[Reprinted from the Annual Report of the Secretary of Commerce, 1939]

COAST AND GEODETIC SURVEY

The Coast and Geodetic Survey carries on extensive surveying operations in all coastal waters of the United States and its possessions and produces the charts required for the safe navigation of coastal and intracoastal waters; compiles aeronautical charts to meet the needs of the pilots of aircraft; makes seismological studies for use in designing structures to reduce the earthquake hazard; determines geographical positions and elevations along the coasts and throughout the interior in order to provide a basic framework for mapping and other engineering work; studies tides and currents and establishes datum planes for engineers and tide-and-current predictions for mariners; observes the earth's magnetism in all parts of the country for information essential to the mariner, aviator, land surveyor, radio engineer, and others; and makes gravitational and astronomical observations and obtains fundamental data for geodetic surveys and scientific investigations of the earth's crust.

Besides the Washington main office, there are field stations located at Boston, New York, New Orleans, San Francisco, Seattle, Honolulu, T. H., and Manila, P. I.; observatories at Gaithersburg and Cheltenham, Md., San Juan, P. R., Tucson, Ariz., Ukiah, Calif., Sitka, Alaska, and Honolulu, T. H.; numerous primary tide stations along our coasts; and a number of stations maintained for various purposes by the Survey in cooperation with other Federal and private agencies.

To the maritime public and to official maritime services, there was an increase in issue of navigational publications of 10.8 percent over 1938. This was 183 percent as compared with the issue of such publications a decade ago. The distribution of nautical charts continued in heavy volume only slightly less than the record distribution of last year. The extension of aerial facilities and the growing desire for knowledge of aerial navigation and the proper use of aeronautical charts was responsible for an increase in the distribution of such charts amounting to 22½ percent over the previous year. These figures are especially remarkable in light of the knowledge that the 1938 issue of both nautical and aeronautical charts was an all-time record.

The annual issue of aeronautical charts was 366,353, exceeding all previous years in the history of the Bureau, while the annual issue of nautical charts was 350,062.

The activities of the Bureau continued to be affected by the increased activities of other agencies. The Lighthouse Service continued actively the construction and installation of new and better aids to navigation. Extensive work was accomplished by the U. S. Engineers in dredging and improving waterways. Especially active

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

ERRATA NOTICE

One or more conditions of the original document may affect the quality of the image, such as:

Discolored pages
Faded or light ink
Binding intrudes into the text

This has been a co-operative project between the NOAA Central Library, the Office of Coast Survey and the National Geodetic Survey. To view the original document please contact the NOAA Central Library in Silver Spring, MD at (301) 713-2607 x124 or www.reference@nodc.noaa.gov.

LASON
Imaging Contractor
12200 Kiln Court
Beltsville, MD 20704-1387
March 22, 2005

was the Civil Aeronautics Authority in marking new air routes and re-marking old ones. Almost all the radio ranges in the country were improved or realigned to an extent which rendered our previous charts obsolete. While all these improvements are exceedingly beneficial to the marine and aviation industries, they do add materially to Bureau work in the revision of its charts and necessitate frequent issues of new editions.

The Bureau had a personnel of 1,125 on duty at the close of June 30, 1939—353 (17 commissioned and 336 civilian) on duty in the Washington office and 772 (159 commissioned and 613 civilian) in the field service. The field personnel included 417 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* were under the jurisdiction of this Bureau but were paid by the Philippine Government.

Acquisitions by the library and archives included 316 hydrographic and 130 topographic sheets, representing new Bureau surveys; 1,182 blueprints (mostly surveys by Army Engineers); 2,563 maps; 1,073 charts; 9,595 field, office, and observatory records; 493 negatives; 1,365 prints; 275 lantern slides; 3,500 books; and 4,371 periodicals.

Collections covering miscellaneous receipts, including nautical and aeronautical charts and publications, totaled $109,950.44, as compared with $109,871.32 during the preceding year.

The regular appropriations for 1938 were $2,665,550. These were supplemented by additional funds, making a total available for obligation of $4,803,600. The supplemental funds were as follows: Transfer from salaries and expenses, Soil Conservation Service (transfer to Commerce) 1939, $35,500; working fund (War: Flood Control, Mississippi River and Tributaries), $18,000; working fund (Navy: Maintenance, Yards and Docks) 1939, $4,600; working fund (War: Rivers and Harbors), $6,000; Public Works Administration, act of 1938 (allotment to Commerce, Coast and Geodetic Survey) 1938–40, $2,051,000; and an allotment from the Department of Commerce for travel of $22,950.

Actual disbursements during the year ended June 30, 1939, totaled $3,517,283.83, distributed among the various appropriations as follows:

Party expenses, 1937	$197.30
Pay, etc., officers and men, vessels, 1937	87.57
General expenses, 1937	.75
Field expenses, 1938	94,785.29
Repairs of vessels, 1938	6,705.71
Pay, etc., officers and men, vessels, 1938	122,872.40
Pay and allowances, commissioned officers, 1938	88,087.59
General expenses, 1938	5,478.23
Aeronautical charts, 1938	9,328.89
Salaries and expenses, Soil Conservation Service (transfer to Commerce, Coast and Geodetic Survey, act of Apr. 27, 1935), 1938	17,566.62
Traveling expenses, Department of Commerce, 1938	8,442.43
Working fund, Commerce, Coast and Geodetic Survey (Navy: Maintenance, Yards and Docks), 1938	1,200.00
Salaries, 1939	579,869.88
Repairs of vessels, 1939	56,464.68
Pay of officers and men, vessels, 1939	420,558.52
Pay and allowances, commissioned officers, 1939	679,820.87
Aeronautical charts, 1939	95,928.86
Coastal surveys, 1939	198,338.86
Research, tides, currents, etc., 1939	11,365.80
Coast Pilot, 1939	3,909.38
Magnetic and seismological work, 1939	54,108.23

Federal, boundary, and State surveys, 1939	$69, 985. 11
Miscellaneous objects, 1939	3, 498. 96
Office expenses, 1939	59, 198. 39
Public Works Administration, act of 1938 (allotment to Commerce, Coast and Geodetic Survey), 1938–40	848, 973. 60
Traveling expenses, Department of Commerce, 1939	17, 688. 52
Working fund, Commerce, Coast and Geodetic Survey (Navy: Maintenance, Yards and Docks), 1939	4, 593. 55
Salaries and expenses, Soil Conservation Service (transfer to Commerce, Coast and Geodetic Survey, act of Apr. 27, 1935), 1939	34, 588. 98
Working fund, Commerce, Coast and Geodetic Survey (War: Flood Control, Mississippi River and Tributaries)	23, 638. 86
Total	3, 517, 283. 83

CHART PRODUCTION

There were issued during the year 81 new editions of 77 different charts, and 420 new prints of 361 different charts. In addition to the revised editions and to meet the new requirements of marine commerce in places where new and detailed surveys have been made recently, the 7 new nautical charts listed below were issued during the year:

TEXAS.—No. 593. Freeport Harbor.
SOUTH CAROLINA.—No. 787. Winyah Bay.
FLORIDA.—No. 1264. Choctawhatchee Bay.
LOUISIANA.—No. 1274. Timbalier and Terrebonne Bays.
LOUISIANA.—No. 1276. Point au Fer to Marsh Island.
PHILIPPINE ISLANDS.—No. 4228. Digollorin Point to Cape Engano.
CALIFORNIA.—No. 5101A. San Diego to Santa Rosa Island.

The total number of charts on issue at the year's end was 794, of which 163 were compiled and printed at Manila. At the end of the fiscal year the Division of Charts was compiling 5 new charts and recompiling 5 old charts; engraving 7 new charts and reengraving 5 old charts; and reproducing by lithography 6 new charts.

An outstanding accomplishment of the year was the issue of nautical chart 5101A. This chart is an innovation, being the first of its kind to be especially prepared and issued for the use of commercial and naval vessels equipped with echo-sounding devices. It contains comparatively few numerical depths, the conformation of the bottom over the entire area covered being given by depth curves at 50-fathom intervals. The result is to bring out the steep slopes and broad plateaus of the bottom topography, with its submerged valleys and mountain ranges, as clearly as a well contoured map of land area shows similar features ashore.

The increase in the demand for aeronautical charts by civil and military aviation has paralleled the continued unprecedented growth of the aviation industry. This can be expected to accelerate during the next few years rather than stabilize, because of the expanded programs of the military forces and the Civil Aeronautics Authority. In order to maintain the accuracy of the aeronautical charts where the establishment of new airways and the construction of new airports and new facilities have made important changes, there were printed 106 new editions of 79 different charts and 64 new prints of 44 different charts.

In addition to the revised editions, there were prepared and issued during the year the following five new aeronautical charts:

KENAI. Alaska. Kenai Peninsula and vicinity.
6M. Regional. Northeast of San Francisco.
8M. Regional. Northwest of St. Louis.
21DF. Direction Finding. Northwest portion of United States.
22DF. Direction Finding. North Central portion of United States.

At the close of the year there were available 98 aeronautical charts of the United States and Alaska and 3 airway maps of the Philippine Islands. These include the entire series of 87 sectional aeronautical charts of the United States, 6 regional charts, and 4 direction-finding charts of the same area, and 1 chart of Alaska. In progress are 8 regional and 2 direction-finding charts, 1 chart of Alaska, and 1 special aeronautical chart of the metropolitan New York area.

During the year the Secretary approved the appointment of recognized dealers for the distribution of aeronautical charts. Fifty of these have been appointed at the major airports.

The manual Practical Air Navigation has continued to increase in popularity. The second edition, mentioned in the annual report for 1938, was exhausted within a few months. Of a reprint of 10,000 copies, delivered during the latter half of March, only 1,700 remained at the end of the year. A third and revised edition now in preparation will be used by the Civil Aeronautics Authority in an extensive pilot-training program.

The demands on the Division can be best illustrated by the fact that the number of printing-press impressions during the fiscal year totaled 8,105,105. This is in comparison with 7,099,304 for the preceding year and vastly exceeds any other year in the Bureau's history. As recently as 5 years ago, the number of press impressions was approximately 2,000,000. The steady and substantial growth in the demand for nautical and aeronautical charts and related publications is shown in the following table containing the statistics for these publications for the past 4 years.

Item	1939	1938	1937	1936
Nautical charts	350,062	351,150	333,366	275,800
Aeronautical charts	366,353	299,094	277,878	178,973
Strip maps				12,186
Air planimetric maps	5,450	6,705	4,544	4,236
Miscellaneous	4,747	3,241	3,166	2,857
U. S. Coast Pilots	7,441	10,842	8,062	6,167
Intracoastal Waterway Pilots	869	1,008	1,463	1,022
Distances Between United States Ports	931	529	559	429
Tide Tables	25,519	24,299	24,567	24,184
Current Tables	10,678	9,769	9,114	9,002
Tidal Current Charts	2,104	1,631	1,628	1,607
Practical Air Navigation	14,507	3,798	1,837	5,167
Total	788,661	712,066	666,184	521,630

HYDROGRAPHY AND TOPOGRAPHY

On the Atlantic coast the survey vessels *Oceanographer* and *Lydonia* continued work on the offshore hydrographic project extending from the New Jersey coast to *Nantucket Lightship*. The special wire-drag investigations of wrecks and critical soundings along the Atlantic coast from Cape Henry to Sandy Hook was continued under the supervision of the commanding officer of the ship

Oceanographer. The launches *Marindin* and *Rodgers* were used on this project.

The *Gilbert* continued work on surveys along the south coast of Cape Cod. During the late winter and early spring this vessel was engaged on special surveys for Navy anchorages in the Hudson River.

The *Mikawe* in the summer of 1938 completed the upper Chesapeake Bay hydrographic project and during the winter of 1939 completed the St. Johns River, Fla., hydrographic project. In the spring of 1939 the *Mikawe* began inshore surveys along the south coast of Cape Cod.

Schemes of second-order coordinating triangulation were extended up the James River, from Newport News to the vicinity of Hopewell, Va., and along the eastern shore of Chesapeake Bay, in the vicinity of Kent Island and the lower Chester River. A similar scheme was begun on the northern shore of Long Island, extending eastward from Oyster Bay.

A shore party at Key West, Fla., completed the new basic surveys of the Florida coast as far west as Key West Harbor. In June 1939 this party shifted operations to Choctawhatchee Bay, Fla. The new project consists of a survey of the eastern half of the bay and of the Intracoastal Waterway between Fort Washington and West Bay.

Small air-photographic compilation units were continued at Baltimore, Md., and Palatka, Fla. Experience with air-photographic surveys in advance of inshore hydrography has proved so timesaving and otherwise efficient 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, continued hydrographic surveys along the Texas coast.

On the Pacific coast the ship *Guide* in 1938 engaged in surveys of the northern California coast. A wire-drag party also continued surveys along this coast.

In the spring of 1939 the *Explorer* started a project of revision surveys of tributaries to the northern part of Puget Sound in the vicinity of Anacortes and Bellingham, Wash.

The project of revision surveys of the Columbia River from its mouth to Vancouver, Wash., begun in 1935, was completed and a scheme of second-order triangulation was extended eastward to The Dalles, Oreg. An arc of second-order triangulation was begun along the Washington coast from the mouth of the Columbia River to Grays Harbor. A revision survey of Willapa Bay, Wash., was in progress at the end of the year.

In southeastern Alaska in 1938, the *Explorer* completed a new survey of Sitka Harbor and immediate approaches, including the wire-dragging of the principal channels in this area and then continued work on the new surveys in Sumner Strait and tributary arms. On account of her age, the *Explorer* was withdrawn from Alaskan surveys at the end of the 1938 season. The *Westdahl* continued work on original hydrographic surveys in Glacier Bay.

In southwestern Alaska the *Surveyor*, assisted by the tender *Wildcat*, extended surveys along the coasts of Unalaska and Umnak Island and in cooperation with the *Pioneer* extended advance triangulation

control as far westward as the Islands of Four Mountains. The *Pioneer* accomplished offshore hydrography in the vicinity of the Islands of Four Mountains and conducted astronomic, gravimetric, and magnetic observations at Dutch Harbor and Nazan Bay. The *Discoverer*, assisted by the tender *Helianthus*, continued surveying operations along the south coast of Unimak Island and the Alaska Peninsula. The *Guide* joined the Alaskan fleet in the spring of 1939 and began original surveys along the north coast of Unimak Island, extending from Cape Saricheff northeastward along the Alaska Peninsula, toward Bristol Bay.

In the Philippine Islands the *Pathfinder* continued original surveys along the west coast of Palawan, revision surveys in Verde Island Pass, and supplemental surveys along the west coast of Luzon.

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

Under an allotment of $1,425,000 from Public Works Administration funds, contracts were awarded for the construction of one main and one auxiliary survey vessel. These two modern units will be completed early in 1940 and assigned to surveys in the Aleutian Islands.

The 13 United States Coast Pilot volumes 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 the waterways, as well as maritime data for the ports of the United States and possessions. These volumes are kept current by annual supplements and revisions. New editions of Coast Pilots are published as often as is warranted by the number of changes that have been made and the amount of new information available. Three supplements were published during the fiscal year. Field examinations were completed for new editions of three Coast Pilots (Puerto Rico and the Virgin Islands; Philippine Islands, part I; and Philippine Islands, part II), and the manuscripts prepared. A new edition of the Alaska Coast Pilot, part II, was published.

A brief outline on the various field projects covered by this Division in hydrographic, topographic, and coastal triangulation surveys, together with statistics of the amount of work accomplished under each survey 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	1,742	72	55,367	201	40			
North coast of Long Island						25	64	74
Hudson River	980	11	95,255					
Atlantic coast east of Fire Island	15,207	11,425	154,106	14				8
New Jersey coast	2,793	1,082	27,605					
Chesapeake Bay	3,575	143	131,290	217	150	25	57	62
James River, Va						50	150	156
St. Johns River, Fla	778	35	42,065	545	290			
Florida keys	1,552	145	56,382					4
Choctawhatchee Bay, Fla	123	5	3,838	5				
Texas coast	18,115	18,074	204,222	107	30	6	6	9
Coast of northern California	1,899	1,083	11,788	11		12	15	11
Columbia River and coast of Washington	692	20	34,790	104		144	1,022	629
Willapa Bay, Wash				70			11	13
Northern Puget Sound	245	14	8,027	41	23	10	15	29
Southeastern Alaska	2,128	86	68,593	144	69	91	262	126
Gulf of Alaska	6,890		11,110					
Alaskan Peninsula	10,628	5,921	123,557	143	375	29	75	11
Aleutian Islands, Alaska	6,887	7,256	86,879	562	382	128	1,130	125
Philippine Islands	15,167	3,370	200,141	101	47	31	191	54
Total	89,461	48,742	1,315,015	2,265	1,406	551	2,998	1,311

GEODETIC WORK

The geodetic work of the Bureau provides data in the form of latitudes, longitudes, elevations, azimuths, and distances, indispensable for mapping, for all classes of public works which deal with the land and for plans for the development and use of our natural resources.

Among the most important uses of control surveys, one that has been stressed but little in former reports is the use made by individuals of the triangulation stations as reference points for real estate as a certain means of perpetuating the boundaries of these holdings. Problems concerned with property boundaries, crop acreage, drainage, and the prevention of soil erosion with which various agencies dealing with agricultural-adjustment problems are concerned, particularly during recent years, are all more and more dependent on adequate maps, based on this Bureau's control surveys.

Five double-observing triangulation parties and three triple-unit level parties operated throughout most of the year, the work being done in 34 States.

Several circuits of triangulation and leveling, left unclosed by curtailment of funds in July 1935, were completed through an allotment of $490,000 of Public Works Administration funds for field geodetic surveys to supplement the control surveys of this Bureau, and the extension of operations into areas needing most urgent attention.

Some work was also done with the small regular appropriation and by the cooperation of other organizations furnishing funds necessary for the extension of control work.

One gravity party was in the field the entire year, except for one short interval required at the Washington office to test the apparatus.

An astronomical party also determined two gravity stations on the Aleutian Islands, Alaska, in addition to its regular work.

During the entire fiscal year this Bureau sponsored a computing office project in New York City as a Works Progress Administration project, with an average employment of 150 relief personnel. Adequate supervision was provided by the assignment of experienced officers and mathematicians from the permanent force. This office was also of material assistance in processing the large amount of field survey data resulting from the expanded program of 1933 to 1935.

On January 3, 1939, this Bureau initiated an office in Philadelphia, Pa., as a Works Progress Administration project, and at the end of June 1939 about 150 people were employed. Supervision was provided by details from the permanent staff.

Latitude observatories at Ukiah, Calif., and Gaithersburg, Md., which are maintained by this Bureau under international agreement for the determination of variation of latitude, were in continuous operation.

The following table gives a brief statistical summary of geodetic operations.

Geodetic work

Locality	Length of scheme	Area	Locality	Length of scheme	Area
FIRST-ORDER TRIANGULATION	*Miles*	*Square miles*	FIRST-ORDER TRIANGULATION—continued	*Miles*	*Square miles*
Grantsville-Tooele area, Utah	45	900	Jackson, Ala., to Bassfield, Miss.	85	850
Erie to Boalsburg, Pa.	155	1,705	Greensburg to Kingman, Kans.	70	700
Weber River area, Utah and Wyo.	115	2,925	Manville to Thermopolis, Wyo.	180	2,520
Frazee to Remer, Minn.	70	700	Mason to Forest City, S. Dak.	165	2,310
Long Prairie to Bemidji, Minn.	115	1,230	West Point to Winona to Greenville, Miss.	170	1,600
Manti area, Utah	85	1,700	Marshall, Okla., to Siloam Springs, Ark.	140	1,400
Minot to Westhope, N. Dak.	60	600	Centerville to Marshfield, Mo.	95	950
Hudson River, Hudson to Albany, N. Y.	60	660	Angle to Laurel Hill, La.	90	720
Beaver River area, Utah	95	1,820	Mexican boundary to Riverside, Calif.	220	3,080
Laurel Hill, Fla., to Mobile, Ala. (including Niceville to Laurel Hill, Fla., and Pensacola to Century, Fla.)	180	1,620	Mexican boundary to Baldwin Lake, Calif.	305	4,380
Muddy River area, Utah	140	2,755	Warm Springs to Strawberry, Nev.	130	1,560
Waverly to Pocahontas, Iowa	120	1,200	Featherville to Stanley, Idaho	50	1,000
Thomson to Polo, Ill.	15	180	Monroe County, N. Y.	30	800
Circleville to Fairhaven and Wilmington to Springfield, Ohio	125	1,280	Hornell to Owego, N. Y.	95	1,140
Dudley to St. Marys, Mo., and Scopus, Mo., to Elco, Ill.	130	1,560	Bolivar to Sheldon, Mo.	65	780
Fredericktown to Ironton, Mo.	40	480	Rockport to Waverly, Ill.	50	500
Vicinity of Selma, Ala.	23	80	Holton to Muncie, Ind.	80	720
Lonoke, Ark., to Monroe, La., and Monticello to Arkansas City, Ark.	205	2,050	Liberty to Stilesville, Ind.	85	765
Mobile to Demopolis, Ala.	155	2,480	Total	5,147	70,511
Earthquake investigation, Brea, Calif.	9	36	SECOND-ORDER TRIANGULATION		
Fields to Crane, Oreg.	90	1,800	Queen Creek area, Ariz.	60	1,320
Vicinity of Crater Lake, Oreg.	240	6,175	Kentwood to Garyville, La.	55	500
Lookout Mountain to Stanley, Idaho	50	1,100	Corpus Christi to Brownsville, Tex.	140	840
Earthquake investigation, Point Reyes to Petaluma, Calif.	50	1,500	San Clemente Island, Calif.	3	3
Demopolis to Russellville, Ala.	145	2,030	Vicinity of Coronado, Calif.	2	2
Winslow to Winkelman, Ariz.	110	1,430	Vicinity of Riverside, Calif.	15	45
Silver City, N. Mex., to Nogales, Ariz., and Paradise, Ariz., to Deming, N. Mex.	295	3,540	Westinghouse Time Capsule, N. Y.	3	3
Childersburg, Ala., to West Point, Miss.	120	1,200	Total	278	2,713
			SECOND-ORDER BASE LINE		
			Coronado, Calif.	0.8	

Geodetic work—Continued

Locality	Length of scheme	Area
FIRST-ORDER TRAVERSE	*Miles*	*Square miles*
Earthquake investigation, Palmdale, Calif.	10.4	
Earthquake investigation, Gorman, Calif.	9.7	
Total	20.1	
FIRST-ORDER RECONNAISSANCE		
Manti area, Utah	85	1,700
Coalville to Mt. Lovenia, Utah	30	300
Hayward, Wis., to Baraga, Mich.	155	2,325
Oquawka to Galesburg, Ill.	30	300
Orr to Namakan Lake, Minn.	35	525
Beaver River area, Utah	95	1,820
Muddy River area, Utah	140	2,755
Thomson to Polo, Ill.	15	180
Rockport to Waverly, Ill.	50	500
Southwestern California	525	7,460
Success to Marshfield, Mo.	40	560
Laura to Watseka, Ill.	100	1,100
Angie to Laurel Hill, La.	85	680
Vicinity of Crater Lake, Oreg.	240	6,175

Locality	Length of scheme	Area
FIRST-ORDER RECONNAISSANCE—continued	*Miles*	*Square miles*
Washington County, Miss.	40	360
Winslow to Winkelman, Ariz.	110	1,430
McKittrick to Fresno, Calif.	180	3,960
Santa Barbara to Maricopa, Calif.	40	1,000
Sacramento to Round Top, Calif.	140	3,125
Hagerstown to Parkton, Md.	55	550
Thurmont to Point-of-Rocks, Md.	25	250
Sacramento River Valley, Calif.	270	5,300
Total	2,485	42,355
SECOND-ORDER RECONNAISSANCE		
Queen Creek area, Ariz.	60	1,320
Corpus Christi to Rio Grande, Tex.	135	1,080
Lucerne Valley to Helendale, Calif.	30	600
Wilsona to Fairmont, Calif.	60	1,050
Kentwood to Garyville, La.	55	500
Fairmont to Santa Barbara, Calif.	50	1,200
Total	390	5,750

State	First order	Second order
LEVELING	*Miles*	*Miles*
Arizona	10	204
Arkansas	115	159
California	524	1,141
Colorado	184	160
Idaho	15	177
Illinois	73	82
Indiana	69	96
Kansas		182
Kentucky	7	126
Louisiana	521	165
Maryland	15	16
Michigan	1	166
Minnesota	95	135
Mississippi	406	33

State	First order	Second order
LEVELING—continued	*Miles*	*Miles*
Missouri	6	163
Montana	8	61
Nebraska	63	811
Nevada		114
New Mexico	23	505
North Dakota	34	444
Ohio	26	1
South Dakota		358
Texas	93	560
Virginia		57
Wisconsin		70
Wyoming	43	150
Total	2,331	6,196

State	Determinations		
	Latitude	Longitude	Azimuth
ASTRONOMY			
Alabama	1	1	1
Alaska	1	2	2
Arkansas	1	1	1
Indiana			1
Louisiana	1	1	1
Nevada			1

State	Determinations		
	Latitude	Longitude	Azimuth
ASTRONOMY—con.			
New Mexico	1	1	1
New York	2	2	1
Texas			1
Total	7	8	10

State	Determinations	
	New	Repeat
GRAVITY		
Alaska	2	
Arizona	17	1
California	25	
Delaware	2	
Idaho	8	
Illinois	1	
Kansas	3	2
Maryland	8	1
Missouri	1	
Nevada	2	

State	Determinations	
	New	Repeat
GRAVITY—continued		
New Jersey	31	
New Mexico	3	
Oklahoma	14	5
Pennsylvania	2	
Texas	8	3
Virginia	3	
Wyoming	5	
Total	135	12

TIDE AND CURRENT WORK

Forty-six primary and 37 secondary tide stations were in operation: 38 on the Atlantic coast; 1 each in Bermuda, the Bahamas, and Cuba; 7 on the Gulf coast; 29 on the Pacific coast; 5 in Alaska; and 1 in the Hawaiian Islands. Of these, 40 were conducted in cooperation with other agencies including the U. S. Engineers, the Navy Department, Territory of Hawaii, City of New York, City of Santa Monica, City of Los Angeles, Port of Willapa Harbor, Woods Hole Oceanographic Institution, Chesapeake Biological Laboratory, and the University of Washington. Shorter periods of observation at approximately 100 additional stations were obtained in connection with hydrographic surveys and other activities.

Added emphasis has been placed on the tide and current work of the Bureau by the expansion of our Navy and merchant marine, as well as by the increasing commercial value of water-front property and the extension of oil fields to tidal waters.

Tide and current predictions and tidal current charts are an indispensable aid to navigation. Tidal datums are essential for harbor improvements, industrial planning, and the determination of boundaries of tide lands, as well as for use in the Bureau's surveying and charting operations. Basic data for these various purposes are derived from tide and current observations.

The tide survey of the Sacramento-San Joaquin Delta, for the precise determination of tidal datum planes and the investigation of changes in the tidal regime resulting from hydrographic changes, was continued throughout the year. The Connecticut River tide survey, in progress at the beginning of the fiscal year, was interrupted by the September 1938 floodwaters. The gages were reestablished in March 1939 and the project is now being continued in cooperation with the U. S. Engineers.

A Public Works Administration grant made possible the needed reconstruction and modernization of 40 of the principal tide stations.

No current surveys were conducted during the year. Some observations were secured by hydrographic parties and by cooperation from other agencies; three stations were occupied in Lower Bay, New York Harbor, in cooperation with the U. S. Engineer Office in New York. Through cooperation with the Lighthouse Service, hourly observations were obtained at Fire Island Lightship throughout the year and at Ambrose Channel and Scotland Lightships for a period of 4½ months. Cooperation was also extended to the Louise A. Boyd Arctic Expedition, 1938, which secured current observations at three localities in Greenland Sea. There are numerous localities along our coasts for which no information is available regarding the ebb and flow of the current. To meet the needs for such information, not only of navigation but also of engineering, fishing, and other interests, the program of making systematic current surveys should be resumed.

The demand for tide and current information was met through correspondence, tide and current tables, and miscellaneous publications, the latter including Tide Tables, Atlantic Ocean, 1940; Tide Tables, Pacific Ocean and Indian Ocean, 1940; Current Tables, At-

lantic Coast, 1940; Current Tables, Pacific Coast, 1940; reprint of Special Publication No. 208, Currents in Narragansett Bay, Buzzards Bay, and Nantucket and Vineyard Sounds; reprint of Special Publication No. 135, Tidal Datum Planes; revised editions of Tidal Current Charts for San Francisco Bay and Boston Harbor; and Tidal Bench Marks for the States of Washington, Alabama, Texas, and North Carolina. There was also issued a pamphlet covering the results of current observations taken in San Pedro Channel, Calif.

The reciprocal agreements between the United States and England, Germany, France, Canada, India, and the Netherlands for exchange of tide predictions for tide tables were continued.

In addition to the tabulation and reduction of tide and current observations and the prediction of tides and currents, tide notes were prepared and verified for 310 charts, planes of reference verified in 738 volumes of soundings, and descriptions and elevations of 585 bench marks furnished for use in connection with hydrographic, geodetic, and other engineering projects.

MAGNETIC WORK

The magnetic work of the Bureau consists of making observations and keeping records of the changes in the earth's magnetism. Changes in direction of the compass needle are of primary importance to the navigators on the seas and in the air, and to the surveyor in the location of boundaries previously surveyed with the compass. The changes in the horizontal and vertical intensities are of importance to the geophysical prospector in the location of natural resources and to investigators of radio transmission and for purely scientific studies.

The picture of magnetic declination for the United States is being greatly improved by observations obtained by magnetic observers attached to geodetic parties. The constant finding of new areas of local disturbance increases the importance of making magnetic surveys of the large areas about which no magnetic information is available. The Bureau is called on frequently to furnish certified compass data for use in court in the adjudication of boundaries and must continue to observe the magnetic elements in order to meet this requirement. The lack of a nonmagnetic ship makes the data furnished for this purpose and for nautical charts more and more unreliable, as accurate magnetic data cannot be determined with steel ships. Any uncertainty is a potential danger to life and property at sea.

Magnetic data were supplied for 170 printings of nautical charts. Publications issued during the year included a corrected edition of Serial No. 166, Directions for Magnetic Measurements; reprint of Special Publication No. 96, Instructions for the Compensation of the Magnetic Compass, for which there has been a large demand by other Government agencies; supplementary tables to bring Special Publication No. 117, The Earth's Magnetism, up to date; and Results for the Tucson Magnetic Observatory for 1929–30. The reduction and preparation for publication of Polar Year magnetic records were continued.

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

State or Territory	Magnetic observations				
	Repeat			Other declination stations	Total
	New—complete	Old			
		Complete	Declination only		
Alabama				29	29
Alaska	1	2		54	57
Arizona				47	47
Arkansas				33	33
California		1		114	115
Colorado			3		3
Florida	2	3	1	5	11
Georgia		1			1
Illinois				31	31
Indiana				23	23
Iowa				31	31
Kansas		2	2	15	19
Kentucky			1		1
Louisiana		[1] 1		63	64
Maine				5	5
Massachusetts				1	1
Michigan		1	3		4
Minnesota		1	1	46	48
Mississippi			1	47	48
Missouri				79	79
Montana	2	4	1		7
Nebraska			1		1
Nevada	1			23	24
New Mexico				34	34
New York				1	1
North Carolina				1	1
North Dakota		2	2	15	19
Ohio	[2] 2		1	10	13
Oklahoma				18	18
Oregon				39	39
Pennsylvania			1	16	17
South Carolina	1	1			2
South Dakota			1	30	31
Tennessee		1			1
Texas				53	53
Utah	1			95	96
Vermont				17	17
Virginia				1	1
Washington	1	1			2
West Virginia			1		1
Wisconsin			2		2
Wyoming		1	2	42	45
Total	11	22	24	1,018	1,075

[1] Declination and horizontal intensity only.
[2] Dip not observed at one of these stations.

SEISMOLOGY

The 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 cooperating with other Government agencies, scientists, and educational institutions in the study of causes and effects of earthquakes, so that means of safeguarding life and property from them can be devised.

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, three of which installed the instruments the past year. A number of

independent stations sent their records to the Bureau for study and interpretation.

Fifty-eight strong-motion seismographs for the recording of strong local shocks were maintained at 50 stations, and 16 records were obtained for 11 semidestructive earthquakes.

One hundred forty-four vibration tests were made in 5 buildings, and 172 ground-period tests at 80 locations. Similar work was done for the Navy Department at certain Navy bases. Shaking table tests were made on 7 instruments, thus obtaining approximately 400 records. Recording of fault noises in two deep wells was carried on intermittently throughout the year. Three tilt meter stations were maintained.

Intensive questionnaire coverage was obtained for 24 earthquakes of semidestructive character, and over 2,300 reports on approximately 400 earthquakes were received.

The seismological data are published in an annual report entitled "United States Earthquakes" and mimeographed quarterly reports. Many institutions requested photostat copies or loan of the original records.

NEW AND IMPROVED METHODS AND EQUIPMENT

The Dorsey Fathometer No. 3, having proved its value as a precision echo-sounding instrument on the *Westdahl*, has now been placed on the ships *Oceanographer*, *Surveyor*, *Guide*, and *Hydrographer*.

Sono-radio buoys have been tried out in Alaska and will be used by the four vessels operating along the Alaska Peninsula. These automatic buoys have now been successfully used to distances of 60 miles and have almost completely supplanted shore stations and the attendant danger of landing equipment through heavy surf.

Using a stock, light-weight commercial transit as a base, a new transit-declinometer was developed for magnetic declination observations. By test and replacement, all traces of magnetic material were removed from the basic instrument, now equipped with a specially designed microscope for precision reading of the magnetic needle.

Many instruments were fitted with better magnets made of new alloy materials.

An arrangement whereby it is possible to mount in succession three quartz horizontal magnetometers on a modified compass declinometer base has made it possible to determine station differences easily and quickly.

A new, all-metal magnetogram reading board was designed and built which is a great improvement over earlier types.

A log magnification attachment and special high-speed recorder for the Honolulu seismograph, built by the Honolulu observer in charge, permits the recording of strong local as well as distant shocks by the same instrument, at a decided saving of expense.

A special ground shaker, vibration meter, and recorder were designed and built to make ground and building vibration measurements to assist in the design of earthquake-resistant structures.

The illumination of theodolite circles was improved by a new design of lighting apparatus which reduces stray light, thereby enhancing the apparent sharpness of the graduation line.

Experiments conducted to determine the effect of various colors in the reading of level rods showed that a yellow-and-black combination provided longer sights and more speedy reading, thereby increasing the efficiency of geodetic leveling operations.

Redesigned signal lamps of all-metal construction eliminate moisture effects, reduce size and weight, and provide an accurately constructed and more sturdy lamp for triangulation purposes.

The program of reproducing the tide and current tables by the photo-offset process is being accomplished as rapidly as available personnel permits. In addition to the two current tables, Tide Tables, Pacific Ocean and Indian Ocean, 1940, were reproduced by this method at a substantial saving.

In the annual report for 1938, mention was made of a method for satisfactorily reproducing two or more gradient tints on aeronautical charts from one color printing plate, but it was not feasible to release employees from other duties to change over to the new method. Experiments have developed a supplement to this gradient tint printing, whereby gradients are made on one aluminum plate, the negatives for each of the colors being made from this one plate, reversed negatives being made to secure the alternate colors.

Several charts have been compiled on celluloid directly from the surveys, at a considerable saving of the compiler's time. This method is particularly applicable in areas where the charts to be constructed are at one-half the scale of the original surveys.

Chart notes were all reconsidered and a new form of tide, abbreviation, and authority notes was put into use, the notes being changed only when new printing plates are necessary for other reasons.

During the year a comprehensive tabulation of nautical chart symbols was prepared, to standardize the symbols used.

A new 14 by 17 inch copying camera, with a special tilting arrangement, has replaced the previous makeshift arrangements for this type of work.

The bromide room in the photographic laboratory has been completely renovated. New tanks of inconel metal and new light fixtures were installed and improvements made in the arrangement of the equipment.

The process room was enlarged and the equipment rearranged, by extending this room to take in a portion of the photographic laboratory.

A new instrument for cutting glass negatives for parallel lines to represent roads was devised, enabling the engraver to do this work with facility as compared with the previous rather unsatisfactory attempts.

The use of fluorescent tubes to replace the drafting lights behind the negatives in the lithographic sections has proved such a great improvement that these tubes will be installed gradually in all tables.

COOPERATIVE ACTIVITIES

The Bureau during the year has rendered the public and numerous Government agencies a service great in volume and variety. As this service is one without duplication, demands have increased as other functions of the Government have expanded. Economy of expendi-

tures has been accomplished although the demands have actually exceeded the volume of available service.

At the request of the Westinghouse Electric & Manufacturing Co., the Bureau determined the location of the "Time Capsule," deposited 50 feet in the earth at the site of their building in the New York World's Fair Grounds at noon on September 23, 1938. It is intended that this capsule, a repository of information concerning our mode of living at the present time, shall be recovered 5,000 years from that date. This Bureau furnished the chief of party and necessary instruments and the Westinghouse Co. all other items of expense.

In cooperation with the Geological Society of America, a series of six special charts was prepared delineating in detail the topographic forms of the ocean bottom on the northeastern Atlantic coast, in the vicinity of the coastal slope. Such charts are only now possible because they are based on the accurate and detailed surveys of the past few years, and are accordingly sought by all students of the earth sciences.

Cadet officers of the U. S. Maritime Commission were given instruction aboard vessels of this Survey, to familiarize them with its many activities benefiting the merchant marine officer. All the larger ships have at various times had from two to six cadets assigned for instruction during the field season on the Atlantic, Gulf, Pacific, and Alaskan coasts.

Science Service paid for the transmission of earthquake code messages from seismograph stations in the United States for the immediate determination of epicenters. The results of these immediate epicenter determinations are furnished in preliminary form to all cooperative stations and those with whom data are exchanged. The service is a definite aid to all the stations concerned and is meeting a constantly increasing demand.

Revision surveys of the Hudson River naval anchorages between Fifty-sixth Street and Yonkers were made by the tender *Gilbert* just prior to the arrival of the fleet. The work was begun while ice was still in the river, but by considerable effort the project was completed in time to permit the issue of charts to the Navy before arrival of the vessels. The finding of an unknown wreck by this field party, in ample time for the removal of the obstruction and the adjustment of the anchorage, proved a timely reminder of the need for such revision surveys. Other cooperative work for the Navy included the locating of beacons for use in fixing anchorage positions in Hampton Roads, Va., for the fleet, special hydrographic surveys in Alaska, and the determination of ground and building vibration characteristics for certain designated localities where a large construction program for naval use is in progress.

Two topographic quadrangle maps were engraved on glass negatives and reproduced for the Tennessee Valley Authority, and at the close of the year an order was received from that agency for the reproduction, by this method, of 10 additional topographic maps. There are being reproduced for the Authority a series of navigational charts of new lakes which have been created by some of the dams and which are being made into recreational areas. All Tennessee Valley Authority work was on a reimbursable basis.

In cooperation with the Army Air Corps, the Bureau, with its nine-lens camera, has taken photographs for the Soil Conservation Service of some 24,000 square miles of soil conservation areas in the High Rock section of North Carolina, in the Susquehanna region of Pennsylvania, and in Texas, Oklahoma, and Colorado, and has furnished transformed prints for use in planimetric mapping.

Extensive cooperation with the Civil Aeronautics Authority has resulted in the Bureau's doing a large amount of reimbursable work for that agency.

Special surveys in upper Chesapeake Bay and in the vicinity of Key West, Fla., were made on requests from the Bureau of Lighthouses. Two officers were assigned for part of the year to liaison duty, one at Norfolk, Va., and the other at Charleston, S. C. Other officers were assigned to temporary duty on lighthouse tenders in Washington, Oregon, and Puerto Rico. These officers instructed the personnel of the tenders in improved methods of position determination in order that greater accuracy might be obtained in the location of aids to navigation when established. Transported by the tenders to small isolated areas, they made revision surveys for corrections to the nautical charts.

During the winter season an officer from the ship *Guide* releveled the bench marks in Santa Clara Valley to check on the subsidence of the valley. This settlement, in progress for some time, is of considerable interest to California geologists and residents of the valley. Other than the chief of party, the personnel was made up of Works Progress Administration employees.

The Mississippi River Commission transferred a total of $26,500 to the Bureau for lines of leveling in the alluvial valley of the Mississippi from Baton Rouge, La., southward via New Orleans to the Head of Passes, and eastward as far as Bay St. Louis, Miss. Field work was completed in the spring of 1939 and the office processing of the material will be completed at the earliest opportunity.

Early during the year a project of local control for the metropolitan district of Baltimore was completed in cooperation with the officials of that city, which supplied all the personnel except the chief of party and instruments.

Triangulation and traverse were extended in three fault zones in the general vicinity of Los Angeles, Calif., as a continuation of the investigation of seismic regions and as recommended by the committee in seismology of the Carnegie Institution of Washington. The Bureau also repeated the triangulation from Point Reyes to Petaluma, Calif., originally done in 1930. Funds for this work were obtained through a special item of appropriation by the Seventy-fifth Congress.

At the request of the city engineer of Riverside, Calif., 10 triangulation stations were established within the city and vicinity to provide control for the city's plane-coordinate system. Expenses of the work were paid by the city and county.

Additional cooperation was extended to Works Progress Administration local control survey projects in 14 States and to King County, Wash., Mercer County, Pa., Minneapolis, Minn., and Cleveland, Ohio, by the loan of equipment or detail of personnel in an advisory capacity, in order to coordinate local surveys into the national net.

Seismographs were operated in cooperation with the following institutions: University of South Carolina, University of Chicago, Montana School of Mines, Montana State College, University of Utah, 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.

Information regarding the effects of occurring earthquakes was 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 (Mountain States Telephone & Telegraph Co. and Bell Telephone Laboratories also cooperating); and daily and weekly radio broadcasts of magnetic conditions, in which the Navy Department and Science Service also aided.

U. S. GOVERNMENT PRINTING OFFICE: 1940