 | Tennessee..... | 13,511.15 |
| Maryland: | | Texas..... | 42,964.94 |
| State..... | 4,259.89 | Utah: | |
| Municipal..... | 1,741.62 | State..... | 5,713.74 |
| | <hr/> | Municipal..... | 5,131.53 |
| | 6,001.51 | | <hr/> |
| Massachusetts..... | 6,761.67 | | 10,845.27 |
| Michigan..... | 95.83 | Vermont..... | 4,863.78 |
| Minnesota: | | Virginia..... | 26,800.14 |
| State..... | 1,283.24 | Washington: | |
| Municipal..... | 1,154.42 | State..... | 6,085.07 |
| | <hr/> | Municipal..... | 10,768.25 |
| | 2,437.66 | | <hr/> |
| Mississippi..... | 1,712.79 | | 16,853.32 |
| Missouri..... | 11,243.79 | West Virginia..... | 3,500.00 |
| Montana..... | 8,657.41 | Wisconsin..... | 6,985.28 |
| Nebraska..... | 21,871.29 | Wyoming..... | 10,964.50 |
| | | | <hr/> |
| | | | 548,337.64 |

Bureau of Reclamation.—The measurement of streams that are to furnish water to reclamation projects was continued on the Black Canyon project and on the lower Colorado River. A reconnaissance was made for a gaging station site near Hoover Dam.

Indian Service.—Stream gaging was continued on the Gila and San Carlos Rivers and was also done in the Blackfoot River Basin of the Fort Hall project and on the Western Shoshone and Yakima Indian reservations.

National Park Service.—Streams in the Yellowstone National Park were measured during the year at stations maintained in cooperation with the National Park Service, and an investigation was made of the ground-water supply at Yorktown, Va.

Department of the Navy.—An investigation for the development of a ground-water supply at the Puget Sound Navy Yard, Washington, was made for the Bureau of Yards and Docks.

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

Weather Bureau.—Stream gaging was continued on the Colorado River in Arizona, and a study was made of the flow of the Columbia River at Umatilla, Oregon.

Office of Public Buildings and Public Parks of the National Capital.—A study of the flow of Rock Creek was continued.

Department of State.—Investigations were continued in connection with matters which fall within the scope of the jurisdiction of the International Joint Commission, the cost thereof being borne by funds transferred to the Geological Survey by the State Department. This work includes stream gaging and surface and ground water studies at points along the boundary between the United States and Canada where international problems are involved. Approximately 100 gaging stations were operated in connection with these investigations; 48 of them were international stations operated jointly or in collaboration with the Dominion Water Power and Hydrometric Bureau because of their relation to matters involving the jurisdiction of the International Joint Commission and the common interest of the two countries. Stream gaging on the Rio Grande on the Mexican boundary was discontinued by the Geological Survey and turned over to the International Water Commission, United States and Mexico, at the beginning of the fiscal year.

Veterans' Administration.—An investigation for the development of a ground-water supply near San Fernando and at Sawtelle, Calif., was made for the Construction Service.

Department of Justice.—An investigation was made of the ground-water supply for the proposed Federal prison near Milan, Mich.

Corps of Engineers, United States Army.—Stream gaging in connection with studies and reports under House Document 308 of the Sixty-ninth Congress, first session, which has been conducted in connection with the Corps of Engineers for three years or more, was essentially completed September 30, 1931. Stream gaging in cooperation with the corps has been continued in connection with authorized projects related to navigation and flood control at about 122 stations in the Pittsburgh, Huntington, Jacksonville, Mobile, Nashville, Kansas City, and St. Paul Army Engineer districts.

Federal Power Commission.—The stream gaging required in connection with 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, Mississippi, Missouri, Montana, New Mexico, New York, North Carolina, Oregon, Pennsylvania, South Carolina, Tennessee, Utah, Virginia, Washington, West Virginia, Wisconsin, and Wyoming. Operations of projects under permits and licenses have been supervised in Arizona, Arkansas, California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wisconsin, and Wyoming.

PUBLICATIONS

The publications of the year prepared by the water-resources branch comprised 45 reports and 5 separate chapters. (See pp. 2-3.) At the end of the year 20 other reports were in press.

CHARACTER AND METHODS OF WORK

The study of surface waters, which consists of the measurement of the flow of rivers, has been conducted in 48 States, the District of Columbia, and Hawaii at selected gaging stations where the volume of water is measured and records of stage and other data are collected, from which the daily discharge of the rivers is computed. In this work 39 States and several Government organizations and individuals cooperated in the maintenance of the regular gaging stations. At the end of the year 2,791 gaging stations were being maintained. Records for about 135 additional stations were received, ready for publication, from Government bureaus and private persons.

The division of ground water investigates the waters that lie below the surface in the zone of saturation (from which the wells and springs are supplied); the source, occurrence, quantity, and head of these waters; their conservation; their availability and adequacy for domestic, industrial, irrigation, and public supplies and as watering places for livestock and desert travelers; and the methods of constructing wells and recovering water from them and of improving springs. 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 50 investigations relating to ground-water and reservoir sites were in progress, and work was done in 25 States, 15 of which cooperated, and in Hawaii.

Cooperation was continued with the 11 State associations of water-well drillers and with the American Association of Water Well Drillers. A. G. Fiedler attended the annual meeting of that association at Milwaukee, Wis., and presented a paper entitled "Mud-scow drilling." He also conferred with a joint committee of the American Association and the American Specification Institute regarding standard specifications for the drilling of wells.

Abstracts of papers relating to ground-water hydrology were prepared for the "Annotated bibliography of economic geology" under the direction of A. N. Sayre. In the hydrologic laboratory V. C. Fishel analyzed 283 samples of water-bearing material.

A course of daily lectures and discussions on the principles of ground-water hydrology and the methods of ground-water work was conducted from February 1 to March 18. O. E. Meinzer read as his presidential address before the Geological Society of Washington a paper on the subject "History and development of ground-water hydrology" and also presented a paper entitled "Relation of ground water to stream flow" at the meeting of the hydrologic power committee of the National Electric Light Association at Cincinnati, Ohio.

The following papers were presented before the meeting of the section of hydrology of the American Geophysical Union and were published in the Transactions of the Union:

Recent investigations of Thiem's method for determining permeability of water-bearing materials, by L. K. Wenzel.

Equation of lines of flow in vicinity of discharging well, by C. V. Theis.

Investigations of the fluctuations of water levels in observation wells in Virginia, by R. C. Cady.

Investigations of the fluctuations of the ground-water table in Pennsylvania, by S. W. Lohman.

Report of the committee on underground water, by D. G. Thompson.

The work on the quality of water included the analysis of the mineral content of 1,025 samples of water from surface and underground sources with reference to the suitability of the waters for industrial and agricultural uses and for domestic use (not related to questions of health), so far as such use is affected by the dissolved mineral matter. The analyses included some for nearly all the studies of ground water in the different States as noted below. Close cooperation was continued with the division of ground water in the study of problems relating to quality of ground water and the preparation of the parts of ground-water reports that involve consideration of the chemical character of the waters. Work was well advanced on the collection of data and the making of analyses for the revision of Water-Supply Paper 496. The studies of the Colorado River and its tributaries were extended to gain further information as to the contribution of the upper tributaries to the load of dissolved and suspended matter carried by the river. Progress was made on the study of some special methods of analysis. A number of partial analyses were made of samples of rain and snow.

The work of the division of power resources comprised the preparation of monthly and annual reports on the production of electricity and consumption of fuel by public-utility power plants, a report on the developed water power of the United States, a report containing the monthly and annual figures of output by States for 1931, 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 annual report on the capacity of water wheels in water-power plants in the United States was released February 5, 1932, and the final report on the monthly and annual production of electricity for public use in 1931 was released April 29, 1932.

The division of water utilization investigates problems affecting the utilization of the waters of streams and performs administrative work relating to supervision and investigation by the field organization of the water-resources branch and of power projects of the Federal Power Commission and of the Interior Department. The field work is generally conducted by personnel otherwise assigned to the division of surface water.

Studies of flood control pertaining to the Roseau River reference before the International Joint Commission were continued in northern Minnesota. The flow of the St. Mary and Milk Rivers, international streams in northern Montana, was divided in accordance with treaty agreement. Studies and reports were made for the International Joint Commission in connection with its consideration of the apportionment of the waters of these streams. The application of a Canadian power company for approval by the International Joint Commission of a dam on the Kootenai River in Canada which is capable of causing backwater in Idaho has necessitated extensive studies of the effect of the dam on the behavior of surface and ground water on the United States side of the boundary. Numerous investigations have been made of a wide variety of problems of water utilization.

At the request of the Federal Power Commission, 30 engineers of the water-resources branch have been designated as representatives of the commission to perform for the commission such field work as may be assigned to them. The operation of about 320 gaging stations was conducted by the branch or was performed by permittees and licensees under the supervision of the branch in connection with 130 projects of the Federal Power Commission. Engineers of the branch have had general supervision of operations under permits and licenses of the Federal Power Commission in connection with 100 projects. Examinations and reports on applications for projects have been made for the commission as requested. Similar activities have been required for certain power projects operating under authority of the Secretary of the Interior. The administrative detail pertaining to such general supervision of projects and examinations and reports was performed in the conservation branch, and the pertinent field work was carried on under a coordinate arrangement through the district offices of the water-resources branch.

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 ending June 30, 1932

| State or Territory | Federal non-cooperative | | | | Cooperative | | Permittees and licensees of the Federal Power Commission | Miscellaneous and partial support | | | Counted more than once | Maintained at end of year | Established during year | Discontinued during year | Gagings | |
|--|-------------------------|----------------|------------------|-----------------------|------------------|-----------|--|-----------------------------------|--------------------|-------------------------|------------------------|---------------------------|-------------------------|--------------------------|---------|---------------|
| | Geological Survey | War Department | State Department | Other Federal bureaus | State | Municipal | | Federal bureaus | State or municipal | Individual or corporate | | | | | Regular | Miscellaneous |
| Alabama..... | 10 | 1 | | | ^a 2 | | 5 | 2 | | | 2 | 18 | 2 | 17 | 314 | 2 |
| Arizona..... | 9 | | | 4 | 37 | | | | | | 4 | 46 | 4 | 20 | 2,404 | 5 |
| Arkansas..... | 1 | | | | 7 | | 4 | | 2 | 1 | 3 | 12 | 2 | 8 | 58 | |
| California..... | | | | | ^b 213 | 15 | 64 | 20 | 27 | 16 | 63 | 292 | 22 | 11 | 7,315 | 685 |
| Colorado..... | 1 | | | | ^c 2 | | | | | | | 13 | 5 | 22 | 166 | |
| Connecticut..... | | | | | ^d 23 | 1 | 9 | | 1 | 2 | 2 | 24 | 5 | 1 | 183 | |
| Delaware..... | | | | | ^e 4 | | | | | | | 4 | 4 | | 73 | 19 |
| Florida..... | 6 | 4 | | | 30 | | 6 | | | | 4 | 42 | 18 | 2 | 334 | 78 |
| Georgia..... | 7 | 1 | | | ^f 2 | | | | 2 | 2 | 7 | 17 | 6 | 15 | 156 | 9 |
| Idaho..... | 4 | | 32 | 1 | 237 | | 18 | 13 | 18 | 110 | 142 | 291 | 124 | 113 | 1,925 | 262 |
| Illinois..... | 1 | | | | 37 | | 1 | 3 | 2 | 1 | 6 | 39 | 5 | 1 | 244 | 2 |
| Indiana..... | 1 | | | | 30 | | | 5 | 3 | 4 | 12 | 31 | 2 | 2 | 180 | |
| Iowa..... | 2 | 1 | | | | | 1 | | | | | 4 | 2 | 4 | 57 | 1 |
| Kansas..... | | | | | 44 | | | 4 | | 1 | 5 | 44 | 31 | 34 | 474 | 4 |
| Kentucky..... | 4 | | | | | | 4 | 5 | | | 5 | 8 | | 28 | 122 | 1 |
| Louisiana..... | | | | | | | | | | | | | | 1 | 2 | |
| Maine..... | | | | | 33 | | | | | 11 | 11 | 33 | 4 | | 255 | 1 |
| Maryland and District of Columbia..... | 2 | | | 2 | 15 | 8 | | | | | | 27 | 8 | 3 | 281 | 20 |
| Massachusetts..... | | | | | 26 | | | | | 1 | 1 | 26 | 2 | | 175 | |
| Michigan..... | | | | | | | 3 | | | | | 2 | | | 5 | 1 |
| Minnesota..... | 3 | 3 | 22 | | 19 | | 3 | | | | | 50 | 15 | 22 | 385 | 22 |
| Mississippi..... | 4 | | | | | | | | 8 | 1 | 16 | 4 | 11 | 7 | 191 | 1 |
| Missouri..... | 4 | 3 | | | 81 | | 4 | | | | | 92 | 11 | 10 | 739 | 8 |
| Montana..... | 6 | 13 | 36 | | ^g 54 | | 12 | 1 | | | | 122 | 18 | 15 | 784 | 8 |
| Nebraska..... | 2 | 1 | | | 12 | | | | 1 | 1 | 1 | 49 | 62 | 27 | 968 | 881 |
| Nevada..... | | | | | 12 | | | 3 | 1 | 4 | 8 | 12 | 1 | | 27 | |
| New Hampshire..... | | | | | ^h 20 | | | | | | | 20 | 1 | 3 | 125 | |
| New Jersey..... | | | | | 46 | | | 1 | 8 | 7 | 16 | 46 | 1 | | 355 | 44 |
| New Mexico..... | | | | | 63 | | | 3 | 2 | 7 | 12 | 63 | 77 | 15 | 873 | 125 |
| New York..... | | | | | ⁱ 98 | 1 | | 1 | 1 | 37 | 39 | 99 | 1 | 5 | 781 | 13 |
| North Carolina..... | 7 | | | | 60 | | | | | 1 | 1 | 71 | 2 | 7 | 423 | 14 |
| North Dakota..... | 3 | 2 | 5 | | 13 | | 4 | | | | | 23 | 7 | 4 | 196 | 2 |
| Ohio..... | | | | | 91 | 14 | | 6 | 1 | 4 | 11 | 105 | 2 | 3 | 707 | 11 |
| Oklahoma..... | 1 | | | | | | 1 | | 1 | | | 3 | | | 20 | |
| Oregon..... | 5 | | | | 162 | 5 | 20 | 7 | 1 | 24 | 33 | 191 | 105 | 7 | 1,489 | 49 |
| Pennsylvania..... | | | | | ^j 90 | | 7 | 7 | 2 | 6 | 17 | 95 | 6 | 13 | 364 | 46 |
| Rhode Island..... | | | | | ^k 1 | | | | | | | 1 | | | 7 | |
| South Carolina..... | 5 | | | | 12 | 3 | 6 | | | | | 19 | 3 | 1 | 155 | 7 |
| South Dakota..... | 8 | | | | ^l 2 | | | | | | | 11 | 13 | 22 | 221 | |
| Tennessee..... | 10 | 2 | | | 96 | | 4 | 1 | 37 | 5 | 43 | 112 | 41 | 6 | 767 | 134 |
| Texas..... | 2 | | | | 98 | | | 7 | 7 | 5 | 19 | 100 | 9 | 20 | 1,364 | 186 |
| Utah..... | 4 | | | | ^m 54 | | 3 | 5 | 3 | 15 | 26 | 58 | 2 | 1 | 597 | 43 |
| Vermont..... | | | | | 26 | | | | | 3 | 3 | 26 | 1 | 1 | 173 | |
| Virginia..... | | 1 | | | 85 | | | | 1 | 14 | 16 | 85 | 9 | 7 | 483 | 24 |
| Washington..... | 9 | | 11 | 2 | 50 | 17 | 15 | 2 | 1 | 24 | 28 | 103 | 11 | 24 | 775 | 42 |
| West Virginia..... | 7 | | | | 30 | | 10 | 10 | 1 | 2 | 13 | 47 | 1 | 13 | 284 | 23 |
| Wisconsin..... | 3 | 2 | | | 36 | | 3 | 1 | | 5 | 6 | 44 | 1 | 4 | 293 | 7 |
| Wyoming..... | 1 | | | | ⁿ 65 | | | 16 | | 2 | 7 | 77 | 32 | 24 | 517 | 40 |
| Hawaii..... | | | | | 90 | | | 1 | 13 | 27 | 41 | 90 | 8 | 6 | 558 | 28 |
| | 132 | 34 | 106 | 9 | 2,242 | 64 | 215 | 124 | 141 | 359 | 635 | 2,791 | 683 | 555 | 29,344 | 2,854 |

^a Cooperation by Tennessee on 2 stations.^b Cooperation by Nevada on 2 stations.^c Cooperation by Nebraska on 1 station and by Wyoming on 1 station.^d Cooperation by Massachusetts on 1 station.^e Cooperation by Pennsylvania.^f Cooperation by Tennessee.^g Cooperation by Wyoming on 1 station.^h Cooperation by Maine on 2 stations and by Vermont on 1 station.ⁱ Cooperation by Pennsylvania on 2 stations.^j Cooperation by Maryland on 2 stations.^k Cooperation by Massachusetts.^l Cooperation by Minnesota on 1 station and by Wyoming on 1 station.^m Cooperation by Wyoming on 1 station.ⁿ Cooperation by Nebraska on 1 station and by Idaho on 2 stations.

Arkansas.—The investigation in the Grand Prairie region was continued in cooperation with the State Geological Survey. Records were obtained by A. H. Prince, under the direction of D. G. Thompson, of water levels in numerous observation wells, and these records were released to the public in manuscript form.

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 28 years. Work was continued with the financial support of the East Bay Municipal Utility District on the investigation of the ground water in the alluvial fan of the Mokelumne River, and the results were released in manuscript form. This investigation was placed in charge of A. M. Piper, who was assisted by H. S. Gale, C. A. McClelland, G. M. Sherwood, B. R. Colby, and H. E. Thomas. A. G. Fiedler spent two weeks in studying well-drilling methods in California and attended a meeting of water-well drillers in Oakland. Investigations and reports were made by S. W. Lohman relating to ground-water supplies for the Veterans' Administration home in Los Angeles and the Veterans' Administration hospital near San Fernando. Analyses were made of samples collected regularly from the Sacramento River at Sacramento.

Colorado.—A. G. Fiedler attended a meeting of water-well drillers in Denver.

Florida.—The investigation of the ground-water resources of Florida was continued, in cooperation with the State Geological Survey, by V. T. Stringfield, under the direction of D. G. Thompson. Mr. Stringfield did field work in Duval, St. Johns, Seminole, Orange, Pinellas, Hillsborough, Manatee, Sarasota, and Charlotte Counties and nearly completed a report on Sarasota County.

Hawaii.—The investigation on the island of Oahu, in cooperation with the Territorial Commission of Public Lands, was continued by H. T. Stearns and K. N. Vaksvik, who nearly completed a comprehensive report on the ground-water resources of that island. A report on the Pearl Harbor Springs, by H. T. Stearns, was released in manuscript form.

Idaho.—Parts of the comprehensive report on ground water in the Snake River Plains, by H. T. Stearns, Lynn Crandall, and W. G. Steward, were released in manuscript form, including a section entitled "Loss and gain of water in the Snake River between Heise and King Hill, Idaho," and the records of wells in the area. The section entitled "Inventory of the water supply on the Snake River Plains in southeastern Idaho" was released in mimeographed form. An investigation of the surface and ground waters of Malad and Curlew Valleys was made in cooperation with the Idaho Department of Reclamation. A report by D. G. Thompson on the ground-water conditions and by R. W. Faris on the reservoir sites was released in manuscript form.

Kansas.—A. G. Fiedler attended a conference of water-well drillers at El Dorado.

Michigan.—R. M. Leggette made an investigation and report for the United States Bureau of Prisons in regard to a proposed water supply at Milan. Plans were made for cooperation with the State geologist for comprehensive investigations of ground-water conditions in the State with special reference to fire protection. D. G. Thompson spent a week in preliminary field work and conference in regard to this project. The district office at Lansing, in charge of Berkeley Johnson, was closed June 30.

Minnesota.—A. G. Fiedler made two trips to Minneapolis to confer with well drillers.

Missouri.—A. G. Fiedler presented a paper on sanitary well construction at the seventh annual Missouri Water and Sewer Conference, in Jefferson City. He also attended the Missouri Well Drillers' convention in Jefferson City.

Montana.—The report by G. M. Hall on ground water in Big Horn County was completed, and progress was made by him on the report on Fergus County.

Nebraska.—The investigation of the ground-water resources of the Platte River Valley was continued in cooperation with the State Conservation and Survey Division, by A. L. Lugin and L. K. Wenzel.

New Jersey.—Comprehensive investigation of the ground-water resources of New Jersey was resumed, through cooperation with the State Water Policy Commission, by D. G. Thompson, H. C. Barksdale, and R. W. Sundstrom. Special attention was given to the conditions in the Runyon, Atlantic City, and Camden areas. A paper entitled "Ground-water supplies of the Atlantic City region" was presented by Mr. Thompson at the meeting of the Four States section of the American Water Works Association in Atlantic City and is to be published in the journal of that association.

New Mexico.—Cooperation was continued with the State engineer in the Roswell artesian basin by A. G. Fiedler, in Mimbres Valley by W. N. White, in Lea County by S. S. Nye, and in Roosevelt and Curry Counties by C. V. Theis. A comprehensive report on the Roswell artesian basin by Messrs. Fiedler and Nye was released in manuscript form. A district office was established at Santa Fe July 16, 1931, with Berkeley Johnson, engineer, in charge.

New York.—An investigation of the ground-water resources of the State was undertaken in cooperation with the joint legislative committee concerned with water resources. Work was begun on Long Island by D. G. Thompson, A. G. Fiedler, and Kyle Forrest. A brief preliminary report was published in New York Legislative Document 104, and some of the data obtained were released in manuscript form.

North Carolina.—O. E. Meinzer spent a week in field work and conference with the State Division of Water Resources and Engineering in regard to observations of water levels in wells and their relation to stream flow.

Ohio.—O. E. Meinzer attended a conference with the State Water Conservation Board of Ohio in regard to plans for a comprehensive survey of the ground-water resources of the State.

Oklahoma.—A. G. Fiedler prepared a paper entitled "Improper construction as a cause of well pollution," which was read at the eighth Oklahoma Sewage and Water Conference at Stillwater and is to be published in the Southwest Waterworks Journal.

Oregon.—Investigations of the ground-water resources of Oregon were continued in cooperation with the State Agricultural Experiment Station. A preliminary report on the Harney Basin was issued in mimeographed form, and field work in that basin was continued by A. M. Piper, T. W. Robinson, and C. F. Park, jr. A. G. Fiedler conferred with drillers in the State in regard to well-drilling methods.

Pennsylvania.—The systematic survey of the ground-water resources of Pennsylvania was continued in cooperation with the State Topographic and Geologic Survey. The report by G. M. Hall on the southeastern part of the State was released in manuscript form, and the report on the northwestern part of the State by R. M. Leggette and that on the northeastern part by S. W. Lohman were virtually completed. A preliminary report on the northeastern area was released in mimeographed form. About 35 observation wells were selected on which weekly measurements of water level are made. The results have been released in mimeographed or manuscript form.

Tennessee.—The report on ground water in south-central Tennessee was nearly completed by C. V. Theis, and observations were continued on water levels in wells in Memphis. The reports on north-central Tennessee by A. M. Piper and on western Tennessee by F. G. Wells are now in press as water-supply papers. All the ground-water work was done in cooperation with the State geologist.

Texas.—Investigations of the ground-water resources of Texas were continued in cooperation with the State Board of Water Engineers, under the direction of W. N. White. The Texas Department of Health and the Bureau of Engineering Research of the Agricultural and Mechanical College also continued to cooperate. Studies of the geology and ground-water resources in the Toyah Basin, in Reeves, Ward, and Pecos Counties, were continued by H. S. Gale and S. S. Nye. The ground-water investigation in Harris County, including the Houston area, was expanded to include parts of Montgomery, Waller, Fort Bend, Brazoria, and Galveston Counties. This investigation was conducted by P. P. Livingston, S. F. Turner, C. W. Cooke, and T. W. Bridges. A survey of the ground-water resources of Bexar County was begun by S. F. Turner. Observations of water-level fluctuations in wells and studies of salt-water contamination were continued in the Winter Garden district by W. A. Lynch. J. T. Lonsdale continued the investigation of the ground-water resources of Webb County and started work in La Salle County. An investigation and report concerning ground-water conditions in the East Texas oil field, in Upshur, Gregg, Rusk, and Smith Counties, were made by S. F. Turner and P. P. Livingston. Further work was done by A. N. Sayre in Medina and Uvalde Counties, by T. W. Robinson and S. F. Turner in Dimmit and Zavala Counties, and by J. T. Lonsdale in Atascosa and Frio Counties. A. G. Fiedler conferred with officials of the United States Department of Justice regarding the completion of a well to provide a water supply for the United States detention farm at El Paso. A paper on the results of the cooperative State and Federal investi-

gation of the ground waters of Texas, prepared by W. N. White, was presented at the fourteenth Texas Water Works Short School at Mineral Wells.

Utah.—An investigation of the ground-water resources of the Jordan Valley, with special reference to an increased water supply for Salt Lake City, was begun in cooperation with the city, by R. M. Leggette and G. H. Taylor.

Virginia.—Cooperation was begun with the State Geological Survey in a comprehensive survey of the ground-water resources of the State. Field work was completed by R. C. Cady in Arlington, Fairfax, Prince William, Loudoun, Clarke, and Frederick Counties. Water-stage recorders were operated on the observation well in Arlington County and on the ebbing and flowing spring near Broadway. A recorder was installed on an ebbing and flowing spring near Marion. A memorandum for the press was issued on the fluctuations of the Arlington well and their relation to precipitation. Special investigations were made by R. C. Cady at Virginia Beach and at several localities in the Shenandoah Valley. An investigation relating to a water supply at Yorktown was made by A. G. Fiedler for the National Park Service.

Washington.—An investigation and report were made by J. T. Pardee for the Navy Department in regard to ground-water supplies at the United States navy yard at Bremerton. A. G. Fiedler conferred with drillers in the State in regard to well-drilling methods.

Wisconsin.—A. G. Fiedler attended the annual meeting of the Wisconsin Well Drillers Association at Milwaukee.

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, was directed at the end of the year through five 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.

Mining division, H. I. Smith, mining engineer, in charge.

Oil and gas leasing division, H. B. Soyster, petroleum engineer, in charge.

The mineral-leasing division of former years was subdivided about the middle of the fiscal year to facilitate administration of its major elements—mining operations and oil and gas operations.

On June 30, 1932, the permanent full-time personnel of the branch numbered 153, consisting of 5 geologists, 9 hydraulic engineers, 12 mining engineers, 40 petroleum engineers, 1 classification engineer, 7 agricultural classifiers, 1 chemist, 1 attorney, 22 accountants and draftsmen, and 55 clerical and miscellaneous employees.

FUNDS

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

| | |
|--|------------|
| Classification of lands..... | \$199, 000 |
| Supervision of leasing operations, public lands..... | 270, 000 |
| Supervision of leasing operations, Indian lands..... | 95, 000 |
| Supervision of naval-reserve operations..... | 50, 000 |
| Federal Power Commission..... | 2, 250 |
| | <hr/> |
| | 616, 250 |

CORRESPONDENCE

During the year 26,187 letter requests for information or technical reports were received in the Washington office of the branch, together with 45,075 pieces of miscellaneous correspondence for filing or for transmission to the appropriate field office. Within the same period 18,933 letters and 18,800 pieces of miscellaneous correspondence were sent out.

In the several field offices 30,508 letters and 578,471 pieces of miscellaneous correspondence were received, and 41,239 letters and 354,847 pieces of miscellaneous correspondence were sent out.

PUBLIC INFORMATION SERVICE

The conservation branch supplies information to the public through personal interviews with callers, by distribution of publications, and by making available for inspection publications or manuscripts not of a confidential character. During the year there were 10,683 personal calls for information at the field offices, 1,502 publications were distributed, and 1,370 were consulted. The following publications and public releases were completed during the year:

- Ageton, R. V., Guides to ore finding in the Tri-State district: Press memorandum.
- Bryan, L. L., and Mansfield, G. R., Water-power resources of Snake River between Jackson Hole and Alpine, Wyo., with description of geology. Manuscript report and press memorandum.
- Bryan, L. L., and Piper, A. M., Water-power resources of Hoh River, Washington, with description of the geology. Manuscript report and press memorandum.
- Deeds, J. F., and Falck, Depue, Land-classification report on Utah, with map. Manuscript report and press memorandum.
- Dobbin, C. E., Structure-contour map of the Spindletop dome, Natrona County, Wyo. Press memorandum.
- Development map of the Bloomfield-Kutz Canyon oil and gas field, San Juan County, N. Mex. Press memorandum.
- Natural gases other than the hydrocarbons. Presented at the meeting of the American Association of Petroleum Geologists in Oklahoma City, Okla., in April, 1932.
- and Erdmann, C. E., Geologic and structure map of the Harley dome, Grand County, Utah. Press memorandum.
- Structure-contour map of the Montana plains. Press memorandum.
- Dyer, B. W., Conditions affecting mining development [of iron ore on Canyon Creek, Fort Apache Indian Reservation, Arizona]: U. S. Geol. Survey Bull. 821, pp. 69-70.
- Erdmann, C. E., and Schwabrow, J. R., Detailed geologic and engineering report on the Border-Red Coulee oil field, Montana-Alberta. Press memorandum for early release in the fiscal year 1933.
- Hoyt, W. G., Water utilization in Snake River Basin. Advance synopsis of U. S. Geol. Survey Water-Supply Paper 657, together with map showing irrigated and irrigable lands, developed and undeveloped power and reservoir sites, and electric transmission lines. Press memorandum.
- Hoyt, W. G., and Troxell, H. C., Forests and stream flow. Read before the American Society of Civil Engineers at its annual convention in Yellowstone Park, July 6, 1932.
- Jones, B. E., Developed water power of the world: Press memorandum.
- Jones, B. E., Oakey, Warren, and Stearns, H. T., Water-power resources of the Rogue River drainage basin, Oregon: U. S. Geol. Survey Water-Supply Paper 638, pp. 35-97.
- Jones, E. E., Water-power resources of Soleduck and Lyre Rivers, Washington. Manuscript report and press memorandum.

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Smith, H. I., Potash mined in United States may meet all domestic needs: Oil, Paint, and Drug Reporter, June 29, 1931.

Stabler, Herman, History and purpose of classification of lands by the United States Geological Survey, with special reference to forest lands. Read before the Society of American Foresters at Washington, D. C., January 4, 1932.

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Williams, C. F. (coauthor), Oklahoma lead and zinc district: Oklahoma Geol. Survey Bull. 56, 1932.

SUMMARY OF CASES

The activities in the Washington office 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. The number of cases received was greater by 529 (4.1 per cent), and the number acted on was less by 1,861 (12.6 per cent) than during the preceding year. The number of cases pending at the end of the year was increased by about 21 per cent.

Summary of cases involving land classification

| Class of cases | Record for fiscal year 1932 | | | | | | Record since receipt of first case | |
|--|-----------------------------|-----------------------------|--------|-----------------------------|-----------------------|---------------------------------|------------------------------------|----------|
| | Pending July 1, 1931 | Received during fiscal year | Total | Acted on during fiscal year | Pending June 30, 1932 | Gain or loss during fiscal year | Received | Acted on |
| General Land Office requests: | | | | | | | | |
| General..... | 242 | 760 | 1,002 | 675 | 327 | -85 | | |
| Time extensions..... | | | | | | | 2,313 | 2,313 |
| Oil development..... | 1 | 891 | 892 | 868 | 24 | -23 | 17,086 | 17,062 |
| Concurrence..... | 17 | 745 | 762 | 750 | 12 | +5 | | |
| Sec. 27 cases..... | | 39 | 39 | | 39 | -39 | 39 | |
| Committee cases—oil..... | 72 | 1,948 | 2,020 | 1,873 | 147 | -75 | 9,305 | 9,158 |
| Applications for classification as to mineral: | | | | | | | | |
| Oil..... | 621 | 3,627 | 4,248 | 3,788 | 460 | +161 | 21,193 | 20,733 |
| Miscellaneous..... | 4 | 16 | 20 | 16 | 4 | -4 | 870 | 866 |
| Applications for mineral permits..... | 25 | 1,392 | 1,417 | 641 | 776 | -751 | 54,507 | 53,731 |
| Applications for mineral leases..... | 10 | 125 | 135 | 133 | 2 | +8 | 1,744 | 1,742 |
| Applications for patent, potassium..... | | | | | | | 124 | 124 |
| Federal Power Commission cases: | | | | | | | | |
| Preliminary permits..... | 10 | 33 | 43 | 37 | 6 | +4 | 229 | 223 |
| Licenses..... | | | | | | | 28 | 28 |
| Determinations under sec. 24..... | 8 | 41 | 49 | 41 | 8 | | 352 | 344 |
| Applications for classification as to power resources..... | 6 | 43 | 49 | 28 | 21 | -15 | 491 | 470 |
| Applications for agricultural classification..... | 65 | 178 | 243 | 169 | 74 | -9 | 1,207 | 1,133 |
| Applications for rights of way..... | 28 | 120 | 148 | 133 | 15 | +13 | 6,749 | 6,734 |
| Irrigation project reports..... | 2 | 2 | 4 | | | +2 | 924 | 924 |
| Applications under enlarged homestead acts..... | 128 | 203 | 331 | 255 | 76 | +52 | 57,671 | 57,595 |
| Applications under stock-raising homestead acts..... | 1,359 | 3,266 | 4,625 | 3,488 | 1,137 | +222 | 137,308 | 136,171 |
| Applications under ground-water reclamation act..... | 7 | 6 | 13 | 12 | 1 | +6 | 971 | 970 |
| Indian Office requests for information..... | | 2 | 2 | | | | 9,547 | 9,547 |
| | 2,605 | 13,437 | 16,042 | 12,913 | 3,129 | -524 | | |

SUMMARY OF FIELD OPERATIONS BY STATES

Alaska.—Supervised one power project. Expended \$8,000 through the Alaskan branch for supervision of 7 leases, 3 licenses, and 25 prospecting permits for coal and 142 prospecting permits for oil and gas. Coal produced, 101,168 tons; accrued rent and royalty, \$8,225.

Alabama.—Examined four tracts in Baldwin, Covington, Marion, and Marshall Counties for mineral classification. Investigated in the field the status of oil and gas prospecting operations throughout the State. Supervised 1 coal lease. Coal produced, 81,630 tons; accrued rent and royalty, \$8,163.

Arizona.—Supervised 11 power projects and surveyed 196 miles of river. Examined 13 tracts for agricultural classification. Supervised on public land 4 prospecting permits for coal, 1 lease and 5 prospecting permits for sodium, 1 prospecting permit for potash, and 91 prospecting permits for oil and gas. No production reported; accrued rent and royalty, \$203. Supervised on Indian land 6 Indian agency coal mines on 5 reservations, and under Navajo Executive order 14 leases for oil and gas. In cooperation with the topographic branch an area of approximately 6 square miles was mapped and 21 asbestos leases examined.

Arkansas.—Supervised 1 prospecting permit for coal and 15 for oil and gas. No production reported.

California.—Examined two tracts in Fresno and Kern Counties for mineral classification. In cooperation with the geologic branch continued a detailed geologic examination of the North, Middle, and South domes of the Kettleman Hills anticline in Kings and Kern Counties. Supervised 31 power projects and surveyed 17 miles of river. Examined 25 tracts for agricultural classification and continued detailed studies of grazing conditions in Mono Lake and Owens Valleys preparatory to administration of lands withdrawn by the act of March 4, 1931 (46 Stat. 1530). Supervised on public land 6 prospecting permits for coal, 15 prospecting permits for sodium, 4 leases and 5 prospecting permits for potash, 193 leases, 4 suspended preference rights to leases, and 427 prospecting permits for oil and gas. Coal produced, 72 tons; accrued rent and royalty, \$18. No potash was produced; 2 leases were conducting experimental work and 1 was producing sodium salts—production, 32,195 tons; accrued rent and royalty, \$12,969. Oil produced, 14,237,495.65 barrels; natural gas, 24,399,649,000 cubic feet; natural-gas gasoline, 55,896,426 gallons; accrued royalty, \$1,599,112. Supervised on naval petroleum reserves 25 leases for oil and gas—oil produced, 3,919,625.61 barrels; natural gas, 4,442,014 cubic feet; natural-gas gasoline, 18,539,144 gallons; accrued royalty, \$690,188.

Colorado.—Examined two tracts in Morgan and Weld Counties for mineral classification. In cooperation with the geologic branch continued a detailed geologic survey of the Julesburg Basin, in the east-central part of the State. Supervised 11 power projects. Examined 78 tracts for agricultural classification. Supervised on public land 86 leases, 4 licenses, 53 permits, and 15 awarded lease applications for coal, 2 prospecting permits for sodium, 1 prospecting permit for potash, and 24 leases, 2 suspended preference rights to leases, and 400 prospecting permits for oil and gas. Coal produced, 342,551 tons; accrued rent and royalties, \$49,136. Oil produced, 544,073 barrels; natural gas, 1,308,602 cubic feet; natural-gas gasoline, 13,992 gallons; accrued royalty, \$25,205. Supervised on Indian lands on 2 reservations, 2 coal mines and 6 leases for oil and gas. Began direct supervision of oil and gas operations and royalty accounting for production from Indian lands.

Florida.—Examined three tracts in Bay, Gadsden, and Walton Counties for mineral classification. Investigated in the field the status of oil and gas prospecting operations throughout the State.

Idaho.—In cooperation with the geologic branch continued a detailed geologic survey of the Afton quadrangle. Supervised 6 power projects. Investigated power-site reserves on the Coeur d'Alene River. Examined 79 tracts for agricultural classification. Supervised on Indian lands on 2 reservations 2 coal mines and 6 leases for phosphate, 65 prospecting permits for oil and gas. Coal produced, 3,229 tons; phosphate, 33,059 tons; accrued rent and royalty, \$5,086.

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

Louisiana.—Examined six tracts in Bossier, Caddo, Catahoula, and Winn Parishes for mineral classification. Investigated in the field the status of oil and gas prospecting operations throughout the State. Supervised 10 leases and 1 prospecting permit for oil and gas. Oil produced, 2,984 barrels; natural gas, 982,216,000 cubic feet; natural-gas gasoline, 34,057 gallons; accrued royalty, \$3,821.

Mississippi.—Examined seven tracts in Attala, Choctaw, George, Greene, Jackson, and Wayne Counties for mineral classification. Investigated in the field the status of oil and gas prospecting operations throughout the State.

Montana.—Examined three tracts in Carter County for mineral classification and one tract in Carbon County for reclassification as to coal. Made structural and stratigraphic investigations in eastern Montana for preparation of structure-contour map of Cedar Creek anticline. In cooperation with geologic branch completed a geologic investigation for phosphate classification near Avon; also continued through that branch a detailed investigation of the coal resources of Custer and Powder River Counties. Supervised 29 power projects and surveyed 120 miles of river. Examined 59 tracts for agricultural classification. Supervised on public land 77 leases, 56 licenses, 40 prospecting permits, and 21 awarded lease applications for coal; 2 phosphate leases; 76 leases, 1 suspended preference right to lease, and 478 prospecting permits for oil and gas. Coal produced, 192,432 tons; accrued rent and royalty, \$23,489. Oil produced, 375,568 barrels; natural gas, 1,639,101,000 cubic feet; accrued royalty, \$39,362. Supervised on Indian lands on 2 reservations, 142 leases for oil and gas. Began direct supervision of oil and gas operations and royalty accounting for production from Indian lands.

Nebraska.—Supervised 3 prospecting permits for potash. Examined 2 tracts for agricultural classification.

Nevada.—Supervised 6 power projects. Examined 21 tracts for agricultural classification and continued regional investigations of agricultural utility precedent to grazing classification in the northeastern part of the State. Supervised 6 prospecting permits for coal, 1 lease and 5 prospecting permits for sodium, 1 lease for phosphate, and 49 prospecting permits for oil and gas. Sodium produced, 700 tons; phosphate, 40 tons; accrued rents and royalties, \$80.

New Mexico.—Made areal, structural, and economic reconnaissance with reference to coal, oil, and gas in northern and western parts of San Juan Basin. Continued through geologic branch similar investigations in southern and eastern parts of the basin. Supervised 3 power projects. Examined 60 tracts for agricultural classification. Supervised on public land 25 leases, 51 prospecting permits, and 1 awarded lease application for coal; 9 prospecting permits for sodium; 6 leases and 124 prospecting permits for potash; 63 leases, 17 suspended preference rights to leases, and 897 prospecting permits for oil and gas. Coal produced, 45,415 tons; potash, 45,967 tons; accrued rent and royalty, \$18,807. Oil produced, 1,683,880 barrels; natural gas, 7,749,785,000 cubic feet; natural-gas gasoline, 1,197,131 gallons; accrued royalty, \$70,666. Supervised on Indian land on 6 reservations, 15 coal mines and 32 leases for oil and gas. Began direct supervision of oil and gas operations and royalty accounting for production from Indian lands.

North Dakota.—Examined 5 tracts for agricultural classification. Supervised 66 leases, 25 licenses, 1 prospecting permit, and 13 awarded lease applications for coal, 4 prospecting permits for sodium, and 18 prospecting permits for oil and gas. Coal produced, 427,199 tons; accrued rent and royalty, \$25,235.

Oklahoma.—Supervised 1 power project. Supervised on public land 17 leases and 5 prospecting permits for oil and gas. Oil produced, 185,900 barrels; natural-gas gasoline, 69,399 gallons; accrued rent and royalty, \$17,608. Supervised on Indian lands on 21 reservations 78 coal leases, 2 leases for volcanic ash, 40 leases for lead and zinc, and 5,887 leases for oil and gas. Made 4,783 field investigations of Indian lands for regulatory, inspectional, and appraisal purposes. Coal produced on Indian lands, 459,848 tons; lead and zinc concentrates produced, 37,537 tons; market value, \$896,305. Royalties from production accrued, oil, \$1,805,932; dry gas, \$41,992; casing-head gas, \$52,992.

Oregon.—Investigated storage and power possibilities on the Walla Walla River and surveyed 80 miles of river. Examined 31 tracts for agricultural classification. Supervised 4 power projects. Supervised 2 leases and 9 prospecting permits for coal, 1 lease for oil shale, 3 prospecting permits for potash, and 15 prospecting permits for oil and gas. Coal produced, 1,369 tons; accrued rents and royalties, \$3,054.

South Dakota.—Examined 5 tracts for agricultural classification. Supervised 4 leases for coal and 15 prospecting permits for oil and gas. Coal produced, 2,153 tons; accrued rent and royalty, \$374.

Utah.—Made structural and stratigraphic investigations of Harley dome, Grand County, for preparation of structure-contour map. Supervised 8 power projects. Examined 48 tracts for agricultural classification. Supervised on

public land 45 leases, 2 licenses, and 65 prospecting permits for coal, 36 prospecting permits for potash, and 12 leases, 2 suspended preference rights to leases, and 522 prospecting permits for oil and gas. Coal produced, 767,553 tons; accrued rent and royalty, \$125,437. Oil produced, 6,695 barrels; natural gas (including carbon dioxide), 44,949,000 cubic feet; accrued royalty, \$713. Supervised on Indian land on one reservation 4 agency coal mines and under Executive order 6 leases for oil and gas.

Washington.—Supervised 10 power projects and surveyed 50 miles of river. Investigated storage and power possibilities on the Queets, Duckabush, and Dosewallips Rivers. Examined 7 tracts for agricultural classification. Supervised 21 prospecting permits for coal and 1 prospecting permit and 1 awarded lease application for sodium. Coal produced, 44,190 tons; accrued rent and royalty, \$11,071.

Wyoming.—Remapped basal Mesaverde coal in Kindt Basin, Carbon County, to conform with township resurveys. Investigated storage and power possibilities and surveyed 65 miles of the Snake River and supervised 4 power projects. Examined 110 tracts for agricultural classification and completed in the western part of the State regional investigations precedent to grazing classification. Supervised on public land 39 leases, 11 licenses, 41 prospecting permits, and 5 awarded lease applications for coal, 2 prospecting permits for sodium, 1 prospecting permit for potash, and 397 leases, 8 suspended preference rights to leases, and 845 prospecting permits for oil and gas. Made 149 analyses of water, 31 of oil, and 41 of oil and gas, and 27,989 determinations of oil gravity. Coal produced, 871,486 tons; accrued rent and royalty, \$112,176. Oil produced, 9,417,622 barrels; natural gas, 14,752,514,000 cubic feet; natural-gas gasoline, 40,726,823 gallons; accrued royalty, \$1,340,988. Made periodic inspection and pressure test of wells shut in on Naval Petroleum Reserve No. 3 and supervised operations for mudding and plugging certain wells that were in unsatisfactory condition. Supervised on Indian land on one reservation 40 leases for oil and gas. Began direct supervision of oil and gas operation and royalty accounting for production from Indian lands.

MINERAL CLASSIFICATION DIVISION

The work of mineral classification 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, through the geologic branch, of field investigations required to provide the basis for appropriate action or recommendation relative to mineral classifications and to 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.

During the fiscal year requests for reports on the prospective value for oil and gas of lands involved in certain types of nonmineral entries and filings totaled 4,248, and reports on 3,788 cases were submitted to the General Land Office.

Some progress was made in 1931 in classifying the vast areas of public land that are still embraced in mineral withdrawals. The results accomplished include net decreases of 816,873 acres in outstanding withdrawals for coal, of 54,100 acres in areas classified as oil-shale land, and of 115,293 acres in outstanding withdrawals for phosphate, and net increases of 508,480 acres in areas classified as coal and of 1,737 acres in areas classified as phosphate.

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, 1932,
in acres*

| State | Coal | | Oil | |
|-------------------|------------|-------------------------|-----------|------------------------|
| | Withdrawn | Classified as coal land | Withdrawn | Classified as oil land |
| Alaska..... | | 56,993 | | |
| Arizona..... | 139,415 | | 356 | |
| Arkansas..... | | 61,160 | | |
| California..... | 17,603 | 8,720 | 1,178,392 | |
| Colorado..... | 4,142,233 | 3,082,272 | 215,370 | |
| Idaho..... | 4,761 | 4,603 | | |
| Louisiana..... | | | 466,990 | 4,233 |
| Montana..... | 7,047,068 | ^a 9,072,342 | 1,336,697 | 67,651 |
| Nevada..... | 83,673 | | | |
| New Mexico..... | 5,061,011 | 570,372 | | |
| North Dakota..... | 5,954,364 | 11,178,286 | 84,894 | |
| Oregon..... | 4,361 | 18,887 | | |
| South Dakota..... | | 250,093 | | |
| Utah..... | 3,404,043 | 1,267,697 | 1,341,264 | |
| Washington..... | 691,801 | 141,444 | | |
| Wyoming..... | 2,260,604 | ^b 6,740,594 | 541,777 | |
| | 28,810,937 | 32,453,463 | 5,165,740 | 71,884 |

| State | Oil shale | | Phosphate | | Potash, with-drawn |
|-----------------|------------|------------------------------|------------|------------------------------|--------------------|
| | With-drawn | Classified as oil shale land | With-drawn | Classified as phosphate land | |
| California..... | | | | | 90,324 |
| Colorado..... | 64,560 | 952,239 | | | |
| Florida..... | | | 66,796 | 120 | |
| Idaho..... | | | 276,239 | 270,036 | |
| Montana..... | | | 279,944 | 3,833 | |
| Nevada..... | 123 | | | | 39,422 |
| New Mexico..... | | | | | 9,282,160 |
| Utah..... | 91,464 | 2,703,755 | 277,344 | 2,937 | |
| Wyoming..... | | 406,003 | 989,149 | 25,293 | |
| | 156,147 | 4,061,997 | 1,889,472 | 302,219 | 9,411,906 |

^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 following table summarizes the year's work to the extent that it involved technical reports on filings under the mineral-leasing laws:

Summary of applications under the mineral-leasing laws, fiscal year 1932

[Includes cases pending July 1, 1931]

| Mineral | Prospecting permits | | Leases | | Relinquishments and cancellations | | Reinstatements and extensions | |
|------------------|---------------------|----------|----------|----------|-----------------------------------|----------|-------------------------------|----------|
| | Received | Acted on | Received | Acted on | Received | Acted on | Received | Acted on |
| Oil and gas..... | 1,156 | 382 | | | 892 | 868 | 2,020 | 1,873 |
| Coal..... | 160 | 159 | 110 | 108 | | | | |
| Phosphate..... | | | 13 | 13 | | | | |
| Sodium..... | 16 | 16 | 2 | 2 | | | | |
| Potassium..... | 85 | 84 | 10 | 10 | | | | |
| | 1,417 | 641 | 135 | 133 | 892 | 868 | 2,020 | 1,873 |

In accordance with the duty delegated to the Geological Survey, definitions of the "known geologic structure" of 20 producing oil and gas fields were prepared and promulgated during the year, as follows:

Definitions of "known geologic structure," fiscal year 1932

| State | Field | Date promulgated | Acres |
|-----------------|----------------------------------|------------------|--------|
| Colorado..... | Powder Wash..... | June 20, 1932 | 6,923 |
| New Mexico..... | Hobbs..... | Dec. 16, 1931 | 10,609 |
| Do..... | North Eunice..... |do..... | 4,110 |
| Do..... | South Eunice..... |do..... | 15,789 |
| Do..... | Baish..... | May 23, 1932 | 2,640 |
| Do..... | Compton..... |do..... | 880 |
| Do..... | Empire..... |do..... | 442 |
| Do..... | Getty..... |do..... | 2,080 |
| Do..... | Grayburg..... |do..... | 1,982 |
| Do..... | Jackson..... |do..... | 6,288 |
| Do..... | Lea..... |do..... | 1,881 |
| Do..... | Leonard-Levers..... |do..... | 2,440 |
| Do..... | Mitchell..... |do..... | 2,567 |
| Do..... | Pecos Valley..... |do..... | 1,678 |
| Do..... | Robinson..... |do..... | 2,683 |
| Do..... | Skelly..... |do..... | 1,400 |
| Wyoming..... | Big Sand Draw (additional)..... | Feb. 25, 1932 | 600 |
| Do..... | Osage (additional)..... | June 22, 1932 | 3,480 |
| Do..... | Midway..... | June 1, 1932.. | 5,032 |
| Do..... | Hamilton Dome (elimination)..... |do..... | 9,249 |

The net area included in outstanding definitions of the "known geologic structure" of producing oil and gas fields on June 30, 1932, was 843,106 acres, in California, Colorado, Montana, New Mexico, Oklahoma, Utah, and Wyoming.

Geologic field work required in the solution of the problems of the branch is performed in part by summer detail of Washington employees of the mineral-classification division, in part by two division geologists and two assistants with headquarters in Denver, Colo., and in part by the geologic branch at the expense of the conservation branch. Investigations during the fiscal year 1932 are included in the summary of field operations by States beginning on page 62.

Reports were submitted during the year for administrative use concerning the Manuelito coal field, McKinley County, N. Mex.; the structure and coal resources of the Hospah-Seven Lakes-Stony Butte region, San Juan and McKinley Counties, N. Mex.; the Cutbank gas area, Glacier County, Mont.; the Bowdoin gas field, Phillips and Valley Counties, Mont.; and the geologic disclosures of well No. 1 Gerard of the Fulton Blackfeet Oil Co., on the Milk River anticline, Glacier County, Mont.

POWER DIVISION

The work of power classification 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 extent of this task is indicated by the fact that areas aggregating nearly 7,000,000 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. The field projects under-

taken during the year are included in the summary of field operations by States (pp. 62-64).

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.

River surveys to the aggregate length of 528 miles were made of the Salt River and its tributaries and the Black and White Rivers, Ariz.; the Walla Walla River in Oregon and Washington; the North Fork of the Nooksak River, Wash., from Maple Falls to the mouth of Ruth Creek; Glacier Creek, Wash., from the mouth to the 2,000-foot contour crossing; a section of the Queets River, Wash.; the Judith River, Mont., from the mouth to Big Spring Creek; Big Spring Creek to Big Springs and Warm Spring Creek to Warm Springs; and Snake River, Wyo. Four dam-site surveys were made in Oregon, two in Washington, and one in Montana; and reconnaissance geologic examinations were made at seven dam sites in Oregon and two in Washington.

Reports were obtained on field inspections of 26 power projects under permit from the Interior Department.

Administration of the field supervision of power projects for the Federal Power Commission is carried on in this office. Investigations and reports have been made on 19 projects, construction and operation are supervised on 125 projects, and cost accounting is being supervised on 10 projects.

The work of the division is briefly summarized in the accompanying tables and in the general summary on pages 62-64.

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), were called upon for detailed reports of the operation or development of their power systems during the calendar year 1931. The total installation of the reporting companies is 3,608,000 horsepower, of which 2,353,000 horsepower is at hydraulic plants and 1,255,000 horsepower at fuel plants. The total energy generated was 7,696,000,000 kilowatt-hours, which was 154,000,000 kilowatt-hours less than in 1930 and was the smallest output since 1925. The energy generated by water power decreased 1,557,000,000 kilowatt-hours, or nearly 23 per cent; and that generated by fuel increased 1,403,000,000 kilowatt-hours, or nearly 143 per cent. The unusually low stream flow during 1931 is reflected in the large increase in the electric energy generated by fuel.

Power output of permittees and grantees, 1916-1931

| 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 | | | 1924----- | 6,100,000,000 | +190,000,000 | +3 |
| 1917----- | 2,000,000,000 | +800,000,000 | +67 | 1925----- | 6,930,000,000 | +830,000,000 | +14 |
| 1918----- | 3,200,000,000 | +1,200,000,000 | +60 | 1926----- | 7,800,000,000 | +870,000,000 | +13 |
| 1919----- | 3,100,000,000 | -100,000,000 | -3 | 1927----- | 8,116,000,000 | +316,000,000 | +4 |
| 1920----- | 4,300,000,000 | +1,100,000,000 | +35 | 1928----- | 8,987,000,000 | +871,000,000 | +11 |
| 1921----- | 3,725,000,000 | -575,000,000 | -13 | 1929----- | 9,352,000,000 | +365,000,000 | +4 |
| 1922----- | 4,947,000,000 | +1,222,000,000 | +33 | 1930----- | 7,850,000,000 | -1,502,000,000 | -16 |
| 1923----- | 5,910,000,000 | +963,000,000 | +19 | 1931----- | 7,696,000,000 | -154,000,000 | -2 |

The following table shows the revenue accrued for occupancy and use of public lands by the power projects mentioned above:

Accrued compensation for occupancy and use of lands under power permits and grants issued by the Interior Department, 1912-1932

| State | 1912-1915 | 1916-1920 | 1921-1925 | 1926-1930 | 1931 | 1932 |
|-------------------|----------------|------------------|------------------|-------------------|-------------------|-------------------|
| Alaska..... | | \$6,960 | \$9,280 | \$2,900 | \$580 | \$580 |
| Arizona..... | \$515 | 1,285 | 1,900 | 1,900 | 460 | 460 |
| California..... | 3,619 | 9,274 | 9,918 | 9,624 | 1,942 | 1,936 |
| Colorado..... | 315 | 875 | 1,765 | 1,465 | 250 | 250 |
| Idaho..... | 20 | 1,670 | 1,700 | 1,640 | 310 | 265 |
| Montana..... | 1,255 | 7,562 | 13,314 | 28,183 | 7,487 | 7,306 |
| Nevada..... | 281 | 2,245 | 2,570 | 3,565 | 1,443 | 1,427 |
| New Mexico..... | | 20 | 60 | 275 | 95 | 95 |
| Oregon..... | 60 | 100 | 700 | 700 | 225 | 225 |
| Utah..... | | 2,568 | 4,395 | 4,460 | 1,150 | 1,181 |
| Washington..... | 15 | 156 | 631 | 3,675 | 1,266 | 1,303 |
| Wyoming..... | | 70 | 175 | 290 | 65 | 65 |
| Minnesota..... | | 20 | 25 | 20 | | |
| Accumulation..... | 6,080 6,080 | 32,805 38,885 | 46,433 85,318 | 58,697 144,015 | 15,274 159,289 | 15,093 174,382 |

Accrued charges for the unauthorized occupancy of public lands by power projects prior to the issuance of licenses therefor by the Federal Power Commission amount to \$109,863.61, of which \$12,-222.28 is before the courts for adjudication.

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, 1931 | Eliminated prior to July 1, 1931 | Outstanding prior to July 1, 1931 | Reserved during fiscal year | Eliminated during fiscal year | Outstanding June 30, 1932 |
|-------------------|--------------------------------|----------------------------------|-----------------------------------|-----------------------------|-------------------------------|---------------------------|
| Alabama..... | 2,377 | | 2,377 | 56 | | 2,433 |
| Alaska..... | 316,319 | 32,164 | 284,155 | 9,352 | 1,479 | 292,028 |
| Arizona..... | 1,338,878 | 141,197 | 1,197,681 | 12 | | 1,197,693 |
| Arkansas..... | 29,718 | 440 | 29,278 | 2,169 | | 31,447 |
| California..... | 1,466,037 | 53,829 | 1,412,208 | 13,352 | 480 | 1,425,080 |
| Colorado..... | 559,112 | 98,829 | 460,283 | 3,041 | 475 | 462,849 |
| Florida..... | 1,131 | | 1,131 | | | 1,131 |
| Idaho..... | 653,511 | 204,752 | 448,759 | 202 | 2,439 | 446,522 |
| Michigan..... | 1,246 | | 1,246 | | | 1,246 |
| Minnesota..... | 19,062 | 532 | 18,530 | | | 18,530 |
| Mississippi..... | 3 | | 3 | | | 3 |
| Missouri..... | 11 | | 11 | 40 | | 51 |
| Montana..... | 308,429 | 99,923 | 208,506 | 429 | 23 | 208,912 |
| Nebraska..... | 761 | | 761 | | | 761 |
| Nevada..... | 360,679 | 1,845 | 358,834 | 303 | | 359,137 |
| New Mexico..... | 272,980 | 16,123 | 256,857 | | | 256,857 |
| Oregon..... | 820,724 | 187,259 | 633,465 | 15,369 | 3,706 | 645,128 |
| South Dakota..... | 796 | | 796 | | | 796 |
| Utah..... | 786,245 | 137,342 | 648,903 | 1,601 | 1,900 | 648,604 |
| Washington..... | 480,526 | 108,857 | 371,669 | 3,721 | | 375,390 |
| Wisconsin..... | 1,906 | 226 | 1,680 | | | 1,680 |
| Wyoming..... | 275,805 | 76,465 | 199,340 | 2,048 | 481 | 200,907 |
| | 7,696,256 | 1,159,783 | 6,536,473 | 51,695 | 10,983 | 6,577,185 |

Summary of outstanding water-resources withdrawals and classifications, June 30, 1932, in acres

| State | Power reserves | | | | | Reservoir with- drawals | Public water reserves |
|--------------|------------------|----------------------|---------------------|--------------------|-----------|----------------------------|-----------------------------|
| | With- drawals | Classifi- cations | Desig- nations * | Miscel- laneous | Total | | |
| Alabama | 120 | 1,735 | | 578 | 2,433 | | |
| Alaska | 88,275 | 117,666 | | 86,087 | 292,028 | | 8 |
| Arizona | 373,899 | 49,861 | 524,200 | 249,733 | 1,197,693 | 23,040 | 21,700 |
| Arkansas | 21,954 | 1,550 | | 7,943 | 31,447 | | |
| California | 286,915 | 377,703 | | 760,462 | 1,425,080 | 45,264 | 200,871 |
| Colorado | 210,044 | 193,558 | | 59,247 | 462,849 | 1,728 | 11,330 |
| Florida | | | | 1,131 | 1,131 | | |
| Idaho | 193,592 | 234,098 | | 18,832 | 446,522 | | 17,502 |
| Michigan | 1,240 | | | 6 | 1,246 | | |
| Minnesota | 12,309 | | | 6,221 | 18,530 | | |
| Mississippi | | | | 3 | 3 | | |
| Missouri | | | | 51 | 51 | | |
| Montana | 126,971 | 55,827 | | 26,114 | 208,912 | 9,080 | 10,457 |
| Nebraska | 761 | | | | 761 | | |
| Nevada | 26,627 | 86,905 | | 245,605 | 359,137 | | 16,221 |
| New Mexico | 115,647 | 49 | 141,161 | | 256,857 | | 10,116 |
| North Dakota | | | | | | 1,091 | |
| Oregon | 316,426 | 218,362 | 14,532 | 95,808 | 645,128 | 18,603 | 29,021 |
| South Dakota | | | | 796 | 796 | | 240 |
| Utah | 433,335 | 178,126 | | 37,143 | 648,604 | 80 | 40,385 |
| Washington | 102,283 | 193,320 | | 79,787 | 375,390 | 31,797 | 920 |
| Wisconsin | | | | 1,680 | 1,680 | | |
| Wyoming | 79,624 | 77,563 | | 43,720 | 200,907 | 1,714 | 89,065 |
| | 2,390,022 | 1,786,323 | 679,893 | 1,720,947 | 6,577,185 | 132,397 | 447,836 |

* Designated and not otherwise withdrawn.

AGRICULTURAL DIVISION

The principal 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; 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; and the preparation of reports showing the agricultural utility of lands in important public-land regions, including a classification of the grazing lands as to forage types and yields and suggestions as to the proper use thereof to maintain a natural ground cover, prevent waste of the forage growth by overgrazing, and incidentally eliminate avoidable erosion losses.

Classifications are made in accordance with the results of field examinations by members of the division and with information obtained from other sources. The work of the division is planned with the primary purpose of acting on pending applications for classification under the above-mentioned laws and to provide in advance the basis for appropriate action on new applications. The number of cases received and acted on during the fiscal year is shown in the

general summary of cases (p. 61). There was a decrease of about 18 per cent in the number received, and the arrearage was 17 per cent less at the end of the year than at the end of the fiscal year 1931.

Summary of enlarged-homestead designations, in acres

[Areas classified as arid and nonirrigable, residence by entrymen required, act of February 19, 1909 (35 Stat. 639), applicable to Arizona, Colorado, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming; act of June 17, 1920 (36 Stat. 531), applicable to Idaho; act of June 13, 1912 (37 Stat. 132), applicable to California, North Dakota; act of March 3, 1915 (38 Stat. 953), applicable to Kansas; act of March 4, 1915 (38 Stat. 1163), applicable to South Dakota. Areas classified as arid, nonirrigable, and lacking domestic water supply, residence by entrymen not required, act of February 19, 1909 (35 Stat. 639), applicable to Utah; act of June 17, 1910 (36 Stat. 531), applicable to Idaho]

| State | Designations prior to July 1, 1931 | Cancellations prior to July 1, 1931 | Outstanding prior to July 1, 1931 | Designations during fiscal year | Cancellations during fiscal year | Outstanding June 30, 1932 |
|--------------|------------------------------------|-------------------------------------|-----------------------------------|---------------------------------|----------------------------------|---------------------------|
| Arizona | 31, 534, 184 | 13, 380, 029 | 18, 154, 155 | 730 | 40, 540 | 18, 114, 345 |
| California | 13, 384, 547 | 457, 333 | 12, 927, 214 | 1, 413 | 1, 801, 070 | 11, 127, 557 |
| Colorado | 33, 978, 782 | 196, 428 | 33, 782, 354 | 1, 713 | | 33, 784, 067 |
| Idaho: | | | | | | |
| Total | 13, 758, 156 | 461, 725 | 13, 296, 431 | 3, 480 | | 13, 299, 911 |
| Nonresidence | 573, 707 | 4, 233 | 569, 474 | 200 | | 569, 674 |
| Kansas | 652, 404 | | 652, 404 | 716 | | 653, 120 |
| Montana | 53, 496, 956 | 245, 728 | 53, 251, 228 | 25, 360 | 360 | 53, 276, 228 |
| Nevada | 50, 219, 304 | 3, 581, 037 | 46, 638, 267 | | | 46, 638, 267 |
| New Mexico | 43, 854, 836 | 228, 012 | 43, 626, 824 | 5, 070 | 25, 596 | 43, 606, 298 |
| North Dakota | 12, 282, 557 | 3, 848 | 12, 278, 709 | 336 | | 12, 279, 045 |
| Oregon | 21, 284, 551 | 1, 001, 222 | 20, 283, 329 | 840 | | 20, 284, 169 |
| South Dakota | 16, 343, 341 | 348, 170 | 15, 995, 171 | 1, 092 | | 15, 996, 263 |
| Utah: | | | | | | |
| Total | 11, 757, 297 | 1, 197, 827 | 10, 559, 470 | 1, 120 | * 1, 480 | 10, 559, 110 |
| Nonresidence | 1, 658, 098 | 509, 103 | 1, 148, 995 | 560 | 760 | 1, 148, 795 |
| Washington | 6, 661, 092 | 251, 842 | 6, 409, 250 | 600 | | 6, 409, 850 |
| Wyoming | 29, 791, 769 | 162, 043 | 29, 629, 726 | 4, 040 | 1, 313, 130 | 28, 320, 636 |
| | 338, 999, 776 | 21, 515, 244 | 317, 484, 532 | 46, 510 | 3, 182, 176 | 314, 348, 866 |

* 80 acres previously designated under secs. 1-5, now under sec. 6.

Summary of stock-raising homestead designations, in acres

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

| State | Designations prior to July 1, 1931 | Cancellations prior to July 1, 1931 | Outstanding prior to July 1, 1931 | Designations during fiscal year | Cancellations during fiscal year | Outstanding June 30, 1932 |
|--------------|------------------------------------|-------------------------------------|-----------------------------------|---------------------------------|----------------------------------|---------------------------|
| Arizona | 14, 273, 509 | 1, 037, 930 | 13, 235, 579 | 65, 663 | 2, 120 | 13, 299, 122 |
| Arkansas | 1, 120 | | 1, 120 | | | 1, 120 |
| California | 8, 186, 239 | 11, 440 | 8, 174, 799 | 69, 386 | 20, 600 | 8, 223, 585 |
| Colorado | 9, 389, 597 | 21, 080 | 9, 368, 517 | 179, 370 | 1, 000 | 9, 546, 887 |
| Florida | 480 | 480 | | | | |
| Idaho | 5, 737, 152 | 2, 014 | 5, 735, 138 | 38, 460 | 1, 854 | 5, 771, 744 |
| Kansas | 116, 299 | | 116, 299 | 440 | | 116, 739 |
| Michigan | 3, 491 | | 3, 491 | | | 3, 491 |
| Minnesota | | | | 80 | | 80 |
| Mississippi | 160 | | 160 | | | 160 |
| Montana | 15, 949, 751 | 51, 201 | 15, 898, 550 | 151, 236 | 280 | 16, 049, 506 |
| Nebraska | 212, 759 | | 212, 759 | 2, 720 | | 215, 479 |
| Nevada | 656, 842 | 3, 120 | 653, 722 | 14, 791 | | 668, 513 |
| New Mexico | 31, 893, 391 | 28, 116 | 31, 865, 275 | 213, 668 | 4, 080 | 32, 074, 863 |
| North Dakota | 404, 407 | | 404, 407 | 9, 988 | | 414, 395 |
| Oklahoma | 89, 130 | | 89, 130 | 1, 283 | | 90, 413 |
| Oregon | 6, 496, 730 | 3, 168 | 6, 493, 562 | 45, 005 | 80 | 6, 538, 487 |
| South Dakota | 6, 548, 130 | 550 | 6, 547, 580 | 5, 190 | | 6, 552, 770 |
| Utah | 2, 167, 377 | 8, 275 | 2, 159, 102 | 112, 199 | 840 | 2, 270, 461 |
| Washington | 713, 668 | 1, 294 | 712, 374 | 6, 395 | | 718, 769 |
| Wyoming | 21, 114, 887 | 7, 733 | 21, 107, 154 | 196, 948 | 264, 100 | 21, 040, 002 |
| | 123, 955, 119 | 1, 176, 401 | 122, 778, 718 | 1, 112, 822 | 294, 954 | 123, 596, 586 |

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 that 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 were 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 it requires a determination 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, 1931 | Eliminated prior to July 1, 1931 | Outstand- ing prior to July 1, 1931 | Reserved during fiscal year | Eliminated during fiscal year | Outstand- ing June 30, 1932 |
|-------------------|--------------------------------------|--|---|-----------------------------------|-------------------------------------|-----------------------------------|
| Alaska..... | | | | 8 | | 8 |
| Arizona..... | 23, 677 | 2, 742 | 20, 935 | 1, 125 | 360 | 21, 700 |
| California..... | 207, 929 | 7, 898 | 200, 031 | 840 | | 200, 871 |
| Colorado..... | 10, 305 | 940 | 9, 365 | 1, 965 | | 11, 330 |
| Idaho..... | 17, 507 | 410 | 17, 097 | 445 | 40 | 17, 502 |
| Montana..... | 11, 529 | 1, 552 | 9, 977 | 520 | 40 | 10, 457 |
| Nevada..... | 19, 151 | 3, 615 | 15, 536 | 685 | | 16, 221 |
| New Mexico..... | 13, 041 | 3, 085 | 9, 956 | 160 | | 10, 116 |
| Oregon..... | 29, 689 | 1, 568 | 28, 301 | 720 | | 29, 021 |
| South Dakota..... | 240 | | 240 | | | 240 |
| Utah..... | 47, 646 | 7, 596 | 40, 050 | 495 | 160 | 40, 385 |
| Washington..... | 920 | | 920 | | | 920 |
| Wyoming..... | 100, 165 | 14, 220 | 85, 945 | 3, 120 | | 89, 065 |
| | 481, 979 | 43, 626 | 438, 353 | 10, 083 | 600 | 447, 836 |

In the field broad areal studies were continued in the Colorado Basin region, a land-classification report for western Colorado is nearing completion, and field studies were completed preliminary to the preparation of land-classification maps for western Wyoming. Intensive grazing studies were made in Mono Lake and Owens Valleys, Calif., preparatory to the administration of lands withdrawn under the act of March 4, 1931 (46 Stat. 1530). A special land-classification report and map was completed for Utah showing irrigated and dry-farming land, together with different range types and a summary of the aggregate forage resources as compared with the livestock population.

W. G. Hoyt, J. F. Deeds, Depue Falck, G. M. Kerr, and J. Q. Peterson served on subcommittees of a National Land Use Planning Committee, organized at the instance of the Secretary of Agriculture to study economic problems arising in connection with the various uses of land in the United States.

During the fiscal year the area designated under the Nevada ground-water reclamation act was increased 6,560 acres, to a total of 1,706,535 acres. Outstanding withdrawals under the act of October 2, 1888 (25 Stat. 527), on the basis of a selection by the Director of the Geological Survey, aggregating 61,397 acres, 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.

MINING AND OIL AND GAS LEASING DIVISIONS

WORK OF THE DIVISIONS

The work of the mining and oil and gas leasing divisions is supervisory (both inspectional and regulatory) with respect to operations on the public domain for the discovery and development of petroleum, natural gas, oil shale, coal, phosphate, sodium, potassium, and sulphur; on certain land grants for gold, silver, and mercury; on naval petroleum reserves for petroleum and natural gas; and on Indian lands for coal, oil and gas, zinc, lead, iron, silver-lead, uranium, vanadium, and radium ores, vermiculite, asbestos, asphalt, volcanic ash, and stone. This work is done with a minimum of administrative supervision from Washington through district offices at or near the primary centers of mining or drilling activity, under the direction of responsible engineers who have full authority to represent the Secretary within their jurisdiction and to order compliance with the law and regulations under which operations are conducted.

BENEFITS DERIVED FROM MINERAL LEASING

Since October 20, 1914, the date of approval of the law providing for the leasing of coal lands in Alaska, \$72,801,387 has accrued from royalties, rentals, and bonuses by reason of mineral production on public land. During the past fiscal year \$3,501,471 accrued from 5,695 leases, licenses, and prospecting permits, involving more than 8,300,000 acres of land in 19 States and Alaska.

Under the mineral leasing act of 1920 the public-land States receive, without expense, 37.5 per cent of all money derived from leases and permits within their respective borders and participate in the benefits resulting from the expenditure of an additional 52.5 per cent of the income by the Bureau of Reclamation. Incidental benefits include taxes on production and on property used in the development of leases, which in some States amount to more than one-fifth of the total income from taxes. Only 10 per cent of the income from mineral-leasing operations is retained in the United States Treasury. Though the expenditures of the United States on account of the public lands far exceed this 10 per cent retained, the reserved mineral deposits bring in a revenue about twenty times all costs of classification and administration.

Alaska, by special legislation, receives all net profits from the operation of Government mines and all royalties and rentals from mineral leases. The money thus derived is applied to the reimbursement of the Federal Government for the construction of railroads in that Territory.

MINING OPERATIONS ON PUBLIC LANDS

At the end of the fiscal year the inspection of mining and prospecting operations was more nearly up to date, and the conditions of the mines in regard to safety and welfare of the workmen and to the ultimate extraction of the maximum amount of coal were at a higher standard, than at any previous time. These results were accomplished by regular though altogether too infrequent inspections and by gaining the confidence of the operators, most of whom are willingly complying with the operating regulations. Operators on fee land as well as operators on leased land make frequent requests for suggestions in regard to better mining practice.

During the fiscal year 279 leases, licenses, and prospecting permits were issued, involving 325,230.28 acres, as compared with 232, involving 227,988.81 acres, in the fiscal year 1931.

Leases, licenses, and permits issued, fiscal year 1932

| | Number | Acres | | Number | Acres |
|----------------|--------|-----------|------------------|--------|------------|
| Leases: | | | Permits: | | |
| Coal..... | 33 | 3,330.72 | Coal..... | 81 | 71,055.67 |
| Potash..... | 3 | 6,808.59 | Potash..... | 102 | 218,938.73 |
| Phosphate..... | 1 | 120.00 | Phosphate..... | ----- | 0 |
| Sodium..... | 0 | 0 | Sodium..... | 13 | 23,228.64 |
| | 37 | 10,259.31 | | 196 | 313,223.04 |
| Licenses..... | 46 | 1,747.93 | Grand total..... | 279 | 325,230.28 |

During the same period 24 coal leases, 18 coal permits, 2 coal licenses, 4 potash permits, 1 sodium lease, and 1 sodium permit were canceled, and 69 coal permits, 8 coal licenses, 29 potash permits, and 24 sodium permits expired by limitation—a total of 180 for 1932 as compared with 156 for 1931.

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

Mining leases, licenses, and permits on the public domain under supervision of the Geological Survey June 30, 1932

| State | Coal | | | | | | Potash | | | |
|-------------------|--------|-----------|---------|------------|----------|----------|--------|-----------|---------|------------|
| | Leases | | Permits | | Licenses | | Leases | | Permits | |
| | Number | Acres | Number | Acres | Number | Acres | Number | Acres | Number | Acres |
| Alaska..... | 6 | 7,027.28 | 20 | 40,479.96 | 3 | 30.00 | ----- | ----- | ----- | ----- |
| Alabama..... | 1 | 1,840.00 | ----- | ----- | ----- | ----- | ----- | ----- | 1 | 634.77 |
| Arizona..... | ----- | ----- | 1 | 2,079.88 | ----- | ----- | ----- | ----- | ----- | ----- |
| Arkansas..... | ----- | ----- | 3 | 6,012.64 | ----- | ----- | ----- | ----- | 5 | 10,870.19 |
| California..... | ----- | ----- | 39 | 25,037.45 | 4 | 160.00 | 4 | 7,783.80 | 1 | 2,150.00 |
| Colorado..... | 77 | 11,665.54 | 11 | 9,877.57 | ----- | ----- | ----- | ----- | ----- | ----- |
| Idaho..... | 76 | 6,791.34 | 35 | 7,255.98 | 51 | 1,992.82 | ----- | ----- | ----- | ----- |
| Montana..... | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 2 | 360.00 |
| Nebraska..... | ----- | ----- | 5 | 8,724.04 | ----- | ----- | ----- | ----- | 3 | 6,413.05 |
| Nevada..... | 22 | 11,483.48 | 28 | 40,032.07 | ----- | ----- | 6 | 14,482.98 | 105 | 228,644.46 |
| New Mexico..... | 60 | 6,582.36 | 1 | 120.00 | 20 | 880.00 | ----- | ----- | ----- | ----- |
| North Dakota..... | 2 | 1,895.24 | 9 | 6,746.38 | ----- | ----- | ----- | ----- | 2 | 4,488.94 |
| Oregon..... | 4 | 239.04 | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| South Dakota..... | 41 | 27,220.83 | 65 | 83,392.00 | 2 | 160.00 | ----- | ----- | 36 | 77,441.90 |
| Utah..... | ----- | ----- | 17 | 14,420.86 | ----- | ----- | ----- | ----- | ----- | ----- |
| Washington..... | 34 | 12,802.71 | 37 | 26,260.17 | 11 | 440.00 | ----- | ----- | ----- | ----- |
| Wyoming..... | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| | 323 | 87,547.82 | 271 | 270,439.00 | 91 | 3,662.82 | 10 | 22,266.78 | 155 | 331,003.31 |

Mining leases, licenses, and permits on the public domain under supervision of the Geological Survey June 30, 1932—Continued

| State | Sodium | | | | Phosphate | | Oil shale | |
|-------------------|-------------|----------|-------------|-----------|-------------|----------|-------------|----------|
| | Leases | | Permits | | Leases | | Leases | |
| | Num- ber | Acres | Num- ber | Acres | Num- ber | Acres | Num- ber | Acres |
| Arizona..... | 1 | 405.20 | 5 | 6,933.96 | | | | |
| California..... | | | 7 | 12,204.33 | | | | |
| Idaho..... | | | | | 2 | 1,700.00 | | |
| Montana..... | | | | | 2 | 1,400.00 | | |
| Nevada..... | 1 | 1,440.00 | 6 | 12,080.13 | 1 | 160.00 | | |
| New Mexico..... | | | 6 | 10,619.19 | | | | |
| North Dakota..... | | | 1 | 520.00 | | | | |
| Oregon..... | | | | | | | 1 | 2,680.00 |
| | 2 | 1,845.20 | 25 | 42,357.61 | 5 | 3,260.00 | 1 | 2,680.00 |

Total leases, 341; licenses, 91; permits, 451.

During the year the number of operating mines of all kinds was increased by 52. The number of coal mines was increased from 382 to 432, there being a decrease of 12 shipping mines and an increase of 62 wagon mines. The phosphate and sodium operations were each increased from 3 to 4. The number of potash operations remained the same. A total of 1,448 inspections of leases, licenses, and permits were made at an average cost of \$31.57 per inspection, which includes all expenditures of the districts. An average of 175 inspections were made by each field engineer.

Operating mines, fiscal year 1932

| State | Phos- phate | Potash | Sodium | Coal | | Total |
|-------------------|----------------|--------|--------|----------|-------|-------|
| | | | | Shipping | Wagon | |
| Alaska..... | | | | 4 | | 4 |
| Alabama..... | | | | 1 | | 1 |
| Arizona..... | | | 1 | | | 1 |
| California..... | | | 2 | | 1 | 3 |
| Colorado..... | | | | 14 | 63 | 77 |
| Idaho..... | 2 | | | | 6 | 8 |
| Montana..... | 1 | | | 3 | 129 | 133 |
| Nevada..... | 1 | | 1 | | | 1 |
| New Mexico..... | | 1 | | 5 | 12 | 18 |
| North Dakota..... | | | | 6 | 66 | 72 |
| Oregon..... | | | | | 3 | 3 |
| South Dakota..... | | | | | 4 | 4 |
| Utah..... | | | | 17 | 32 | 49 |
| Washington..... | | | | 1 | | 1 |
| Wyoming..... | | | | 16 | 49 | 65 |
| | 4 | 1 | 4 | 67 | 365 | 441 |

Thirty-nine prospect wells, drilled to a total depth of 29,931 feet, were supervised during the year, as compared to 25 wells, with a total depth of 10,902 feet, supervised during the previous year.

Production.—The value of the minerals produced on public lands during the year, at prevailing market prices, was \$7,880,454 divided as follows: Coal, \$6,502,304; phosphate, \$115,806; potash, \$759,071; sodium, \$503,273. There was no production or development of oil shale or sulphur prior to or during the year.

Coal.—At the end of the year there were in effect 323 coal leases, 91 coal licenses, and 271 coal permits involving 361,649.64 acres. During the year 2,880,447.89 tons of coal was produced from public lands in 12 States and Alaska, from which \$375,939 accrued in rents, royalties, and bonuses. There was a decrease in production of 5 per cent from the preceding year, but the number of mines increased 13 per cent. Four test holes were drilled to a total depth of 3,255 feet.

Of the 24 coal mines in the United States receiving awards from the Joseph A. Holmes Safety Association for production without a fatality during 1932 the following were operated on leased public lands: Liberty Fuel Co., 1,018,000 tons; No. 4 mine, Union Pacific Coal Co., 2,476,122 tons; C mine, Union Pacific Coal Co., 1,019,753 tons; Hotchkiss mine, Hotchkiss Coal Co., 672,107 tons without a fatality and 30,826 tons with but one compensable accident. The ratio of the awards to Government lessees to the total in the United States is 1 to 6, with a production ratio of but 1 ton to 175. One strip mine, not mentioned, has produced about 7,000,000 tons without a fatality and comparatively few accidents involving lost time.

The first fatal accident in wagon mines on public land in the Billings district occurred this year, as compared with 7 to 10 annually in small mines in the district not under Government supervision. No fatal accidents have occurred on public lands in California, Montana, Nevada, Oregon, South Dakota, and Washington since the passage of the mineral-leasing act.

Observations were made of 21 coal fires on public lands during the year; 14 were old fires and 7 were new. Of the 14 old fires under observation 3 were underground and 11 were outcrop fires—6 in Wyoming, 2 in Montana, 2 in Utah, and 1 in Oregon. One of the outcrop fires that was dormant was reopened by a coal trespasser and is burning with renewed vigor. Of the 7 new fires inspected, 4 were stripping operations and 3 underground. Four fires, through prompt action, were successfully extinguished without damage. The fifth was believed to be extinguished but later rekindled; two are still under observation but are believed to be under control. Four of the fires started from burning Russian thistles and one from an accumulation of slack coal in a stripping mine operated in trespass.

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

| State | 1912-1925 | 1926-1930 | 1931 | 1932 | 1912-1932 |
|-------------------|--------------|---------------|--------------|--------------|---------------|
| Alaska..... | 455,497.43 | 527,740.36 | 112,961.79 | 101,168.07 | 1,197,367.65 |
| Alabama..... | | 322,926.00 | 121,002.00 | 81,630.00 | 525,558.00 |
| California..... | | 104.00 | 250.00 | 72.00 | 426.00 |
| Colorado..... | 2,028,940.29 | 2,166,953.40 | 396,389.11 | 342,551.09 | 4,934,833.89 |
| Idaho..... | | 1,833.30 | 986.52 | 3,228.70 | 6,048.52 |
| Montana..... | 252,973.58 | 1,304,053.74 | 114,929.27 | 192,432.47 | 1,864,389.06 |
| Nevada..... | | 91.15 | 29.00 | | 120.15 |
| New Mexico..... | 74,427.26 | 357,129.62 | 50,713.21 | 45,414.62 | 527,684.71 |
| North Dakota..... | 453,695.38 | 1,693,443.14 | 363,476.32 | 427,199.30 | 2,937,814.14 |
| Oregon..... | 688.97 | 8,798.66 | 755.50 | 1,369.43 | 11,612.56 |
| South Dakota..... | 1,842.63 | 2,772.82 | 489.29 | 2,152.95 | 7,257.69 |
| Utah..... | 487,303.62 | 2,117,190.17 | 830,187.56 | 767,553.37 | 4,202,234.72 |
| Washington..... | 164,280.14 | 88,508.03 | 25,461.74 | 44,190.25 | 322,440.45 |
| Wyoming..... | 4,465,885.23 | 5,137,978.53 | 1,035,557.77 | 871,485.64 | 11,510,907.17 |
| | 8,385,534.82 | 13,729,522.92 | 3,053,189.08 | 2,880,447.89 | 28,048,694.71 |

Phosphate.—Five phosphate leases were in effect during the year—2 in Idaho, 2 in Montana, and 1 in Nevada. Phosphate deposits of the West were developed primarily to dispose of sulphuric acid from copper smelters and to supply a postwar foreign fertilizer market, but now they are a source of fertilizer for sugar beets and wheat in the Rocky Mountain region of the United States and Canada.

Triple superphosphate is manufactured in Montana and Canada from the phosphate rock mined from Government leases in Idaho and from fee land in Montana. Government land in Montana is being developed, and the initial shipment is expected soon. Phosphate in the form of guano is mined in Nevada and shipped to California without treatment.

Phosphate, potassium, and sodium produced from public lands, in tons, by fiscal years

| Mineral | 1921-1925 | 1926-1930 | 1931 | 1932 | Total |
|----------------------------|------------|-------------|-------------|-------------|--------------|
| Phosphate: | | | | | |
| Idaho..... | 6, 132. 44 | 91, 505. 02 | 68, 974. 33 | 33, 058. 88 | 199, 670. 67 |
| Nevada..... | | 45. 45 | 80. 72 | 40. 25 | 166. 42 |
| | 6, 132. 44 | 91, 550. 47 | 69, 055. 05 | 33, 099. 13 | 199, 837. 09 |
| Potassium: New Mexico..... | | | 4, 726. 94 | 45, 966. 78 | 50, 693. 72 |
| Sodium: | | | | | |
| California..... | 3, 145. 30 | 73, 362. 37 | 30, 226. 00 | 32, 195. 00 | 138, 928. 67 |
| Nevada..... | 248. 25 | 2, 546. 08 | | 700. 00 | 3, 494. 33 |
| New Mexico..... | | | 30. 52 | | 30. 52 |
| Oregon..... | | a 80. 00 | | | 80. 00 |
| | 3, 393. 55 | 75, 988. 45 | 30, 256. 52 | 32, 895. 00 | 142, 533. 52 |

a Produced in 1926-1928; not previously reported.

Potash.—At the end of the fiscal year 10 potash leases involving 22,266.78 acres and 155 permits involving 331,003.31 acres were in effect. One leasehold produced potash, 1 produced sodium salts, and on 2 experiments for recovery of potash were conducted.

During the year 45,967 tons of potash, an increase of about 872.4 per cent, was produced from public lands, from which \$22,327 accrued in rentals and royalties. During the year 19 test holes were drilled for potash in New Mexico to a total depth of 17,146 feet and 4 in Utah to a depth of 6,630 feet, a total of 23 to a total depth of 23,776 feet. Over 300 assays for potash were made at the wells in Utah.

For the development of potash in New Mexico 5.1 miles of standard railroad, 13.6 miles of narrow-gage railroad, and 18 miles of highway were built. A new headframe 110 feet high has been erected for skip hoisting, and a refinery for treating potash salts, which will make available any grade of muriate potash salts desired, is nearing completion.

The value of the output from the potash mine in New Mexico during the year is comparable to the amount of money spent by the Government during the last 20 years in its search for natural deposits of potash-bearing minerals in the United States. The New Mexico production and that from private lands in California will save to the industry in this country a large expenditure previously made in Europe. (For the production of potassium, see table above.)

Sodium.—In addition to 25 sodium permits covering 42,357.61 acres there were 2 sodium leases under supervision—1 in Nevada and 1 in Arizona. The Nevada lease is the source of a high-grade salt cake produced by leaching the sodium sulphate salts from the soil and evaporating the solution in solar ponds. The lease in Verde Valley, Ariz., is being further prospected. A mine on patented land, adjoining the leased land, has been in operation for several years. In prospecting for borax in the Kramer district, Calif., two wells were churn drilled to a total depth of 2,100 feet during the year. A total of 32,995 tons of soda ash, salt cake, borax, and sodium chloride, with a value of \$503,273, was produced from potash leases in California and New Mexico and from the sodium lease in Nevada. (For the production of sodium, see table above.)

Oil shale.—Of the two oil-shale leases so far issued one has been canceled and the other has been inactive.

Royalty, rentals, and bonuses.—Royalties, rentals, and bonuses accrued from mining operations on public land are shown in the following table:

Royalties, rentals, and bonuses accrued from mining operations on public lands by States for 1932 and by fiscal years in summary

| | Coal | Sodium | Phosphate | Potash | Bonuses | Total |
|-------------------|-----------------|------------|--------------|---------------|--------------|-----------------|
| 1932 | | | | | | |
| Alabama..... | \$8, 163. 00 | | | | | \$8, 163. 00 |
| Alaska..... | 8, 225. 09 | | | | | 8, 225. 09 |
| Arizona..... | | \$203. 00 | | | | 203. 00 |
| California..... | 18. 00 | | | \$12, 968. 52 | | 12, 986. 52 |
| Colorado..... | 49, 135. 90 | | | | | 49, 135. 90 |
| Idaho..... | 807. 19 | | \$4, 278. 93 | | | 5, 086. 12 |
| Montana..... | 22, 818. 85 | | 670. 00 | | \$261. 00 | 23, 749. 85 |
| Nevada..... | | | 80. 00 | | | 80. 00 |
| New Mexico..... | 9, 447. 64 | | | 9, 358. 93 | | 18, 806. 57 |
| North Dakota..... | 25, 235. 38 | | | | | 25, 235. 38 |
| Oregon..... | 3, 053. 86 | | | | | 3, 053. 86 |
| South Dakota..... | 3, 373. 95 | | | | | 373. 95 |
| Utah..... | 125, 437. 02 | | | | 5. 00 | 125, 442. 02 |
| Washington..... | 11, 047. 56 | 23. 05 | | | | 11, 070. 61 |
| Wyoming..... | 112, 175. 78 | | | | | 112, 175. 78 |
| | 375, 939. 22 | 226. 05 | 5, 028. 93 | 22, 327. 45 | 266. 00 | 403, 787. 65 |
| SUMMARY | | | | | | |
| 1912-1925..... | 776, 069. 09 | 301. 07 | 1, 111. 38 | 24, 458. 65 | 148, 384. 00 | 950, 324. 19 |
| 1926-1930..... | 1, 609, 049. 71 | 7, 200. 00 | 10, 534. 05 | 51, 776. 51 | 4, 495. 00 | 1, 683, 055. 27 |
| 1931..... | 370, 350. 52 | 2, 261. 50 | 6, 634. 21 | 19, 760. 59 | 2, 074. 00 | 401, 080. 82 |
| 1932..... | 375, 939. 22 | 226. 05 | 5, 028. 93 | 22, 327. 45 | 266. 00 | 403, 787. 65 |
| | 3, 131, 408. 54 | 9, 988. 62 | 23, 308. 57 | 118, 323. 20 | 156, 219. 00 | 3, 438, 247. 93 |

MINING OPERATIONS ON INDIAN LANDS

The greater part of the mining on Indian lands is in Oklahoma, where there are zinc and lead mines on restricted Quapaw land; coal mines on the segregated Choctaw and Chickasaw coal and asphalt lands and on restricted Indian lands; and scattered deposits of volcanic ash, building stone, gravel, lead, zinc, and other minerals of less value on other Indian lands. The Geological Survey functions as an agent for the Indian Service in the engineering phases of supervision over these operations.

Quapaw lead and zinc lands.—On the restricted Quapaw lead and zinc lands there are about 400 shafts, only 24 of which were used to hoist ore from 20 leaseholds for reduction in 13 mills during the past year. Only 3 mines of the 39 departmental leases in effect were operating at the end of the year. From the 39 leases 62 allottees and heirs received \$85,684.99 in royalties, in comparison with 50 allottees and heirs who received \$1,679,863.75 in royalties in 1926, the year of the greatest royalty returns.

The production in the calendar year 1931 represented 1.3 per cent of the lead and 5.3 per cent of the zinc produced in the United States. Continued efforts during the last several years have resulted in securing re-treatment of practically all of the re-treatable mill tailings on restricted land. The value of tailings re-treated since May, 1926, is \$4,569,677, and the royalty accruing to the Indians therefrom amounts to \$456,967.70. The value in mill tailings depreciates rapidly by oxidation and leaching, and early treatment conserves this value.

During the present depressed market more than usual effort was necessary to keep the idle shafts in repair to prevent caving and damage to surface and to mines and to protect the inhabitants of the community.

Segregated coal lands.—After 14 years of effort to sell the segregated Choctaw and Chickasaw coal lands there remains 390,739.48 acres unpatented. All the leases on these lands will have expired by September 25, 1932, and provisions have been made by Congress to re-lease the developed tracts to qualified applicants and to sell the remaining coal lands. Only 1 leased tract and 2 unleased tracts, containing 2,400 acres, were sold during the year; the sale price was \$86,760. To date 86,513.51 acres have been sold. The sale of 18,043.18 acres has been canceled, and 44,049.15 acres have been paid for and removed from supervision. With the extension of the use of natural gas and oil, the market for Oklahoma coals is much restricted, and further curtailment of sales and mining is to be expected. In addition to supervising the physical operations of leased tracts, the operations on lands sold but not patented are carefully watched to see that the deposits are not destroyed should the tract revert to the owners. The cancellation of 30 coal leases, cases of trespass, coal fires, and sales of land occupied much of the engineer's attention. Of the 12 mines effectively rock dusted in Oklahoma, 7 are on segregated Indian coal land, and of the 13 mines in which some rock dusting has been done, 10 are on segregated land.

Since 1926, when it became mandatory to furnish projected plans for approval before opening new mines, 18 mines have departed from the old systems and are meeting success with new methods. Electric cap lamps have been installed in all except eight mines on segregated lands at which no electric current is available. A large part of the segregated land has been remapped geologically. Of particular importance was the recent correlation of beds and the relocation of the outcrop lines which were mapped nearly 30 years ago. Further geologic work is needed.

Restricted Indian lands.—On restricted allotted Cherokee, Choctaw, and Creek Indian lands there are 57 coal leases, 2 volcanic-ash leases, and 1 lead-zinc lease. On these lands 14 mines were in operation, producing 48,763.60 tons of coal with a royalty, rental, and bonus value of \$8,074.12.

Agency coal mines.—In Arizona, Colorado, New Mexico, and Utah the cost of coal has been reduced at several coal mines operated by the Indian Service by adopting improved mining methods, locating sites and deposits where the coal could be more economically mined, and encouraging at some plants the use of mine-run coal and at others the use of more of the smaller sizes of coal which were formerly wasted. Several coal samples were taken, 33 coal mines operated for agency coal were examined, and 15 maps were made from surveys.

Miscellaneous Indian mining leases.—In California reports were made for the Indian Service on 2 mining-lease applications, and in Arizona a large area containing asbestos was mapped in cooperation with the topographic branch and 21 asbestos mines were examined. A report was published on another area containing a large deposit of iron ore.

OIL AND GAS OPERATIONS ON PUBLIC LAND

General features.—Engineering and geologic details were completed and departmental approval obtained for the cooperative or unit plans of development of the Big Sand Draw and Billy Creek gas fields, Wyoming, pursuant to the act approved March 4, 1931 (46 Stat. 1523), amending the general leasing law of February 25, 1920.

The department has cooperated with lessees and permittees by relieving them from unnecessary financial burdens through extending permits, granting relief from the drilling and producing requirements under leases, and allowing suspended preference rights to lands not required by law to be leased, all subject to conditions that fully protect the public interest. One of the relief measures provides that permittees or lessees, in lieu of drilling necessary offset wells to protect the property from drainage of oil or gas, may pay a sum estimated to reimburse the United States for current loss of royalty through drainage. This provision has obviated the necessity

for expenditures of large sums for drilling wells from which but small revenue might be obtained because of present overproduction and consequent limited market. During the fiscal year approximately \$10,000 accrued as compensatory royalty because of drainage of oil and gas from public land.

Investigations were made in California and Wyoming relative to the establishment of minimum field prices for crude oil, natural gas, and natural-gas gasoline from public land, and reports were submitted to the department.

Permits and leases.—During the fiscal year 1,112 prospecting permits for oil and gas were canceled and 12 leases were relinquished or canceled, as compared with a total cancellation of 1,565 permits and leases during 1931.

Oil and gas leases and permits on the public domain

| State | Issued during fiscal year 1932 | | | | Under supervision of Geological Survey June 30, 1932 | | | | | |
|-------------------|--------------------------------|-----------|---------|-----------|--|------------|---------|--------------|---------------------------------------|-----------|
| | Leases | | Permits | | Leases | | Permits | | Suspended preference rights to leases | |
| | Number | Acres | Number | Acres | Number | Acres | Number | Acres | Number | Acres |
| Alaska..... | | | 8 | 17,082.03 | | | 142 | 403,189.13 | | |
| Arizona..... | | | | | | | 91 | 214,399.23 | | |
| Arkansas..... | | | | | | | 15 | 23,502.60 | | |
| California..... | 3 | 1,280.00 | 3 | 559.82 | 193 | 51,698.87 | 427 | 345,234.87 | 4 | 2,103.10 |
| Colorado..... | 3 | 1,817.64 | 5 | 2,715.01 | 24 | 18,312.77 | 400 | 563,713.35 | 2 | 3,712.21 |
| Idaho..... | | | 4 | 3,693.21 | | | 65 | 126,380.71 | | |
| Kansas..... | | | | | | | 1 | 155.32 | | |
| Louisiana..... | | | | | 10 | 770.82 | 1 | 40.00 | | |
| Montana..... | 3 | 674.68 | 7 | 10,006.51 | 76 | 15,858.94 | 478 | 569,942.77 | 1 | 1,358.82 |
| Nevada..... | | | | | | | 49 | 114,758.37 | | |
| New Mexico..... | 22 | 11,454.32 | 1 | 3,520.20 | 63 | 43,407.31 | 897 | 1,960,741.78 | 17 | 26,865.84 |
| North Dakota..... | | | 4 | 3,239.91 | | | 18 | 24,131.16 | | |
| Oklahoma..... | | | | | 17 | 730.20 | 5 | 1,682.00 | | |
| Oregon..... | | | 1 | 880.11 | | | 15 | 31,679.46 | | |
| South Dakota..... | | | | | | | 15 | 16,123.76 | | |
| Utah..... | 1 | 200.00 | 3 | 3,153.68 | 12 | 4,700.74 | 522 | 955,225.31 | 2 | 3,720.00 |
| Wyoming..... | 20 | 12,284.62 | 5 | 11,012.73 | 397 | 121,461.42 | 845 | 1,768,543.42 | 8 | 11,023.53 |
| | 52 | 27,711.26 | 41 | 55,803.21 | 792 | 256,941.07 | 3,986 | 7,119,443.24 | 34 | 48,783.50 |

Wells.—On June 30, 1932, there were under supervision on public land a total of 6,595 wells, of which 3,593 were capable of producing oil or gas.

The effect of continued overproduction and the liberal conservation and cooperative policies of the department are reflected in the continued decrease in the number of wells completed to production and the increase in the number of wells shut in on public land in the major oil-producing public-land States. Completions decreased from 146 during the calendar year 1930 to 50 during 1931, or 65.7 per cent, and from 30 during the first six months of 1931 to 16 during the corresponding period in 1932, or approximately 46.7 per cent; wells shut in increased from 699 on July 1, 1931, to 841 on July 1, 1932, or approximately 20.3 per cent.

New wells and wells shut in in major oil-producing public-land States

| State | Wells completed to production on public lands | | | | Wells completed to production on all lands | | | |
|-----------------|---|------|------|----------------------------|--|-------|------|----------------------------|
| | 1929 | 1930 | 1931 | Jan. 1- July 1, 1932 | 1929 | 1930 | 1931 | Jan. 1- July 1, 1932 |
| California..... | 63 | 32 | 7 | 2 | 874 | 752 | 230 | 89 |
| Colorado..... | 4 | 6 | 2 | 0 | 35 | 14 | 15 | 1 |
| Montana..... | 24 | 19 | 9 | 2 | 292 | 125 | 80 | 16 |
| New Mexico..... | 27 | 24 | 8 | 4 | 42 | 169 | 31 | 18 |
| Utah..... | 0 | 4 | 3 | 1 | 9 | 13 | 5 | 1 |
| Wyoming..... | 91 | 61 | 21 | 7 | 134 | 115 | 55 | 17 |
| | 209 | 146 | 50 | 16 | 1,386 | 1,188 | 416 | 142 |

| State | Wells shut in on public lands | | | | Wells shut in on all lands | | | |
|-----------------|-------------------------------|-----------------|-----------------|-----------------|----------------------------|-----------------|-----------------|-----------------|
| | Mar. 12, 1929 | July 1, 1930 | July 1, 1931 | July 1, 1932 | Mar. 12, 1929 | July 1, 1930 | July 1, 1931 | July 1, 1932 |
| California..... | 270 | 311 | 339 | 302 | 3,560 | 5,431 | 7,180 | 6,741 |
| Colorado..... | 4 | 2 | 6 | 8 | 8 | 9 | 15 | 24 |
| Montana..... | 22 | 40 | 43 | 42 | 95 | 189 | 191 | 198 |
| New Mexico..... | 5 | 33 | 39 | 21 | 17 | 70 | 124 | 89 |
| Utah..... | 6 | 9 | 13 | 15 | 15 | 24 | 30 | 26 |
| Wyoming..... | 159 | 204 | 259 | 453 | 417 | 465 | 549 | 826 |
| | 466 | 599 | 699 | 841 | 4,112 | 6,188 | 8,089 | 7,904 |

Production.—Production of oil and gas from public lands during the fiscal year compared with production during 1931 as follows: Crude oil increased 2,633,106 barrels, or 11.1 per cent; natural gas increased 8,914,632,000 cubic feet, or 21.2 per cent; natural-gas gasoline decreased 13,561,770 gallons, or 12.2 per cent. In the following tables the figures for 1930 are included in the 5-year total for 1926–1930 and are also shown separately for comparison with 1931 and 1932.

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

1932, by States

| | Petroleum (barrels) | Natural gas (M cubic feet) | Gasoline (gallons) |
|-----------------|------------------------|-------------------------------|-----------------------|
| California..... | 14,237,495.65 | 24,399,649.00 | 55,896,426.00 |
| Colorado..... | 544,073.02 | ^a 1,308,602.00 | 13,992.00 |
| Louisiana..... | 2,983.99 | 982,216.00 | 34,056.56 |
| Montana..... | 375,567.60 | 1,639,101.00 | |
| New Mexico..... | 1,683,880.30 | 7,749,785.00 | 1,197,131.00 |
| Oklahoma..... | 185,899.57 | | 69,399.34 |
| Utah..... | 6,695.11 | ^b 44,949.00 | |
| Wyoming..... | 9,417,621.87 | 14,752,514.00 | 40,726,823.00 |
| | 26,454,217.11 | 50,876,816.00 | 97,937,827.90 |

Total

| | | | |
|----------------|-----------------|-----------------|------------------|
| 1921–1925..... | 118,333,954.01 | 60,298,796.00 | 63,997,718.97 |
| 1926–1930..... | 128,609,878.94 | 117,075,826.64 | 264,503,664.58 |
| 1930..... | (27,419,509.35) | (39,124,116.00) | (101,470,301.33) |
| 1931..... | 23,821,111.33 | 41,962,184.00 | 111,499,588.39 |
| 1932..... | 26,454,217.11 | 50,876,816.00 | 97,937,827.90 |
| | 297,219,161.39 | 270,213,622.64 | 537,938,809.84 |

^a Includes under natural gas 742,000 cubic feet of carbon dioxide gas.^b Includes under natural gas 34,059,000 cubic feet of carbon dioxide gas.

Royalties and bonuses.—Royalties accrued from oil and gas operations on public lands during the fiscal year compared with royalties accrued during 1931 as follows: Crude oil decreased \$62,837, or 2.4 per cent; natural gas increased \$117,913, or 66.6 per cent; natural-gas gasoline increased \$39,211, or 20.6 per cent; a total net increase of \$94,287, or 3.2 per cent.

In the following table figures for 1930 are included in the 5-year total for 1926–1930 and also shown separately for comparison with 1931 and 1932.

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

1932, by States

| | Petroleum | Natural gas | Gasoline | Bonuses | Total |
|-----------------|----------------|--------------|--------------|-----------|----------------|
| California..... | \$1,274,060.14 | \$190,791.11 | \$134,260.99 | ----- | \$1,599,112.24 |
| Colorado..... | 20,968.98 | 4,225.46 | 10.48 | ----- | 25,204.92 |
| Louisiana..... | 282.33 | 3,478.91 | 59.29 | ----- | 3,820.53 |
| Montana..... | 32,120.43 | 7,241.31 | ----- | \$88.00 | 39,449.74 |
| New Mexico..... | 48,815.04 | 20,198.54 | 895.78 | 757.00 | 70,666.36 |
| Oklahoma..... | 17,504.44 | ----- | 103.76 | ----- | 17,608.20 |
| Utah..... | 468.02 | 245.13 | ----- | 120.00 | 833.15 |
| Wyoming..... | 1,110,971.15 | 68,819.48 | 93,973.21 | 67,223.89 | 1,340,987.73 |
| | 2,505,190.53 | 294,999.94 | 229,303.51 | 68,188.89 | 3,097,682.87 |

Total

| | | | | | |
|----------------|-----------------|--------------|--------------|----------------|-----------------|
| 1921-1925..... | \$32,038,494.47 | \$398,543.30 | \$251,197.70 | \$2,768,085.14 | \$36,356,320.61 |
| 1926-1930..... | 24,460,387.20 | 591,767.49 | 714,943.75 | 935,722.21 | 26,702,820.65 |
| 1930..... | (3,809,947.58) | (172,878.79) | (164,181.04) | (1,600.20) | (4,148,607.61) |
| 1931..... | 2,568,027.70 | 177,087.05 | 190,092.48 | 271,108.14 | 3,206,315.37 |
| 1932..... | 2,505,190.53 | 294,999.94 | 229,303.51 | 68,188.89 | 3,097,682.87 |
| | 62,472,099.90 | 1,462,397.78 | 1,385,537.44 | 4,043,104.38 | 69,363,139.50 |

OIL AND GAS OPERATIONS ON NAVAL PETROLEUM RESERVES

Leases and wells on naval petroleum reserves June 30, 1932

| State | Leases | | Wells | | |
|--------------------|--------|-----------|------------|---------|-------|
| | Number | Acres | Productive | | Total |
| | | | Active | Shut in | |
| California: | | | | | |
| Reserve No. 1..... | 5 | 1,090.32 | 51 | 43 | 134 |
| Reserve No. 2..... | 20 | 9,518.65 | 177 | 184 | 470 |
| Wyoming: | | | | | |
| Reserve No. 3..... | ----- | ----- | ----- | 74 | 87 |
| | 25 | 10,608.97 | 228 | 301 | 691 |

Production from Naval Petroleum Reserve No. 3, in Wyoming, was suspended December 31, 1927, and the total royalty accrued from 1923 to the date of suspension amounted to \$848,947.91. Supervision on this reserve is confined at present to periodic observation of well pressures, well repairs from time to time, and advice to the Navy Department.

Royalties accrued during the fiscal year from Naval Petroleum Reserves Nos. 1 and 2, in California, as follows: Petroleum, \$581,857; natural gas, \$37,868; natural-gas gasoline, \$70,463. The total royalties accruing from the three reserves for the fiscal years 1921 to 1932 amount to \$25,856,989.

Petroleum, natural gas, and gasoline produced from naval reserves

| | Fiscal year | Petroleum (barrels) | Natural gas (M cubic feet) | Gasoline (gallons) |
|-----------------|-------------|------------------------|-------------------------------|-----------------------|
| California----- | 1921-1925 | 37, 882, 945. 09 | 35, 544, 349. 81 | 34, 508, 751. 07 |
| | 1926-1930 | 49, 389, 149. 93 | 48, 852, 746. 46 | 19, 177, 197. 23 |
| | 1930 | (6, 978, 922. 16) | (6, 817, 458. 00) | (25, 567, 986. 00) |
| | 1931 | 5, 590, 418. 46 | 5, 123, 456. 00 | 22, 748, 665. 00 |
| | 1932 | 3, 919, 625. 61 | 4, 442, 014. 00 | 18, 539, 144. 00 |
| Wyoming----- | 1923-1928 | 96, 782, 139. 09 | 93, 962, 566. 27 | 194, 973, 757. 30 |
| | | 3, 550, 227. 63 | 5, 162, 869. 00 | 2, 483, 896. 00 |
| Total----- | 1921-1932 | 100, 332, 366. 72 | 99, 125, 435. 27 | 197, 457, 653. 30 |

OIL AND GAS OPERATIONS ON INDIAN LAND

Cooperation with the Indian Service was continued in Oklahoma through inspection and supervision of oil and gas operations and royalty accounting for all Indian lands in the State except those of the Five Civilized Tribes and the Osage Reservation. In the area owned by the Five Civilized Tribes the Geological Survey acts only in a cooperative or consulting capacity, and in the Osage Reservation its activities are limited to response to requests by the superintendent for specific information or special reports of investigations.

Under a cooperative agreement approved by the department November 12, 1931, the Geological Survey assumed direct technical supervision of all oil and gas operations on Indian lands in the Rocky Mountain States, and on January 1, 1932, it undertook the accounting for royalties from production of oil, gas, and gasoline from Indian lands in those States.

Through careful supervision of royalty accounting, irregular practices by lessees in Oklahoma in submitting royalty statements, resulting in loss of revenue to the Indians, were discontinued. In Oklahoma the Geological Survey witnessed 526 oil runs and 62 physical tests on casing-head gas, assessed more than \$15,600 as back royalty due to the Indians in 4 cases as a result of correcting oil-gravity calculation, appraised 435 Indian allotments prior to sale of leases and reported as to the adequacy of bonuses offered, made royalty appraisals on 38 tracts of land, and made 4,310 field investigations of well operations, wastage, pollution, and general lease conditions and submitted reports thereon to the superintendents.

*Oil and gas leases and wells on Indian reservations under supervision of the
Geological Survey June 30, 1932*

| State, reservation, and land designation | Leases | | | Wells | | Total royalty and rentals, fiscal year 1932 |
|---|--------------------|-----------------|-------|-----------------|------------------|--|
| | Nonpro- ductive | Produc- tive | Total | Produc- tive | Being drilled | |
| Arizona: | | | | | | |
| Navajo Executive order..... | 14 | | 14 | | | |
| Colorado: | | | | | | |
| Ute tribal..... | | 1 | 1 | 11 | | |
| Ceded Ute..... | 4 | 1 | 5 | 14 | 1 | |
| | 4 | 2 | 6 | 25 | 1 | |
| Montana: | | | | | | |
| Blackfeet allotted..... | 37 | | 37 | | 1 | |
| Blackfeet tribal..... | 1 | | 1 | | | |
| Crow allotted..... | 95 | 2 | 97 | 3 | | |
| Crow tribal..... | 6 | 1 | 7 | 2 | | |
| | 139 | 3 | 142 | 5 | 1 | |
| New Mexico: | | | | | | |
| Navajo allotted..... | 18 | | 18 | 7 | | |
| Navajo tribal..... | | 3 | 3 | 28 | 4 | |
| Navajo Executive order..... | 9 | | 9 | 1 | | |
| Ute tribal..... | | 2 | 2 | 3 | | |
| | 27 | 5 | 32 | 39 | 4 | |
| Oklahoma: | | | | | | |
| Five Civilized Tribes Agency— | | | | | | |
| Cherokee allotted..... | 3,303 | 323 | 4,367 | 4,684 | 9 | \$1,455,004.15 |
| Choctaw allotted..... | | 61 | | | | |
| Creek allotted..... | | 504 | | | | |
| Chickasaw allotted..... | | 20 | | | | |
| Seminole allotted..... | | 150 | | | | |
| Seminole tribal..... | | 1 | | | | |
| Kiowa Agency— | | | | | | |
| Kiowa allotted..... | 125 | | 125 | | | 124,184.72 |
| Comanche allotted..... | 83 | 12 | 95 | 22 | | |
| Apache allotted..... | 17 | 6 | 23 | 18 | | |
| Wichita allotted..... | 252 | | 252 | | | |
| Caddo allotted..... | 195 | | 195 | | | |
| Pawnee Agency— | | | | | | |
| Ponca allotted..... | 44 | 11 | 55 | 50 | | 96,955.74 |
| Ponca tribal..... | | 1 | 1 | 1 | | |
| Otoe allotted..... | 97 | 2 | 99 | 2 | | |
| Tonkawa allotted..... | 7 | | 7 | | | |
| Pawnee allotted..... | 85 | 20 | 105 | 61 | | |
| Pawnee tribal..... | 3 | | 3 | | | |
| Kaw allotted..... | 11 | 3 | 14 | 32 | | |
| Shawnee Agency— | | | | | | |
| Iowa allotted..... | 27 | | 27 | | | 100,770.60 |
| Kickapoo allotted..... | 54 | | 54 | | | |
| Pottawatomie allotted..... | 28 | 10 | 38 | 31 | 1 | |
| Sac and Fox allotted..... | 82 | 8 | 90 | 22 | | |
| Sac and Fox tribal..... | | 1 | 1 | 3 | | |
| Shawnee allotted..... | 137 | | 137 | | | |
| Cheyenne and Arapahoe Agency allotted..... | 199 | | 199 | | | 29,016.62 |
| | 4,754 | 1,133 | 5,887 | 4,926 | 10 | 1,805,931.83 |
| Utah: Navajo Executive order..... | 6 | | 6 | | | |
| Wyoming: | | | | | | |
| Shoshone allotted..... | 4 | 6 | 10 | 41 | | |
| Shoshone tribal..... | 1 | 1 | 2 | 5 | | |
| Shoshone ceded..... | 28 | | 28 | 34 | | |
| | 33 | 7 | 40 | 80 | | |
| Grand total..... | 4,977 | 1,150 | 6,127 | 5,075 | 16 | |

WORK ON PUBLICATIONS

TEXTS

BERNARD H. LANE, *Editor*

During the year 22,332 pages of manuscript were edited and prepared for printing by the section of texts, and 3,904 galley proofs and 9,634 page proofs were read and corrected. This work included the editing and some of the proofreading of 29 guidebooks for the excursions of the Sixteenth International Geological Congress, to be held in the United States in 1933. Indexes were prepared for 42 publications, covering 6,373 pages. Copy and proof or stencils for 2,052 pages of multigraph and mimeograph matter were read. The publications issued during the year are listed on pages 1-3. The total number of pages in the new book publications was 11,238. In addition to the publications in the regular series 71 brief papers, some of them accompanied by maps, were issued in mimeographed form as memoranda for the press.

At the end of the year five persons were employed in this section.

The editor continued to serve as a member of the department subcommittee to assist in the revision of the Style Manual of the Government Printing Office. The subcommittee has submitted its report to the Public Printer, whose style board is now studying it.

ILLUSTRATIONS

C. A. WECKERLY, *Chief Illustrator*

The number of drawings and photographs prepared by the section of illustrations was 2,156, including 312 maps, 354 sections and diagrams, 18 plates of sections, 18 charts and plans, 439 photographs, and 1,015 paleontologic drawings; 217 miscellaneous jobs were also done by the section. The illustrations transmitted to accompany 60 reports numbered 1,499, to be reproduced by chromolithography, photolithography, halftone, and zinc etching. The number of proofs received and examined was 1,673. At the end of the year material for illustrating 32 reports was in hand. The section consists of nine employees. During the year two additional draftsmen were loaned by the geologic branch and one for part time by the water-resources branch.

GEOLOGIC EDITING AND DRAFTING OF MAPS AND ILLUSTRATIONS

GEORGE W. STOSE, *Editor of Geologic Maps*

The compilation and drafting of the geologic map of the United States on the scale of 1:2,500,000 was completed, and 90 per cent of the boundaries and letter symbols were engraved. The north-east quarter of the map was transferred to stone, and 75 per cent of the color stones were prepared. The southeast quarter, carrying the title and explanation, was transferred to stone, and color-stone sheets were prepared. The west half was nearly ready for transfer to stone.

The compilation and drafting of the geologic map of California on the scale of 1:500,000 was completed and the map sent to the California Division of Mines for correction, further compilation, and addition before publication. The geologic map of Minnesota was

edited in this section and printed under the supervision of the section for the State geological survey. Two-color proofs of the geologic map of Pennsylvania, which was compiled in this section for the State topographic and geologic survey, were read by the section and approved for printing. The geologic map of West Virginia, compiled in this section and being published by the State geological and economic survey, reached color proof. The preliminary geologic map of Texas was photolithographed and copies distributed for criticism. The geologic map of Colorado, compiled in cooperation with the State, was received for editing and preparation for publication. Compilation of the geologic map of Montana in cooperation with the State bureau of mines and geology was begun. A preliminary geologic map of Nevada was compiled in cooperation with the State bureau of mines.

Folio 222 (Gaffney-Kings Mountain, S. C.-N. C.) was published. The maps and text of Folio 223 (Coatesville-West Chester, Pa.) were printed. The color proofs of the maps of Folio 224 (Somerset-Windber, Pa.) were approved for printing. The maps of Folio 226 (Montevallo-Columbiana, Ala.) reached stone proof.

Illustrations for 54 reports were examined and edited and in part drawn for the section of illustrations, and 30 illustrations for 12 reports by geologists were drawn.

The oil and gas map of the United States was completed and published.

INSPECTION AND EDITING OF TOPOGRAPHIC MAPS

W. M. BEAMAN, Chief

During the year 112 new topographic maps were edited and transmitted for engraving, 259 published topographic maps, 10 State maps, and 5 State index circulars were edited for reprint, and 303 maps were edited as illustrations for Geological Survey reports—a total of 689 maps edited. First, second, combined, and woodland proofs of engraving for new topographic maps and reprints numbering 598 and proofs of maps reproduced by photolithography in one to three colors numbering 238 were read. At the end of the year 170 new topographic maps were in progress of engraving and printing and 200 new topographic maps were in preparation for submission for reproduction. The topographic maps published during the year are listed on pages 3-6.

DISTRIBUTION

R. C. SHELSE, Chief

A total of 601 publications, comprising 81 new books and pamphlets, 141 new or revised topographic and other maps, 1 geologic folio, and 378 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 164,174 books and pamphlets, 3,552 geologic folios, and 1,496,165 topographic and other maps, a grand total of 1,663,891, or more than twice as many as in 1931.

The division distributed 182,059 books and pamphlets, 4,649 geologic folios, and 706,730 maps, a grand total of 893,438, of which 3,877 folios and 547,746 maps were sold. Compared with 1931 these

figures show increases of about 65,000 books and pamphlets and nearly 400 geologic folios but a decrease of about 100,000 maps. The sum received for publications and deposited in the Treasury was \$34,737.32, including \$33,948.36 for topographic and geologic maps and \$788.96 for geologic folios. In addition \$1,733.90 was repaid by other establishments of the Federal Government at whose request maps or folios were furnished. The total receipts, therefore, were \$36,471.22.

The division received and answered 46,947 letters.

At the end of the year the division included 15 employees.

ENGRAVING AND PRINTING

S. J. KUBEL, Chief Engraver

TOPOGRAPHIC MAPS AND GEOLOGIC FOLIOS

During the fiscal year 137 newly engraved topographic maps were printed, including 11 revised maps. The division also engraved and printed the sheet of standard symbols and the United States base map, scale 1:2,500,000. Two new maps were photolithographed and printed, making a total of 141 new maps printed and delivered. Corrections were engraved on the plates of 253 maps. Reprint editions of 375 engraved topographic maps and 3 photolithographed State and other maps were printed and delivered. In addition, 43 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, 519 different editions, amounting to 1,489,975 copies, were delivered. One new geologic folio was printed, its edition amounting to 3,552 copies. Extra geologic folio sheets numbering 2,750 copies were also delivered.

OTHER GOVERNMENT MAP PRINTING

A large amount of work was done for 43 other units of the Government and 6 State governments, including many reprints, and the charges for it amounted to about \$142,000, for which the appropriation for engraving and printing geologic and topographic maps was reimbursed.

Transfer impressions numbering 288 were made during the year, including 190 furnished to contracting lithographic printers on requisition of the Government Printing Office, 11 furnished to other branches of the Government, 10 furnished to State surveys, and 77 furnished to private firms. The amount turned over to miscellaneous receipts from this source was \$195.67.

Of contract and miscellaneous work of all kinds, 2,570,089 copies were printed. Including topographic maps, a grand total of 4,060,064 copies were printed and delivered.

PHOTOGRAPHIC LABORATORY

The output of the photographic laboratory consisted of 18,128 negatives (5,616 wet (of which 4,601 were for photolithographs), 142 paper, 1,915 dry, 9,278 field negatives, and 1,177 lantern slides), 33,946 prints (4,943 maps and diagrams and 29,003 photographs for illustrations), 3,678 zinc plates, 307 zinc etchings, 42 celluloid prints, 152 lantern slides colored, 2 transparencies colored, 2 prints colored, and 5,274 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 1931.

Mails, files, and records.—During the year 100,052 pieces of mail, of which 2,366 were registered, were opened and referred. In addition 158,456 letters were received direct by the other units, making a total of 258,508, an increase of 5 per cent compared with 1931. Of the letters opened in this section 18,235 contained \$35,052.36 remitted for Geological Survey publications. The number of ordinary letters mailed through the section was 56,899; of registered letters and packages, 1,099. In addition, 146,944 pieces of mail were sent out direct from other units. The total number of outgoing pieces of mail for the Geological Survey was 204,942.

Freight and express.—During the year 2,920 pieces of freight and express were handled, 1,664 outgoing and 1,256 incoming.

Personnel.—The roll of secretary's appointees numbered 1,117 at the end of the fiscal year, 10 less than at the end of the fiscal year 1931. The total number of changes in personnel was 316, including 81 appointments, 91 separations, and 204 miscellaneous changes.

During the calendar year 1931, 22,470 days of annual leave and 4,467 days of sick leave were granted, being 72 per cent of the amount of annual leave that could have been taken and 14 per cent of the sick leave that it would have been possible to grant. In addition, 7,836 days of leave without pay and furloughs were granted.

ACCOUNTS

C. K. FRANCIS, Chief

During the year 16,876 Federal field accounts, 2,733 State field accounts, 734 special disbursing agent accounts, 1,461 transportation bills, and 224 telegraph bills were audited and transmitted for payment. In the audit of these accounts 857 suspensions and disallowances were made. The section received 336 printing and binding requisitions, 1,062 stationery requisitions, 3,338 miscellaneous supply requisitions, 2,228 letters of employment, and 355 contracts.

Condensed statements covering 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, 1932

| | Funds available | | | | Expenditures | | | Balance |
|---|-------------------------|---|-------------------------|--------------|---------------|-------------------------|--------------|--------------|
| | Amount of appropriation | Repayments on account of work performed | | Total | Disbursements | Outstanding liabilities | Total | |
| | | Made | To be made | | | | | |
| APPROPRIATIONS | | | | | | | | |
| Salaries..... | \$150,000.00 | \$290.00 | | \$150,290.00 | \$150,045.48 | \$218.33 | \$150,263.81 | \$26.19 |
| Topographic surveys..... | 780,000.00 | 318,764.42 | \$20,575.33 | 1,119,339.75 | 905,414.07 | 24,142.32 | 929,556.39 | b 189,783.36 |
| Geologic surveys..... | 400,000.00 | 29,449.99 | 4,716.09 | 434,166.08 | 426,113.93 | 7,662.17 | 433,776.10 | 389.98 |
| Fundamental research in geologic science..... | 100,000.00 | 249.35 | | 100,249.35 | 96,916.77 | 2,723.82 | 99,640.59 | 608.76 |
| Volcanologic surveys..... | 35,000.00 | | | 35,000.00 | 30,966.79 | 3,248.70 | 34,215.49 | 784.51 |
| Alaskan mineral resources..... | 84,500.00 | 238.98 | | 84,738.98 | 72,890.05 | 11,783.10 | 84,673.15 | 65.83 |
| Gaging streams..... | 720,000.00 | 283,611.49 | 64,923.87 | 1,068,535.36 | 1,030,271.18 | 25,254.46 | 1,055,525.64 | * 13,009.72 |
| Classification of lands..... | 199,000.00 | 898.90 | | 199,898.90 | 195,745.24 | 4,096.71 | 199,841.95 | 56.95 |
| Printing and binding..... | 190,000.00 | 1,086.77 | 150.66 | 191,237.43 | 65,621.88 | 125,615.55 | 191,237.43 | .00 |
| Preparation of illustrations..... | 23,240.00 | 212.91 | | 23,452.91 | 23,399.92 | 40.25 | 23,440.17 | 12.74 |
| Geologic and topographic maps..... | 190,000.00 | 110,434.80 | 24,897.09 | 325,331.89 | 308,437.97 | 16,190.36 | 324,628.33 | 703.56 |
| Mineral leasing..... | 270,000.00 | 739.44 | 186.91 | 270,926.35 | 262,811.86 | 7,144.11 | 269,955.97 | 970.38 |
| | 3,141,740.00 | ^d 745,977.05 | ^d 115,449.95 | 4,003,167.00 | 3,568,635.14 | 228,119.88 | 3,796,755.02 | 206,411.98 |
| TRANSFERS | | | | | | | | |
| Alaska Railroad appropriated fund (act Feb. 14, 1931)..... | 71,300.00 | 732.78 | 3.89 | 72,036.67 | 54,819.23 | 1,701.97 | 56,521.20 | * 15,515.47 |
| Engineer operations in the field (War Department, act Feb. 14, 1931), 1931-Dec. 31, 1932..... | 4,500.00 | | | 4,500.00 | 3,346.32 | 129.72 | 3,476.04 | * 1,023.96 |
| Federal jails, buildings, and equipment (Justice Department, act Feb. 14, 1931)..... | 828.32 | | | 828.32 | 828.32 | | 828.32 | .00 |
| Federal Power Commission (act Feb. 14, 1931), 1932..... | 4,200.00 | 23.40 | | 4,223.40 | 3,172.42 | 468.32 | 3,640.74 | 582.66 |
| Flood control, Mississippi River and tributaries (War Department, act Feb. 14, 1931)..... | 264,361.00 | 405.73 | | 264,766.73 | 204,060.53 | 2,590.91 | 206,651.44 | * 58,115.29 |
| Fredericksburg and Spotsylvania County Battlefield Memorial, Virginia (War Department, act Feb. 14, 1931), 1931-32..... | 1,155.43 | | | 1,155.43 | 1,073.06 | 82.37 | 1,155.43 | .00 |
| George Washington Bicentennial Commission (act May 21, 1920)..... | 2,900.00 | | | 2,900.00 | 2,727.69 | 110.53 | 2,838.22 | * 61.78 |
| Helium investigations, Bureau of Mines (Commerce Department, act Feb. 14, 1931), 1932..... | 950.07 | | | 950.07 | 950.07 | | 950.07 | .00 |
| Irrigation, Indian reservations (reimbursable, act Feb. 14, 1931), 1931-32..... | 5,490.00 | | | 5,490.00 | 5,243.75 | 223.69 | 5,467.44 | 22.56 |
| Irrigation, San Carlos and Florence-Casa Grande projects, Arizona (reimbursable, act Feb. 14, 1931), 1931-32..... | 4,013.00 | | | 4,013.00 | 3,744.77 | 268.23 | 4,013.00 | .00 |
| Maintenance and improvement of existing river and harbor works (War Department, act Feb. 14, 1931)..... | 83,938.29 | 202.60 | 173.16 | 84,314.05 | 72,231.36 | 790.45 | 73,021.81 | * 11,292.24 |
| Maps of the United States (act May 21, 1920), 1932..... | 12,166.00 | | | 12,166.00 | 6,960.00 | 5,206.00 | 12,166.00 | .00 |

| | | | | | | | | |
|--|--------------|------------|------------|--------------|--------------|------------|--------------|------------|
| Military surveys and maps (War Department, act Feb. 14, 1931), 1930-Dec. 31, 1931..... | 341.63 | | | 341.63 | 341.63 | | 341.63 | .00 |
| National Park Service (act Feb. 14, 1931), 1931-32..... | 3,022.28 | | | 3,022.28 | 3,022.28 | | 3,022.28 | .00 |
| Operation and conservation of naval petroleum reserves (Navy Department, act Feb. 14, 1931), 1932..... | 50,000.00 | | | 50,000.00 | 49,471.28 | 525.70 | 49,996.98 | 3.02 |
| Supervising mining operations on leased Indian lands (act Feb. 14, 1931), 1932..... | 95,000.00 | 1.00 | 466.66 | 95,467.66 | 92,866.07 | 1,338.25 | 94,204.32 | 1,263.34 |
| Waterways treaty, United States and Great Britain (State Department, act Feb. 23, 1931), 1932..... | 57,900.00 | 630.23 | 143.25 | 58,673.48 | 57,254.96 | 1,418.52 | 58,673.48 | .00 |
| Grand total..... | 3,803,806.02 | 747,972.79 | 116,236.91 | 4,668,015.72 | 4,130,748.88 | 242,974.54 | 4,373,723.42 | 294,292.30 |

^a In addition to these appropriations, there was an allotment of \$12,573.23 for miscellaneous supplies from the appropriation for contingent expenses of the Interior Department.

^b Included in this balance is \$150,000 which is continued available for expenditure in the fiscal year 1933.

^c Included in this balance is \$9,000 over appropriated.

^d Included in these amounts is \$63,052.62 covering work performed by Geological Survey units for other Geological Survey units, necessarily reported in combining totals but otherwise a duplication.

^e These balances continue available for expenditure in the fiscal year 1933.

Classification of expenditures by the United States Geological Survey pertaining to the fiscal year ended June 30, 1932

| Object and expenditure | Geological Survey salaries | Topo- graphic surveys | Geologic surveys | Funda- mental research | Volcano- logic surveys | Alaskan mineral resources | Gaging streams | Classifica- tion of lands | Printing and binding | Prepara- tion of illustra- tions | Geologic and topo- graphic maps of the United States | Mineral leasing | Total |
|---|----------------------------------|-----------------------------|---------------------|------------------------------|------------------------------|---------------------------------|-------------------|---------------------------------|----------------------------|---|---|--------------------|----------------|
| Personal services | \$150,263.81 | \$804,851.42 | \$373,627.68 | \$87,243.43 | \$25,511.33 | \$95,944.29 | \$819,517.86 | \$164,905.59 | | \$23,141.27 | \$231,207.20 | \$324,146.65 | \$3,100,360.53 |
| Stationery and office supplies | | 3,285.15 | 1,512.85 | 29.85 | 154.10 | 293.43 | 11,478.64 | 247.05 | | 163.67 | 33,801.17 | 3,050.15 | 54,016.06 |
| Scientific and educational supplies | | 609.49 | 2,254.52 | 102.02 | 82.44 | 2.94 | 977.17 | 90.77 | | 8.41 | 10.41 | 355.56 | 4,493.73 |
| Sundry supplies | | 3,305.29 | 1,090.10 | 59.93 | 783.18 | 877.73 | 6,309.13 | 257.90 | | | 7,753.00 | 744.59 | 21,279.85 |
| Subsistence and care of ani- mals and storage and care of vehicles | | 1,263.73 | 593.51 | | | | 20.73 | 188.55 | | | | | 2,066.52 |
| Telegraph service | | 551.26 | 172.36 | .45 | 2.25 | 108.51 | 998.81 | 46.33 | | | 3.47 | 496.61 | 2,380.05 |
| Telephone service | | 237.38 | 170.91 | 4.80 | 60.35 | 20.75 | 2,293.58 | 95.17 | | | | 2,463.06 | 5,352.00 |
| Other communication service | | 25.82 | 14.45 | | 1.65 | | 40.55 | | | | | 84.25 | 160.72 |
| Travel expenses | | 107,987.75 | 23,330.90 | 6,032.15 | 2,529.87 | 25,809.78 | 92,465.38 | 17,236.30 | | 1.50 | 156.29 | 23,076.01 | 298,625.93 |
| Attendance at meetings | | 156.17 | 1,368.34 | | | 103.48 | 774.92 | | | | | 728.43 | 3,131.34 |
| Hire, maintenance, operation, repair of horse-drawn and motor-propelled passenger- carrying vehicles | | 1,914.14 | 3,496.11 | 713.48 | 398.51 | 499.61 | 32,687.08 | 4,631.58 | | | | 22,106.65 | 66,447.16 |
| Transportation of things | | 49,402.75 | 6,645.08 | 762.27 | 632.47 | 5,256.34 | 27,260.72 | 3,231.91 | | | 86.83 | 3,065.71 | 96,344.08 |
| Printing and binding | | | | | | | | | \$191,237.43 | | | | 191,237.43 |
| Lithographing, engraving, and engrossing | | 13,713.31 | 570.94 | 29.50 | | | 506.04 | 1,729.24 | | 21.25 | | 42.41 | 16,702.69 |
| Stenographic work, typewrit- ing, and duplicating work, etc. (job work) | | 6.00 | 27.55 | | | | 17.49 | | | | | 6.00 | 57.04 |
| Photographing and making photographs and prints | | 40,128.98 | 3,192.03 | 2,088.69 | 191.88 | 859.35 | 3,268.87 | 2,186.85 | | 54.80 | 12,322.30 | 436.70 | 64,730.45 |
| Heat, light, power, water, and electricity | | | 77.69 | | 58.31 | 40.16 | 363.50 | | | | | 4,098.62 | 4,638.28 |
| Rents | | 824.04 | 201.03 | 12.00 | 40.00 | 51.62 | 6,508.66 | | | | | 7,965.64 | 15,602.99 |
| Repairs and alterations | | 4,190.67 | 241.32 | 7.77 | 133.76 | 55.65 | 3,142.53 | 9.65 | | 2.44 | 7,245.78 | 2,149.12 | 17,178.69 |
| Special and miscellaneous cur- rent expenses | | 34.80 | 84.31 | | | 429.73 | 148.69 | 6.96 | | | | 525.98 | 1,230.47 |
| Purchase of passenger-carry- ing vehicles | | 1,632.11 | 431.55 | | 1,020.80 | | 21,878.07 | 1,946.09 | | | | 12,751.38 | 39,660.00 |
| Furniture, furnishings, and fixtures | | 499.04 | 190.07 | | 218.65 | 631.14 | 970.46 | 82.80 | | | 197.13 | 1,088.89 | 3,878.18 |
| Educational and scientific equipment | | 12,884.90 | 10,564.19 | 836.34 | 526.28 | 1,251.62 | 70,046.42 | 735.40 | | 4.84 | 7,422.20 | 2,570.71 | 106,842.90 |

| | | | | | | | | | | | | | |
|---|------------|--------------|------------|-----------|-----------|------------|--------------|------------|------------|-----------|------------|------------|--------------|
| Livestock | | | | | | 513.70 | | | | | | | 513.70 |
| Other equipment | | 17,871.80 | 1,389.08 | 515.53 | 75.28 | 1,306.77 | 11,194.72 | 21.45 | | | 35,062.56 | 424.76 | 67,861.95 |
| Structures | | | | | 1,659.49 | | 40,781.31 | | | | 321.38 | | 42,762.18 |
| Miscellaneous transfers and adjustments | | 34,097.33 | 3,464.60 | 1,202.38 | 134.89 | 7,137.75 | 90,716.61 | 3,386.23 | | 41.99 | 4,201.33 | 1,779.39 | 146,162.50 |
| | 150,263.81 | 1,099,473.33 | 434,726.17 | 99,640.59 | 34,215.49 | 141,194.35 | 1,244,547.94 | 201,035.82 | 191,237.43 | 23,440.17 | 339,791.05 | 414,157.27 | 4,373,723.42 |

In addition to the above amounts, there was expended directly by cooperating agencies \$108,701.29 in connection with cooperative topographic surveys and \$338,370.49 in connection with cooperative stream gaging.

LIBRARY

GUY E. MITCHELL, Librarian

The two main regular items of expenditure in the library, aside from the salaries, cover the purchase of new books and the binding of old books and accumulated parts. More money was available for both these items in 1932 than ever before—\$3,000 for new books and \$7,500 for binding—and in consequence the library shelves present a much better appearance. Besides the 3,100 books bound at the Government Printing Office, 369 books were bound in the library in serviceable fashion. About 20,000 books bound wholly or partly in leather were treated with petrolatum, which experiments made in the chemical laboratory had shown to be a safe and satisfactory leather preservative.

The cooperative project of inventorying the location, throughout the United States and Canada, of all files of serial publications issued by foreign governments was completed.

The accessions during the year comprised 13,193 books, pamphlets, and periodicals and 1,136 maps. The readers and users of books and maps in the library numbered 7,614, of whom 2,111 were not members of the Geological Survey. The loans for use outside the library included 6,267 books and 299 maps. In the work of cataloging 4,988 cards were added to the catalogue, 1,028 catalogue cards were revised, 358 titles were sent to the Library of Congress for printing, and 101 galley proofs were read. The books collated and sent to the bindery numbered 3,100, and 2,992 newly bound books were recorded and labeled. Translations of 67 communications were made for other divisions of the Geological Survey.

Work on the bibliography of North American geology for 1931 and 1932 was about 60 per cent completed at the end of the year.

The division of engraving and printing and the division of field equipment have rendered special assistance during the year.

The service rendered by the library, stated in terms of the number of users of library material and books and maps shipped on loan, was 39 per cent to the Geological Survey and 61 per cent outside. The usefulness of this unique collection is appreciated more and more each year.

DIVISION OF FIELD EQUIPMENT

R. L. ATKINSON, Chief

In the instrument shop special attention has been given to the design and construction of instruments to facilitate the work of the engineers in the several branches, including discharge integrators, improvements in current meters, a deep-well measuring apparatus, stainless-steel connector and weight hangers, a tag-line reel, a depth recorder for reels, a collimator for adjusting instruments, and a bracket so designed that clocks and gear ratio on recorders can be readily changed. Numerous other pieces of equipment were made, many of them of stainless steel. The shop repaired and rebuilt more than 2,200 instruments of different kinds and did work for several Government units outside of the Geological Survey.

The cabinet shop made 6 discharge-integrator cases and shipping boxes, 42 special current-meter boxes, a special well-core case, an equipment case and a focusing frame for large camera, and several other special pieces, besides the routine cabinet work.

The electrical shop made monthly inspection and repairs of 82 motors and did work for the Geological Survey laboratories on other electrical appliances.

The clerical force filled 2,571 requisitions for instruments, issued 18,625 pieces of equipment, mailed 2,586 packages, shipped 1,664 pieces of express and freight weighing 97,610 pounds, and received 1,092 pieces of express and freight weighing 75,797 pounds.

W. C. MENDENHALL,
Director.

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