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COAST AND GEODETIC SURVEY

The Coast and Geodetic Survey carries on a number of activities which are vital to the promotion of commerce and to the national defense. Its duties include the surveying and charting of all coastal waters under the jurisdiction of the United States; the production of aeronautical charts for air navigation; and the procurement of tidal, magnetic, geodetic, and other data required for water and air navigation as well as for a wide variety of engineering and scientific purposes.

During the past year services great in volume and variety have been rendered to the public and to numerous Government agencies; the normal increase in the demand for the Bureau's products, which has prevailed for several years, being further augmented by the additional requirements of the Army, Navy, and other services in connection with preparations for the national defense. The issue of 463,917 aeronautical charts and 407,186 nautical charts, an increase of 21.6 percent over 1939, again exceeded the distribution during any previous year in the history of the Bureau.

NATIONAL DEFENSE

The work of this Bureau is as necessary for national defense as it is for other purposes. The project of original basic surveys of the Alaskan Peninsula and Aleutian Islands; on which the Coast and Geodetic Survey has been engaged since 1934, is of paramount importance in this respect. The magnitude of this undertaking may be visualized when one realizes the Aleutian Islands extend westward over 1,000 miles from the western end of the Alaskan Peninsula and approach to within 250 miles of the islands off the Siberian coast.

Geodetic surveys are essential for the control of military and other mapping projects and for the establishment of artillery fire control systems and other purposes.

Tide tables, current tables, and tidal current charts are needed for navigation, the launching of ships, and for speed trials, and tidal datums are required in connection with harbor fortifications and for the construction of Army and Naval bases. Reprints of tide and current tables are necessary during the year to meet the increased demands of our expanding Navy. A study was also begun of methods of reproducing predictions prepared by foreign countries, to make this country independent of predictions supplied by other governments under exchange agreements. Correct magnetic information is necessary for both water and air navigation. Some European countries have made more adequate magnetic surveys a part of their military program. In naval and other communications, the new broadcasting of three-hourly intensity numbers, made possible chiefly

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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through observatory work, shows whether transmission difficulties at a given time are due to instrumental conditions or to the medium carrying the message. The same knowledge of magnetic conditions is useful in the transmission, during magnetically disturbed conditions, of transoceanic messages by indirect paths.

All seismologic data obtained by the Bureau have been applied to naval and other defense construction. An important addition to these data are the records of the Imperial Valley, Calif., earthquake of May 18, 1940. The experience of the Coast and Geodetic Survey in vibrating various kinds of buildings and building sites, and the development of instruments for this type of work, are proving useful. Both the Army and Navy have frequently called upon the Bureau for data or assistance in determining earth and building motions caused by earthquakes or other shocks.

While it is not yet possible to apply all the information gathered, continuity in obtaining information insures continued attention to application of our latest knowledge in design of structures. Defense structures should not be menaced by earthquake at the time of possible enemy action. Buildings at Mare Island Navy Yard were severely damaged by an earthquake during the Spanish American War.

Of the 407,186 nautical charts issued during the year, 154,165, or 38 percent, were issued to the Navy and Coast Guard. Large quantities were also issued the Army, Maritime Commission, and other organizations engaged directly or indirectly on national defense work. Further assistance was extended to the Navy through the accumulation of reserve stocks of charts and the accomplishment of a considerable amount of special work.

Of the 463,917 aeronautical charts issued during the year, 334,104, or 72 percent, were issued to the Army, Navy, Civil Aeronautics Authority, and Coast Guard. Other large quantities went to organizations such as the civil pilot training schools, engaged directly or indirectly on national defense.

The Army Air Corps and Civil Aeronautics Authority have requested that the regional and Alaska aeronautical charts be completed at the earliest practicable date. The Civil Aeronautics Authority has also requested that the program for airport charts be started as soon as possible. Numerous special investigations and experimental projects are now under way for these services.

Special Publication No. 197, "Practical Air Navigation and Use of the Aeronautical Charts of the Coast and Geodetic Survey," is now one of the Government's best sellers. On June 1 the Army Air Corps and Civil Aeronautics Authority, both of whom use this publication as a manual in the training of pilots, requested a special printing of 20,000 copies of the third edition. Eleven thousand copies of this manual on the shelves of the Superintendent of Documents were sold in a month and a half and a new printing ordered.

Aside from the vital importance of nautical and aeronautical charts to the national defense, a very large percentage of so-called miscellaneous work is directly or indirectly related thereto. Under this classification are the printing of special prints and maps for the Civil Aeronautics Authority and the Maritime Commission; and the printing of geodetic control data and of planimetric maps, over 50 percent of the issue of which goes to the military services.

COOPERATIVE ACTIVITIES

Four members of the Bureau were on temporary duty for two weeks or more each with the Field Artillery Observation Battalion at Fort Bragg, N. C. On special request of the War Department, two of these men were detailed for maneuvers in Georgia, Louisiana, and Texas. The use of survey methods such as are employed by the Coast and Geodetic Survey personnel during their routine operations was a valuable adjunct to this battalion.

Other cooperation with the War Department included a gravity determination at the Aberdeen, Md., Proving Grounds, at the request of the Ordnance Department; and the following work, all at the request of the Corps of Engineers: Extension of triangulation over a large part of the Shasta Dam project area on the Sacramento River; extension of horizontal and vertical control along the Arkansas River, from above Muskogee, Okla., to its confluence with the Mississippi River southeast of Pine Bluff, Ark.; level lines to bench marks referencing river gages established along the San Joaquin, Sacramento, and Mokelumne Rivers in California; and extension of control work over small areas in the vicinities of Norfolk, Va., New York, N. Y., and Boston, Mass.

Cooperation was extended the Army Air Corps in the determination of the following airplane speed trial courses: From Wright Field, Ohio, to Scott Field, Ill.; from Wright Field to the vicinity of Eaton, Ohio; 3-kilometer courses each at Fairfield, Ohio, and Denver, Colo.; from Denver to Castle Rock, Colo.; and from Denver, Colo., to Tucumcari, N. Mex. Much of this work was done during December and January, the most severe weather of the winter.

With the excellent cooperation of the Air Corps and the United States Coast Guard, which supplied pilots and planes, 11 sectional aeronautical charts were flight checked during the year and a considerable amount of airphotographic work was accomplished. This Bureau obtained the type of photographs needed for the most efficient prosecution of coastal topographic mapping, while personnel of the other services received valuable training and experience in airphotographic operations.

Cooperation was extended the United States Navy by running precise spirit levels and making horizontal observations of alignment in connection with the laying of the track for model basin towing equipment. This work was performed in the large enclosed building at Carderock, Md., under conditions of almost constant temperature and formed an ideal laboratory for work of this character.

Lines of levels in the alluvial valley of the Mississippi River necessary to compute and adjust that region's entire network were completed for the Mississippi River Commission.

Eleven topographic quadrangle maps, and four navigational charts of the lake created by the Guntersville Dam, were reproduced for the Tennessee Valley Authority.

A large amount of photolithographic printing was also done for the Civil Aeronautics Authority, the Maritime Commission, and other agencies and bureaus.

Forty-nine cadet officers of the United States Maritime Commission were given instruction aboard Survey vessels, to familiarize them with the many Bureau activities benefiting the merchant marine officer.

The larger ships had at various times from two to six cadets assigned during the field season on the Atlantic, Gulf, Pacific, and Alaskan coasts.

Gravity observations were obtained at a number of stations in Wyoming and Idaho for the Geological Survey, as a basis for investigations to correlate various forms of geophysical and geological data in mountainous regions.

Reciprocal agreements continued between the United States and England, France, Canada, India, and the Netherlands for the exchange of tide predictions.

Cooperation with various projects of the Work Projects Administration included a leveling project in the Santa Clara Valley, Calif., for the examination for the eighth consecutive time of a region of large settlement in the general vicinity of San Jose. The results of the last leveling in the fall of 1939 indicate that subsidence, in one place more than 5 feet, has not only ceased but that there has been a slight rise in elevation of the entire net during the past 2 years. Since there was a rise in the ground water level at the same time, geologists and others most capable of passing judgment on this matter, attribute the surface rise to the raised water level.

Cooperation was also extended to Work Projects Administration in the sponsorship of computing offices in New York, N. Y., and Philadelphia, Pa., at each of which there were employed an average of about 180 persons.

Various items of equipment have continued on loan to Work Projects Administration projects. These include steel towers to the Massachusetts and Connecticut geodetic surveys and the Minneapolis city survey; theodolites to the Massachusetts geodetic survey and the Cleveland city survey; precise levels to the Georgia and Arkansas geodetic surveys and the Cleveland and Minneapolis city surveys; and a repeating theodolite and base tapes to the Mercer County, Pa., project.

An administration fund was transferred to the Bureau to cover such expenses in connection with assistance given to Work Projects Administration projects. This fund was also available for costs of computing forms furnished to such projects and to defray express and freight shipments.

Science Service paid for the transmission of earthquake code messages from seismograph stations in the United States for the immediate determination of epicenters. These determinations are sent to all cooperative stations.

The Gulf Research and Development Corporation loaned the Bureau instruments used in the determination of differences of vertical magnetic intensity at various piers at the Cheltenham Observatory. Data on magnetic conditions were furnished the corporation throughout the year, and tests of their new type magnetometer started.

The Bureau of Reclamation transferred \$25,000 to the Bureau for the establishment of three seismological stations in the vicinity of Boulder Dam as a cooperative project of the two Bureaus and the National Park Service. The stations are used to determine the epicenter of nearby earthquakes.

Close cooperation was maintained with the California Institute of Technology, especially the seismological laboratory, in seismological problems, including instrumental development.

At the request of the American Standards Association, a Bureau representative is serving on sectional committee A-58, Building Code Requirements for Minimum Design Loads in Buildings. The Bureau furnishes fundamental seismological data necessary for the design of earthquake resistant structures.

Seismographs were operated in cooperation with the University of South Carolina, University of Chicago, Montana School of Mines, Montana State College, University of Utah, Utah State Agricultural College, Nebraska Wesleyan University, University of Hawaii, University of Alaska, Woods Hole Oceanographic Institute, and the Bermuda Biological Station. The Jesuit Seismological Association operated a number of seismographs and close cooperation was maintained in the exchange of records and data.

Tilt meters for determining the earth's tilt, and its relation to seismology, were continued in cooperation with the University of California.

Reports on the effects of earthquakes were obtained with the assistance of the Weather Bureau, several universities, many commercial agencies, and individuals.

The following activities were continued with the cooperation of the department of terrestrial magnetism, Carnegie Institution of Washington: Operation of a cosmic ray meter at Cheltenham Observatory; maintenance at Cheltenham Observatory of international magnetic standards; atmospheric and earth electric currents at Tucson Observatory (the Mountain States Telephone & Telegraph Co. and Bell Telephone Laboratories also cooperating); daily and weekly radio broadcasts of magnetic conditions, in which the Navy Department and Science Service have also aided; and training personnel and furnishing instruments for the United States Antarctic Expedition.

Two scientific assemblies were held in Washington, D. C., during the year. The first was the Seventh Assembly of the International Union of Geodesy and Geophysics, in September 1939. Various members of the Bureau are officers of the organization and took prominent parts in preparations for the meetings, as well as arranging for the entertainment, excursions, programs, and other features. Others presented papers and took an active part in the scientific discussions.

The second was the Eighth American Scientific Congress, in May 1940. Members of the Bureau also took an active part in presenting papers and in the discussions.

While such conferences are an ideal medium for the promotion of international scientific cooperation and cordial contact between nations, recent world events have been disastrous to many such organizations.

NEW AND IMPROVED METHODS AND EQUIPMENT

Two new ships of the most modern type for duty in the Aleutian Islands were added to the Bureau's survey fleet in the spring of 1940. The *Explorer*, a 220-foot vessel powered by a 2,000 horsepower steam turbine, with a cruising radius of 8,000 miles, is designed especially

for long voyages in isolated areas. The *E. Lester Jones* is a sturdy 88-foot wooden tender built for work in more protected waters.

The thermostatic control of the pendulum apparatus used in gravity determinations, undertaken some 2 years ago, has now been perfected. The chief difficulty in the adoption of this equipment to field work has been to eliminate any magnetic or electrical effect on the period of the pendulum.

A small rotary offset press, similar to the larger presses now in use, has been installed in the Washington office, to relieve the larger presses from special work which does not require large printing plates.

The Dorsey Fathometer No. 3 has now been installed on the survey ships *Discoverer*, *Pioneer*, *Explorer*, and *E. Lester Jones*, and automatic depth recorders to supplement the Fathometer have been placed on the ships *Explorer*, *Oceanographer*, *Lydonia*, *E. Lester Jones*, *Gilbert*, and on several launches.

Improvements continue in sono-radio buoys, now successfully used to distances of 85 miles. A mechanism was also designed to permit release in deep water of the anchor of the sono-radio buoy, so as to salvage the expensive anchor cable.

Excellent results have been obtained with an experimental model of a newly designed portable tide gage. A radical departure from the older model, it is designed to eliminate nearly all lost motion and friction and is less expensive to manufacture. An improvement was also made in the standard tide gage, to reduce the weight and cost of manufacture.

The support used for base measuring tapes was redesigned for construction of cast duraluminum, thereby providing a much lighter and cheaper device.

Physical changes in high precision theodolites are constantly occurring during field use, by reason of handling, temperature changes, lack of proper adjustment, and other causes. A program has been adopted of instrument testing which it is believed will safeguard instruments from future serious faults of this kind.

Signal lamps were improved as to rigidity of mounting and ease of focusing, and theodolites were improved by design of a positive yet simple means of adjusting the microscopes.

Two dozen light tables, equipped with latest type fluorescent lamps, were constructed for use in negative cutting. These tables provide soft even illumination, with an almost total absence of objectionable heat as the new lamps consume very little current.

CHART PRODUCTION

With demands for nautical and aeronautical charts increasing rapidly from year-to-year under normal conditions, there was suddenly added near the end of the year in connection with the national defense an unprecedented additional demand for these charts. The increasing output is shown in the following tabulation of annual issues and percentage increases for the last 4 years. Only a small portion of the demand resulting from the national defense program is reflected in these figures, since that program was not inaugurated until near the end of the fiscal year.

Charts	1937	1938	1939	1940
Nautical.....	333,366	351,150	350,062	407,186
Aeronautical.....	277,878	299,094	306,353	463,917
Total.....	611,244	650,244	716,415	871,103
Annual increase:				
Number.....		39,000	66,171	154,688
Percent.....		6.4	10.1	21.6

The total number of individual nautical charts available at the end of the year was 801, of which 163 were compiled and printed in Manila. Of the charts published in Washington there were 684 printings of 638 charts as follows: 10 new charts, 71 new editions, 534 new prints, 65 reprints, and 1 advance print. At the end of the year the Bureau was compiling 8 new original charts and recompiling 2 new charts.

The 10 new charts published during the year are as follows:

- 825. Manasquan Inlet to Little Egg Harbor.
- 826. Little Egg Harbor to Longport.
- 827. Longport to Cape May.
- 849. Elliott Key to Florida Bay.
- 937. Frederiksted Road, Saint Croix, V. I.
- 1050. New Orleans to Calcasieu River (East section).
- 1051. New Orleans to Calcasieu River (West section).
- 1263. St. Joseph and St. Andrew Bays.
- 5020. San Diego to Monterey.
- 5118. San Clemente Island, northern part Wilson Cove.

Of the above, special mention should be made of charts 825, 826, and 827, prepared to meet the demand for large-scale charts of the inland waterway along the New Jersey coast. These three cancel chart 3243, on a smaller scale. With new chart 849, and others completed previously, there are provided a complete set of inland waterway charts on a large scale from northern New Jersey to Miami, Fla.

The principal data received during the year consisted of 103 topographic surveys, 124 hydrographic surveys, 1,368 surveys from other organizations, and 741 chart letters. There were 5,693 changes in aids to navigation during the year. Dangers for hand corrections and data covering chart and related information were supplied the United States Coast Guard for announcement in its weekly Notice to Mariners. Although charts went to the press on an average of one in 11 months, it was necessary to apply 1,603,186 hand changes to 313,419 charts to correct them to the date of issue.

The issue of aeronautical charts shows a 27 percent increase over the fiscal year 1939. This is a logical trend accompanying all other statistics of the aviation industry which show comparable increases.

The Bureau now publishes 106 aeronautical charts. Two new Direction Finding charts (23-DF and 26-DF), and four new Regional charts (1M, 11M, 13M, and 17M), were added. There remain seven Regional and five Alaska charts still to be published to complete the present program. To maintain their accuracy, 234 printings were necessary, of which 55 new editions were required because of extensive changes in air navigation data. The redesignation, for the Civil Aeronautics Authority, of civil airways effective in March 1940, has been an improvement over former designations and their addition to charts has progressed satisfactorily.

HYDROGRAPHIC AND TOPOGRAPHIC WORK

During the year increased appropriations made possible the more nearly continuous field operation of hydrographic units. To accelerate the necessary preliminary office work on the resulting increased volume of field records, processing offices were established at Norfolk, Va., Pensacola, Fla., Oakland, Calif., and Seattle, Wash.

A summary of activities in hydrography, topography, and coastal triangulation follows:

Locality	Hydrography			Topography		Coastal triangulation		
	Sound- ing lines	Area	Sound- ings	Shore line	Area	Length of scheme	Area	Geo- graphic posi- tions
	Miles	Square miles	Number	Miles	Square miles	Miles	Square miles	Number
Gulf of Maine.....	7, 227	4, 989	70, 029					
Boston Harbor.....	706	36	31, 908					
Nantucket Sound.....	4, 805	142	185, 469	398	125			
North coast of Long Island.....						7	21	
Atlantic coast east of Fire Island.....	14, 113	6, 199	162, 168	3		54	134	182
Chesapeake Bay.....	136	9	5, 453	601	212			
Atlantic coast south of Cape Fear.....	11, 521	5, 842	114, 309					
St. Johns River, Fla.....				253	134			
Indian River, Fla.....						40	300	140
West coast of Florida.....				708	265			
Choctawhatchee Bay, Fla.....	1, 752	57	68, 425	65	20			5
Gulf of Mexico.....	24, 908	41, 620	254, 679	18	4			
San Francisco Bay.....	462	19	15, 570	34	10		9	14
Coast of northern California.....	972	289	9, 452					
Columbia River and coast of Washington.....	2, 071	95	89, 728	176	50	25	130	72
Grays Harbor, Wash.....	263	7	10, 668	92	7	56	507	52
Northern Puget Sound.....	3, 560	117	105, 138	110	174	74	264	180
Southeastern Alaska.....	1, 639	119	41, 213	198	85			
Gulf of Alaska.....	7, 300		7, 750					
Central Alaskan coast.....	3, 384	2, 627	29, 677	16				
Alaskan Peninsula.....	10, 611	11, 893	137, 009	116	186	63	377	40
Aleutian Islands, Alaska.....	9, 887	7, 882	168, 111	171	171	59	291	62
Puerto Rico.....	41	2	1, 687			4		2
Philippine Islands.....	7, 958	1, 418	166, 985	121	24	102	1, 081	208
Total.....	113, 316	83, 371	1, 676, 028	3, 080	1, 467	490	3, 114	957

On the Atlantic coast the survey vessel *Oceanographer* completed her part of the offshore hydrographic project extending from the New Jersey coast to Nantucket Lightship, and began new basic surveys in the Gulf of Maine. The *Lydonia* continued on the former project. During the winter months both vessels were engaged on offshore hydrographic surveys along the coasts of North and South Carolina.

Wire-drag investigations along the Atlantic coast in the vicinity of Sandy Hook were completed under the supervision of the commanding officer of the ship *Oceanographer*.

The *Gilbert* continued work on surveys along the south coast of Cape Cod and cooperated with the *Lydonia* in the survey of Nantucket Shoals. The launch *Elsie III* began operations as a mobile revision unit along the Intracoastal Waterways of the Atlantic coast.

The *Mikawe* during the summer of 1939 continued surveys along the south coast of Cape Cod. With the close of the season the vessel proceeded to Norfolk, Va., arriving October 23. This vessel was destroyed by fire on the morning of October 27 while taking on gaso-

line, resulting in the death of Clement A. Bennett, oiler, and the serious injury of Lt. Max G. Ricketts; Anon J. Small, boatswain; William D. Bennett, quartermaster; Elton E. Mooney, seaman A. B.; and Isaac R. Jones, ship's cook.

After the loss of the *Mikawa*, the personnel were assigned to the launches *Ogden* and *Mitchell* which took up combined operations in the Indian River, Fla., during the winter months. In the spring of 1940 this party began surveys in Chesapeake Bay in the vicinity of Chester River and Eastern Bay.

The scheme of second-order coordinating triangulation along the northern shore of Long Island from Oyster Bay to Gardiners Bay was completed.

Coast Pilot revision parties were engaged in the collection of data for new editions of sections A and B of the Coast Pilot, covering the coastal areas from the Canadian boundary to New York Harbor.

Compilations of line maps from air photographs taken with the Bureau's 9-lens camera were made of Boston Harbor, Chester River, and adjacent tributaries of Chesapeake Bay, and Apalachee Bay and St. Marks River on the Florida Gulf coast. Small air-photographic compilation units were in operation at Baltimore, Md., and Tampa, Fla. Air-photographic surveys in advance of inshore hydrography have proved so efficient and time saving that this procedure is being used whenever conditions permit.

In the Gulf of Mexico, the ship *Hydrographer*, with the tender *Faris* operating as a subparty, completed her assignment along the Texas coast and began operations in the central and eastern parts of the Gulf, with headquarters at Pensacola, Fla.

A shore party completed the survey of the eastern half of Choctawatchee Bay, Fla., and of the Intracoastal Waterway between Fort Washington and West Bay.

On the Pacific coast all vessels were employed on a program of winter surveys. The ship *Guide* operated off Cape Mendocino, Calif., in San Francisco Bay and off the Santa Barbara Islands, Calif.; the *Surveyor* and *Westdahl* completed winter assignments in the San Juan Islands, Wash.; and the *Discoverer* began a revision survey of Grays Harbor, Wash.

The old *Explorer* discontinued work in Puget Sound in the fall of 1939 and was transferred to the National Youth Administration at Seattle, Wash., after service in the Coast and Geodetic Survey for 35 years. The new *Explorer*, and the motor vessel *E. Lester Jones*, built under an allotment from Public Works Administration funds, were commissioned in the spring of 1940 and assigned to Aleutian Island surveys.

A wire-drag party completed its assignment on surveys along the California coast. An arc of second-order triangulation was completed along the Washington coast from the mouth of the Columbia River to Grays Harbor, Wash., and a revision survey was made of Willapa Bay.

In southeastern Alaska the new motor vessel *E. Lester Jones* accomplished a short project in the outer southern approaches to Sitka, Alaska, before joining the fleet in the Aleutian Islands. The motor

vessel *Westdahl* continued work on original hydrographic surveys of Glacier Bay.

The *Surveyor* was transferred from the Aleutian Islands where she had been engaged on surveys along the coasts of Unalaska and Umnak Islands, and began work on the eastern end of a project of original surveys of the Alaskan coast, between Cape Fairweather and Cape St. Elias.

In southwestern Alaska the new *Explorer* and the new *E. Lester Jones* extended surveys in the Aleutian Islands westward from Umnak Island. The *Pioneer*, working in cooperation with the *Explorer*, extended triangulation to Amukta Island and accomplished offshore hydrography south of the Islands of Four Mountains.

The *Discoverer*, assisted by the tender *Wildcat*, continued operations along the south coast of the Alaskan Peninsula eastward from the Sanak Islands. The *Guide* continued work on the Bering Sea side of the Peninsula on the project extending northeastward from Cape Saricheff.

In the Philippine Islands the *Pathfinder* continued surveys on the west coast of Palawan. The *Fathomer* was recommissioned early in the year and began survey operations in the area between Balabac and Cagayan Sulu.

The 13 United States Coast Pilot volumes, which are kept current by annual supplements, contain a wide variety of important information supplemental to that shown on the chart, such as detailed description of the coast and information concerning the waterways, as well as maritime data for the ports of the United States and possessions. New editions of Coast Pilots are published as often as warranted by the number of changes made and the amount of new information available. Three supplements to United States Coast Pilots and one to the Hawaiian Coast Pilot were published during the fiscal year. New editions of the West Indies Coast Pilot and volumes I and II of the Philippine Islands Coast Pilots were published. Manuscript was prepared for a new edition of United States Coast Pilot B, covering the Atlantic coast from Cape Cod to Sandy Hook.

The field stations of the Bureau in the United States, Honolulu, and Manila, continued to render valuable service in supplying information for the correction of charts in their vicinities and in disseminating navigational and engineering data in response to requests from local public and official sources.

GEODETIC WORK

The demand for geodetic data was greater than for any year in the history of the Bureau. In addition to furnishing data in response to a large and increasing variety of requests, there has been conducted a large amount of field work in cooperation with other organizations, for which the latter furnished the necessary funds.

A brief outline of work accomplished in connection with geodetic triangulation, base lines, reconnaissance, and leveling and astronomical and gravity observations follows:

Locality	Length of scheme	Area	Locality	Length of scheme	Area
<i>First-order triangulation</i>			<i>First-order base lines</i>		
Bloomington to Clarks Hill, Ind.	Miles 75	Square miles 750	Steamboat Springs, Colo.	Miles 4.7	
Albany to Glasgow Junction, Ky.	55	495	Orland, Calif.	5.1	
Wilmington to Georgetown, Ohio.	50	600	Total	9.8	
Oquawka to Watseka, Ill.	135	1,485	<i>First-order reconnaissance</i>		
Longmont to Steamboat Springs, Colo.	100	2,000	Stillwater, N. J., to Herkimer, N. Y.	140	1,400
Hagerstown to Parkton and Thurmont to Brunswick, Md.	90	900	Forty-first parallel, California, Nevada, and Utah.	380	15,200
Hamburg to Cortland, N. Y.	150	1,500	Francesville, Ind., to Watseka, Ill.	55	550
Hayward, Wis., to Calumet, Mich.	190	2,850	Monroeville, to North Manchester, Ind.	50	500
Missoula to Trail Creek, Mont.	115	1,610	Greencastle to Clinton, Ind.	35	350
Billings to Rothiemay, Mont.	80	1,440	Arkansas River, Ark., and Okla.	625	7,660
Sacramento to Redding, Calif.	320	6,750	Vicinity of Petaluma, Calif.	20	100
Vicinity of Petaluma, Calif.	20	100	Total	1,305	25,760
Arkansas River, Ark., and Okla.	485	5,950	<i>Second-order reconnaissance</i>		
Vicinity of Placerville, Calif.	20	700	Monroe to Opelousas, La., and Winnfield to St. Joseph, La.	180	1,800
Total	1,885	27,130	Minden to Lake Charles, La.	155	1,550
<i>Second-order triangulation</i>			Willamette River Valley, Oreg.	80	1,600
Cape Charles, Cape Henry, and Port Monroe, Va.	30	150	Total	415	4,950
Vicinity of Fort Tilden, N. Y.	15	45			
Vicinity of Fort Hancock, N. J.	5	20			
Vicinity of Boston Harbor, Mass.	10	20			
Airplane Record Courses, Illinois, Colorado, New Mexico and Ohio.	10	20			
Total	70	255			

State	First-order	Second-order	State	First-order	Second-order
<i>Leveling</i>	Miles	Miles	<i>Leveling—Continued</i>	Miles	Miles
Arkansas	3	436	Nebraska	32	
California	550	118	Nevada		140
Kansas	72	153	Oklahoma		98
Louisiana	6		Total	732	1,006
Mississippi	37				
Missouri	32	61			

State	Determinations			State	Determinations		
	Latitude	Longitude	Azimuth		Latitude	Longitude	Azimuth
<i>Astronomy</i>				<i>Astronomy</i>			
Alaska			1	Minnesota	1	1	1
California			1	Montana	1	1	1
Colorado	1	1	1	Nevada	1	1	
Illinois	1	1	1	New York			1
Indiana	1	1		South Dakota	1	1	1
Michigan	1	1	1	Total	8	8	9

State	Determinations		State	Determinations	
	New	Repeat		New	Repeat
<i>Gravity</i>			<i>Gravity</i>		
Colorado.....	3		Nebraska.....	1	
Idaho.....	3		Wyoming.....	14	
Illinois.....	1				
Maryland.....	1	1	Total.....	23	1

Evidence of the value of control surveys continues to increase as the work advances. This natural reaction is doubtless due in large measure to the final geodetic datums for triangulation and leveling adopted in 1927 and 1929, respectively. Strangely enough it took more than a century before the Federal control of this country, started by Hassler in 1817, had attained the scope of a nation-wide network, ready for adjustment into a rigid and final system of coordinates for geographic positions and of elevations. The importance of this work is more deeply appreciated when one realizes that the maximum value of control work can be obtained only where it is completely coordinated into a single system or datum as a means of obtaining uniformity in field and office procedure over the country. Once a point on the earth has been marked by a monument and its position fixed, through the horizontal control system of the United States, or an elevation has been definitely established, it is of value to citizens for all time to come. Points not so coordinated are less useful.

These data of geographic positions, azimuths, distances between stations, elevations, basic gravity values, etc., are of indispensable value in the extension of all kinds of public works projects, flood control, surveying, mapping, and other engineering and scientific activities where coordination is essential so adjoining projects may meet without gaps or overlaps.

Three triangulation, two leveling, one astronomical, and one gravity parties operated through most of the year in the accomplishment of control in various sections of the country. Much effort was directed to the completion of gaps in previous work, so as to consolidate the existing fundamental net, coordinate supplemental projects of other organizations, and make available the processed data as early as practicable.

Variation of latitude observatories at Ukiah, Calif., and Gaithersburg, Md., were continued in operation. This program was initiated many years ago under the joint auspices of the International Astronomical Union and the International Union of Geodesy and Geophysics.

The expanded geodetic program of 1932-35 left a large accumulation of field records. Since that time and particularly during the past year, this situation was relieved by the processing of material through the efforts of the Washington Office and personnel in the New York and Philadelphia processing offices. It is believed that another year will relieve the arrearage almost completely. Some of the principal projects which have been processed during the year include:

Triangulation.—The adjustment of cooperative projects of triangulation in the Sacramento River Valley, Calif., along the Arkansas

and Columbia Rivers; and in Puerto Rico. Further adjustments, smaller in scope, were begun in Norfolk, New York, and Boston Harbors. Adjustments of the triangulation along the Hudson River from New York City to above Troy, N. Y., and in northern Maryland and eastern Pennsylvania, were also completed.

This year witnessed the completion of the adjustment of the triangulation along the Mississippi River from the headwaters in Minnesota to the Gulf of Mexico, in cooperation with the United States Engineers over a period of some 10 years, beginning in 1929. This project coordinated the field surveys in that region by the Corps of Engineers with those of the Bureau.

Leveling.—The adjustment of the net in the general vicinity of Cleveland; a local net in Kentucky; and a special adjustment of the leveling in the Boulder Dam area.

TIDE AND CURRENT WORK

Eighty-five primary and secondary tide stations were in operation during the year: 41 on the Atlantic coast, 6 on the Gulf coast, and 38 on the Pacific coast. Of these, 38 were conducted in cooperation with other agencies, including the United States Engineers, the Navy Department, Territory of Hawaii, cities of New York, Santa Monica, and Los Angeles, Port of Willapa Harbor, Woods Hole Oceanographic Institution, Chesapeake Biological Laboratory, and University of Washington.

Shorter periods of observations at approximately 120 additional stations were obtained in connection with hydrographic surveys and other activities.

A tide survey of the Sacramento-San Joaquin Rivers was continued throughout the fiscal year with 12 standard gages in continuous operation. Also continued throughout the year was a tide survey of the Connecticut River, in cooperation with the office of the District Engineer at Providence. Six stations were in operation between Saybrook and Hartford.

No current surveys were conducted. Some current observations were secured however by hydrographic parties and in cooperation with other organizations. Through the cooperation of the United States Coast Guard, a 13-month series of hourly current observations was completed at Fire Island Lightship, approximately $6\frac{1}{2}$ months of similar observations were secured at Overfalls Lightship and 1 month at Portland Lightship. At the end of the year observations were still in progress at Overfalls and Portland Lightships. In cooperation with the Department of Highways, Suffolk County, N. Y., current observations were obtained at nine stations in the vicinity of Shinnecock Bay, Long Island.

The need for comprehensive current surveys in important waterways was emphasized by numerous requests for current data which could not be adequately supplied because of the meagerness or total lack of observational material for the localities concerned.

MAGNETIC WORK

Continuous magnetic information was obtained at five observatories located at Cheltenham, Md.; Honolulu, T. H.; San Juan, P. R.; Sitka, Alaska; and Tuscon, Ariz. Magnetic observations were made either to improve the magnetic survey or to keep record of the

changes in the earth's magnetism. The resulting information is used by the navigators of sea or air, the land surveyor, and the explorer of oil and mineral resources, and has proved exceptionally valuable in connection with radio communication. New methods have made it possible to furnish this information in convenient form by radio broadcast or otherwise. Special effort was given to making accumulated data of the past available for use. Two Work Projects Administration undertakings—one in New York City and the other in Puerto Rico—have done considerable work on the Polar Year records. Magnetic data were supplied for 180 charts.

The need for a nonmagnetic ship with which to make magnetic observations at sea is becoming more acute. Observations cannot be made with the present steel ships, and since the destruction of the *Carnegie* in 1929 none has been obtained. Therefore, the value of the magnetic declination on the charts is becoming less and less reliable.

Changed magnetic conditions necessitated the construction of a new observatory at Sitka, Alaska. Many improvements were made to instruments and methods with the aim of reducing time spent in eventual processing of records as well as increasing the accuracy.

The distribution of magnetic observations during the year is shown in the following table:

State or Territory	Repeat stations			Other declination stations	Total
	New—complete	Old			
		Com-plete	Declina-tion only		
Alabama			3		3
Alaska	3	24		73	100
California			1	3	4
Colorado				30	30
Florida		1		7	8
Georgia			4		4
Idaho			2	10	12
Illinois			14	43	47
Indiana			2	10	12
Iowa			1		1
Kansas			2		2
Kentucky				6	6
Louisiana		1	3		4
Maine				3	3
Maryland	1			12	13
Massachusetts				3	3
Michigan			12	15	17
Minnesota		1	5		6
Mississippi			2		2
Missouri				1	1
Montana			3	30	33
Nebraska			3		3
Nevada				8	8
New Hampshire				2	2
New York			3	62	65
North Carolina		1	4		5
North Dakota		2	1		3
Ohio				6	6
Oregon			1	10	11
Pennsylvania			2	5	7
South Dakota			3		3
Texas	1	1	9	9	20
Vermont			1	17	18
Virginia	1	1	3		5
Washington				² 87	87
Wisconsin			5	22	27

¹ Including H observations at 1 station.

² Including D test observations at 4 sites.

SEISMOLOGICAL WORK

The Bureau's seismological work consists in recording distant and local earthquakes; obtaining data by an elaborate system of questionnaires; exchanging information with many institutions; measuring the character and magnitude of natural periods of vibrations of structures and the ground; and cooperation with other Government agencies, scientists, and educational institutions in the study of effects of earthquakes, with a view to improving present means of safeguarding life and property.

Seismographs were operated at observatories in Tucson, Ariz.; Honolulu, T. H.; Sitka, Alaska; and San Juan, P. R. The Bureau cooperated in the maintenance of seismographs at nine colleges and an equal number of independent stations sent their records to the Bureau for study and interpretation.

Sixty strong-motion seismographs for the recording of strong local shocks were maintained at 52 stations, and 24 records were obtained for 6 earthquakes.

Twenty-three vibration tests were made in 5 buildings, 3 tests on 1 bridge, and 88 ground period tests at 17 locations. Approximately 100 records were obtained on shaking table tests of instrumental equipment. Recording of fault noises in two deep wells was carried on intermittently. Three tilt-meter stations were maintained.

Intensive questionnaire coverage was obtained for 14 earthquakes of semidestructive character and over 3,300 reports on approximately 400 earthquakes were received.

Many institutions requested photographic copies of the original records.

PERSONNEL AND FINANCES

The Bureau had a personnel of 1,430 on duty at the close of June 30, 1940—398 (18 commissioned and 380 civilian, including 20 civilians paid from emergency allotments) on duty in the Washington office, and 1,032 (146 commissioned and 886 civilian) in the field service. The field personnel included 51 civilian employees on duty at the Manila Field Station and 50 members of the crew of the ship *Fathomer* paid by the Philippine Insular Government but under the jurisdiction of this Bureau.

Acquisitions by the library and archives included 124 hydrographic and 103 topographic sheets, representing new Bureau surveys; 1,120 blueprints (mostly surveys by Army Engineers); 2,134 maps; 646 charts; 7,435 field, office, and observatory records; 302 negatives; 1,928 prints; 333 lantern slides; 1,111 books; and 3,957 periodicals.

Collections covering miscellaneous receipts, including nautical and aeronautical charts and publications, totaled \$133,246.64, as compared with \$109,950.44 during the preceding year.

The regular appropriations for the year totaled \$3,125,000. These were supplemented by the following additional appropriations:

Working fund, 13-21-3000-(08) (War, Rivers, and Harbors)-----	\$12,600.00
Working fund, 13X6908.001 (special fund) (Bureau of Reclamation)-	25,000.00
Working fund, 13X5908 (War, flood control):	
Limitation .001-----	2,000.00
Limitation .002-----	61,200.00

Working fund, 265009.4-650999, administrative expenses (Emergency Relief, Work Projects Administration), 1940-----	\$29,292.00
Working fund, 139/05908, Commerce, Coast and Geodetic Survey, 1939-40 (transfer from War Department):	
Limitation .001-----	8,000.00
Limitation .002-----	8,000.00
Limitation .003-----	8,714.31
Working fund, 1305908.001, Commerce (Coast and Geodetic Survey), 1940-----	1,285.69
Allotment from the Department of Commerce for travel-----	23,500.00

There were also allotted for nonconstruction projects in Puerto Rico the following:

202037-650999, Emergency Relief, Nonconstruction projects (transfer from W. P. A.), 1940-----	\$29,769.00
202038-650999, Emergency Relief, Administrative Expenses (transfer from W. P. A.), 1940-----	1,048.00

Transfers and reimbursements from other departments were received to the credit of the following appropriations: Salaries, 1940, \$2,931.74; aeronautical charts, 1940, \$32,267.25; and office expenses, 1940, \$1,126.87.