[Reprinted from the Annual Report of the Secretary of Commerce, 1938]

COAST AND GEODETIC SURVEY

REVIEW OF THE YEAR

The work of the United States Coast and Geodetic Survey for the year past carries many accomplishments of interest and importance. The Bureau has progressively improved methods and appliances, without reducing its high standard of precision but with an appreciable reduction in operating costs. Among other things, its records cover nautical and aeronautical charts, compass variations, tide and current predictions, control surveys, which include the exact geographical locations and elevations of thousands of points throughout the United States, earthquake data, and related subjects, such as gravity, variation in sea levels, current diagrams, information on ocean depths, the size and shape of the earth, manuals on its various kinds of surveying, and many other matters. These records also include basic data of great educational value, reaching from ready commercial use to vital contributions to the ultimate solutions of fundamental scientific problems.

The Bureau has responded to the rapidly rising demand for its products and it is appropriate to cite that the many collateral uses to which these data are put increase their value. For example, each year more and more gaps are filled in the basic geodetic control survey of the country, furnishing accurately determined latitudes, longitudes, distances, and true bearings, and these data are not only used to insure the accuracy of positions on charts, but the taxpayer is learning they are available as a money saver in engineering and industrial operations, such as hydroelectric power development, drainage and irrigation projects, flood control, highway location, boundary lines, etc.

Operations on land, sea, and in the air and the compilation and issuance of the finished products by the Washington office must be a continuing process with such increases from year to year as are necessary to anticipate the most urgent needs of the public. A stoppage of any of the projects, many requiring more than one season for accomplishment, is expensive.

Because of the many changes which occur and the need for publicizing new conditions, the Bureau's work for the area covered is not finished with the issuance of a chart. Ever keeping in stride with the greater requirements of the users of nautical and aeronautical charts, those of today show a wealth of detail which in other days were as impracticable as they were unnecessary.

There was an increase in orders this fiscal year over last of 7 percent for aeronautical charts and 5 percent for nautical charts, while for all navigational publications the increase was approximately 6.5 percent, and 141 percent as compared with the number issued a

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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March 22, 2005

decade ago. These increases are the more remarkable when it is realized that 1937 was in itself a record year in each of the instances mentioned. Over 351,000 nautical charts were issued, exceeding that for 1937 and for all previous years in the history of the Bureau.

Bureau work continues to be augmented by the increased activities of other agencies. This should be met by a small increment in appropriation to permit the proper publication of the changes in existing conditions. Construction of new and better navigation aids by the Lighthouse Service, the dredging and other improvement of waterways by the United States Engineers, and the marking of new air routes by the Bureau of Air Commerce, are improvements which, while beneficial to the marine and aviation industries, add materially to the work of revising charts and necessitate the issuance of frequent new editions.

The unprecedented use of the Bureau's products and the work accomplished by other Bureaus which must be shown on its charts are creating a situation with which it is increasingly difficult to cope with the present available appropriations and personnel.

Some relief came toward the end of the year in the form of an allotment of $2,051,000, under the terms of the Public Works Administration Act of 1938: covering $490,000 for geodetic surveys in 34 States; $136,000 for replacement of fathometer equipment on 5 survey ships, repairs to observatory buildings and equipment for 44 tide stations; and $1,425,000 for the construction of 2 vessels. One of the latter will be a survey ship of about 1,500-ton displacement, for offshore surveys in the Aleutian Islands, with an 8,000-mile cruising radius and a complement of 90 officers and men, and the other, an 88-foot tender to replace the *Helianthus*. The regular appropriation of $2,665,500 for the fiscal year 1939 will be materially aided by the Public Works Administration Act allotment, particularly with respect to the geodetic work.

DEVELOPMENT OF METHODS AND INSTRUMENTS

The Dorsey Fathometer No. 3, a precision echo-sounding instrument, has been developed for use both in shoal and deep water. Placed on one of the Alaska ships, the *Westdahl*, it has already measured depths from 5 to 450 fathoms. It is expected that this type will come into general use on Survey ships, because of its increased precision and adaptability.

The regular use of automatic buoys, known as sono-radio buoys, in lieu of the small survey vessels formerly used as station ships in radio acoustic position finding, has accomplished a considerable reduction in operating cost and relieved station ships for regular survey duties.

A delicate apparatus built in the Bureau's shops has eliminated practically all traces of magnetic material in the construction of instruments for measuring and recording the earth's magnetic properties.

A new sea water sampler has been designed which makes use of pneumatic pressure set up within the instrument itself as it is lowered into the sea, to trap a true sample of the surrounding water at any desired depth.

Experiments conducted over a period of several months have provided a method whereby two or more gradient tints on aeronautical charts can be printed from one color plate. It is estimated that former nine press-runs can now be made with four press-runs. This method is also contemplated for use on the shoal-water tint of nautical charts.

A master plate or disk engraved in the office and fitted to the sounding machine permits the cutting of certain lettering on the nautical charts in the same manner that soundings are now cut.

A thermostatic device for maintaining a uniform temperature of the Brown gravity apparatus permits the use of the more stable bronze instead of invar pendulums, and eliminates magnetic effects.

Other improvements include easier identification markings for level rods; stronger and more lasting rod cases; rapid introduction of positive-type planetable sheet clamps; better methods of holding theodolites and collimators in their cases to prevent jarring out of adjustment; and an improved magazine roll element for the standard tide gage.

COOPERATIVE ACTIVITIES

The following projects were accomplished on a cooperative basis with the organizations named:

Special map work: Cooperation with various bureaus of the Federal Government in many minor tasks which in the aggregate required much time. An example is the enlargement, preparation, and printing of a special map of North America for the United States Weather Bureau. This will be used in the main office of that Bureau as a master map for the preparation of many others showing different data and information for the public.

United States Maritime Commission: Cadet officers of the Commission are being given instruction, in the Washington office and aboard survey vessels, to learn the many activities of the Bureau benefiting the merchant-marine officer. Six cadet officers were recently assigned for a period of training for 6 months on the survey vessel *Oceanographer*.

Soil Conservation Service: Continuation of the extension of first- and second-order triangulation over certain areas in Colorado, Utah, and Wyoming, totaling 40,000 square miles, for use in controlling mosaics from air photographs made in connection with the mapping of those areas.

The Comision Mixta of Guatemala and El Salvador: Establishment of an astronomical station near the Pacific end of the common boundary. Additional cooperation was extended the two countries by furnishing each with two astronomical stations to be used in coordinating proposed nets of triangulation in preparation for air photographic mapping. Cooperation of this nature has now been extended three countries of Central America, namely, Honduras, Guatemala, and El Salvador, and the results of the work have been of such usefulness that other countries may ask similar cooperation.

Corps of Engineers, United States Army: Extension of first-order leveling from Biloxi, Miss., through New Orleans, La., to the Head of Passes, and from New Orleans to Baton Rouge, La.

Committee in Seismology, Carnegie Institution of Washington: Extension of 200 miles of triangulation and traverse across eight zones along the San Andreas and three other faults in California, for studying earth movements.

Ardmore, Pa.: Detail of an officer to assist in obtaining geographic positions in lower Merion Township as a basis for local surveys and to provide a connection with the Pennsylvania State coordinate system.

Baltimore County, Md.: Detail of an officer to extend a system of triangulation over the metropolitan area, to provide a basis for the reference of property boundary lines, and for the preparation of tax-assessment maps. Forty-six triangulation stations were established and adjusted to the national control survey net.

California Works Progress Administration: Continuation of the releveling of level lines in the vicinity of San Jose, Calif., for the study of earth settlement.

Works Progress Administration project of King County, Wash.: Continued detail of an officer as technical adviser to parties extending necessary triangulation for control surveys for mapping the county and to an office force reducing the records.

Florida mapping project, Works Progress Administration: Completion of arcs of first- and second-order triangulation totaling 432 miles in length and covering more than 4,000 square miles, under the technical direction of one of the Bureau officers, and the technical supervision by another officer of the computing office.

Technical advice to other States: For limited periods during the year, officers have acted as technical advisers to the Engineering Department of Minneapolis, Minn., and to the Cleveland, Ohio, Regional Geodetic and Topographic Survey, in the extension, through Works Progress Administration projects, of triangulation, traverse, and leveling over their areas and to provide proper connections with the national control surveys. An officer was assigned each of the computing offices of the State geodetic survey projects in Arkansas, Connecticut, Georgia, and Oklahoma, to supervise the personnel, paid by the Works Progress Administration, engaged on geodetic computations. The Bureau continued serving in an advisory capacity with 15 States in carrying on horizontal and vertical control surveys as part of the Works Progress Administration program initiated by the Bureau in November 1933 under the Civil Works Administration.

Seismological observatories: Operated on a cooperative basis with the institutions named, at Columbia, S. C., University of South Carolina; Chicago, Ill., University of Chicago and United States Weather Bureau; Butte, Mont., Montana School of Mines; Bozeman, Mont., Montana State College; Honolulu, Territory of Hawaii, College of Hawaii; and College, Alaska, near Fairbanks, University of Alaska.

Science Service, a Washington institution for the popularization of science, financed the transmission of earthquake code messages for the purpose of having Survey seismologists locate earthquakes within a day or so of their occurrence.

The Massachusetts Institute of Technology cooperated in studying methods of analyzing seismographic records with special analyzing

machines available only at that institution. Methods of improving the operation of seismological instruments have been studied and specifications to accomplish this have been prepared in the Bureau.

The University of California cooperated in maintenance of tilt meters in connection with the Bureau's seismological program.

The United States Weather Bureau, a number of universities interested in seismological research, and a large number of commercial agencies and individuals, cooperate actively in collecting earthquake information.

The cooperation of the Department of Terrestrial Magnetism, Carnegie Institution of Washington included: Better determination and maintenance of national and international magnetic standards as a result of joint observational programs at the Cheltenham Magnetic Observatory; operation of a cosmic ray meter at Cheltenham Magnetic Observatory; continuation of atmospheric electric and earth current observations at Tucson Magnetic Observatory (with added cooperation of the Bell Telephone laboratories and the Mountain States Telephone & Telegraph Co. in the work at Tucson); and the extension of weekly broadcasts of magnetic conditions for the benefit of the investigators in the field of radio transmission. The Navy Department, Science Service, and others also have cooperated in the latter work.

This Bureau continued cooperation with foreign governments in the maintenance of international magnetic standards.

CHART PRODUCTION

Good progress was made during the year with the issue of 123 revised editions of existing nautical charts. To meet further the requirements of marine commerce in those places where detailed surveys had recently been made, the 15 charts listed below were compiled and issued, making a total of 792 nautical charts of United States waters now available. These include the completion of the Intracoastal Waterway series from Norfolk to Miami.

MARYLAND-DELAWARE: Chesapeake and Delaware Canal.
VIRGINIA-NORTH CAROLINA (Intracoastal Waterway):
Dismal Swamp Canal.
Norfolk to North River.
NORTH CAROLINA (Intracoastal Waterway):
North River to Alligator River—Pungo River Canal.
Alligator River—Pungo River Canal to Neuse River.
Neuse River to New River Inlet.
SOUTH CAROLINA:
Stone and North Edisto Rivers.
St. Helena Sound.
FLORIDA:
Fort Pierce Harbor.
Intracoastal Waterway—Cape Florida to Blackwater Sound.
LOUISIANA: Isles Dernieres to Point au Fer.
CALIFORNIA:
Pyramid Cove and Approaches.
Estero Bay.
ALASKA:
Portland Inlet to Nakat Bay.
Kodiak Island.

Orders for aeronautical charts to meet the needs of civil and military aviation have continued to increase parallel with the growth of the aviation industry. To maintain the accuracy of these charts in sections of the country where the establishment of new airways, airports, and other new construction has made important changes, there were printed 48 revised editions of 45 individual charts.

At the close of the year there were available the entire series of 87 sectional aeronautical charts covering the entire United States, 4 of the regional series, and 2 of the direction finding series. This latter series was first issued this year to provide charts for air navigation by radio control.

The demands on the Division of Charts can be best illustrated by the fact that the number of press impressions during the fiscal year was more than 7,000,000. This is in comparison with only slightly more than 5,000,000 in the preceding year and approximately 2,000,000 4 years ago. The steady and substantial growth in the need for nautical and aeronautical charts and related publications is shown by the following tabulation of these publications for the past 4 years:

Item	1938	1937	1936	1935
Nautical charts [1]	351,150	333,366	275,800	309,765
Aeronautical charts [1]	299,094	277,878	178,973	61,268
Strip maps			12,186	9,210
Air planimetric maps	6,705	4,544	4,236	2,907
Miscellaneous	3,241	3,166	2,857	2,192
United States coast pilots	10,842	8,062	6,167	6,077
Intracoastal Waterway pilots	1,008	1,463	1,022	943
Distances between United States ports	529	559	429	588
Tide tables	24,299	24,567	24,184	21,984
Current tables	9,769	9,114	9,002	7,588
Tidal current charts	1,631	1,628	1,607	1,705
Practical air navigation	3,798	1,837	5,167	
Total	712,066	666,184	521,630	424,227

[1] Annual reports prior to 1936 did not include charts withdrawn because of the issue of revised editions.

A second and revised edition of the manual "Practical Air Navigation" was issued toward the close of the fiscal year. First published in 1936, this book was entirely rewritten and enlarged to include much new material of benefit to the aviation industry. It has already received many favorable comments from officers of commercial air lines and the military air forces.

HYDROGRAPHIC AND TOPOGRAPHIC WORK

During the year topographic and hydrographic surveys, including the necessary control triangulation, were made on the Atlantic, Gulf, and Pacific coasts of the United States, in Alaska, Hawaii, and the Philippines. The field stations of the Bureau in the United States, Honolulu, and Manila, continued invaluable service in supplying data for the correction of charts in their vicinities, and in disseminating information of the Bureau's activities.

A brief outline of and statistics for the various projects follows:

Hydrography, topography, and coastal triangulation

Locality	Hydrography			Topography		Coastal triangulation		
	Sounding lines	Area	Soundings	Shoreline	Area	Length of scheme	Area	Geographic positions
	Miles	*Square miles*	*Number*	*Miles*	*Square miles*	*Miles*	*Square miles*	*Number*
Nantucket Sound	46	2	2,419	16.0	4.0	5	6	9
Atlantic coast of Long Island	2,865	1,184	29,594					
New Jersey coast	12,304	6,660	124,749					
New Jersey Inland Waterway	1,628	56	58,648					
Chesapeake Bay	516	24	22,290	367.0	140.0	30	76	46
Inland Waters, Va., and N. C	295	24	13,745	142.0	390.0	29	92	53
St. Johns River, Fla	797	28	38,823	387.0	257.0			
Florida Keys	2,091	173	71,540	900.5	123.7	8	13	2
Texas coast	15,829	11,683	145,536	86.0	48.0			
Vicinity of Santa Barbara Islands, Calif	4,618	3,642	22,972					
Coast of Northern California and Oregon	3,214	[1] 2,732	29,538	102.4	4.0	8	14	16
Columbia River, Oreg., and Wash	1,231	43	47,010	189.0	10.0	50	49	221
Southeastern Alaska	2,028	[2] 174	45,494	184.7	399.7	60	173	144
Goodnews Bay, Alaska	16	1	432			2	2	13
Gulf of Alaska	4,983		5,417					
Alaskan Peninsula	6,701	5,460	84,876	92.7	184.5	22	63	15
Aleutian Islands, Alaska	4,031	1,919	58,000	138.0	305.0	98	905	68
Philippine Islands	3,995	618	61,117	7.5	22.0	83	521	49
Total	67,188	34,423	862,200	2,612.8	1,887.9	395	1,914	636

[1] Includes 153 square miles of wire drag.
[2] Includes 18 square miles of wire drag.

On the Atlantic coast the survey vessels *Oceanographer* and *Lydonia* continued hydrographic surveys off New Jersey and Long Island. The successful functioning of the new sono-radio buoys, described in previous reports, made it possible to relieve the *Gilbert* from station-ship duty with these vessels and to assign her to surveys on the south coast of Cape Cod. A special wire-drag survey of reported shoal areas and wrecks along the Atlantic coast, from Cape Henry to Sandy Hook, has been under way since May. The launches *Marindin* and *Rodgers* are being used on the project, under the supervision of the commanding officer of the ship *Oceanographer*.

The *Mikawe* in the summer of 1937 completed the survey of the New Jersey Intracoastal Waterway and during the winter continued surveys of the St. Johns River above Lake George, Fla. The vessel is now engaged on hydrographic surveys in upper Chesapeake Bay.

Small air photographic compilation units continued at Baltimore, Md., Palatka, Fla., and at Norfolk, Va., during the winter months, when personnel were available from ships in port for the annual repair period. Air photographic surveys were made with the Bureau's newly developed nine-lens camera in upper Chesapeake Bay, and in cooperation with the Army, for the Soil Conservation Service, in the High Rock Reservoir area in North Carolina. Use of this nine-lens camera makes possible an increase in efficiency of about 20 percent over former methods in areas of flat terrain. In areas of considerable relief, a specially constructed rectifying camera and a contour plotting machine are used.

Basic surveys were continued by the shore party operating in the vicinity of Key West, Fla.

In the Gulf of Mexico the vessel *Hydrographer*, with the tender *Faris* operating as a subparty, continued hydrographic surveys along the Texas coast.

On the Pacific coast the *Guide* was engaged on inshore and offshore hydrography in the vicinity of Cape Mendocino and wire-drag surveys off Cape Mendocino, Cape Blanco, Point Reyes, and Del Mar. A shore party continued combined operations along the Columbia River. The *Pioneer* completed her assignment on offshore surveys in the vicinity of Santa Barbara Islands in the fall of 1937, and in 1938 transferred to southwestern Alaskan waters for control and other surveys westward from Umnak Island. The *Surveyor*, with the tender *Wildcat*, continued combined operations in the vicinity of Umnak Pass, Alaska, while the *Discoverer*, with the tender *Helianthus*, extended combined operations eastward from Unimak Pass. To and from the working grounds the vessels operating in southwestern Alaska ran sounding lines across the Gulf of Alaska.

A resurvey of part of the approaches to Goodnews Bay was made in cooperation with the Alaska Steamship Co.

In southeastern Alaska the *Explorer*, in 1937, engaged on new surveys in Sumner Strait and tributary arms and revision surveys in Wrangell Harbor, in 1938 taking up combined operations and wire-drag surveys in Sitka Harbor and approaches. In 1937 the *Westdahl*, made new surveys in Stephens Passage and Taku Inlet and in 1938 engaged on surveys in Elfin Cove and Glacier Bay.

The 13 United States Coast Pilot volumes showing the results of field inspections made by this Bureau contain a wide variety of important information supplemental to that shown on the chart, such as a detailed description of the coast and information concerning waterways, as well as maritime data for all the ports of the United States and possessions. These volumes are kept up-to-date by annual supplements and revisions based on supplemental field examinations and new surveys. Ten supplements were published, one new edition was issued, and three volumes were in process of revision during the year. Two field examinations were made in the Intracoastal Waterway, and others were in progress in the Philippine Islands, the Virgin Islands, and Puerto Rico, on which to base other supplements and new editions. The publication Distances Between United States Ports was also completely revised and a number of new tables added.

In the Philippine Islands the *Fathomer* engaged on surveys on the northern coasts of Luzon and the west coast of Palawan. In cooperation with the survey ship *Herald* of the British Navy, a triangulation connection was made between the Sibutu Islands and Borneo. In the spring the *Fathomer* was decommissioned and the *Pathfinder* recommissioned and assigned to work on the southeast coast of Luzon.

GEODETIC WORK

One gravity party was in the field the entire year, except for two short intervals required for standardizing apparatus at the Washington base station. A total of 148 new stations located in 13 States, in places best suited for geodetic purposes and geological studies, was determined and 7 old stations reoccupied.

The two observatories for the determination of variation of latitude, at Ukiah, Calif., and Gaithersburg, Md., have been kept in continuous operation under a cooperative international agreement. The records were sent to the central office of the International Latitude Service, now located in Italy, that the results may be computed with relation to those obtained at other international stations. The following table gives a brief statistical summary of geodetic work accomplished:

Geodetic triangulation, base lines, reconnaissance, and leveling, and astronomical and gravity observations

Locality	Length of scheme	Area
TRIANGULATION, FIRST ORDER		
	Miles	*Square miles*
Amsterdam Avenue base net, New York	4	2
Vicinity of New York, N. Y.	10	2
Soil-conservation area, Utah, Colorado, and Wyoming	495	12,180
Connecticut-Rhode Island boundary, Connecticut and Rhode Island	45	360
Reed base net, Nevada	12	60
Colquitt, Ga., to Laurel Hill, Fla.	145	1,450
Hudson River, N. Y., to Hudson, N. Y.	150	1,550
Baltimore County, Md.	22	180
Earthquake investigation:		
Maricopa, Calif.	16	80
Palmdale, Calif.	15	75
Gorman, Calif.	24	120
Hartford to Torrington, Conn.	24	200
Virgin River area, Utah and Arizona	180	6,000
Total	1,142	22,259
TRIANGULATION, SECOND ORDER		
Arcadia to Fort Ogden, Fla.	17	170
Lake Okeechobee to Fort Myers, Fla.	70	490
Lower Merion Township, Pa.	10	50
Highland to Francis, Fla.	60	600
Soil-conservation area, Utah, Colorado, and Wyoming	950	22,550
Carrabelle, Fla., to Colquitt, Ga.	80	720
Early to Campbellton, Fla.	60	600
Total	1,247	25,180
BASE LINES, FIRST ORDER		
Amsterdam Avenue, New York	4.0	
Lonoke, Ark. (remeasurement)	9.3	
Total	13.3	

Locality	Length of scheme	Area
TRAVERSE, FIRST ORDER		
	Miles	*Square miles*
Earthquake investigation, Maricopa, Calif.	14.4	
RECONNAISSANCE, FIRST ORDER TRIANGULATION		
Amsterdam Avenue base net, New York	4	2
Vicinity of New York, N. Y.	10	2
Colquitt, Ga., to Mobile, Ala.	260	2,695
Baltimore County, Md.	22	180
Soil-conservation area, Utah, Colorado, and Wyoming	495	12,180
Earthquake investigation:		
Cajon Pass, Calif.	9	12
Whitewater, Calif.	7	10
Moreno, Calif.	11	44
Whittier, Calif.	9	36
Inglewood, Calif.	10	50
Palmdale, Calif.	15	75
Gorman, Calif.	24	120
Maricopa, Calif.	16	80
Greenville, Ala., to Cuthbert, Ga.	95	950
Rockford to Roanoke, Ala.	55	550
Fredericktown to Success, Mo.	95	950
Virgin River area, Utah and Arizona	180	6,000
Total	1,317	23,936
RECONNAISSANCE, SECOND ORDER TRIANGULATION		
Kingman, Kans., to Ninaview, Colo.	290	2,900
Highland to Francis, Fla.	60	600
Arcadia to Fort Ogden, Fla.	17	170
Lower Merion Township, Pa.	10	50
Soil-conservation area, Utah, Colorado, and Wyoming	950	22,550
Grantsville-Tooele area, Utah	45	900
Weber River area, Utah	115	2,925
Total	1,487	30,095

State	First order	Second order
LEVELING		
	Miles	*Miles*
California	325	
Colorado	100	287
Idaho	75	101
Louisiana	261	
Maryland	53	7
Mississippi	50	
Montana		404

State	First order	Second order
LEVELING—continued		
	Miles	*Miles*
Nevada	4	39
New Mexico	7	11
Virginia		215
Utah	44	209
Wyoming		115
Total	919	1,388

Geodetic triangulation, base lines, reconnaissance, and leveling, and astronomical and gravity observations—Continued

State	Determinations		State	Determinations	
	New	Repeat		New	Repeat
GRAVITY			GRAVITY—continued		
Alabama	15		North Carolina	23	1
Connecticut	3		Pennsylvania	27	1
Florida	18	2	Rhode Island	4	
Georgia	17		South Carolina	1	
Massachusetts	12	1	Virginia	12	1
New Hampshire	1				
New Jersey	6				
New York	9	1	Total	148	7

The office computation and adjustment of 41 arcs of first-order and 52 arcs of second-order triangulation were completed, and progress made on the computation of an additional 15 arcs of first-order and 19 arcs of second-order triangulation. Office computation was also made of the first-order base along Amsterdam Avenue, in New York City.

The adjustment of the triangulation of the United States on the 1927 North American datum continued rapidly, so that the geographic positions of approximately 60,000 stations have now been computed on that datum. Plane coordinates of approximately 24,000 stations have also been computed.

Personnel detailed to the Washington office by the Chief of Engineers, United States Army, continued on the adjustment of the Mississippi River triangulation from Vicksburg, Miss., to New Orleans, La. By the close of the year adjustments were completed and the preparation of the manuscript was in progress.

The computation of the elevations of bench marks based on the 1929 adjustment of the first-order level net continued. Adjustments were made of numerous small sections in Arkansas, Connecticut, Georgia, Idaho, Oklahoma, Oregon, and Texas. An intensive treatment of the subordinate leveling in Georgia was completed and the descriptions and adjusted elevations of bench marks issued in lithographed form.

Office computations were made of 153 new gravity stations and 8 reoccupied stations. The isostatic reductions were completed for 153 gravity stations determined by this Bureau; 83 stations determined by the Gulf Research & Development Co., data for which were furnished by that organization to this Bureau; and 5 gravity-at-sea stations of the 1936–37 expedition of the United States Navy and the American Geophysical Union. In addition, the isostatic reductions were revised for 214 gravity stations in the United States, because of an improved reduction method giving somewhat better accuracy and because of the availability of better maps.

Three geodetic publications were printed during the year, two giving results of triangulation in Utah and Wyoming and the other containing leveling data for North Carolina.

TIDE AND CURRENT WORK

Tide and current data are required not only for use in this Bureau's surveying and charting activities but for varied navigation and engineering purposes. The tide is the vertical rise and fall of the water. The current is the horizontal movement or flow of the water which accompanies the tide. Each of these movements is of direct practical importance in the divers commercial activities of our waterways.

Automatic tide gages were in operation at 40 primary and 27 secondary stations—35 on the Atlantic coast, 5 on the Gulf coast, 22 on the Pacific coast, 4 in Alaska, and 1 in the Hawaiian Islands. Thirty-one of these were maintained in cooperation with other agencies, including the United States Engineers, the Navy Department, the States of Texas and Delaware, the cities of Santa Monica and Los Angeles, town of Stratford, port of Willapa Harbor, Woods Hole Oceanographic Institution, Chesapeake Biological Laboratory, and University of Washington. Supplementary data for shorter periods were obtained at 115 other stations in connection with hydrographic surveys and other activities.

The tide survey of San Francisco Bay, begun last year, for the precise determination of tidal datum planes and possible changes in the tidal regime in consequence of hydrographic changes, was completed and the survey extended to the Sacramento-San Joaquin delta. Two other tide surveys were carried on in cooperation with the United States Engineers, one of Galveston Bay to furnish data for model studies of channel improvements, and the other of the Connecticut River, for information in connection with studies of flood control.

The ebb and flow of the current must be taken into consideration in problems of harbor improvements, sewage disposal, and navigation. Data for use in the solution of such problems are derived from current observations. During the past year, practically all of the current observations obtained were in connection with hydrographic surveys, data being obtained for only 37 stations, covering a total period of but 148 days. As the current varies from place to place to a much greater extent than the tide, a measurement at one place supplies information for that place only.

Forecasts of the rise and fall of the tide appear in annual tide tables. Tide Tables, Atlantic Ocean, 1939, prepared during the year, gives daily predictions for 55 reference stations including the 6 new stations: Tampa Bay, Fla.; Surinam River Entrance, Surinam; Pernambuco, Brazil; Takoradi, Gold Coast; and Flushing and Hook of Holland, Netherlands. A table of differences is available for obtaining predictions for about 2,400 other places. Tide Tables, Pacific Ocean and Indian Ocean, 1939, contains daily predictions for some 1,800 other places. Predictions for Port Phillip, Australia, were substituted for those for Melbourne and exchanges of tide predictions were continued with England, Germany, France, Canada, India, and the Netherlands.

Advance information regarding the velocity and direction of the current is made available in two annuals: Current Tables, Atlantic Coast, 1939, and Current Tables, Pacific Coast, 1939, both prepared this year. The tables of daily predictions for these publications were typed in the Bureau on a special machine for photographic reproduction, at a saving in printing costs of over $1,500. The logical program to reproduce all of the material in the tide and current tables by the photo offset process is being accomplished as rapidly as available personnel permits.

A special publication on currents was issued, giving detailed results of current surveys in St. Johns River, Savannah River, and Intervening Waterways.

A Manual of Current Observations, prepared for Bureau work, is also of value to engineers engaged on problems involving measurements and analyses of tidal currents.

Compilations of tidal bench marks for Florida and New Jersey, and information concerning those connected during the recent tide and current survey in Los Angeles and Long Beach Harbors, were published. Considerable progress was also made on a revised edition of Tidal Bench Marks, State of Washington, omitting the Columbia River area in Oregon and Washington, to be covered by a separate publication.

Tide notes were prepared and verified for 208 charts and descriptions and elevations of 967 bench marks were furnished for use in hydrographic, geodetic, and other engineering work.

MAGNETIC WORK

With the increasing use of the airplane as a means of transportation over land and sea, magnetic data assume new importance, since the magnetic compass is the controlling directional guide in all aircraft. Each airport should have a magnetic station with necessary auxiliaries for testing the airplane's compass. At present the Bureau has made observations at only five or six airports. There are many large areas in mountainous regions where the declination has not been observed, where pilots have reported areas of local attraction, which should be investigated by making additional magnetic observations.

The needs at sea continue equally important. Owing to the lack of proper equipment, such as nonmagnetic ships, this Bureau is now without sufficient data to give reliable magnetic information for some of the charts. In fact, there have been no observations along our coast lines in this country and Alaska since 1928.

The never-ending demand for magnetic information has been met through correspondence, by publications, by furnishing original or photostatic copies of records, and by broadcasts of magnetic information originating within the Bureau. During the year, the following publications have been issued: Uses of Magnetic Stations, Magnetic Declination in Arkansas in 1935, and United States Magnetic Tables and Magnetic Charts for 1935. The facilities of the computing office in New York City, employing Works Progress Administration personnel, supervised by regular Bureau personnel from the

Washington office, have made it possible to make some headway with the preparation of observatory results for publication.

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

Place	Stations				
	Repeat			Other declination stations	Total
	Old	New	Declination only		
Alaska				37	37
Arkansas			1		1
California				7	7
Connecticut				1	1
Florida				42	42
Kentucky			1		1
Massachusetts				1	1
Michigan	1		2		3
Missouri	1	1	1		3
Montana				2	2
New York				10	10
North Carolina		1			1
Ohio	1				1
Oregon				4	4
Tennessee	1				1
Texas				17	17
Vermont				7	7
Washington				6	6
Total	4	2	5	134	145

SEISMOLOGIC WORK

The seismological work of the Bureau properly deals with furnishing data needed for the solution of practical problems. Earthquakes are located and described by collecting and analyzing noninstrumental and instrumental reports received from many sources. Instruments are maintained in readiness to obtain records of destructive earthquake motions so essential in connection with the design of earthquake resistant structures. For the same reason the natural vibration periods of buildings and other structures and of the ground have been determined, and ground-tilt measured. Measurement of crustal changes by geodetic methods is described elsewhere in this report.

The instrumental data for locating earthquakes are obtained from a number of seismological observatories, of which the Bureau operates 4 directly: San Juan, P. R.; Tucson, Ariz.; Sitka, Alaska; and Ukiah, Calif. (at the International Latitude Station). Six other observatories are operated on a cooperative basis and a number of independent stations make their records available. Many of these records are furnished various organizations for special studies.

Immediate interpretations of the instrumental records are furnished by many stations, so that epicenters are located immediately for all important earthquakes, in cooperation with the Jesuit Seismological Association and Science Service. This preliminary information is of interest to the public and useful to individual stations.

Information regarding earthquakes and related matters appears in form of bulletins and in the annual series of publications entitled "United States Earthquakes." Intensive questionnaire coverage was obtained in the case of 27 earthquakes. More than 2,200 noninstrumental reports on earthquakes were received, covering approximately 450 earthquakes.

Recording of strong motions continued in California, Nevada, Montana, and Panama, and new stations were established at Boulder Dam. Fifty-one instruments were operated in California, 4 in Nevada, 4 in Montana, 1 in Panama, and 3 at Boulder Dam, and 2 instruments were held in reserve at Washington, D. C., and 1 at Chicago.

Tests of accelerographs on a shaking platform at the Massachusetts Institute of Technology, to appraise instrumental performance and methods of analysis, are still under way. Important conclusions have already been reached.

Twenty-one vibration tests were made in 3 buildings, and 61 ground tests at 51 locations. Shaking table tests were made on 12 instruments, supplying 730 test records. At the close of the year plans were under way to make ground vibration observations for the Navy in the San Francisco Bay area.

Three tilt meters were kept in operation with the cooperation of the University of California, and 1 used for experimental work.

PERSONNEL AND FINANCES

With a personnel of 1,135 on June 30, 1938, 345 were on duty in the Washington office (18 commissioned and 327 civilian), and 790 in the field service (158 commissioned and 632 civilian). The civilian employees in the field included 435 seamen and 127 hands, of which number 51 civilians on duty at the Manila office and 50 members of the crew of the ship *Fathomer* are paid by the Philippine insular government but under the jurisdiction of this Bureau.

The library and archives acquired during the year 114 hydrographic and 102 topographic sheets, representing new Bureau surveys. Other additions were 1,089 blueprints (mostly surveys by Army Engineers); 2,719 maps; 1,345 charts; 7,096 field, office, and observatory records; 250 negatives; 609 prints; 251 lantern slides; 898 books; and 3,819 periodicals.

Collections on account of the sale of nautical charts and other publications, deposited in the Treasury Department to the account of miscellaneous receipts, totaled $109,871.32, as compared with $109,659.29 during the preceding year.

The regular appropriations for the year totaled $2,649,400. These were supplemented by the following additional appropriations: Transfer from Salaries and Expenses, Soil Conservation Service (transfer to Commerce), 1938, $74,450; Working Fund (War, Flood, Mississippi River and Tributaries), $8,500; Working Fund (Navy, Maintenance, Yards and Docks), 1938, $1,2000; and an allotment from the Department of Commerce for travel of $22,830.

Disbursements during the year ended June 30, 1938, totaled $2,677,085.83, distributed among the various appropriations as follows:

Party expenses, 1936	$180.20
Repairs of vessels, 1936	90.00
Pay, etc., officers and men, vessels, 1936	158.92
Pay and allowances, commissioned officers, 1936	403.23
Party expenses, 1937	86,193.20
Repairs of vessels, 1937	12,982.77
Pay, etc., officers and men, vessels, 1937	102,950.02
Pay and allowances, commissioned officers, 1937	74,171.11
General expenses, 1937	27,904.42
Maintenance of air navigation facilities, 1937	6,412.32
Salaries, 1938	566,447.06
Field expenses, 1938	372,582.49
Repairs of vessels, 1938	55,483.24
Pay, etc., officers and men, vessels, 1938	453,792.73
Pay and allowances, commissioned officers, 1938	708,544.14
General expenses, 1938	48,464.27
Aeronautical charts, 1938	97,474.55
National Industrial Recovery, 1933–39	3,579.19
Working Fund, Commerce, C. and G. Survey (Hospital and Domiciliary Facilities and Services, V. A.)	516.77
Salaries and Expenses, Soil Conservation Service (transfer to Commerce, C. and G. Survey, Act of Apr. 27, 1935), 1937	1,005.37
Salaries and Expenses, Soil Conservation Service (transfer to Commerce, C. and G. Survey, Act of Apr. 27, 1935), 1938	43,943.72
Traveling expenses, Department of Commerce, 1938	11,031.33
Working Fund, Commerce, C. and G. Survey (War, Flood Control, Mississippi River and Tributaries)	2,774.78
Total	**2,677,085.83**

U. S. GOVERNMENT PRINTING OFFICE: 1939