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U. S. Coast and Geodetic Survey

Reprinted from

Thirty-Fourth Annual Report of the
Secretary of Commerce, 1946

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1947

U.S. COAST & GEODETIC SURVEY
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National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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March 22, 2005

U. S. Coast and Geodetic Survey

GENERAL STATEMENT

The surrender of Japan in August 1945 marked the beginning of the postwar readjustment period in the work of the Bureau. From that time on to the close of the fiscal year our major effort was centered on channeling back our activities to a peacetime basis. In the past 5 years projects in surveying and mapping were very properly limited to those areas which were of interest to our military activities. This necessarily resulted in bypassing many projects that would normally have been undertaken by the Bureau. With the war over it is essential that this accumulation of surveying needs be resolved at an accelerated and expanded rate in order that, for purposes of security and advancement, we shall not fail to chart all changes of nature along our coasts and of the improvements made to promote commerce in this period. Furthermore our work must be made more responsive to and commensurate with the needs of an expanding and developing America.

World War II, more than any other, has demonstrated the close relationship that exists between the functions of the Coast and Geodetic Survey and the successful operation of our land, sea, and air forces. The dependence of our commerce and industry in peacetime upon adequate maps and charts and upon basic mapping programs has been amply demonstrated.

We are now on the threshold of a new and promising era in the field of work of this Bureau. While it would be difficult to predict what the full impact of the war will be upon surveying and mapping of the future, it is reasonable to expect that many of the techniques developed will find application to our peacetime needs. One of the most promising of these developments is in the field of electronics. Applications of this science to plane and ship location have given us a new conception of its applicability to surveying and mapping work. Experiments are being carried on with various forms of radar for the control of offshore hydrographic surveys. Indications are that these methods will not only displace our present acoustic methods but will permit the extension of accurate hydrographic surveys to distances offshore hitherto considered impossible. Electronic methods will doubtless have applications to certain types of geodetic control. It is expected they will permit the extension of such surveys beyond the limits of present visual methods and speed up the determination of hemispheric data.

Likewise, the use of electronic devices in commercial ships or on channel buoys and other aids to navigation will impose new demands on our nautical charts. Under study at the present time are the

changes that may be required to adapt our product to the changing conditions in the field of marine navigation.

The application of electronics to some of our surveying instruments seems feasible, but further research is required in this as well as other fields.

Under the impetus and pressure of war many improvements in processes and techniques have been made in the Bureau, particularly in chart reproduction. The commercial manufacture of vinylite, a plastic product of high dimensional stability under extreme ranges of humidity, found wide application in the lithographic process and opened the door to many innovations in color separation work, in the preparation of color proofs, and in gradient tint work for nautical and aeronautical charts. With further research wider and additional applications are indicated.

In the interest of broadening the technical services of the Bureau, and in keeping with its public-service nature, we are trying to establish a closer liaison with the public and to secure a wider dissemination and use of our products. The data of the Bureau have many collateral uses for engineering, industrial, and scientific purposes. For example, successive hydrographic and topographic resurveys of changeable areas furnish an authentic record of shore-line changes useful in the study of beach erosion and protection, and in the settlement of riparian rights based on water boundaries; triangulation and leveling data are available for use in water-power development, irrigation projects, flood control, and highway location; magnetic data furnish information in the study of radio transmission; tide and current data are used in planning harbor and water-front improvements; and gravity measurements are needed for geophysical prospecting for oil.

In our experience we have found that much of our available and useful data is either unknown to the average engineer and surveyor, or there is a lack of understanding as to its use. It is not meant to imply that work of the Bureau is not known by many individuals—the demand for marine and aeronautical charts, magnetic, tide, and geodetic data will indicate otherwise. It does mean that our data, which are so meticulously collected, analyzed, and compiled for public use, could have greater appreciation and utilization in the economic welfare of our country. To bridge this gap will be one of our immediate concerns, so that a program may be developed that will result in a better understanding, a more effective distribution, and a greater usefulness of the products of the Bureau's activities.

The Bureau has recognized the need for closer relationship between the surveying and mapping agencies of the Government and for closer contact of the general public with these agencies. In addition to fostering projects within its own jurisdiction, the Bureau has cooperated during the past 4 years in publicizing the work of other Federal agencies among State, municipal, and private surveyors. Personnel of the Bureau have contributed to this end through their work with Surveying and Mapping, the official journal of the American Congress on Surveying and Mapping. This is the only publication in this country that deals exclusively with surveying and mapping matters, and as such affords an excellent medium for the dissemination of such

information. Through the regional representatives of the Congress and through its annual meetings, a closer liaison has been effected with individuals and others who are interested in the development of our natural resources, and who recognize that the first need in such development is the making of accurate surveys and the preparation of detailed maps.

THE COAST SURVEY—ITS BEGINNINGS AND DEVELOPMENT

In 1807, the Congress recognized the necessity for maps and charts of the coasts and harbors of the country for the benefit of commerce and navigation, by directing the President to cause a survey of the coast to be made, as well as the islands and shoals offshore. The work was entrusted by the President to the Treasury Department. The procurement of precise instruments and other delays, including the War of 1812, postponed actual field work until 1816. Other interruptions occurred over the next quarter century, until in 1843 a plan of survey operations was adopted which has since been followed as the basic principle of the work of the Bureau.

In 1871 the Congress authorized the work to be expanded to provide a geodetic connection between the Atlantic and Pacific coasts and to provide the States with geographic positions for control of their topographic and geologic surveys. Since that time the execution of these geodetic surveys has been for the purpose of establishing a fundamental Federal framework on which all land surveys—whether Federal, State, municipal, or private—are or should be based.

Two other activities, not contemplated in the original act, have been added to the functions of the Bureau in recent years. One is earthquake investigation—known as seismology—transferred by the Congress in 1925 from the Weather Bureau, and the other is the preparation of aeronautical charts, delegated to the Secretary of Commerce under the Air Commerce Act of 1926.

The Coast and Geodetic Survey today renders a considerable variety of essential services for the advancement of marine, aviation, commercial, and industrial interests of the country. The Bureau can be likened to a manufacturing establishment. Surveying parties go into the field and gather the raw materials. Those raw materials are shipped to Washington, where the central plant is located. In this plant the materials are worked over, and from them are derived certain final products in forms suitable for public use. These products invariably take the form of publications, and the final and culminating step in the process is the quantity production of these publications. Charts and maps are produced in our own printing plant. Other publications are printed at the Government Printing Office.

The products of the Bureau which are available to the public are: Nautical charts, related nautical publications, control surveys in the interior, tide and current tables, geomagnetic surveys, seismologic investigations, aeronautical charts, and topographic maps.

The question might rightfully be asked to what extent the program of surveying and charting the country is completed. The answer, however, cannot be simply given. As our country expands commercially and industrially, new demands are made on the products of the Bureau,

and new uses for those products are brought to light. Our concept of public service is ever changing and ever widening. As an example may be cited many of the hydrographic surveys that were made a generation or two ago which are now in a stage of obsolescence because of the more exacting requirements of present-day water-borne transportation.

CHARTING OUR COASTAL WATERS

One of the principal products of the Bureau's activities is the nautical chart. Its importance to our commercial development was recognized at an early period in the history of our country. The duty of surveying and charting the approaches to the shores of a nation stands high on the list of international obligations for the promotion of international water-borne commerce. Without adequate charts, free and unrestricted intercourse by water would be impossible, and harbors as effectively closed to the commerce of the world as though blockaded by an enemy fleet. Charts are essential not only for our own Navy and merchant marine, but it is just as important that they be available to foreign vessels plying our waters, if they are to engage in commerce with us.

The function of the nautical chart is to safeguard our seaways. It keeps commerce informed as to hydrographic conditions. It guides the mariner over what has often been called the trackless sea, it directs him to the lanes of travel that are safe, and warns him of the rocks and the shoals that may bring him to grief. The chart is a basic implement of water-borne commerce, as essential to the ship as the compass, radio, or the rudder. As our ports and harbors grow, the charts must grow with them. The millions spent annually on harbor improvements, port facilities, lighthouses, and buoys, as well as the elaborate hydrographic and topographic surveys made by this Bureau, would fail of their full purpose if these changes and improvements were not shown on the charts.

To cover our extensive coast line, 879 different charts are published at the present time. Charts are designed on several scales to meet the different needs of navigation. The scale of a chart generally determines the amount of detail that it is possible to include, and this in turn determines the use to which the chart can be put. At one end of the range of charts are the charts designed for offshore navigation between distant ports. These must embrace large areas, hence the scale must be made small. Detail on such charts is of secondary importance. At the other end are the charts designed for navigation in harbors, which require a maximum of detail consistent with clarity and legibility. Such charts being of limited extent can be constructed on much larger scales, permitting fullness of detail in topographic and hydrographic features including the channels to be followed, the positions of lights, beacons, buoys, and prominent landmarks from which the mariner can identify his position as he comes to a safe anchorage. Between these two extremes there are other series of charts that are required to safeguard navigation. For example, in the vicinity of New York there are five different chart series on scales ranging from 1:10,000 to 1:1,200,000.

The publication of a chart by no means completes the work of the Bureau in that locality. Charts must be kept alive if they are to serve their purpose properly. They must be revised frequently to give an accurate and up-to-date picture of existing conditions. The coastal region, which the chart portrays, is the zone where two great physical provinces meet—the land and the sea—and where constant changes are in progress, due alike to natural forces and to the works of man. Ocean waves and currents are constantly taking material from one place and depositing it in another, as is evidenced by the westward growth of Rockaway Point, Long Island—a growth of over 4 miles in 100 years. Rivers empty vast quantities of sediment near their mouths to build out the coastline, a striking example of this being the Mississippi. In times of heavy storm, barrier beaches are often broken through to form inlets of a temporary or permanent nature. Bars and channels are constantly shifting. Men are dredging channels, filling up tide flats and building their manufacturing plants or terminal facilities upon them, and establishing or shifting lighthouses, beacons, and buoys to conform to the changing demands of commerce.

The charts must be kept corrected to show all these changes. This means that each edition of the chart of any of our important seaports soon becomes obsolete and must be superseded by a new edition showing the changes that have occurred since the preceding one was printed. In the case of the New York Harbor Chart, it has been found necessary to print it about four times a year. Between printings important corrections, such as changes in lights, buoys, beacons, recently reported dangers, and other critical information are applied by hand before the chart is issued to the public. Once issued, changes in the chart are published in the weekly Notice to Mariners, which the navigator uses to apply to his chart until a new edition is issued. Every effort is made to keep the navigator fully informed of vital changes in the chart.

CHARTING OUR AIRWAYS

Because of the basic similarity between nautical and aeronautical charts, the Bureau was instructed under the Air Commerce Act of 1926, "to provide as adequate charts for air navigation as it now provides for ocean navigation." In fulfillment of this directive, the Bureau has compiled and printed 579 aeronautical charts of the United States and its possessions. These range from large-scale charts for piloting and contact flying to small-scale charts for use in the navigation of high-speed transports, special charts for radio navigation, and charts for instrument approach and landing procedures. Some 50 miscellaneous sources are used in compiling these charts. Upon the basic chart, airports, beacon lights, radio-range stations, and other aeronautical data are overprinted, usually in red. These charts must be kept current, particularly for the aeronautical data, in order to provide the aviator with knowledge of existing conditions.

An important phase in the preparation of an aeronautical chart is the flight check. To insure accuracy of the detail shown, the charted area is flown over, before final publication, by an experienced observer and details on the chart are compared with the ground below. Neces-

sary corrections are indicated, and prominent landmarks are noted for addition to the charts. Some of the most important information on ground conditions is obtained for the aviator from the flight check.

The publication, Practical Air Navigation, prepared by one of the Bureau's cartigraphic engineers, has been adopted as a standard text by the Civil Aeronautics Administration, and is now published as Civil Aeronautics Bulletin No. 24. A second edition of this widely used publication was issued during the year.

CHART PRODUCTION

The demand for nautical and aeronautical charts has decreased to some extent since the ending of the war, although requirements for aeronautical charts have shown an appreciable increase in recent months. Nautical charts are averaging approximately 50 percent of the total for the last year of the war, while aeronautical charts are averaging 65 to 70 percent. A total of 14,038,555 copies of charts was issued. The relative annual output of navigational charts and related publications for the past 4 years is given in the following table:

Charts and related publications issued

Type of chart or publication	1943	1944	1945	1946
Nautical charts	1,916,599	2,913,666	4,330,547	2,235,396
Aeronautical charts	11,773,464	17,645,892	16,899,049	11,803,159
Coast pilots	35,661	16,086	13,884	14,067
Tide tables	56,109	81,449	98,016	80,014
Current tables	36,698	86,038	40,933	37,856

The distribution of nautical and aeronautical charts during the year is given in the following table:

Distribution of nautical and aeronautical charts

NAUTICAL

		Percent	
Free issue:			
Navy Department:			
Hydrographic Office	1,700,581	76.3	
Coast Guard	3,134	.1	
War Department	9,605	.4	
Coast and Geodetic Survey	12,564	.6	
Other departments	6,678	.3	
	1,732,562	77.7	
Sales	378,644	17.0	
Condemned	119,284	5.3	
	2,230,490	100.0	2,230,490
Special printing of charts for Hydrographic Office			4,906
			2,235,396

U. S. AERONAUTICAL

		Percent	
Free issue:			
War Department	4,824,112	66.8	
Navy (including Coast Guard)	1,190,311	16.5	
Civil Aeronautics	55,087	.8	
Coast and Geodetic Survey	15,535	.2	
	6,085,045	84.3	
Sales	813,014	11.3	
Condemned	321,455	4.4	
	7,219,514	100.0	7,219,514

SPECIAL AND FOREIGN AERONAUTICAL

To war agencies	4,583,645
Total	14,038,555

The number of individual nautical charts published at the end of the year was 879. To produce the 2,235,396 copies issued, 369 printings were made, as follows: 11 new charts, 12 new editions, 309 new prints, and 37 reprints. Due to rapid changes in navigational data, it was necessary to apply more than 12 million hand corrections to correct the charts to date of issue. Dangers requiring hand corrections and other navigational information were reported to the Coast Guard and Hydrographic Office for publication in the weekly Notice to Mariners.

Two special nautical charts, covering areas in Alaska including Point Barrow and vicinity, were constructed upon request of the Navy Department. These charts include comprehensive detail of the planimetry, such as lakes and drainage patterns. This new approach to nautical charting in Alaska adds much to the value of the charts.

Two experimental charts for use in radar navigation—one of Santa Cruz Channel, Calif., and the other of the approaches to Strait of Juan de Fuca—were produced showing the topography by gradient tints instead of the customary yellow land tint. This type of topographic treatment, it is believed, will facilitate the correlation of the charted detail with the radar scope on the vessel. All the gradient tints are included on 1 printing plate so that no additional press runs are required.

For some months work has been in progress on the development of a chart for use with the Loran system of navigation. Loran curves will be printed in color on the reverse side of the regular navigational chart in exact registry with the face. A plotted Loran position can be pricked through the paper giving the vessel's position in relation to the charted detail. If this form of chart meets with the marine public's favor, it will greatly simplify the adaptation of the Bureau's charts to Loran navigation.

Work was in progress during the year on the charting of the Gulf Intracoastal Waterway between Carrabelle, Fla., and the Mexican border.

The Bureau has taken over during the year the publication and maintenance of nine charts of the Hawaiian Islands group. These charts were compiled and formerly published by the Hydrographic Office of the Navy Department.

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In the field of related nautical chart publications, the Bureau publishes a series of coast pilot volumes. An organizational change effected in this activity during the year should result in a broadening of its scope and a closer tie-in of the pilots with the nautical charts, which they supplement. The present program is designed to produce new editions of all principal pilots within 5 years as against the present average of 7½ years. The first coast pilot fieldwork since the beginning of the war was started during the year. The examination of the Atlantic coast pilot in the vicinity of Norfolk and up the James River as far as Claremont, Va., was completed.

The standard aeronautical charts of the United States and possessions, 579 in number, were maintained as to aeronautical data. This total includes 329 instrument approach and landing charts, which were released for distribution to the public during the year. The 37 flight charts of the United States at a scale of 1:1,000,000 were completed. These charts were constructed from color separation drawings of the existing world aeronautical charts through the use of photographic positive prints on sensitized vinylite. The standard 1:1,000,000 scale charts of Alaska were revised on the basis of new photographic source material.

Three flight check parties were in the field during the year, for a total of 11 man-months. The flight checking of the 87 sectional charts of the United States is now complete. Constant flight checking will be maintained so that each chart will be inspected about once every 3 years.

None of the world aeronautical charts of Alaska have been flight checked. Due to limited funds for flight check work in 1947 this much needed work will have to be postponed.

Three field stations, located at New York, Baltimore, and Norfolk, were in operation during the year for the compilation of aeronautical charts. Work in the New York office was discontinued on October 26, 1945.

A new field station was established on January 2, 1946, at Fort Worth, Tex. This is the third station established by the Bureau for liaison with the Civil Aeronautics Administration, for the distribution of aeronautical charts, for the dissemination of survey data to the public, and to serve as headquarters for flight check parties operating in the vicinity. The other two stations are at Kansas City, Mo., and at Atlanta, Ga. These stations have proven mutually beneficial to the CAA, to the Bureau, and to the public users of maps and charts, and indicate the value of having representatives of the Bureau and the Department in reasonably close proximity to the local map users.

The Kansas City office has been enlarged and will take over the responsibility for the supply of all aeronautical chart agencies west of the Mississippi River. This will enable agents located on the west coast to obtain delivery of charts from 3 to 5 days sooner than when supplied from Washington.

The establishment of these regional distribution centers has greatly relieved the cramped and overburdened facilities of the Washington office, which were further taxed during the year by the added responsibility of distributing approximately 2,500 aeronautical charts released through declassification by the War and Navy Departments.

Further relief to our central plant will be afforded by the establishment of a distribution center at the Baltimore office.

In addition to the production of the standard aeronautical charts, certain special work was accomplished or in hand during the year for the War and Navy Departments. These included the following:

The 41 gnomonic tracking charts for the Army Air Forces were completed. This series of charts has been favorably received, and it has been indicated that as a result the Navy Department has curtailed the number of charts in the naval tracking series. Work continued on two life raft charts for the Army Air Forces as well as a sizable number of approach and landing charts for airfields of foreign countries. Two azimuthal equidistant charts of the world for the Army Air Forces were nearing completion at the end of the year. One is centered on Sverdlovsk, Russia, and the other on Meade's Ranch, Kans. An Army installations chart was completed for the Corps of Engineers, United States Army, and six radar navigational charts were completed for the Office of Research and Inventions, Navy Department.

An important contribution to existing geographic knowledge was the completion of the Map of the Northern Hemisphere, north of 30°30′ showing topography. This map was produced in two sections on a stereographic projection at the scale of 1:6,336,000 true along the standard parallel of 65° and conforming in general treatment to the world planning charts. The map and accompanying gazetteer were recently released for civil requirements and are now being distributed on a sales basis.

As a result of a conference in March with representatives of the principal commercial air lines and the Air Transport Association, special aircraft plotting charts were scheduled for priority production. The first chart of the series known as the aircraft position chart of the North Atlantic was published in June. The chart was favorably received without exception. Work was also in progress on a special chart, requested by the commercial air lines, from Chicago, Ill., to Gander, Newfoundland, constructed on an oblique Mercator projection.

Reproduction for the Civil Aeronautics Administration of the bimonthly publication, Air Navigation Radio Aids, was continued through the May 1, 1946, edition. This publication has now been combined with two other CAA publications—the biweekly Notices to Airmen and the Directory of Airports—to form the Airman's Guide.

An air coordinating committee was established by Executive order to coordinate the aviation activities of the various Federal agencies. The chief of the Aeronautical Chart Branch of this Bureau represents the Department of Commerce on a subcommittee on aeronautical charts. The subcommittee has obtained agreement on the symbols to be used on all aeronautical charts produced in the United States. Except for minor exceptions these symbols are in accordance with those agreed on by PICAO. An agreement was also reached for standardizing the specifications for the instrument approach and landing charts.

COASTAL SURVEYS

Coastal surveys, which include hydrography, topography, and coastal triangulation, provide the fundamental data for the production of nautical and aeronautical charts. These surveys are carried on by ships and shore-based units to obtain information concerning obstructions to navigation, locations of channels, characteristics of the sea bottom, shore lines and other topographic features along the coasts, and much other data required for the production of marine charts and coast pilots.

When the Coast Survey was first organized, its work included only the coastal strip along the Atlantic coast comprising about 15,000 statute miles. With the Nation's territorial expansion the activities of the Bureau have grown until today its jurisdiction extends to all the waters of continental United States, Alaska, the Philippines, Guam, the Hawaiian Islands, Puerto Rico, the Canal Zone, and the Virgin Islands—comprising a total shore line of over 100,000 statute miles. The vast coastal waters fringing this shore line cover a total area of well over a million square miles. Many sections of our coast line are changing constantly, in varying degrees, due to natural causes and the works of man. Changes are likewise taking place in the ocean bottom. Shifting of channels and other features, and water-front developments and harbor improvements, require continual and extensive changes in the systems of aids to navigation.

Before the war, water areas averaging about 40,000 square miles were surveyed annually in order to obtain information concerning these changes and to provide additional charts required on account of commercial developments. This was sufficient to maintain reasonably accurate charts of commercially important areas; that is, important ports, the approaches thereto, and the water lanes between them. Regions of lesser commercial importance have been neglected for many years, present charts in many cases being based upon surveys from 40 to 50 years old. There has been neglect of numerous coastal areas used for recreation and by small local industries. Annual surveys of 40,000 square miles of water area may, therefore, be considered the minimum work load for hydrographic surveys under present conditions, but this minimum should not be considered a yardstick for the charting needs of the people of this Nation in these modern times. New navigational devices, such as the echo-sounding machine, have made many of our early surveys in deep water inadequate because they lack the detail which the modern navigator requires for use with his improved instruments. Such areas must be resurveyed in order that the charts may be modernized.

Coastal surveys are carried on from survey vessels and shore-based units. During the period of hostilities surveys were conducted primarily in areas of strategic importance. With the end of the war the work has expanded into adjoining areas of commercial importance to domestic and foreign shipping and to air transportation, and into relatively undeveloped regions containing mining, fishing, and oil resources.

During 1946, 13 survey vessels were engaged in these coastal surveys. A summary of the results accomplished is given in the following table.

The small mileage for topography in the table is due to the activation of the Division of Photogrammetry on October 1, 1945. All aerial topography is now under the jurisdiction of that Division and topographic work accomplished as a part of coastal surveys is now confined to planetable topography for graphic control or other limited purposes.

Statistical summary of coastal surveys

Locality	Hydrography				Topography		Triangulation		
	Sounding lines	Area	Wire drag	Area	Shore line	Area	Length of schemes	Area	Geographic positions
	Miles	*Square miles*	*Miles*	*Square miles*	*Miles*	*Square miles*	*Miles*	*Square miles*	*Number*
Coast of Maine	4,126	414	12.4	6					
Massachusetts to Cape Charles, Va.	1,595	54	109	13					
Chesapeake Bay	4,284	25	19	9	6	4			
Cape Charles to Florida	3,186	362	5	.2					
Oregon	360	9							
Puget Sound	9	1							
Alaska	16,788	10,754			439	303	366	2,273	328
Philippine Islands	211	1			7	10	7	38	11
Total	30,559	11,820	145	28	452	317	373	2,311	339

On the Atlantic Coast, the survey vessels *Lydonia*, *Cowie*, *Faris*, *Gilbert*, *Hilgard*, *Wainwright*, and *Sosbee* were engaged in hydrographic or wire-drag surveys. Surveys included special investigations requested by the Navy of areas to be used for anchoring surplus naval vessels, locating wrecks in channels and sea lanes, and revising charts in the vicinity of new developments.

The *Lydonia* made hydrographic surveys off the coasts of Maine and South Carolina.

The *Faris* made surveys in the vicinity of New York and Virginia. After May 1, 1946, this vessel was used for coast pilot investigations along the Atlantic coast.

The *Gilbert* made surveys in Boston Harbor off the coast of Maine, and in the James River, Va.

The *Cowie* was engaged in making surveys in Chesapeake Bay throughout the year.

The *Hilgard* and *Wainwright* made hydrographic and wire-drag surveys in Chesapeake Bay, off the Virginia coast, and in Boston Harbor. The project included locating wrecks resulting from enemy action and determining the least depth over sunken obstructions.

The *Sosbee*, which was transferred to the Bureau by the Coast Guard, was outfitted for survey duty and was engaged in hydrographic surveys in Lynnhaven Roads, Va., and in wire-drag investigations off Cape Henry and Thimble Shoals, Va.

On the Pacific coast, the *E. Lester Jones* made radio-current meter surveys in Puget Sound and in the vicinity of Seattle, Wash. The *Patton* assisted the *Jones* in the Puget Sound surveys.

The *Westdahl* completed triangulation in Coos Bay, Oreg., which was requested by the Army engineers, and started triangulation, topographic, and hydrographic surveys on the Willamette River, near Portland, Oreg. At the request of the Army engineers, a special

survey was made of Vancouver Lake, Wash., to determine its suitability for mooring surplus vessels.

Major combined operations surveys were carried on in Alaska, principally in the area bordering the Aleutian Islands between Adak and the west coast of Attu. Advance tracings of the hydrographic and topographic surveys were furnished to Army and Navy ships operating in this region. The results of triangulation were also furnished for use in controlling developments at bases, including roads, waterworks, and docks; for coordinating gunfire; and for locating aids to navigation and aviation, including Radar and Loran stations and Racons.

The *Surveyor* carried on combined operations along the north and south coasts of Amchitka, in the Delarof Group between Tanaga and Amchitka Islands, in Tanaga Bay, and off the northe and south coatsts of Tanaga Island.

The *Explorer*, *Surveyor*, and *Derickson* cooperated in extending an arc of triangulation from Kiska to Attu. This arc of triangulation bridged the last gap in the network of triangulation extending through continental North America, Alaska, and the Aleutian Islands. All of this work is now on the North American datum of 1927.

The *Explorer* assisted by the *Derickson* executed triangulation, topographic, and hydrographic surveys off the south and north coasts of Attu and in other areas in the Near Island group.

The *Patton* assisted the *Surveyor* in the Delarof area and in the region of Attu. The *Patton* also made triangulation, topographic, and hydrographic surveys in the vicinity of Adak and in Edna Bay, southeastern Alaska. Edna Bay is being developed by the Aluminum Company of America.

The *E. Lester Jones* executed triangulation and topographic surveys and made a field inspection of aerial photographs along the south coast of the Alaskan Peninsula.

The *Westdahl* made a hydrographic survey in the vicinity of Sitka.

A shore-based party was engaged in combined operations in the vicinity of Point Barrow, Alaska, for the Navy Department.

In the Philippine Islands the Coast Survey Office, reopened when Manila was reoccupied by American forces, was in continuous operation under the directorship of a commissioned officer transferred to the War Department. The program planned for the Philippines contemplates completing the basic surveys of the islands, preparing charts of unsurveyed regions, revising obsolete charts, and training, both in the Philippines and in the United States, a selected group of Filipinos for office and field work.

During the year work was accomplished towards furthering this program—ships have been procured from the War Department, personnel have been recruited, a training program has been organized, and hydrographic and topographic resurveys in Manila Bay have been started. A chart agency has been established under the Office of the Director of the Philippine Bureau for the distribution of charts and survey data.

Negotiations are in progress for procuring a survey ship for the Philippines to replace the *Fathomer* which was destroyed during the war.

District offices were maintained during the year at the following ports: Boston, Mass., New York, N. Y., Norfolk, Va., San Juan, P. R., New Orleans, La., Los Angeles and San Francisco, Calif., Portland, Oreg., Seattle, Wash., and Honolulu, T. H. These offices render valuable service in supplying information for the correction of charts, in disseminating nautical and engineering data in response to requests from local, public, and official sources; in assisting the field parties of the Bureau in obtaining supplies and personnel, and in planning field work of the parties working in their respective districts. From local knowledge of surveys needed in the district, the district office makes recommendations to Washington that such surveys be accomplished.

Processing offices were continued at the two principal bases of the field parties, Norfolk, Va., and Seattle, Wash. These offices process field records, plot hydrographic surveys, and perform other work in connection with the survey records. The operation of these field offices expedites the transition of field surveys to the finished nautical charts and permits close cooperation between the field engineer and the office cartographer. By being relieved of a great amount of office work, the survey parties are able to engage in a year-round program of field work.

Transfer and Retransfer of Ships

The *Hydrographer*, transferred to the Navy Department in 1942, was returned to the Bureau and is being reconverted for survey duty along the Atlantic and Gulf coasts.

The *Pathfinder*, transferred to the Navy Department in 1942, was returned to the Bureau and is being reconverted for survey duty in Alaska.

Negotiations are in progress for the transfer from the Navy Department of two seaplane tenders, three submarine chasers, and two small wooden vessels.

The *Stirni*, *Parker*, and *Bowen*, former Navy submarine chasers, have been converted for wire-drag duty and will be used mainly to search for, and locate, wrecks caused by enemy action off the Atlantic coast.

PHOTOGRAMMETRIC SURVEYS

Topographic surveys as a basis for the land information shown on the nautical charts have always been a necessary function of the Bureau. Originally these surveys were all made by plane table, but since 1922 an increasing use has been made of aerial photographs. Today topographic surveys are almost invariably based on aerial photographs. Aerial photographs have also been found to be indispensable in connection with other survey work of the Bureau, such as airport surveys and reconnaissance studies for triangulation in Alaska.

All topographic surveys based on aerial photographs are considered photogrammetric surveys. These surveys may be generally subdivided into the following phases of work: The taking of the aerial

photographs, the laboratory processing of the photographs, field inspection of the photographs and the necessary supplemental ground surveys, office compilation, and the office review and drafting.

As in past years, the United States Coast Guard cooperated with this Bureau in furnishing an airplane and crew for aerial photography. The Bureau's nine-lens camera was rebuilt after the airplane carrying it had crashed in Alaska in 1943, and was again ready for use in August of 1945. The principal areas photographed were: The northeastern part of Maine, the Delaware Bay and River area, the Cape Hatteras-Neuse River area, the Homestead and the Fort Pierce areas in Florida, and the Lake Becharof area of the Alaska Peninsula. In addition, 79 airports were photographed for airport surveys and numerous scattered photographs were taken for use in revising nautical charts. All laboratory processing of these photographs was done in the laboratory in Washington.

During the year photogrammetric field surveys were in progress in the following areas: In the vicinity of Mount Desert Island, Maine, and eastward to near Columbia Falls; in Delaware Bay and River; in Tidewater Virginia; and in the Palm Beach-Miami, Fla., area.

Field surveys were made along 445 statute miles of the Gulf Intracoastal Waterway from Carrabelle, Fla., westward to Houma, La. This project was principally to locate aids to navigation along the waterway, to revise prior planimetric maps, and to obtain up-to-date information for the 15 new Intracoastal Waterway charts approved for this part of the waterway.

A combined field and office party was organized to make a large-scale industrial planning map of Portland, Oreg., and vicinity in collaboration with local officials. Most of the field work and much of the compilation had been completed at the year's end.

Photogrammetric offices continued in operation at Baltimore, Md., and Tampa, Fla., where topographic and planimetric maps were compiled of coastal areas in Maine; Patuxent River, Md.; Tidewater Virginia; the Palm Beach-Miami area; and San Francisco Bay.

The office review and drafting were continued in the Washington office. All topographic maps are being inspected after compilation and returned to the field for a thorough comparison with the actual ground details, after which they are thoroughly reviewed and drafted.

Surveys at airports throughout the country to be used as the basis for the instrument approach and landing charts were in progress at the beginning of the year. At the request of the Civil Aeronautics Administration, these surveys were expanded to locate and determine the elevations of obstructions in the vicinity of the fields, so that the Civil Aeronautics Administration can determine the allowable pay load which can be accommodated by each type of aircraft at each field. Ninety-three airports were surveyed for all purposes during the year and 17 obstruction plans had been published at the year's end.

A summary of the year's photogrammetric activities is given in the following table:

Summary of photogrammetric mapping

Locality	Aerial photography	Photogrammetric field surveys				Compilations completed				Maps published	
		Shoreline	Interior area	Contours (plane-table)	Contours (stereoscopic)	Planimetric maps		Topographic maps		Planimetric	
	Square miles	*Miles*	*Square miles*	*Square miles*	*Square miles*	*Square miles*	*Number*	*Square miles*	*Number*	*Square miles*	*Number*
Alaska (Alaska Peninsula)	3,370	299	897								
California (San Francisco Bay)						83	2				
Delaware, New Jersey (Delaware River)	900	40	250	225							
Florida (Fort Meyer to Tampa)										616	28
Florida (Fort Pierce)	800										
Florida (Miami to Palm Beach)		397	578	508				325	8		
Florida area (Homestead, Key Largo)	650										
Maine (Portland to Canadian Boundary)	390	694	277		45	150	14			92	7
Maryland (Patuxent River)		165	31			274	9				
Massachusetts (Cape Cod)						30	2			76	4
North Carolina	3,710										
Oregon (Portland)		287	453			235	17				
Virginia (Rappahannock River to James River)		35	1,200	60	530			560	12		
Washington (Puget Sound)	380										
Total	10,200	1,917	3,686	793	575	772	44	885	20	784	39

GEODETIC CONTROL SURVEYS

In surveys covering extensive areas, account must be taken of the earth's curvature in the computation of the results; otherwise serious errors will develop. Such surveys are termed geodetic surveys and represent the highest form of survey engineering. Geodetic surveys include the determination of the latitudes and longitudes (by triangulation or traverse), and elevations above sea level (by leveling) of numerous points throughout the country. They involve astronomic observations, measurement of base lines, measurement of the force and direction of gravity, and the computation and final adjustment of all field operations required for the establishment of a consistent network of marked points and bench marks on a single basic datum of control for all surveys.

From the very inception of the Coast Survey control surveys have been carried on along the coasts to provide the framework for the nautical charts published by the Bureau. By the act of 1871, the Coast Survey was recognized as the proper governmental agency to furnish the basic control for the topographic and geologic mapping of the interior of the country. This extension of geodetic surveys at first provided control points at widely spaced intervals, but with the commercial and industrial development of the country, it became necessary to break down the major arcs of triangulation into subsidiary arcs so that control points would be available for State and local surveys. It is the present policy of the Bureau to determine a large number of supplemental triangulation or traverse stations at the same time the main scheme of triangulation is carried forward. These additional stations provide a closer spacing of control and of area coverage for local use, especially along the main highways where they are more readily accessible for the surveyor or engineer.

For many reasons, it is in the best national interest to have all surveys—no matter how localized they may be—tied in with the national control net established by this Bureau. The extent to which this ideal is reached will depend largely upon the availability of control points to the local surveyor and engineer. It is therefore a part of the Bureau's geodetic program to establish closely spaced control points as rapidly as possible, the distribution varying in accordance with the requirements of each region. In general the distance between points should not exceed 3 or 4 miles in rich argicultural land, nor 2 to 3 miles in metropolitan and industrial regions.

Geodetic control surveys are not only essential to the mapping of the country but have a number of collateral uses. The increased requests for data from oil companies engaged in geophysical prospecting and from local surveyors and engineers concerned with the coordination of property and boundary surveys and with general engineering continue to evidence the utility of geodetic data for nearly all kinds of engineering projects.

The principal projects engaged in during the year have been concerned with the extension of geodetic control surveys for large-scale public works, such as the flood control and reclamation projects of the Corps of Engineers and the Bureau of Reclamation in the Columbia River basin and the Missouri River valley. For the present arcs of

triangulation and lines of levels are being extended only in priority areas established by the Corps of Engineers.

Four triangulation parties and one leveling party of three to four units operated in the Columbia River basin along the Snake and Salmon Rivers in Idaho and eastern Oregon. In addition to locating the main stations of the control scheme many supplemental points which could be spotted on aerial photographs were located. This area is in most difficult terrain. Transportation of personnel and equipment was by back packing, horse packs, automobile trucks, canoes, river barges, and airplanes.

Joint efforts between our leveling parties and those of the Geodetic Survey of Canada are underway to expedite and coordinate vertical control along the International Boundary in Washington, Idaho, and Montana. This work is being done for the International Joint Engineering Board.

In the Missouri River valley one triangulation party operated on the arc from Williston to Minot, N. Dak. A unit of this party made numerous connections between Missouri River Commission station marks and those of the Coast and Geodetic Survey along the river from Kansas City, Mo., to Williston, N. Dak. This will enable the local surveys to be coordinated into the Federal net. One level party of three to four units operated in the States of Missouri, North Dakota, South Dakota, Nebraska, and Kansas.

Triangulation and leveling were also carried on in Indiana where control is necessary in connection with the mapping program of the Geological Survey. Similar activities were conducted in the vicinity of Fort Worth and Dallas, Tex., at the request of the Corps of Engineers for use in the development of the Trinity River.

Triangulation and leveling were executed in Mississippi and in Alabama along the Black Warrior and Tombigbee Rivers where the Corps of Engineers is engaged in river improvement projects.

Triangulation was accomplished in New Mexico and Arizona, regions of primary interest to the Forest Service in their mapping plans.

Triangulation was extended in the Alaskan Peninsula from Portage Bay to Egegik on Bristol Bay for the purpose of furnishing control for the location of fish-traps leased by veterans who are engaged in the fishing industry in this locality.

Surveys were accomplished for the Army Air Forces to locate additional points on the precision bombing field at Eglin Field, Fla.

Astronomic observations for latitude, longitude, and azimuth were made along arcs of triangulation in seven States and in Alaska for use in the adjustment of the triangulation.

Base lines were measured in Idaho, Mississippi, New Mexico, North Dakota, Oregon, Texas, and Washington to control the lengths in the triangulation arcs. Base lines for special purposes were measured in California, Minnesota, and New Jersey.

The astronomic observatories at Ukiah, Calif., and Gaithersburg, Md., maintained to study the variation of latitude, were continued in operation throughout the year, during which time 2,700 pairs of stars were observed. These are two of five observatories on the same parallel of latitude used in this study, the others being located at

Carloforte, Sardinia; Kitab Kaska, Turkestan, Russia; and Mizusawa, Japan.

The Bureau engaged in a cooperative project with the Corps of Engineers and the Hydrographic Office to provide a triangulation connection between the mainland of Florida and three of the islands of the Bahama group. The distances involved are from 60 to 120 miles. Simultaneous observations were made on flares released from airplanes at three selected points between the mainland and the islands. This unique method resulted in accuracies better than 1 part in 70,000 for the position determinations on the islands.

The field activities during the year are summarized in the following tables:

Triangulation

Locality	Number of stations	Length of scheme	Area
		Miles	*Square miles*
FIRST-ORDER TRIANGULATION			
Eglin Field, Fla	57	15	150
Parade Base Net, S. Dak	3	10	50
Humboldt, Nebr., to Savannah, Mo	38	50	700
Magdalena to Aztec, N. Mex	64	160	7,470
Williston to Stanley, N. Dak	60	65	1,280
Speed Course, Wright Field, Ohio	29	15	165
Salmon River, Dixie to Salmon, Idaho	78	85	1,700
Antonito, Colo., to Des Moines, N. Mex	74	210	4,010
Vicinity of Boonville, Ind	21	20	260
Salmon River, Keuterville to Dixie, Idaho	104	100	1,295
Snake River, Weiser to Lewiston, Idaho	134	125	2,220
Spokane Base Net, Wash	10	30	3,450
Chama to Belen, N. Mex	155	210	2,730
Snake River, Hagerman to Shoshone Falls, Idaho	42	35	245
Glenbar to Tombstone, Ariz	64	120	1,620
Vicinity of Bookhaven, Miss	34	50	500
Bridgeport to Rio Vista, Tex	66	100	1,560
Southern Indiana	94	85	900
La Grande to Enterprise, Oreg., and Grande Ronde River, Oreg., and Wash	90	140	1,870
Vicinity of Iadho Falls, Idaho	74	105	4,300
Vicinity of Bristol Bay, Alaska	14	40	570
Tonto National Forest, Ariz	24	50	2,350
Deschutes River, Oreg	192	120	2,760
Stanley to Towner, N. Dak	97	108	2,580
Arlington to John Day, Oreg	162	269	4,290
Total	2,017	2,317	49,025
SECOND-ORDER TRIANGULATION			
Missouri River, Bismarck, N. Dak	13	25	200
Missouri River, S. Dak	7	20	90
Missouri River, Washburn, N. Dak	7	20	150
Williamette Valley, Salem to Newberg, Oreg	10	15	40
Snake River, Lewiston, Idaho to Pasco, Wash	113	130	1,170
Vicinity of Oregon City, Oreg	12	27	70
Total	162	237	1,720

Base line measurement

Locality	Length of scheme	Locality	Length of scheme
FIRST-ORDER BASE LINES	*Miles*	FIRST- ORDER BASE LINES—continued	*Miles*
Island Beach, N. J	2.1	Brookhaven, Miss	6.5
Shooks, Minn	5.2	Stanley, N. Dak	7.6
Salmon, Idaho	6.3	Idaho Falls, Idaho	11.0
Fenn, Idaho	5.6	Ashton, Idaho	6.0
Spokane, Wash	6.6	Total	81.8
Santa Fe, N. Mex	7.3	SECOND-ORDER BASE LINE	
Fort Worth, Tex	5.8		
Muroc, Calif	1.9	Imbler, Oreg	2.0
Filer, Idaho	2.8		
Madras, Oreg	7.1		

RECONNAISSANCE

Locality	Length of scheme	Area
FIRST-ORDER RECONNAISSANCE	*Miles*	*Square miles*
Minot to Devils Lake, N. Dak	115	2,395
Vicinity of Wright Field, Ohio	15	165
Salmon River, Idaho	195	3,500
Idaho Falls, Idaho to Pinedale, Wyo	110	2,110
Southern Indiana	455	5,290
Vicinity of Santa Fe, N. Mex	30	330
Texas Panhandle, Tex	240	3,340
John Day River, Oreg	150	2,345
Enterprise to La Grande, Oreg	85	1,505
Grande Ronde River, Oreg. and Wash	35	340
Deschutes River, Bend to Madras to Maupin to Columbia River, Oreg	120	3,380
Cowlitz River, Kelso to Kosmos, Wash	75	1,210
Lower Klickitat River, Wash	50	630
Fort Worth-Dallas Areas, Tex	80	1,790
Snake River, Henrys Fork, Idaho	115	2,850
Dallas to Hubbard, Tex	75	2,055
Trinity River, Dallas to Fairfield, Tex	85	2,120
Dallas-Greenville Area, Tex	75	1,640
Gasconade River, Mo	315	4,960
Northeastern Indiana	435	5,180
Upper Klickitat River, Wash	60	655
Stump and Crow Creeks, Idaho and Wyo	40	885
Northwestern Nebraska	169	4,100
Tonto National Forest, Ariz	265	4,690
Vicinity of Trinidad, Colo	30	300
Northwestern Indiana	190	2,320
Vicinity of Bristol Bay, Alaska	100	1,600
Big Blue River (Missouri River Basin), Nebr. and Kans	100	5,500
Total	3,809	67,185
SECOND-ORDER RECONNAISSANCE		
Snake River, Idaho and Oreg	100	1,980
Vicinity of Idaho Falls, Idaho	80	2,480
Snake River, vicinity of Boise, Idaho	60	370
Snake River, Pasco, Wash., to Lewiston, Idaho	130	1,170
Hagerman to Twin Falls, Idaho	25	175
Canby to Oregon City, Oreg	20	210
Willamette River, Canby to Newberg, Oreg	15	50
Total	430	6,435

Leveling

State	First-order	Second-order	State	First-order	Second-order
	Miles	*Miles*		*Miles*	*Miles*
Alabama	3	764	Nebraska	103	60
California	476	6	North Dakota	25	227
Florida	6		Oregon	25	955
Idaho	188	332	South Dakota	56	661
Indiana	173	931	Texas	42	834
Kansas	4	130	Washington	71	374
Maryland	7	3	Wyoming		12
Mississippi	64	517			
Missouri	1	263	Total	1,242	6,070
Montana	34	1			

Astronomy

State or territory	Determinations			State or territory	Determinations		
	Latitude	Longitude	Azimuth		Latitude	Longitude	Azimuth
Alaska			1	North Dakota			1
Arizona			1	Oregon			1
Idaho	1	1	1	Washington			1
Indiana			1				
New Mexico	2	2	2	Totals	3	3	9

The office force in Washington has been engaged on the processing of the field data resulting from triangulation, leveling, and astronomic observations, and in the distribution of the data to the public and Government mapping bureaus. The computation and adjustment of 97 triangulation projects were completed, resulting in the addition to the files of 6,434 geographic positions of stations expressed on the North American datum of 1927. These triangulation projects are located in 24 States, the District of Columbia, and Alaska. Six subordinate networks of leveling were adjusted and in addition junction details and minor adjustments were made during the processing of the leveling to 238 airports. Preliminary computations were made for 4,370 miles of leveling. Descriptions of 12,978 bench marks and standard elevations for 11,588 bench marks were prepared for distribution.

Assistance was given to the Army Air Forces in computing distances from Shoran observations in a study of methods to attain an accuracy comparable to that obtained by geodetic surveying methods. The Shoran determination of distance as used on these field experiments is practicable for distances in excess of 100 miles. The field procedure consists of obtaining readings on the Shoran equipment from an airplane flying at right angles to and crossing the line of sight between the two points for which the distance is required. A radio impulse is transmitted from the plane and retransmitted from the apparatus at the station points. The time of transmission of the initial pulse from the plane to the time of receipt at the plane of the retransmitted impulse is recorded visually on the Shoran equipment in the plane. The height of the plane is also determined and used in the computations. With these observations and the velocity of the radio wave, distances can be determined. The distance between the two stations will be obtained when the sum of the time intervals is a minimum. Further study of the methods of computation to be used for triangulation by Sharon methods is necessary.

The operation of the field computing office in New York City was continued. This office has been of great assistance in computing and adjusting field survey notes.

TIDE AND CURRENT SURVEYS

The tidal work of the Coast and Geodetic Survey had its origin in the necessity for correcting the soundings taken in hydrographic surveys for the rise and fall of the ocean tides, so that the nautical charts would show all depths reduced to a common datum. With the increased drafts of vessels it became necessary to make available to the mariner an advance knowledge of the times and heights of high and low water at the more important ports. Such information is furnished him in the form of tide tables which are published annually by the Bureau and issued in advance of the beginning of each year.

Besides these two principal purposes the tidal work of the Bureau has many collateral uses in the fields of practical engineering and scientific research. Among these may be mentioned its use in the determination of mean sea level at various points along the coast to serve as a basic datum for the network of leveling extended over the country; in coastal construction in the location and design of piers, bridges, and

factories; in the determination of title to property bordering on tidewater; in the study of marine life, phenomena associated with storms and earthquakes, and in the study of the important question of coastal stability. Continuous tide observations supply the only quantitative data for determining the slow change taking place in the relation of land to sea.

The Coast and Geodetic Survey is the sole agency of the United States Government that is charged with the function of obtaining and publishing tidal data.

Accompanying the rise and fall of the tide is a horizontal movement of the water known as the tidal current. A knowledge of the currents in a locality is a prerequisite to safe navigation. There are many cases on record where vessels have come to grief because they lacked information on currents or because they failed to take existing currents into account.

In addition to its importance in navigation, currents must be considered by the civil or military engineer engaged in harbor improvement and marine construction, and by the sanitary engineer in dealing with the problem of sewage disposal in metropolitan districts. Information on the ebb and flow of the current is furnished to the public in the form of current tables published annually by the Bureau and in other forms.

To obtain the data for tide and current information, the Bureau operates some 80 tide stations at coastal ports, makes supplemental short-period tide observations at numerous other places, carries on combined tide and current surveys of important waterways, and analyzes data for making tide and current predictions.

During the year, the Bureau had in continuous operation 39 primary and secondary tide stations on the Atlantic and Gulf coasts; 28 stations on the Pacific coast, in Alaska, and in the Hawaiian Islands; 8 stations in foreign countries; and, under the State Department program of coperation with American Republics, 11 stations in Central and South America. Fifty of these stations were maintained in cooperation with other agencies, including the governments in Central and South America, the various units of the Army, Navy, and Coast Guard, and with municipal and research organizations.

Temperature and density observations of sea water were obtained during the year at 58 of the tide stations and from 8 stations established for observing temperature and density only.

A tidal bench mark recovery party continued operations along the Pacific coast of the United States and in Alaska servicing tide stations and recovering and leveling to bench marks.

Supplementing the current survey of Puget Sound, 24 additional current stations were occupied during the year. Work preliminary to the preparation of tidal current charts for this area, for which there have been a number of requests, is now in progress.

With the end of the war in the Pacific requests for information from the Armed Forces have materially diminished. However, the preparation of special tide and current reports for particular areas for the use of the Joint Army-Navy Intelligence Service is being

continued at the request of the Hydrographic Office. Two such reports were completed during the year and one more is nearing completion. Data derived from special current surveys in San Francisco Bay, made at the request of the Navy Department, were furnished to naval authorities in San Francisco. For use in connection with Operation Crossroads the Bureau prepared special sheets of predicted tide curves for Bikini covering the months of March–August 1946. Information on current movements in the oceanic area off New York Harbor was furnished the Fish and Wildlife Service in connection with the proposed dumping of industrial wastes. Other current information for numerous localities was furnished in compliance with special requests.

Reciprocal arrangements for the exchange of tidal information between the Bureau and England, Canada, India, Argentina, and France were in effect during the year. In a resumption of an arrangement of former years, interrupted by the war, the Netherlands supplied tide predictions for Flushing and Hook. Assistance was again extended to Norway. In response to a request from that country this Bureau prepared special tide predictions for nine Norwegian ports for the year 1947. Daily predictions together with rolls of predicted tide curves for Bangkok Bar covering the years 1946 and 1947 were supplied to Siam on request.

Daily predictions for four new reference stations (one in the tide tables and three in the current tables) were included in the regular tables. An innovation during the year was the inclusion in the tide and current tables of sets of typical curves depicting the variations in the daily tide and current at representative places.

GEOMAGNETIC SURVEYS

The geomagnetic work of the Bureau began in 1840 as one of the essential steps in the preparation of nautical charts. As long as the navigator steers his vessel by the magnetic compass, so long will he require information on the amount of the compass needle deviates from true north at any given locality. Both the nautical and aeronautical charts of the Bureau provide such information. The Survey is able to furnish such information as a result of its complete magnetic survey of the United States and the regions under its jurisdiction.

Geomagnetic surveys are also important to land surveyors in retracing boundary lines surveyed with the magnetic compass many years ago; to geophysical prospectors who use magnetic methods in their search for oil and other minerals; to investigators of radio transmission; and to other scientific investigators.

Magnetic observations have been made at thousands of places throughout the United States and its Territories to determine the change in declination from place to place. In the United States the variation ranges from 24° east to 23° west of true north, or a total range of 47°. Because of the constantly changing direction and strength of the earth's magnetic forces, observations are necessary at periodic intervals. The present program of the Bureau calls for the

determination of the magnetic elements at about 6,000 repeat stations at 5-year intervals.

During the year continuous photographic records of the principal magnetic elements were obtained at the magnetic observatories at Cheltenham, Md.; Honolulu, T. H.; San Juan, P. R.; Sitka, Alaska; and Tucson, Ariz. In addition, an automatic declination recording station was operated for about 6 months at Gatlinburg, Tenn., in the Great Smokies National Park. No regular field parties were in operation, since the data needed for the 1945 edition of the United States isogonic chart had already been obtained; this is the normal situation at the end of each 5-year period.

Special magnetic projects were undertaken in certain areas and at our magnetic observatories to meet requests of the Armed Forces. These included observations with special instruments or the training of personnel to operate specialized equipment. Observations of magnetic declination were made at nine airports in eight States. This furnished the information required in airplane compass adjustment, a necessary preliminary to safe air navigation. In the Washington office, the special project of furnishing world-wide isogonic data for use of the Armed Forces was brought to a close.

The 1945 edition of chart 3077, isogonic chart of United States, was issued during the year. This chart, which shows the lines of equal magnetic declination, is a basic source of information for many classes of scientific and technical users, as well as for the general public. The 1945 edition marks a departure from former editions in several respects. A larger base map is used which shows more detail and extends farther into the north Atlantic Ocean. The isogonic lines are drawn by a new procedure which more consistently reflects the local irregularities shown by the observations.

Magnetic conditions based on records at the Cheltenham Observatory were reported daily to the National Bureau of Standards in connection with its program of forecasting radio transmission conditions. In addition, magnetic data were furnished other Government agencies.

Special compilations of data for use of the Weather Bureau in a research project were finished. This project was declassified during the year and the results were published by the Weather Bureau in the Journal of Terrestrial Magnetism and Atmospheric Electricity.

Cooperation between the Bureau and the Department of Terrestrial Magnetism of the Carnegie Institution of Washington was continued. Geomagnetic data were exchanged and magnetic instruments loaned. Among the more important items were: Maintenance of international magnetic standard at the Cheltenham Observatory by means of the sine galvanometer and the operation there of a cosmic-ray meter; continuance of atmospheric-electric observations at Tucson, Ariz.; and close collaboration in the matter of special instruments.

The following table shows the distribution of magnetic observations during the year:

Distribution of magnetic observations

Locality	Repeat stations				Other stations	Total
	New		Old			
	Complete [1]	Declination only	Complete [1]	Declination only		
Colorado					1	1
Delaware					1	1
Illinois					2	2
Indiana					1	1
Maine					1	1
Minnesota					1	1
New York					1	1
Tennessee		1				1
Utah					1	1
Vermont					1	1
Virginia					4	4
Washington					1	1
West Virginia					1	1
Alaska					9	9
Canal Zone	1					1
Mexico			1		2	3
Costa Rica			1			1
El Salvador			1			1
Guatemala			1			1
Honduras			1			1
Nicaragua	1					1
Panama			1			1
British Guiana	1					1
Colombia			2	1		3
Venezuela			4	1	1	6
Antigua (British)			1			1
Bahamas			2			2
Cuba	1		3			4
Dominican Republic			1			1
Haiti	1					1
Jamaica			1			1
Trinidad			1			1
Total	5	1	21	2	28	57

[1] A complete station comprises measurement of declination, horizontal intensity, and dip, thus completely defining the field.

SEISMOLOGY

Seismology, or the science of earthquakes and attendant phenomena, is a comparatively new field of investigation for the Coast and Geodetic Survey. This work was assigned to the Bureau in 1925 when it was recognized that earthquake study was important to the country as a whole and that it must be dealt with on a highly cooperative basis. Because of its highly trained personnel, skilled in the operation of delicate recording instruments and in the interpretation of records, it was the consensus of scientific opinion that this work should be taken up by the Coast and Geodetic Survey which for many years before had been operating seismographs at its magnetic observatories.

While it is true that earthquakes cannot be prevented, the practical purpose of the work is to discover ways and means of lessening their destructive effects. This can be done only by a systematic program of collecting and analyzing data pertaining to earthquakes.

The program of seismologic work in the Coast and Geodetic Survey is designed to locate all significant earthquake areas in the United

States and its possessions, to determine the destructive effects, as well as the nature of earthquake motions, and to safeguard life and property by giving to the engineer data which will enable him to determine where and to what degree earthquake-resistant designing of structures is needed. Progress has been made toward improvement of structural design as a result of the seismologic work of the Bureau. These efforts have aroused widespread interest in this country and abroad. Building codes have been improved and it is generally felt that lives and property are thus being materially safeguarded.

The Bureau maintains close cooperation with business, engineering, and scientific agencies interested in this highly specialized activity from the viewpoint of public safety and scientific research.

The seismologic work of the Bureau was concentrated during the year on projects which had fallen in arrears due to the war. Seismographs were operated at four magnetic observatories and at the Ukiah Latitude Observatory.

Fifty-eight strong-motion seismograph stations were in operation in four western States and in the Canal Zone. Seventy-seven records were obtained from 14 earthquakes of moderate intensity in the western part of the country. Three records were obtained from one of four strong-motion seismographs established in South America in connection with a State Department project. The information from these stations was used by a number of engineering laboratories conducting research in the design of earthquake-resistant structures. Interest among engineers in the advancement of these studies reached a new high during the year in anticipation of extensive building plans.

The operation of seismographs in the region of Boulder, Shasta, and Grand Coulee Dams was continued under a cooperative arrangement with the Bureau of Reclamation. The accumulated data have furnished important engineering information in regard to the influence of reservoir loading on the occurrence of local earthquakes.

Assistance was given the War and Navy Departments in the instrumental aspects of various magnetic and seismologic projects. Seismograph records were furnished in connection with the atomic bomb experiment in New Mexico.

The Bureau cooperated with New Zealand by preparing directions for operation of accelerographs.

Vibration observations were made on one oil refinery tank. Ground vibrations were observed during blasting experiments in Idaho conducted by the military. In the Panama Canal Zone vibration tests were made in connection with a foundation problem which developed along the route of a proposed new canal.

Tiltmeters were continued in operation at the University of California, Berkeley, and in the Long Beach area to detect any ground tilting which might possibly serve as an earthquake warning.

Earthquake investigation in the United States is a highly cooperative undertaking and involves close contacts with many commercial agencies and public utilities, the Weather Bureau, a number of seismologic and engineering organizations, universities, postmasters, and several thousand selected individuals. From them, nearly 3,000 information reports were received for 159 earthquakes. In addition, special canvasses were made for 25 unusually strong shocks and in one

case the affected area was visited by a Bureau seismologist. Assistance was given 12 universities and 4 private stations in maintaining seismographs. This consisted primarily in furnishing materials and in interpreting and publishing the instrumental data. This cooperative effort resulted in more accurate earthquake locations than would otherwise have been obtained. The instrumental data were furnished seismologic stations in this country and to a limited extent abroad, and in return similar data were made available to the Bureau.

Cooperation with science service was continued. This permitted the immediate location of important earthquakes from seismologic data transmitted by that organization. Forty-eight epicenters were located in this way. In exchange, the position reports made by this Bureau were made available to science service for local and general publicity purposes. They were also distributed to cooperating stations.

An earthquake and tidal wave originating in the Aleutian Islands and causing loss of life and property at Hilo, Hawaii, focused public attention on the question of utilizing seismographic data to predict seismic sea waves. This is considered to be a more costly and less reliable method than the method of broadcasting their existence from points near the origin of the wave.

IMPROVEMENT IN INSTRUMENTS, EQUIPMENT, AND TECHNIQUES

The Bureau has from its inception recognized the importance of research in its several activities and in adapting the current findings of science to its own needs. It has constantly aimed to test, develop, and employ new and improved instruments, equipment, and techniques whereby better results can be obtained at reduced costs. The Bureau services the equipment and instruments used in its specialized functions. It has been found necessary to maintain a radiosonic laboratory for improvements and adjustments of equipment used in electronics, and to provide a photogrammetric laboratory and technical group for the development of instruments and methods to give the precision required in this type of work.

During the year several notable improvements have been made in the instruments and equipment used in the field and in the office that will result in higher accuracy and greater efficiency in our work.

The most outstanding of these developments has been in the field of hydrographic surveying. Shoran equipment, used during the war for precision bombing, was installed and used on three survey vessels—two operating in the western Aleutians and one off the coast of Maine. Tests indicate that with this type of equipment the survey vessel's position can be determined with an accuracy comparable to visual fix control.

A new electronic instrument, known as radio ranger, has been designed in the Bureau for use in offshore hydrographic surveys beyond the limits of Shoran equipment. Preliminary tests indicate that satisfactory results are obtainable at distances up to 300 miles from shore. This instrument will make possible more accurate oceanographic investigations, particularly of the waters beyond the Continental Shelf, of offshore seamounts, and of submarine canyons, as well as

a complete study of the Gulf Stream. Another application will be in oil prospecting far from shore.

Other improvements made during the year are the following:

The transit micrometer for our astronomical transit has developed errors due to wear. It has been redesigned with roller guides for the moving element and with the same form of thrust bearing that has been found successful in the micrometers of our theodolites.

The telescopes of the second-order theodolites under construction will be made largely from strong aluminum alloy and will be decidedly lighter than those of brass. The vertical circle will be graduated directly on the aluminum.

A recent optical development is the mechanical coating of lenses to reduce internal reflections. A very thin coating of a suitable material is applied, forming a hard surface, which has the property of increasing the distinctness and brilliance of the image by a very appreciable amount. Several theodolite lenses have been so treated, and it is planned to apply this treatment to all of our major instruments. A considerable number of binoculars have been purchased having these treated lenses.

A newly developed nylon yarn, about 50 percent finer than prewar fibers, has been found particularly desirable for use as telescope cross wires. Nylon is strong and elastic, and the new fiber, although too coarse for the finest instruments, can be used for all telescopes except those of precise levels.

Improvements were made to the instrument installed at the automatic recording declination station at Gatlinburg, Tenn. Two additional similar instruments to make continuous automatic records of declination at a fixed station were constructed. The purpose of this instrument is to reduce the amount of fieldwork and to improve our knowledge of declination changes for chart purposes.

A new type of unifilar accelerometer suspension was designed and a contract awarded for construction of 50 instruments.

Rebuilding of variometers and recorder was completed for installation in the new geomagnetic observatory now under construction at Honolulu.

An improvement was made in our observing tent frames by substituting strong aluminum alloy tubing for the steel. This resulted in reducing the weight for a tent unit from 32 pounds to 12 pounds. Welding also made possible a better and stronger frame.

A new process printing frame and two new whirlers were received and installed in our chart reproduction plant, and a number of new machines were purchased for our instrument plant.

The Bureau has cooperated with various Government agencies during the year. They were given the benefit of the Bureau's experience in survey instruments and equipment, and were assisted in procuring proper equipment for their purpose. A number of the agencies, particularly the Army and Navy, have adopted many of our designs. Five new magnetometers, belonging to the Navy Department, were improved and standardized at the Cheltenham Observatory. Special equipment was prepared in connection with Operation Crossroads. Several foreign governments have expressed interest in our equipment, and at least one, Brazil, is actually purchasing instruments of Bureau design.

During the year a number of improvements have been made in methods of compilation and reproduction of nautical and aeronautical charts. A process was developed by which color proofs, in perfect registry, are obtained from the negatives of a multicolor chart prior to making the printing plates. The process consists in exposing each negative to sensitized vinylite which is recoated for each exposure, suitable dyes being included in the coating solution to produce the color desired. This method effects a considerable saving in time, labor, and materials over the conventional press proof method.

An improved method of preparing and processing negatives was developed for use in connection with the application of stick-up lettering to the chart compilation. This method eliminates one set of negatives, saves a certain amount of process work, and results in improved reproduction.

A method of stripping names, notes, and symbols to existing negatives of charts and maps was developed which avoids the laborious task of engraving extensive changes in names on the negatives.

COOPERATION WITH AMERICAN REPUBLICS

For the sixth consecutive year the Coast and Geodetic Survey continued its participation in the interdepartmental program for cultural and scientific cooperation with the American Republics, which is sponsored and financed by the State Department. This program, which began with the introduction of our methods and instruments in gravity and tidal surveys in the American countries, has been expanded to include work in other fields, such as geomagnetism, seismology, geodesy, and hydrography. In addition, the fellowship program, inaugurated last year, and designed to train qualified applicants from the Americas in the fields of geodetic and hydrographic surveying and in map and chart production, was continued during the year.

Important benefits have already accrued from this cooperative program. Through our representatives who have visited the American Republics cordial and helpful relations have been established between this Bureau and military, naval, and scientific organizations and personnel. Through the fellowship-training program an effective medium has been provided for the mutual exchange of surveying and mapping procedures and developments.

One outstanding result of the entire program has been the unification of effort and the standardization of methods and equipment for the South American continent. Some of the countries represented have already taken steps to modernize their methods and equipment in line with our own and have sent purchasing missions to this country.

During the year 11 tide stations in Central and South America were operated on a cooperative basis, the Coast and Geodetic Survey furnishing and installing the instrumental equipment and the cooperating countries providing the maintenance. Two of these stations are located in Mexico, one each in Costa Rica, Colombia, and Ecuador, and three each in Peru and Chile. The observations from each station are analyzed in this Bureau and a copy of the results mailed to each cooperating authority. These observations are supplying valuable data for the prediction of tides, for the construction of nautical charts,

and for the determination of various datum planes required in the development of coastal areas and in the study of coastal stability.

Magnetic surveys were conducted in nine American Republics, namely: Mexico, Panama, Costa Rica, Nicaragua, Honduras, El Salvador, Guatemala, Colombia, and Venezuela. The special program of frequent repeat observations at Paricutin Volcano, Mexico, the new volcano which developed in a farmer's field in February 1943 and grew to over a thousand feet in height, was concluded. The purpose of these observations is to determine the extent of local magnetic disturbances caused by this violent volcano.

A representative of the Bureau visited a number of the American Republics in connection with the acquisition and exchange of earthquake information. Seismologists and others interested were consulted and advised regarding earthquake-resistant construction methods; officers in charge of seismological stations were assisted in testing and adjusting instruments; sites for proposed new stations were tested; talks to engineers and scientists were given; and various publications, books, and miscellaneous information were distributed. As part of this program, strong-motion seismographs have been furnished and installed in areas subject to strong earthquakes. Two were placed in 1944 in Peru and Chile. Two more were installed during 1945 in Colombia and Ecuador. This year arrangements were made for the installation of accelerographs in Guatemala and Costa Rica. Records resulting from this cooperative activity will be available to the Bureau and to the engineers of all American Republics. This is an active means of stimulating interest and improving knowledge in the countries concerned. The information gained will contribute to improved building design and add to the general knowledge of earthquake probabilities.

A commissioned officer of the Bureau was assigned as a geodetic expert to the countries of Chile, Paraguay, Uruguay, and Brazil. He spent from 4 to 6 weeks in each of these countries, participating in geodetic fieldwork, and observing particularly the methods of field and office procedures of the geodetic surveying units. He became familiar with the work of the various countries and was able to observe the activities of the men who had participated in the fellowship-training program in this country. Assistance was also given geodetic organizations on various technical matters.

As a part of the cooperative program a commissioned officer attended a meeting of the executive committee of the Pan-American Institute of Geography and History and the Commission on Cartography of the Institute at Mexico City for the purpose of discussing plans and preparing an agenda for the third Pan-American consultation of geography and cartography to be held at Caracas, Venezuela.

Under the fellowship-training program 16 fellowships were awarded as follows:

In map and chart production to Bolivia (1), Brazil (1), Chile (1), Mexico (1), Paraguay (1), and Peru (1); in geodetic surveying to Bolivia (2), Brazil (1), Colombia (1), Ecuador (2), Paraguay (2), and Peru (2). In addition, two trainees (from Brazil) under the 1945 program were given extensions of 2 months each in 1946.

These fellowship grants are awarded to graduate engineers, preferably to those who have had experience and responsibility in the respective fields they are to pursue. Many of these fellows occupy high positions in the civil and military set-ups of their governments and the recommendations they take back are apt to be followed in those countries. An example of this is the case of Brazil. As a result of the recommendations made by trainees from that country, Dr. Jorge Zarur, assistant director of the Conselho National de Geografia of Brazil, spent considerable time in the Bureau obtaining information relative to the purchase of supplies and equipment.

The period of training varies from 4 to 8 months. No formal classroom work is given as the objective is to learn by doing rather than by theoretical studies. For those taking geodetic surveying, the major portion of the time is spent on actual fieldwork with enough time in the Washington office to become familiar with office methods of processing the field data. For those training in map and chart production, the policy is to give the trainees specialized training to meet their particular interests, with a general orientation in the related processes of chart production and reproduction. From conferences with the trainees and from observations made by one of the Bureau Officers on a visit to some of the American Republics, the training in modern methods of compilation and photolithographic reproduction appears to be one of the most urgent needs of these countries. Every effort will be made in the 1947 program to secure trainees for these branches.

An indirect cooperative activity of the Bureau has been the assistance given the American Congress on Surveying and Mapping in the publication of a Spanish edition of its official journal Surveying and Mapping. The Spanish issue was prepared in cooperation with the Commission on Cartography of the State Department and with other federal mapping agencies as a gesture of friendship and was designed to promote interest in mutual surveying and mapping problems. Approximately 60 members of the Congress are from the American Republics and represent governmental and private mapping interests.

PERSONNEL AND FINANCES

The number of persons in the service of the Coast and Geodetic Survey at the close of the fiscal year was 2,117.

On June 30, 1946, 13 commissioned officers were serving with the armed forces, to which they had been transferred by Executive order. Of these, 2 were in the Navy, 3 in the Marine Corps, and 8 in the Army.

In September 1945 a new section of personnel management was created and was engaged in the completion of classification surveys, the establishment of new procedures and regulations regarding leave and appointments in both the office and field, and the creation and maintenance of a ceiling control system.

During the year, 1,208 appointments were effected, 898 separations occurred, 12 employees were retired, 35 were inducted into the armed forces, and 229 line promotions (including reallocations) and 842 within-grade promotions were made. Of the 1,208 appointments made, 248 were employees who returned to duty from military fur-

lough and 306 were veterans who received new appointments, making a total of 554 veterans placed in the Bureau during the year.

An officer was assigned to liaison duties with the Corps of Engineers at Portland, Oreg., to expedite the field operations in the Columbia River basin, by arranging for purchases of supplies and materials and for assignment of personnel.

In connection with the photogrammetric mapping program of the Bureau, two officers were receiving flight training at Navy flight schools.

An officer continued on duty at Adak, Alaska, with the headquarters of the Seventeenth Naval District and directed surveying activity in areas of strategic importance to the armed forces.

An officer, transferred to the War Department, was appointed director of the Philippine Bureau of the Coast and Geodetic Survey. Four other officers have been assisting in reestablishing field operations in the Philippines.

Personnel of the Bureau were assigned to Operation Crossroads to make instrumental measurements of earth motions at distant points as well as strong ground motions near the scene of the blasts. The tests will provide, among other things, an opportunity to obtain evidence on the geologic structure of the Pacific basin.

A geophysicist of the Bureau was attached to a United States naval expedition to the North American Arctic for geomagnetic observations.

All wage board employees of the Bureau were given an increase of approximately 15 percent in base pay as a result of the Commerce Department Wage Board order of November 19, 1945. In accordance with the Department's order of June 17, 1946, automatic promotions to and including step three, will be permitted annually to wage board employees with an efficiency rating of good or better. To advance beyond step three will require a rating of very good or better.

The following table shows the personnel ceilings alloted by the Bureau of the Budget under the provisions of the Federal Employees Pay Act of 1945 and the maximum number employed under those restrictions. Since commissioned officers are excluded from the Budget Bureau's determination of ceilings, they have been omitted from the figures. Also omitted are without-compensation and $1-a-year men, and part-time employees.

Personnel ceilings allotted by Budget Bureau

Period	Budget allotment	Maximum number of employees (within budget restrictions)
Quarter ended Sept. 30, 1945	2,196	1,773
Quarter ended Dec. 31, 1945	1,939	1,572
Quarter ended Mar. 31, 1946	1,843	1,751
Quarter ended June 30, 1946	2,184	1,964

Collections covering miscellaneous recipts, including nautical and aeronautical charts and related publications, totaled $436,078 as compared with $154,033 during the preceding year.

The following funds, from the sources indicated, were available to the Bureau during the fiscal year 1946:

Available funds

Regular appropriation	$6,450,000
Public Law 349	427,000
Second Deficiency Appropriation Act, 1946	259,000
Total appropriations	7,136,000
Reimbursements to credit of appropriation for:	
Salaries and expenses, departmental	134,054
Salaries and expenses, field	26,552
Total reimbursements	160,606
Working funds received from:	
Bureau of Reclamation (seismologic work, Boulder Dam)	8,500
Bureau of Reclamation (seismologic work, Coulee Dam)	2,500
Bureau of Reclamation (seismologic work, Shasta Dam)	2,500
War Department (aeronautical charts)	517,207
Navy Department ("Crossroads" program)	1,600
Navy Department ("Crossroads" program)	3,800
Total working funds	536,107
Allotments from:	
State Department (cooperation with American Republics)	76,680
Department of Commerce (printing and binding)	71,100
Total allotments	147,780
Total funds received	7,980,493
Of this, the following amount was unobligated June 30, 1946, and therefore remains available for 1947	109,999

PUBLICATIONS

The principal publications of the Bureau are its marine and air charts, which are printed in the Washington office. In addition to these, the Bureau prepares other publications through which the results of its work are disseminated to the public.

In the field of related marine-chart publications, 11 supplements to the Coast Pilot volumes were issued during the year. These volumes contain a wide variety of important information which supplements that shown on the nautical charts. A new edition of a Pilot is published about every 7 years, although this interval may vary depending on the importance of the region, the number of changes, and other factors. Supplements, containing corrections, changes, and new information, are published about once a year.

Tide and current tables are published annually by the Bureau and contain tide and current predictions for numerous ports in the United States and in foreign areas. In addition to these, a revised edition of Tidal Current Charts, New York Harbor, was submitted for publication during the year. The new edition incorporates the results of recent current observations in the East River in the vicinity of Corlears Hook.

Index maps of tidal bench marks were completed during the year for New Hampshire and Washington, and loose-leaf compilations of descriptions and elevations of bench marks were completed for New Hampshire and were nearing completion for Washington. These data are published to supply information essential to surveyors and engineers in establishing vertical control for hydrographic operations, coastal construction, and other engineering projects. Formerly this information was made available in book form, but this has been replaced by loose-leaf compilations in order that the data may be kept more up to date as well as to increase the economy of distribution.

A revised 1945 edition of the publication, Density of Sea Water, Atlantic and Gulf Coasts, was published, and a revised 1946 edition of Density of Sea Water, Pacific Ocean, was sent to the printer. Work was also in progress on the preparation of a 1947 edition of Surface Water Temperatures, Atlantic and Gulf Coasts. The information in these publications is valuable to the shipping industry, to industrial plants using sea water, and to the fishing industry.

In the field of seismology, Serial 682, United States Earthquakes, 1944, was sent to the printer during the year. The quarterly Progress Report of Strong-Motion Earthquake Work, containing abstracts of important earthquakes, analyses of strong-motion seismograph records, and miscellaneous news items, was issued for the first quarter of 1946.

In the field of geomagnetism, the manuscript for Serial 664, Magnetic Declination in the United States, 1945, was completed and sent to the printer. This is a revision of a volume which is in much demand by land surveyors and others. Alaska Magnetic Tables and Magnetic Charts for 1940 was reproduced in the Bureau by offset lithography. The manuscript for Magnetic Observations in the American Republics, 1941–44, being published under the interdepartmental program of cultural and scientific cooperation with the American Republics, was in the hands of the printer at the end of the year.

Two volumes of observatory results were issued during the year. These reports comprise the principal record of the work of the observatories and are used in basic researches into earth magnetism and the ionosphere, as well as for immediate practical application to charts.

The following special publications relating to cartography and control surveys were reprinted:

No. 5. Tables for a polyconic projection of maps and lengths of terrestrial arcs of meridian and parallels.

No. 8. Formulas and tables for the computation of geographic positions.

No. 65. Instructions to light keepers on first-order triangulation.

No. 120. Manual of first-order triangulation.

No. 138. Manual of triangulation computation and adjustment.

No. 145. Manual of second- and third-order triangulation and traverse.

No. 231. Natural sines and cosines to eight decimal places.

In addition to these formal publications, a number of articles, papers, and lectures were prepared by the Bureau personnel designed to interpret the work and activities of the Bureau to scientific and engineering societies and to the public in general.

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