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U. S. Coast and Geodetic Survey

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Annual Report of the Superintendent of the Coast Survey

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United States Coast and Geodetic Survey

GENERAL STATEMENT

During the past year the Bureau was faced with the need for accelerating its normal coastal surveys to overcome the backlog which accumulated during the war period, when concentration on military needs resulted in a neglect of many areas of commercial importance. Difficulties are foreseen in early accomplishment of the desired surveys because of the increasing cost of operating floating equipment and isolated field units.

During the year comprehensive survey work was begun north of the Alaska Peninsula; in Bristol Bay and in the Arctic Ocean near the Canadian border. Except for a few isolated surveys, this area was untouched heretofore because of the difficulties of terrain and the hazards of weather. Ice conditions and low temperatures introduced many new problems for our survey parties. It is a pioneering undertaking which will entail many hardships and a number of years of slow progress. Very little is known of the depths of water, the character of the sea bottom, or the behavior of tides and currents of Bering Sea and Arctic coastal waters. Information on conditions in this area is important for commercial development, for fisheries, and for the national defense.

Another important project begun during the year was the systematic search for and location of wrecks that occurred during the war along the Atlantic coast. These wrecks are not always hazards to surface navigation but are dangerous to fishing nets and to submarines.

Interest in flood-control work and in other large-scale projects for development of water uses brought an increased demand for geodetic surveys in order that comprehensive plans might be properly coordinated upon basic engineering data. Requests for such work were over three times the amount that could be accomplished with existing facilities, and it became necessary to establish priorities to accomplish the most urgent projects first.

Dissemination of Technical Information

An important part of the Bureau's work is the dissemination of its technical information. While our nautical and aeronautical charts are well known to mariners and aviators, much of our other data is

either unknown to the average engineer and surveyor, or its usefulness is not fully understood. It is in the interest of the public that maximum use be made of these data which are meticulously collected, analyzed, and compiled. To this end we are gradually developing a program of broadening our technical service in order to accomplish a better understanding, a more effective distribution, and a greater utilization of the products of our activities.

A closer liaison has been established with governmental and private agencies through representation on scientific and technical boards, panels, and commissions, and through active participation by Bureau personnel in the activities of national and international bodies dealing with surveying and mapping activities or related fields. These contacts make it possible to note trends and developments in our fields of interest.

As part of the over-all program, a provisional Handbook of Technical Services for the State of New Jersey has been published. This describes and illustrates the kind of data and services which are available to engineers, surveyors, and the chart and map-using public. Another means for the dissemination of Bureau information to the public has been through specially prepared exhibits of the operations, equipment, and products of the Bureau. These have been displayed in various parts of the country in connection with national meetings and conventions of technical organizations. We have continued to furnish news releases to the daily press and to technical magazines, announcing survey projects, new and revised charts, issued, and new publications. Papers were prepared on the work and progress of the survey for magazines, newspapers, encyclopedias, and yearbooks, and for presentation before scientific and engineering societies.

This broadened program of service to the public has resulted in a noticeable increase in requests for geodetic and other data.

We have for some time recognized the urgent need for keeping our widely scattered operating units and field offices abreast of new developments in methods and techniques. To meet this need, we published during the year the first issue of the Journal of the Coast and Geodetic Survey. The Journal will provide a forum for the presentation and discussion of new methods in the field and office. It will be published as material accumulates and at such intervals as to be of maximum use to our personnel.

Technical Improvements and Developments

Development work in various activities during the year has resulted in marked improvements in instruments and techniques.

Progress in the field of electronics has proceeded at a gradual rate. The Coast and Geodetic Survey electronic position indicator for locating hydrographic soundings at distances beyond 100 miles from shore has been tested under service conditions. Modifications and improvements were incorporated in a second model, which was nearly completed at the end of the year. The Bureau is the only agency developing this type of equipment. Since it is being done in conjunction with our other activities, progress in its development has been limited.

Improvements were made in the Bureau's nine-lens aerial camera and its associated stereoscopic plotting equipment. A photogrammetric test area has been established which will allow accurate adjustment and calibration of the camera and thereby give greater accuracy to the compilation of topographic maps from aerial photographs.

Progress was made towards the development of a general warning system for seismic sea waves. A local sea wave detector, which utilizes the arrival of the first part of the seismic sea wave for alerting the area, was developed and placed in operation at Honolulu. It is intended to install similar detectors at naval bases in the Aleutian Islands and at Midway, and at other locations in the Pacific through cooperation with the Civil Aeronautics Administration and the territorial surveyor.

A new series of aeronautical charts was introduced for use with high frequency instrument landing system equipment. These charts give, in both plan and perspective, all information necessary for safe landing at airports. Forty charts were published during the year and additional charts are being completed as installations are commissioned.

An important scientific study is being conducted in the Bureau to determine the feasibility of using gravity anomalies for ascertaining the deflection of the vertical. This method, if successful, will permit correcting astronomical observations to conform to a standard datum.

We have experimented with high-speed calculating machines for the processing of field data and found punched-card methods applicable to our specialized activities. In consequence, a group of specialized equipment is being installed. The innovation will save many man-hours and will relieve personnel of much of the nerve-taxing computing that is characteristic of a good deal of our work.

Other improvements in methods and equipment include: An electronically operated torsion pendulum analyser to facilitate the determination of dynamic forces in buildings due to destructive ground motions; a photographic method for producing precise level rods which materially reduces the time required to graduate a rod; and the further application of plastics in our lithographic and cartographic work, with a corresponding elimination of certain reproduction steps.

Cooperation With Other Agencies

Because of its specialized activities and its technically trained personnel, the Bureau is consulted and actively cooperates on a wide variety of problems dealing with surveying and mapping and related fields. Information was furnished to various government and private organizations on our methods and techniques. Priorities were established for field work to correlate with mapping and construction programs of other agencies. Principal among these were the geodetic control surveys accomplished in the Missouri River Valley, at the request of the Corps of Engineers, Bureau of Reclamation, and Geological Survey.

A noteworthy cooperative undertaking was the establishment of urban control in the city of Cincinnati and environs. There is a growing appreciation of the value of precise surveys in providing a permanent base for the tie-in and coordination of local surveys.

The Bureau was consulted by the Department of Justice on technical matters growing out of the California submerged lands case. Assistance was given the Department in the preparation of supplementary briefs. A study of original data was made and maps prepared showing changes in shore line for the entire California coast since the earliest surveys.

Technical advice in geomagnetic operations and processes was given representatives from Federal agencies and from China, the Philippines, Argentina, and Turkey. Conferences on a wide variety of seismological problems were held with emissaries from India, China, Iceland, Ecuador, Peru, and Venezuela. Magnetic and seismologic instruments were furnished for expeditions to remote areas under cooperative arrangements which secure records and observations for analysis by the Bureau.

In cooperation with the Department of National Defense and the National Geographic Society observations were made in the Aleutians in connection with the annular eclipse of May 8, 1948. From the data obtained from this and other eclipse expeditions in Asia, along the path of totality, it is hoped that information can be adduced for checking the dimensions of the earth and for coordinating world networks of triangulation.

Participation was continued in the Philippine Rehabilitation Program, authorized by the Seventy-ninth Congress. Under this program three officers and three civilians were assigned to the Manila office to assist in field operations and training selected groups of Filipinos. Two groups received training in the United States in survey methods. The first of these returned to Manila to man and operate survey ships and shore units. The program will continue until June 30, 1950.

Effect of Recent Legislation on Operations of Bureau

Several legislative acts were passed by the Congress during the past year that will have important bearings on future operations of the Bureau. One of these is the act defining the functions of the Bureau.

No comprehensive legislation had ever been enacted which fully defined the scope of the Bureau's activities. Since its inception the Bureau has operated on authorizations contained in appropriation acts based generally on the very brief statement included in the original resolution passed by Congress in 1807 authorizing "a survey to be taken of the coasts of the United States, in which shall be designated the islands and shoals * * *"

The need for new legislation had been recognized for some time and a proposed bill was prepared in 1945. After careful consideration by the Bureau of the Budget of the functions of other mapping agencies the authorizing language was agreed on. On August 6, 1947, the President approved the act entitled "An act to define the functions and duties of the Coast and Geodetic Survey, and for other purposes."

The new act authorizes the Bureau to perform the activities necessary to provide charts and related information for the safe navigation of marine and air commerce and to provide basic data for engineering and scientific purposes and for other commercial and industrial needs. Authorization is made for the dissemination of the products resulting from the compilation, analyses, and processing of the field data. The Bureau is made the central depository of the United States Government for geomagnetic data. Finally, the act authorizes the appropriation of funds required to carry out the activities enumerated.

Legislation was enacted to bring the promotion and retirement system for commissioned officers more nearly in line with that of the other commissioned services. The new legislation provides a means of advancing outstanding officers and retarding or separating those officers who do not meet the necessary standards. Its salutary effect on the morale and efficiency of the service is already apparent.

In connection with the Mississippi River Basin, Congress provided legislative authority for a flood-control program and for the integration of plans for water uses for all purposes in this vast region comprising nearly half the country in area and population. As a result of this authorization the President recommended a 10-year integrated program. Plans were made in the Bureau for the necessary geodetic control surveys, and conferences were held with the Corps of Engineers respecting priorities for survey projects in the various river valleys. A plan was prepared to conform with this part of the program in 1949 and following years.

Needs of the Bureau

There are many undeveloped areas in the United States and in Alaska for which basic surveys have not been made. Such surveys are prerequisites to many commercial and industrial undertakings. It is in the national interest that the surveys in these areas be advanced. An accelerated program would serve our military needs in any future emergency. The minimum requirement for carrying out this program will be a recognition of the continual rise in cost of survey operations in regions where extreme conditions of weather and terrain increase the difficulties of transportation and supply.

The flight-checking of aeronautical charts should be resumed. This is an important phase in the preparation of aeronautical charts. Safer air navigation is assured as a result of these checks. Constant flight-checking should be maintained and each fifth edition of a chart should be inspected before issue.

A close liaison must be maintained, through the Department, with the National Security Council, and with the National Military Establishment. Existing legislation provides for transfer of personnel, ships, and equipment to the latter under a national emergency. The Coast and Geodetic Survey is a compact organization whose technical services can be made readily available for defense needs. Our survey expeditions are pioneering in character and are equipped for immediate service in outpost areas.

Our service to the public will be improved by the extent to which these needs are met.

FUNCTIONS OF THE BUREAU

The Coast and Geodetic Survey, which in the beginning was known as the Coast Survey, was first organized in 1807 to survey and chart the then existing coastal waters of the United States, in the interest of promoting commerce between the various States and with foreign countries. The need to obtain precise instruments and the War of 1812 caused postponement of actual field work until 1816, when surveys were begun in the vicinity of New York.

As the Nation grew the work of the Bureau was extended to the Pacific and Gulf coasts. In 1871 Congress authorized a geodetic connection to be made between the Atlantic and Pacific coasts and charged the Bureau with the duty of providing the States with geographic positions and bench marks for the control of their topographic and geologic surveys. Since that date the Bureau has been actively engaged in extending triangulation and precise levels in the interior of the country for the purpose of establishing a Federal framework on which all land surveys and engineering undertakings could be based, as well as continuing the same work along our coasts for charting the water areas.

These two operations are parts of an integrated activity. Our coastal triangulation, to which hydrographic surveys (including photogrammetry, and tidal and magnetic measurements) are tied, is a basic part of the continental network. Similarly, the datum of mean sea level, determined from observations along the coast forms the fundamental datum for all bench marks in the interior.

Another main function of the Bureau is the preparation and publication of aeronautical charts for our civil airways. This work was first assigned to the Secretary of Commerce under the Air Commerce Act of 1926, and was delegated to the Coast and Geodetic Survey because of its similiarity to nautical charting. In 1947, the Bureau was charged by legislation with the responsibility for this activity.

Earthquake investigation is another comparatively recent activity of the Bureau, having been transferred from the Weather Bureau in 1925. The program includes the mapping of earthquake areas and the evaluation of earthquake risk through the operation of seismographs and the systematic collection of earthquake information from cooperative private agencies.

The importance of the over-all program of the Bureau has become increasingly evident from the benefits that have accrued to commerce and industry, to science, engineering, and the national defense. Some of the more specific of these have been the decrease in shipwrecks and lower insurance rates that invariably follow the completion of comprehensive coastal surveys. Several of the activities of the Bureau on land, sea, and in the air furnish basic data not available from any other source.

Products of the Bureau

A considerable variety of essential services for the advancement of marine, aviation, commercial, and industrial interests of the country

are provided in the products of the Bureau. Charts and maps and some processed publications are produced in our printing plant. Other publications are printed at the Government Printing Office. Available to the public are:

NAUTICAL CHARTS AND COAST PILOTS for use by the Navy, Merchant Marine, fishing industry, and the small pleasure-boat owner.

AERONAUTICAL CHARTS for use by the armed services, commercial air carriers, and private pilots.

PLANIMETRIC MAPS of coastal areas for use in charting and for planning engineering and other construction.

GEODETIC CONTROL DATA (triangulation, leveling, and gravity) for use by Federal, State, and local mapping and engineering agencies, by private surveyors and engineers, and by scientific investigators.

TIDE AND CURRENT PUBLICATIONS (Tide and Current Tables, Tidal Current Charts, and special tide and current surveys) for use in navigation, coastal construction, water-front litigation, and scientific investigations.

GEOMAGNETIC PUBLICATIONS for use by Federal mapping and charting agencies, by local surveyors in boundary surveys, and by geophysical prospectors in search for oil and other minerals.

EARTHQUAKE REPORTS for use by construction engineers in the design of earthquake-resisting structures, by geologists and insurance statisticians in earthquake areas, and by scientists in the study of earthquake phenomena.

CHARTING OUR COASTAL WATERS

The nautical chart is one of the major products of the Bureau's activities. Designed to facilitate water-borne commerce, the nautical chart has changed with new developments in navigation. Only a comparatively few charts were necessary in the early days of the Bureau to cover our limited coast line. Today some 900 charts are published for the waters of the United States and possessions to meet the various needs of the navigator. These range from large-scale harbor charts, used for piloting and close inshore navigation, to small-scale sailing charts for navigation offshore.

Nautical charts are compiled from the basic field surveys of the Bureau, supplemented by data from other organizations, especially data relating to channel and harbor improvements and changes in aids to navigation. They depict graphically such details as the nature and form of our seacoasts, character of the sea bottom, location of channels, aids to navigation, and position of reefs, shoals, and other dangers. This is information that the mariner needs in order to bring his ship safely into port. Charts must be revised frequently to give an accurate picture of existing conditions. Constant changes are taking place along our coasts due to the forces of nature and the works of man. Ocean waves and currents are moving sand and mud from one place to another and shifting channels and sand bars. Millions of dollars are being spent annually on harbor improvements and port facilities.

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To show such changes on the charts, it is necessary to print new editions at frequent intervals. In some of our seaports, changes are so numerous that the charts must be revised and printed as often as four times a year. The problem of nautical charting is therefore a never-ending process. Our service to commerce will be measured by the degree to which we can keep our charts current.

CHARTING OUR AIRWAYS

Government responsibility for charting our coastal waters was recognized in the organic act creating the Coast Survey. Similar responsibility for charting our airways was affirmed in the passage of the Air Commerce Act of 1926. Because of the basic similarity between marine and air charting, the Bureau was assigned the task of preparing and publishing aeronautical charts.

Aeronautical charts are compiled from the basic survey, data of the Bureau, supplemented by the best topographic data from more than 50 miscellaneous sources. Emphasis is given to features of aeronautical importance, so that the chart can be read easily by the pilot in a rapidly moving airplane. Airports, beacon lights, radio-range stations, and other aeronautical data are overprinted in color, usually magenta.

When funds are available, charts are flight-checked, before final publication, by an experienced observer and details on the chart compared with actual ground feature. The flight-check not only insures the incorporation in the chart of latest changes, but it also gives the compiler the airman's view of what should be emphasized on the chart.

Once an aeronautical chart is published there arises the problem of maintenance. A constant flow of information must go out to aviators regarding changes in culture, in aids to navigation, and in other vital aeronautical data affecting our airways and airports. In some of the chart series it is necessary to maintain a weekly revision schedule. Public safety requires the use of up-to-date and reliable charts.

The present program of the Bureau includes the publication of several series of charts to meet the different needs of air navigation. A total of 822 charts has been published to date for the United States and possessions. These range from large-scale charts for use in approach and landing operations at airports to small-scale charts for use in navigating high-speed transports, and include complete representation of radio facilities. The base charts, prepared by the Bureau, are used by State aeronautical commissions for their regulations in promoting safe navigation within their borders.

CHART PRODUCTION AND DISTRIBUTION

During the fiscal year 1948, only limited progress was made by the Bureau in reducing the heavy backlog of revision data for its nautical and aeronautical charts. Because of the large accumulations of data

during the war years, it has been necessary to institute a program of reconstruction and extensive revision of all charts. Concerted efforts were made to improve the quality of existing charts, but only the most vital information could be applied to them. There are increasing demands for new charts and for new types of charts, particularly aeronautical charts.

Sales of nautical and aeronautical charts to the public are handled from the Washington office and through field offices and authorized agents located in major cities in the United States, Alaska, Hawaii, and the Philippines. Regional chart distribution centers, for supplying bulk orders to the agents in their areas, are maintained at New York, Baltimore, and Kansas City. The establishment of these centers has resulted in more efficient service to the public, and in relieving the overburdened facilities of the Washington office.

Mailing lists for the automatic distribution of informational pamphlets, listing the dates of latest prints for each series of aeronautical charts, have been maintained for chart agents and for others desiring these bulletins. This is an important step in encouraging the use of the latest charts, thereby promoting greater safety in aviation. Instrument approach and landing charts and radio facility charts are sold on a subscription basis.

The annual output of navigation 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	1945	1946	1947	1948
Nautical charts	4,330,547	2,235,396	1,225,639	1,178,346
Aeronautical charts	16,899,049	9,097,817	7,988,426	6,581,130
Airport and radio facility charts	----------	2,705,446	4,885,703	6,533,924
Coast Pilots	13,884	14,067	15,993	17,171
Tide Tables	98,016	80,014	65,767	43,481
Current Tables	40,933	37,856	45,778	39,051

The distribution of nautical and aeronautical charts during the year was as follows:

Distribution of nautical and aeronautical charts in 1948

NAUTICAL

		Percent	
Free issue:			
Navy Department	543,075	46.1	
Coast Guard	6,812	.6	
War Department	24,531	2.1	
Coast and Geodetic Survey	14,922	1.3	
Other departments	4,280	.3	
	593,620	50.4	
Sales	433,486	36.8	
Condemned	151,240	12.8	
	1,178,346	100.0	1,178,346

Distribution of nautical and aeronautical charts in 1948—Continued

UNITED STATES AERONAUTICAL			
		Percent	
Free issue:			
War Department	2, 416, 817	41. 7	
Navy Department	784, 035	13. 5	
Civil Aeronautics	35, 090	. 6	
Coast and Geodetic Survey	62, 818	1. 1	
Other departments	11, 148	. 2	
	3, 309, 908	57. 1	
Sales	1, 455, 712	25. 1	
Condemned	1, 032, 107	17. 8	
	5, 797, 727	100. 0	5, 797, 727
UNITED STATES AIRPORT AND RADIO FACILITY			
Total issue			6, 533, 924
SPECIAL AND FOREIGN AERONAUTICAL			
Total issue			783, 403
Total			14, 293, 400

Nautical Charts

A total of 897 nautical charts were on issue at the end of the year. To produce the 1,178,346 copies distributed, 602 printings were necessary, as follows: 16 new charts, 62 new editions, 500 new prints, and 24 reprints.

A new system has been inaugurated whereby charts on which many or critical corrections must be made by the purchaser are withdrawn from sale when new prints are issued. This prevents the issue of charts which might result in hazardous use.

Approximately 8,000,000 hand corrections were necessary to correct the nautical charts to date of issue. Dangers requiring hand corrections were reported to the Coast Guard and the Hydrographic Office for publication in the Weekly Notice to Mariners. Facilities for hand-correcting nautical charts in stock at the district offices have been expanded, and charts are now hand-corrected at Boston, New York, Baltimore, Norfolk, Los Angeles, San Francisco, and Seattle.

The project of charting the Gulf Intracoastal Waterway, begun toward the end of 1946, is being expedited. There is an increasing demand for charts of this waterway. The volume of traffic in the completed portion of the waterway has reached a total many times that in the Atlantic waterway. The completed project, extending 1,076 miles from Carrabelle, Fla., to the Mexican border, will require 33 large-scale charts similar in design to the Atlantic Intracoastal Waterway charts. Eleven of these charts have been published to date, covering the waterway from Carrabelle, Fa., to Biloxi, Miss., and four others are in various stages of completion.

Three new charts in the Arctice Ocean area, based on recent hydrographic and topographic surveys made by the Bureau, were compiled and published.

The new chart for use with the Loran system of navigation, developed last year, has been published. The Bureau has received a

number of favorable comments from those who have used it, and it is believed the problem of combining Loran curves of position with the conventional nautical chart has been solved. Two charts of this type now cover the entire Atlantic coast at a small scale. It is planned to extend the program by applying Loran curves to larger-scale charts.

To eliminate the uncertainty in fish-trap area limits, the Bureau cooperated with the Office of the Chief of Engineers, which will publish and legalize the limits of such areas stated in geographic coordinates. The official designation of these limits will be "as shown on the various Coast and Geodetic Survey charts."

In the field of related nautical chart publications, the Bureau publishes a series of Coast Pilots to supplement the information shown on the charts. Field inspection for the revision of the Atlantic and Gulf Coast Pilots continued throughout the year. Inspection of Atlantic Coast, Section D, Cape Henry to Key West, was completed, and inspection of the Gulf Coast had progressed westward to Galveston.

During the year, 29 additional nautical chart agents were appointed and 10 agencies were canceled, bringing the total number at the end of the year to 200. Inspections were made at 118 agencies.

Aeronautical Charts

At the end of the fiscal year, 822 aeronautical charts were being maintained by the Bureau. These include 259 standard aeronautical charts, 518 instrument approach and landing charts (including 44 instrument landing system charts), and 45 radio facility charts. In addition to handling the issue of the Department of Commerce aeronautical charts, the Bureau acts as a distributing agency for charts published by the Aeronautical Chart Service of the Department of the Air Force.

During the year 1 new sectional chart, 13 local charts, and 1 aircraft position chart were compiled and published. The publication of 3 direction-finding charts of Alaska and 1 planning chart of the United States, formerly published by the Aeronautical Chart Service, has been assumed by the Bureau.

Existing work schedules were revised to include the new commitments assumed during the year, and also to conform with the inspection schedules of the Civil Aeronautics Administration in the various regions. It is expected that this cooperation will result in the receipt of new information, acquired by the airport inspectors, in time for incorporation on the charts at scheduled printings. Due to the small civil issue of flight charts, this entire series was placed on a yearly printing schedule, rather than the semiannual basis which is still being maintained for the United States sectional and world aeronautical charts.

A new series of charts, known as instrument landing system charts, was inaugurated during the year. These charts, size 8 by 10½ inches, are designed for final instrument approaches using very-high-frequency instrument-landing-system equipment. One side of the chart, the approach side, shows the transition procedure from standard approaches on low-frequency facilities; the other side, the procedure side.

presents, in both plan and perspective, details of the glide path, bearings, elevations, and other necessary information. Forty charts were published during the year, and additional charts are being completed as installations are commissioned. These charts do not replace the standard instrument approach and landing charts.

New editions of approach and landing charts during the year totaled 672.

The series of radio facility charts of the United States has been increased during the year to 45 by the addition of 3 new large-scale charts of congested areas. Improvement in the cartography of these charts is under study. A check list showing the dates of current charts is now furnished bimonthly to assist users in keeping their files current. During the year, 400 new editions were necessary to keep these charts up to date, a large number of which resulted from the changes in identifier designations of radio ranges. Since these changes could not be applied to the standard charts except at the times of scheduled printings, the prompt issue of radio facility charts carrying this information kept the public informed.

One flight-check party operated during the last half of the year. Four sectional and two local charts were completed. The airplane used was obtained on loan from the Civil Aeronautics Administration and the cost of personnel, repairs, and maintenance was paid by the Bureau.

Ninety-six new authorized agents for aeronautical charts were appointed and 54 were canceled making a total of 406 agents under contract with the Bureau at the end of the fiscal year. Three hundred agencies were inspected and 59 were given an additional inspection. The results of these inspections have been very gratifying because much more satisfactory conditions were found at the time of the second inspections.

The standardization of aeronautical charts, both national and international, was furthered through work with the Air Coordinating Committee, which was established by Executive order during the fiscal year 1946. The task of applying international standards to the charts of the Bureau was continued.

SURVEYS OF COASTAL WATERS

Coastal surveys include hydrography, topography, and coastal triangulation, and furnish information concerning shore lines, characteristics of the sea bottom, location of channels and shoals, aids to navigation, and much other data required for the production of marine charts and coast pilots.

Nearly 90,000 statute miles of tidal shore line, fringed by over a million square miles of coastal waters—covering continental United States, Alaska, the Hawaiian Islands, Guam, Puerto Rico, the Canal Zone, and the Virgin Islands—are under the jurisdiction of the Bureau and must be safeguarded for navigation. Periodic resurveys are required in many of these areas because changes are taking place in our shore lines and in the ocean bottom as a result of natural causes and the works of man. Many of the other areas, though unchangeable, require resurveys because the present charts lack the detail which the

modern navigator needs for use with improved navigational devices. The problem of surveying our coastal waters is thus a continuing one.

During the period of hostilities our normal program of surveying these areas had to give way to the survey of strategically important areas. Since the war this program has been resumed and surveys have been carried into areas of importance to commercial shipping and into undeveloped regions containing oil, fishing, and mining resources.

During the year 19 survey ships and 3 shore-based parties were engaged on coastal surveys along the Atlantic, Gulf, and Pacific coasts of the United States, and in Alaska. One ship was engaged on hydrographic surveys in the Philippine Islands under the Philippine Rehabilitation Program. A summary of the surveys accomplished is given in the following table:

Statistical summary of coastal surveys

	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	5,568	838	------	------	------	------	------	------	------
Massachusetts to Cape Charles	229	5	39	24	28	6	1	2	9
Chesapeake Bay	2,898	106	143	35	22	------	------	------	------
Gulf Coast	9,840	19,070	------	------	6	5	------	5	------
California and Oregon	3,387	108	------	------	35	------	18	60	21
Lake Pend Oreille, Idaho, and Lake Franklin D. Roosevelt, Washington	3,176	126	------	------	107	58	40	101	65
Alaska	38,722	35,563	------	------	150	------	368	1,509	544
Philippine Islands	1,321	18	------	------	58	36	26	46	87
Total	65,141	55,834	182	59	401	105	453	1,718	731

Along the Atlantic and Gulf coasts, the survey vessels *Lydonia*, *Cowie*, *Gilbert*, *Hilgard*, *Wainwright*, *Sosbee*, *Parker*, *Bowen*, *Stirni*, and *Hydrographer* accomplished hydrographic wire-drag, current, or coast pilot surveys.

The *Lydonia* conducted Shoran-controlled hydrography off the coasts of Maine, New Hampshire, and Massachusetts until the close of the 1947 field season. On November 17, 1947, after 30 years of service in the Government, including two world wars, the vessel was decommissioned, because of old age and obsolete power machinery, and transferred to the United States Maritime Commission for disposal.

The *Cowie* was engaged on hydrographic surveys in the James River and Chesapeake Bay areas.

The *Gilbert* made hydrographic surveys along the coast of Maine and later began surveys in the vicinity of Point Judith, R. I.

The *Hilgard* and *Wainwright* completed current observations in Delaware River and Bay. At the request of the Coast Guard, a special wire-drag examination was made of Baltimore Harbor to locate a missing Coast Guard plane. A wire-drag investigation was made in the vicinity of Old Field Point, Long Island, and a measured-mile

speed course eastward of Old Field Point was established. Both vessels continued hydrographic surveys in Boston Harbor.

The *Sosbee* completed coast pilot inspection along the Atlantic coast from Ocracoke Inlet, N. C., through the Intracoastal Waterway to Florida, and along the Gulf coast from Key West to Galveston.

The *Parker*, *Bowen*, and *Stirni* continued wire-drag surveys off the entrance to Chesapeake Bay to search for, locate, and determine the least depths over numerous wrecks.

The *Hydrographer* made hydrographic surveys in the Gulf of Mexica, using the specially designed electronic position indicator. The hydrographic work was controlled from stations established on Santa Rosa Island and at Carrabelle, Fla. Horizontal control was carried for a distance of 225 nautical miles from shore. At the request of the Corps of Engineers, a 3-kilometer first-order base line was measured in the vicinity of Fort Walton, Fla.

On the Pacific coast and in Alaska the survey ships *Explorer*, *Pioneer*, *Surveyor*, *Pathfinder*, *Derickson*, *Patton*, *Lester Jones*, *Hodgson*, and *Bowie* were engaged on hydrography, topography, tiangulation, or current surveys.

The *Explorer* and *Pioneer* operated in the Aleutian Islands, along the coast of Kiska and Little Kiska Islands, and performed Shoran-controlled hydrography, topography, and triangulation. The ship *Explorer*, on its passage to the westward, made a partial hydrographic development of Hodgkins Seamount, about 125 miles southwest of Dixon Entrance, and found a least depth of 37 fathoms in general depths of 1,800 fathoms. At the close of the Alaska work, the ships ran two deep-sea sounding lines across the Gulf of Alaska from the vicinity of Adak, Alaska—one line terminating at San Francisco, and the other in the vicinity of St. George Reef, Calif., from where it was carried to the Strait of Juan de Fuca.

The *Surveyor* continued hydrographic surveys along the Alaska Peninsula in the entrance to Shelikof Strait, including Puale Bay and Dry Bay, until the close of the field season in October 1947. The vessel returned to Seattle and was placed on an inactive status, with reduced complement, because of insufficient operating funds.

The *Pathfinder* performed combined operations in Bristol and Kvichak Bays. At the close of the season a deep-sea sounding line was run from Unimak Pass to Seattle. An uncharted seamount was crossed on this line, about 800 miles northwest of Seattle, in latitude 51° N., longitude 143° W., and a least depth of 460 fathoms found in surrounding depths of about 2,000 fathoms.

The *Derickson* made triangulation and hydrographic surveys along the northern part of Prince William Sound.

The *Patton* was engaged on combined operations from Sitka Sound to Salisbury Sound. A scheme of triangulation was begun north of Sitka, through Olga and Neva Straits.

The *Lester Jones* made an air photographic inspection along the Alaska Peninsula, in the vicinity of Stepovak Bay. A hydrographic survey was made in Cook Inlet, between Fire Island and Cape Mackenzie. The vessel also furnished water transportation to a geodetic party in Cook Inlet and a triangulation party on the Walrus Islands in Bristol Bay.

The *Hodgson* was engaged on hydrographic surveys in the Columbia and Willamette Rivers. A special hydrographic survey was made of Portland Harbor. A measured-mile course in the vicinity of Portland was established, at the request of the Power Squadron and Yacht Club.

The *Bowie* continued combined operations in San Francisco Bay. At the request of the Navy Department a special inshore hydrographic survey was made of Treasure and Yerba Buena Islands.

The Arctic shore party, engaged on reconnaissance and control surveys along the Arctic coast of Alaska, progressed to the vicinity of Icy Cape and accomplished surveys in the Barter Island area.

Hydrographic surveys were continued in Pend Oreille Lake, Idaho.

At the request of the Bureau of Reclamation, a shore party began a basic hydrographic survey of Lake Franklin D. Roosevelt, from Coulee Dam upstream to the international boundary.

A shore party extended the aircraft speed-trial course at Muroc Air Base, Calif., 500 meters at each end, at the request of the Department of the Air Force.

In the Republic of the Philippines, the Manila office of the Bureau, under the direction of the Director of Coast Surveys of the Philippine Islands, continued survey work and training of Filipinos, authorized by the Philippine Rehabilitation Program. Three commissioned officers and three civilian employees continued on duty in the Manila office to assist in field operations, revision of obsolete charts, and training. The ship *Tulip* was engaged on reconnaissance, triangulation, topography, hydrography, and wire-drag investigations in Manila Harbor. A group of Filipino trainees received instruction and training in electronics and in hydrographic surveying methods in the Washington office and in the field. Funds for carrying out the program, with the exception of the pay of commissioned officers, were transferred from the Department of State.

District offices were maintained during the year at the following ports: Boston, New York, Norfolk, New Orleans, Los Angeles, San Francisco, Portland, Oreg., Seattle, and Honolulu. These offices rendered valuable service in supplying information for the correction of charts, in disseminating nautical and engineering data in response to requests from 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.

Processing offices were continued at the two principal bases of the field parties, Norfolk and Seattle. These offices process field records, plot hydrographic surveys, and perform other work in connection with the survey records. The operation of these field offices expedite the application of field surveys to the finished nautical charts and permits close cooperation between the field engineer and the office cartographer.

PHOTOGRAMMETRIC SURVEYS

Photogrammetric surveys are topographic surveys based on aerial photographs. Topographic surveys are undertaken by the Bureau to obtain the necessary land details for use on nautical charts, by means of which the mariner determines his position in the water

when he is in sight of land. As a byproduct of this work, the basic topographic map coverage of the United States is extended and provides the engineering profession and other private and public organizations with an increased fund of data from which to study and plan many important works with greater efficiency and lower cost. The aerial photographs themselves are also used by the Bureau for the revision of nautical and aeronautical charts, for airport surveys, and for triangulation reconnaissance. The aerial photographs are extremely useful to Government and private agencies for planning in advance of surveys or for close examination of the wealth of information they contain that cannot generally be represented on the maps. By virtue of an agreement made with the Geological Survey, original topographic maps compiled by the Coast and Geodetic Survey are sent to the Geological Survey for publication and distribution.

The first use of aerial photographs in the Bureau was in 1922. Their use has continued on an increasing scale to the point where today almost all topographic maps are based on them. While photographs have greatly increased the accuracy and completeness of maps, they have not eliminated the necessity for ground surveying for control and field interpretation, which account for approximately one-half the total cost of a map. The main work phases in map production from aerial photographs are: Aerial photography, laboratory processing of photographs, supplemental ground surveys and field inspection, office compilation, field edit, office review and drafting, and publication.

For the most part, aerial photographs have been taken by Bureau personnel operating in cooperation with the United States Coast Guard, which furnishes the airplane and flight crew. Some photography of airports was also accomplished by Bureau personnel operating a Civil Aeronautics Administration plane. The areas photographed during the year were: Parts of the north shore of Long Island Sound and off-lying islands; Pamlico Sound, N. C.; the east coast of Florida in the vicinity of Cape Canaveral; the Louisiana coast in the vicinity of Vermilion Bay and White Lake; Humboldt Bay, Calif.; Coquille River, Coos Bay, and Umpqua River, Oreg.; Columbia River from Bonneville Dam to The Dalles; and in Alaska, Prince William Sound, Bristol Bay, Kamishak Bay, Norton Sound, Kotzebue Sound, Arctic Ocean from Point Barrow to the Canadian border, and various places in the Aleutian Islands. In addition, photographs were taken of 116 airports for obstruction surveys, and of the photogrammetric test area at McClure, Ohio, for camera calibration studies.

Photogrammetric field surveys were in progress in the following areas: Eastern Maine; Connecticut River; Hempstead Bay, Long Island; Delaware River; District of Columbia-Virginia boundary line; Pamlico Sound-Neuse River area, North Carolina; the east coast of Florida from Homestead to Cape Canaveral; the Gulf Intracoastal Waterway from Houma, La., to Corpus Christi, Tex.; Louisiana coast from Houma to Vermilion Bay; Humboldt Bay, Calif.; Columbia River, Oreg. and Wash.; Coos Bay and Coquille River, Oreg.; Roosevelt Lake, Wash.; along the north shore of Bristol Bay, Alaska; and in the photogrammetric test area in Ohio.

Field work preliminary to topographic mapping by stereoscopic instruments was started by ships of the Bureau in the Aleutian Islands in conjunction with hydrographic surveys, at the specific request of the Department of the Army and by mutual agreement with the Geological Survey.

Field inspection and identification of control, location of aids to navigation, landmarks, etc., were made along the Gulf Intracoastal Waterway, preliminary to photogrammetric compilation. This was made necessary by new construction and relocation of aids to navigation in the waterway. At Roosevelt Lake, the special cooperative project with the Bureau of Reclamation and the Geological Survey continued with the identification of control and field inspection for special hydrographic and topographic surveys for navigation and studies of silting.

In connection with the photogrammetric test area at McClure, Ohio, geographic positions and elevations were determined for some 81 stations distributed at critical locations throughout the area and marked with targets that would show on the aerial negative. This will permit accurate comparisons to be made of the photograph and true positions of these stations, and provide a means of accurate adjustment and calibration of the nine-lens camera. Considerable interest has been expressed in this project by various agencies using and testing aerial cameras and lenses, and a number of requests have been received for complete sets of data on positions, descriptions, etc., of the points located.

Photogrammetric offices continued in operation at Baltimore, Md., and Tampa, Fla., compiling topographic and planimetric maps of coastal areas in eastern Maine; Delaware Bay and River; the barrier beach and adjacent shores of Pamlico Sound, N. C.; east coast of Florida; and the Alaska Peninsula. At Portland, Oreg., a combined field and office party continued operations under the direction of the Supervisor, Midwestern District. Field work and compilation were in progress for Roosevelt Lake, Wash.; Humboldt Bay, Calif.; Coquille River, Coos Bay, and Umpqua River, Oreg.; Columbia River, Oreg. and Wash.; and Bristol Bay, Alaska.

In the Washington office the compilation, reviewing, and drafting of planimetric and topographic maps prior to publication were continued. Major projects included completion of the series of large-scale planimetric maps for the determination of the District of Columbia-Virginia boundary; delineation of shore-line details along the Delaware River with the stereoplanigraph; contouring in Tidewater Virginia with the Reading Plotter; compilation of shore-line surveys for the preparation of new nautical charts of the Gulf Intracoastal Waterway from Houma to Morgan City, La.; and in Alaska, the preparation of maps, mosaics, and reconnaissance surveys of various areas, including the Aleutian Islands, Bristol Bay, Kotzebue Sound, Arctic Ocean, and Mount McKinley.

Five airport survey parties operated throughout the United States during the fiscal year and completed surveys at 103 airports. These surveys are used in the production and maintenance of aeronautical instrument approach and landing charts and airport obstruction plans.

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One hundred and ten airport obstruction plans were published during the year, bringing the total published to date to 198. This is part of a program for obstruction plans for some 550 airports requested by the Civil Aeronautics Administration. The plans are used by that agency in administering regulations regarding the allowable pay load of various types of aircraft.

Increasing demands for copies of aerial photographs from the general public and other Federal agencies have added materially to the work load and strain on facilities of the air photographic laboratory. At times official requests have been so heavy that outside orders have been quoted on a 3- to 4-month delivery basis.

A summary of the photogrammetric mapping of coastal areas for the fiscal year 1948 is given in the following tabulation:

Summary of photogrammetric mapping

Locality	Aerial photography	Photogrammetric field surveys				Compilations completed				Planimetric maps published	
		Shoreline	Interior area	Contours (plane-table)	Contours (stereoscopic)	Planimetric maps and shore-line surveys		Topographic maps			
	Square miles	*Miles*	*Square miles*	*Square miles*	*Square miles*	*Square miles*	*Number*	*Square miles*	*Number*	*Square miles*	*Number*
Maine (Portland to Canadian boundary)					215			215	8	744	70
Long Island Sound	532	82	36								
New York (Hempstead Bay, Long Island)		277	170								
Delaware River		73	106	55		95	12	288	7		
Virginia (James River)										25	2
North Carolina	2,109	548	704	752				390	18		
Florida:											
East coast	2,645	350	562	534				487	14		
Fort Meyer to Tampa										105	5
Louisiana	3,309	150	1,090								
Louisiana and Texas (Intracoastal Waterway)		510	2,570			390	12				
California:											
San Francisco Bay										108	5
Humboldt Bay	210	32	60								
Oregon:											
Willamette River						215	4				
Coos Bay, Coquille River	413	35	67								
Columbia River	360	74	65								
Washington (Lake Roosevelt)		437	798			565	17				
Alaska:											
Aleutian Islands	1,050	68	180								
Alaska Peninsula	3,590				350			350	6		
Arctic coast	11,540	182	604								
Bristol Bay	5,300	515	2,560								
Total	31,058	3,333	9,572	1,341	565	1,265	45	1,730	53	982	82

GEODETIC CONTROL SURVEYS

Geodetic control surveys consist of the determination of precise latitude, longitude, and azimuth for marked points, and the determination of elevations above sea level for bench marks. Geodetic surveys take into account the spheroidal shape of the earth. Horizontal locations are referred to the same geographic datum so that all points for which determinations are made are correctly related in position with respect to each other. Similarly, bench marks are referred to the datum of mean sea level so that all elevations are correctly related to each other.

Geodetic control surveys provide the framework for the mapping and charting program of the United States, and are prerequisites in the planning and construction phases of large-scale engineering projects, such as those for flood control, irrigation, hydroelectric development, navigation, water supply and drainage, and for transmission lines, sewerage systems, highways, railroads, tunnels, canals, airports, and similar projects.

The major activity during the past year has been the continuation of horizontal and vertical geodetic control in the Missouri River Valley, requested by the Corps of Engineers, Bureau of Reclamation, and Geological Survey. The Missouri River Valley project includes flood control, irrigation, and water power development works along the Missouri River and its tributaries, which drain an area of 580,000 square miles. The establishment of geodetic control throughout the river valley will permit coordination of the maps and plans required in the preliminary and construction stages of the work. The survey program as planned is of several years' duration. Monthly meetings of the Missouri Basin Inter-Agency Committee, representing various Federal, State, municipal, and local organizations, are attended by Bureau officers so that the survey operations can be coordinated with the programs of the participating organizations. A priority list for surveys is established by the construction agencies and field work is conducted accordingly.

Surveys were continued in connection with a number of other large-scale projects undertaken by the Corps of Engineers and the Bureau of Reclamation. In the Columbia River Valley, triangulation was accomplished in southeastern Washington between Pasco and Wenatchee, and along the Klickitat and Cowlitz Rivers, with a connection between the two arcs. The recent floods in the Columbia River have emphasized the need for adequately controlled maps of the complete Columbia River watershed. Triangulation, with numerous connections to local survey monuments of the Corps of Engineers, was accomplished in Mississippi southwestward of Jackson to Port Gibson, and area leveling was accomplished in Alabama and Georgia, along the Coosa, Black Warrior, and Tombigbee Rivers, as part of river-improvement projects. Triangulation and leveling surveys were conducted in the Trinity River Valley area southeastward of Fort Worth, Tex., for water- and land-development plans. Triangulation was accomplished in the Green River area of Utah in connection with the development of the central Utah project, and westward of Phoenix, Ariz., for the central Arizona project.

Control surveys for mapping requested by the United States Geological Survey were accomplished as follows: In Indiana, two triangulation parties established stations 8 to 10 miles apart, with supplemental points, located along the main highways, at a spacing of 4 miles. Precise leveling for area coverage was also accomplished with elevations established at 1-mile intervals along highways 5 to 6 miles apart. In North Carolina, triangulation was established between Charlotte and Greensboro, and northwestward of Fayetteville. In northeastern California, triangulation was accomplished in the vicinity of Alturas and Tule Lake.

Two releveling projects were undertaken at the request of the United States Geological Survey. In the vicinity of San Jose, Calif., an area which lowered about 5 feet between 1920 and 1939, repeat leveling was done to ascertain the present elevations and to determine whether substantial movements are still occurring. A releveling program was initiated in the vicinity of Delano, Calif., where there is evidence of settlement.

At the request of the Navada State Planning Board and the United States Forest Service, triangulation was accomplished in northeastern Nevada northward from Montello to the Utah-Idaho-Nevada boundary, in the Minidoka National Forest, and northward from Elko to the Idaho boundary.

Several points were located in the vicinity of Albuquerque, N. Mex., and near Muroc, Calif., for the Air Forces in connection with speed tests for airplanes. Precise locations and elevations were also determined near Inyokern, Calif., for the Bureau of Ordnance, Department of the Navy.

A noteworthy cooperative undertaking, resulting in the accomplishment of precise surveys of value to the Federal, county, and city governments, and to many private concerns and individuals, was the establishment of urban control for Cincinnati, Ohio, and environs, at the request of the city engineer's office. The Bureau furnished supervisory personnel, instrumental equipment, and portable steel triangulation towers, and the city of Cincinnati furnished other party personnel, office quarters, and operating expenses. Four base lines were measured, 81 triangulation stations located, and 214 bench marks established over 110 miles of leveling. The final computations and adjustments were made in the Washington office.

An astronomic party operated in the States of Ohio, Missouri, Washington, Arizona, and Texas and established astronomic latitude, longitude, and azimuth along arcs of triangulation for computational and adjustment purposes.

The variation of latitude observatories at Ukiah, Calif., and Gaithersburg, Md., continued in operation throughout the year. These are two of five observatories on the same parallel of latitude (39°08′ N.) which take part in an international program of observations to detect the movement of the polar axis. The foreign observatories are at Carloforte, Italy; Kitab, Uzbekistan, U. S. S. R.; and Mizusawa, Japan. During the year 1,922 star pairs were observed at Ukiah and 1,741 at Gaithersburg.

Triangulation was continued in western Alaska along the north shore of Bristol Bay westward from Kvichak Bay. This is an area

of great economic importance, where king salmon are trapped and large canneries operate during the fishing season. The control surveys furnish the framework for the construction of the charts of the coastal areas, which are of benefit to the large freighters plying this region during the navigable season. They also provide precise locations for the fish traps which are leased by veterans.

Spirit leveling was conducted in western Alaska along the Tok Highway from Mentasta Pass to the Alaskan Highway, completing the loop formed by the Richardson, Tok, and Alaskan Highways.

Several special projects were undertaken or continued during the year. In connection with seismological studies, repeat triangulation observations were made over selected stations along the California coast. It is evident from observations made over a period of years since 1885 that horizontal movement is occurring to the westward of the San Andreas fault line in California, amounting to over 10 feet for some localities. Data concerning such movement are of value to seismologists as an indication of the possibility of a definite fracture in the earth's crust resulting from accumulated strain, causing an earthquake.

Geodetic surveys, consisting of a pattern of precisely located horizontal control monuments and bench marks for vertical control, were established in the vicinity of McClure, Ohio. These will be used as a test area for the Bureau's nine-lens aerial camera to calibrate the adjustment of the mirrors and lenses.

A project of significance is the reconstitution and extension of horizontal control in the Hawaiian Islands, in cooperation with the Territorial Survey Office. The program, which will continue for several years, contemplates the reestalishment of monuments, destroyed or uprooted during the war, and the extension of control with closer spacing of monuments to provide a more precise and comprehensive scheme. The Bureau furnishes supervisory personnel, instruments, and truck equipment, and performs the computations and adjustment. The Territorial Government furnishes personnel and pays operating expenses.

During the year, the field program of gravity observations, discontinued during the war, was resumed primarily in connection with our studies of the possibility of determining the deflection of the vertical from gravity anomalies. This is a basic study in geophysical science requested by the Department of National Defense, which is bearing the greater part of the expense. Observations are being made with the pendulum gravity instrument and with a gravity meter. The latter is owned by the United States Geological Survey and is operated by personnel from that agency.

To increase our coverage of gravity determinations in connection with the above study, a number of oil companies have made available data obtained in their geophysical explorations. This represents a considerable saving to the Government.

We are cooperating with the Department of National Defense in the underground explosion tests being made in the vicinity of Tooele, Utah. Various amounts of explosives are being detonated and their effects noted on different types of underground structures built in

several types of soil. Our contribution is to determine after each explosion the amount of movement of each structure vertically and horizontally with the greatest precision of measurement within practical limits.

In cooperation with the National Geographic Society and the Department of National Defense, two units of two men each were assigned to make land observations in the Aleutian Islands along the path of totality of the annular eclipse of May 8, 1948. Observation sites were occupied at widely separated points on Adak Island. Unfortunately, a heavy fall of snow made it impossible to obtain acceptable observations. In anticipation of unfavorable weather the Department of National Defense assigned airplanes to the project, and observations of the eclipse were obtained at an altitude of about 20,000 feet. The planes in flight were located with respect to Shoran stations established on land. Time control was rigid for all observations, and the Shoran stations were accurately located by triangulation by our parties, with latitudes and longitudes given on the North American 1927 datum. From these observations and additional data obtained by eclipse expeditions in Asia, it is hoped that a distance determination may be made between the various points for use in checking the dimensions of the earth.

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

Area triangulation—first- and second-order

Locality	Number of stations	Length of scheme	Area
		Miles	*Square miles*
Annapolis to Kent Island, Md	3	10	35
Taylors Island, Md	1	10	20
Gasconade and Osage Rivers, Mo	88	90	2,240
Mount Hood National Forest, Oreg	31	35	700
Slana to Tok Junction, Alaska	7	50	500
Northeastern Indiana	119	85	1,385
Big Blue River, Kans. and Nebr	410	280	7,375
Vernal to Provo to Fillmore, Utah	113	210	4,110
Klickitat and Cowlitz Rivers, Wash	82	140	1,760
Deer River to Orr, Minn	26	100	1,000
Missouri River, Rulo to Blair, Nebr	96	135	1,330
Southern Indiana	120	65	990
Bristol Bay area, Alaska	62	100	1,800
Vicinity of Cincinnati, Ohio	135	80	990
Modoc and Shasta National Forests, Calif	51	60	1,760
North Manchester, Ind., to Watseka, Ill	83	105	1,155
Pomme de Terre and Osage Rivers, Mo	115	97	4,625
Pend Oreille Lake, Idaho	4	15	60
Terre Haute area, Indiana	131	70	2,280
Montello, Nev., to Twin Falls, Idaho and Elba to Three Creek, Idaho	54	185	2,590
Gibsons Valley to Charleston, Nev	61	115	1,265
Vicinity of Tucson, Ariz	37	105	1,860
Vicinity of Muroc, Calif	18	25	270
Trinity River area, Texas	112	75	1,980
Lawton area, Oklahoma	137	90	4,515
Altus area, Oklahoma	43	60	1,425
Port Gibson area, Mississippi	125	55	2,210
Datil, Albuquerque, and Vaughn, N. Mex	4	45	265
Phoenix to Parker, Ariz	91	110	4,100
High Point to Charlotte area, North Carolina	209	75	3,220
Kvichak Bay, Alaska	4	20	200
Central Indiana	16	20	215
Casper area, Wyoming	27	55	1,200
Missouri River, Pierre to Mobridge, S. Dak	45	105	1,260
Missouri River, Blair, Nebr., to Yankton, S. Dak	75	125	1,680
Missouri River, Bismarck, N. Dak., to Mobridge, S. Dak	23	90	500
Hawaii Island, Hawaii	40	60	450
Vicinity of Kingman, Ariz	66	90	4,130

Area triangulation—first- and second-order—Continued

Locality	Number of stations	Length of scheme	Area
		Miles	*Square miles*
Columbia River, Pasco to Wenatchee, Wash	185	120	7,200
North shore of Bristol Bay, Alaska	24	45	930
Vicinity of McClure, Ohio	80	10	40
Total	3,153	3,417	76,220
Earthquake investigation, Bakersfield to Salinas and vicinity of Petaluma, Calif. (reobservations)	38	375	14,300

First-order base-line measurement

Locality	Length of scheme	Locality	Length of scheme
	Miles		*Miles*
Delta, Utah	7.0	Walapai, Ariz	7.3
Saltillo, Nebr	4.9	Quincy-Winchester, Wash	6.3
Jansen, Nebr	6.0	Pleasanton-Mosher, Ariz	5.8
Forest, Ohio	2.6	Range-Desert, Ariz	5.7
Werk, Ohio	2.5	Rockwell, N. C	4.0
Blue Ash, Ohio	3.2	Lawton, Okla	3.9
Hamilton, Ohio	5.8	Bristol, Alaska	4.9
Terre Haute, Ind	4.9	Appleton, Mo	5.9
Elkhorn, Nebr	7.6		
Rensselaer, Ind	4.6	Total	92.9

Reconnaissance

[For area triangulation—first- and second-order]

Locality	Length of scheme	Area
	Miles	*Square miles*
Central Indiana	215	7,440
Northeast California and southern Oregon	15	620
Vicinity Bristol Bay, Alaska	25	975
Missouri River, Sioux City, Iowa to Bismarck, N. Dak	465	6,800
Vernal to Provo to Fillmore, Utah	150	1,950
Klamath Indian Reservation, Oreg	75	3,945
Fremont National Forest, Oreg	70	3,010
Nushagak Peninsula to Goodnews Bay, Alaska	140	2,470
Lassen National Forest, Calif	100	5,920
High Point to Charlotte area, North Carolina	80	3,830
Vicinity of Muroc, Calif	20	270
Casper area, Wyoming	120	4,620
Pend Oreille Lake, Idaho	15	60
Altus area, Oklahoma	60	1,425
Western Arizona	115	3,875
Needles, Calif., to Parker, Ariz	50	1,210
Platte River area, Nebraska	80	2,900
Vicinity of Baker, Calif	65	1,920
Lawton area, Oklahoma	90	4,515
Quartzsite area, Arizona	100	4,970
Honnessey to Selling, Okla	60	1,455
Neosho, Mo. to Delaware, Okla	60	1,395
Midland area, California	55	1,850
Winston-Salem to Hickory area, North Carolina	110	3,225
Lufkin area, Texas	75	4,130
Datil, Albuquerque, and Vaughn, N. Mex	45	265
Roy and Nara Vista areas, New Mexico, and Texas	150	5,300
Vicinity of Cincinnati, Ohio	30	390
Missouri River, Bainville to Fort Peck, Mont	130	3,290
Chariton, Lamine, and Blackwater Rivers area, Missouri	120	6,720
Laramie area, Wyoming-Colorado	70	3,000
Goodnews Bay, Alaska	45	310
Total	3,000	94,055

Leveling

State	First-order	Second-order	State	First-order	Second-order
	Miles	*Miles*		*Miles*	*Miles*
Alabama	36	531	Montana	93	20
Arizona	214	92	Nebraska	148	598
California	859	195	Nevada	40	
Georgia	8	170	North Dakota		9
Idaho	8	135	Ohio	213	359
Illinois	206	16	Oregon		35
Indiana	177	1,134	Tennessee	211	5
Iowa	152	237	Texas	48	1,019
Kansas	160	11	Washington	149	115
Kentucky	73	2	Wyoming	205	5
Minnesota	41	562	Alaska	52	
Mississippi	1	1			
Missouri	2	3	Total	3,096	5,254

Astronomy

State	Determinations			State	Determinations		
	Latitude	Longitude	Azimuth		Latitude	Longitude	Azimuth
Arizona	2	2	1	Texas	2	2	0
Indiana			3	Utah	1	1	1
Missouri	1	1		Washington	1	1	2
Nevada	1	1	1	Alaska	1	2	2
Ohio	1		1				
Oregon	1	1	1	Total	11	11	12

Gravity

Location	Determinations
Kansas	198
Oklahoma	400
Total	598

Summary of geodetic work, June 30, 1948

Work	July 1, 1947, to June 30, 1948	Total to June 30, 1948
	Miles	*Miles*
Triangulation, first- and second-order, length of arc	3,417	107,127
Leveling, first- and second-order	8,350	357,459
	Number	*Number*
First-order base lines	18	324
Second-order base lines	0	56
Latitude stations	11	1,013
Longitude stations	11	816
Azimuth stations	12	1,304
Gravity stations	598	2,002

The processing of field records continued in the offices in Washington and New York City. In general, progress on the adjustment and computation of the various triangulation projects has kept pace with

current field surveys. Some progress has been made on the processing of older surveys in Alaska and along the New England coast. Computations and adjustments for 85 triangulation projects, involving 5,528 stations, were completed during the year. The adjusting of triangulation over large areas by the variation of coordinates method, initiated last year, has now become standard. The procedures are being simplified and refinements added with increased experience.

Preliminary computations were made for 1,964 miles of first-order and 1,698 miles of second-order leveling. Distribution of corrections were made on 21,844 miles of first- and second-order leveling mainly for lines in the Pacific Northwest Supplementary Adjustment of 1947. Twenty-four supplementary adjustments involving 383 miles of first-order and 8,635 miles of second-order leveling were completed.

The computing office in New York City has been instrumental in reducing the work load of the Washington office. This auxiliary office supplements the program of computation and adjustment carried on in the Washington office.

Good progress has been made on the study of the feasibility of determining the deflection of the vertical from gravity anomalies. Indications are that with an adequate coverage of gravity determinations the deflection can be determined with an accuracy far superior to the isostatic method formerly used. This method will be particularly beneficial in correcting astronomical observations to conform to a standard datum.

The computation of trigonometric elevations of mountain peaks in Alaska from vertical angle computations was virtually completed at the end of the year. About 2,000 elevations have been added to the files for mapping purposes.

Special projection tables for world aeronautical charts were computed for the Air Forces. These are for belts of 4° in latitude based on the Lambert conformal projection and extend from the Equator to 80°. From there to the pole the stereographic projection is used.

Special reports covering the geodetic work of the Bureau for the period January 1, 1939, to December 31, 1947, were prepared and forwarded for distribution at the Eighth General Assembly of the International Union of Geodesy and Geophysics.

TIDE AND CURRENT SURVEYS

Tidal work has always been a necessary function of the Bureau as observations and investigations of tides and currents provide basic data for its surveying activities. Soundings taken during hydrographic surveys must be corrected for the height of the tide, so that the nautical chart will show all depths referred to a uniform datum. In geodetic operations, the basic datum of mean sea level, used in the network of leveling extending over the country, must be determined from tide observations at various places along our coasts.

Tide and current observations also furnish the essential data for the prediction of tides and currents. With modern deep-draft vessels operating on fixed schedules, advance information on the rise and fall of the tide and the ebb and flow of the current are prerequisites to safe navigation. Such information is made available to the mariner through annual tide and current tables, and tidal current charts.

Besides these principal uses, tide and current data have many collateral uses, such as for engineering projects and industrial development associated with coastal waters; for the determination of boundaries of tide lands; for offshore oil production projects; for the solution of problems of sewage disposal and water pollution; for legal proceedings concerning water-front properties; for sports and recreational activities; and for studies of the secular subsidence or elevation of coastal regions. Continuous tide observations supply the only quantitative data for determining the slow change taking place in the relation of land to sea.

In connection with its oceanographic work the Bureau makes observations of the temperature and density of sea water at most of its tide stations in the United States and its cooperative tide stations in foreign countries. This information is useful in the shipping and fishing industries, in industrial plants using sea water, and in various scientific activities. There has been a noticeable increase in the use of such information, particularly temperature data, for use in studies by air lines, and similar organizations, concerned with weather conditions.

During the year, the Bureau's program included the operation of 46 primary and secondary tide stations on the Atlantic and Gulf coasts; 32 stations on the Pacific coast, in Alaska, and in the Hawaiian Islands; 14 stations in foreign countries including the western Pacific islands; and, under the State Department program of cooperation with the American Republics, eight stations in Central and South America. Sixty of these stations were maintained in cooperation with other agencies, including the governments in Central and South America, various units of the Army, Navy, and Coast Guard, the Civil Aeronautics Administration, and municipal and research organizations.

The Bureau is cooperating with the Caribbean Defense Command in obtaining tide observations in the Latin American countries for the determination of tidal datum planes in connection with the Inter-American Geodetic Survey.

The cooperative project, initiated late in 1946, for obtaining systematic tide observations in the western Pacific area was continued at 11 places.

Observations of the temperature and density of sea water were obtained at most of the tide stations. Fifteen new stations were added and eight were discontinued, making a total of 85 stations from which observational data were being obtained. Five thermographs for continuous recording of fluctuations of seawater temperature were in operation during the year. A thermograph installation was made at the Battery in New York Harbor, and recent requests for this type of information suggest the advisability of extending the network of stations.

Tidal bench mark recovery operations were carried on along the Pacific, Gulf, and Atlantic States.

Detailed information on the complex tidal current movement in the southern part of Puget Sound was made available through the publication of Tidal Current Charts, Puget Sound (southern part). Field work for the current survey of Delaware Bay and River was completed, and considerable progress was made on the preparation of

tidal current charts for this waterway. Through a cooperative arrangement with the Coast Guard, hourly current observations were continued during the year at Overfalls and Five Fathom Bank Lightships in the vicinity of Delaware Bay. The series at Overfalls Lightship has been terminated and a new series will be undertaken at Frying Pan Shoals Lightship, off Cape Fear, N. C.

An extensive classified report on tides, for use of the Intelligence Services, and two smaller reports were prepared at the request of the Navy Hydrographic Office.

Two series of tide observations were obtaind in the David Taylor Model Basin at Carderock, Md., one extending over a period of 1 week and the other of 3 days. The results from these observations furnish a valuable contribution to the study of earth tides.

Considerable progress was made on a system for warning the Hawaiian Islands of an impending seismic sea wave. One seismic seawave detector was installed at Honolulu, a second was tested and shipped for installation at Hilo, and testing of a third for use at Midway was completed. Preliminary arrangements have been made with the Department of the Navy for expanding this project to include installations of detectors at naval operating bases and for setting up a system of rapid communication within the general warning system.

Exchange of tide predictions was carried out with Canada, Argentina, England, France, Netherlands, Germany, and India. Daily tide predictions, together with a roll of predicted tide curves for Bangkok Bar, covering the year 1949, were furnished Siam. At the request of the United States Committee for the Study of Paricutin Volcano, predictions were prepared of the vertical component of the tide-producing forces in the vicinity of Paricutin Volcano, Mexico, covering the period September 1947 to August 1948, for use in a study of the possible correlation between earth and volcanic activity.

GEOMAGNETIC SURVEYS

Geomagnetic surveys are surveys which determine the earth's magnetic field, and involve a measurement of declination, horizontal intensity, and dip. The magnetic work of the Bureau was begun as one of the essential steps in the preparation of nautical charts. As long as the navigator of a vessel or of an airplane uses the magnetic compass to steer by, so long must he know the declination of the needle at any given locality for any given time. The Bureau is able to provide this information on its nautical and aeronautical charts as a result of its program of magnetic observations, which dates back to 1843.

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 direction of magnetic north ranges from 22° W. in Maine to 24° E. in the State of Washington. Besides the change with locality, there is an irregular and unpredictable secular, or long-period, change. To define this, observations are required at periodic intervals. The present program of the Bureau calls for the determination of the magnetic elements at 5-year intervals for about 200 repeat stations.

In addition to its use in navigation, the magnetic survey of the Bureau furnishes information to land surveyors engaged in retracing old boundary lines defined in terms of compass bearings. There are other collateral uses of our magnetic observations, such as in the study of sun-spot activity and aurora and related ionospheric disturbances; in activities dependent on radio communication and radio aids to navigation; and in geophysical prospecting where magnetic methods are used to search for oil-bearing structures and mineral wealth.

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 and College, Alaska; and Tucson, Ariz. Permanent buildings and installation of equipment for the new observatory at College were completed during the year, with actual operation beginning on December 20, 1947. The observatory will be operated in close cooperation with the Geophysical Institute of the University of Alaska in scientific investigations of Arctic phenomena.

The automatic declination recording station at Gatlinburg, Tenn., was continued in operation, and in October a similar station was placed in operation at Logan, Utah, in cooperation with the Utah State Agricultural College.

Field parties operated during parts of the year, obtaining data on the distribution of secular change in the United States.

Studies are in progress looking toward the compilation of the world magnetic charts scheduled for issue in 1950. Under arrangements with the United States Hydrographic Office, which publishes these charts, their preparation will henceforth be conducted under technical direction of the Coast and Geodetic Survey. In connection with this new responsibility, the Bureau has been designated by law as the official depository for world magnetic data, and is actively engaged in acquiring and cataloging such data. Steps have been taken to effect interim coordination of the isogonic lines used by the different mapping services in the overlapping areas which are of mutual concern.

Manuscript for a new isogonic chart for northern Venezuela was prepared at the request of the Hydrographic Office.

Instruction in geomagnetic operations and processes was given to representatives from other Federal agencies and from China, the Philippines, Argentina, and Turkey.

As in past years, current revisions of magnetic declination data were made for several hundred nautical and aeronautical charts. 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. Magnetic data were also furnished to other Government agencies. The weekly K-index report on Cheltenham magnetic conditions was continued throughout the year.

The Bureau continued to cooperate with the Department of Terrestrial Magnetism of the Carnegie Institution of Washington in several major projects, among which are maintenance of the international magnetic standard by means of the sine galvanometer and the operation of a cosmic-ray meter, both at the Cheltenham Observatory;

observations of atmospheric-electric conditions at the Tucson Observatory; and close collaboration in the exchange of magnetic data and instruments. The Bureau colloborated with the Department and the International Association of Terrestrial Magnetism and Electricity in the compilation of world-wide magnetic data for the period 1940–47.

The following table shows the distribution of magnetic observations made by field parties during the year:

Distribution of magnetic observations

Location	Repeat stations				Other stations	Total
	New		Old			
	Complete	Declination only	Complete	Declination only		
Florida	2		3			5
Idaho					6	6
Illinois	1		1			2
Maine	1		1		2	4
Maryland			1			1
Michigan	2					2
Montana	2		2			4
Nevada	1		1			2
New Jersey	1					1
North Carolina			2	1		3
North Dakota	1		1			2
Oregon					5	5
South Carolina			1	1		2
South Dakota	1		1			2
Tennessee	1		1		1	3
Utah	1		1			2
Vermont	2				1	3
Virginia					3	3
Washington					5	3
Wyoming	1		1			5
Alaska					39	39
Total	17		17	2	62	98

SEISMOLOGY

Seismology, or the science of earthquakes and attendant phenomena, is a comparatively new field of investigation for the Coast and Geodetic Survey. It was begun in 1925 and had for its main objective the mitigation of loss of life and property in the United States due to earthquakes. While earthquakes cannot be prevented, the practical purpose of the work is to discover ways and means to lessen their destructive effects. To this end the Bureau maps earthquake areas and evaluates earthquake risk through the operation of seismographs and the systematic collection of earthquake information; operates seismographs of a special type to furnish the structural engineer with accurate records of destructive earthquake motions; analyzes the records for practical application to engineering problems and for the improvement of building codes; and investigates the scientific aspects of earthquakes to obtain a better understanding of the principles underlying their cause, frequency, and distribution.

The earthquake program includes the collection of general information from a large corps of volunteer observers. This leads to epicenter locations where instrumental control is inadequate. These reports

furnish data on intensity distribution and the influence of geology, as well as statistical data for insurance companies. About 40,000 representatives of interested business concerns, railroads, public utility companies, the Weather Bureau, and other organizations participate in this program. Collaborators associated with universities supervise this activity for the Bureau in nine western States.

To improve earthquake locations and the usefulness of seismographic data for basic research, the Bureau aided 10 universities by making vibration tests of proposed station sites, by installing equipment, and by aiding in maintenance and interpretation problems. This encourages the establishment of new stations and produces data otherwise unavailable.

Normal teleseismic work during the year involved the maintenance of 22 seismological stations, processing of records for locating earthquake foci, and publishing results. Of these stations, 16 were maintained in collaboration with universities or scientific institutions. Station data and bulletins were exchanged with other stations in the United States and throughout the world. The popular service of announcing epicenters within a few days is being stepped up so that many more locations can be reported than heretofore and with greater accuracy. In this effort, Science Service and the Jesuit Seismological Association at St. Louis University cooperated actively. Approximately 2,400 earthquake messages were transmitted to Washington, and 124 earthquake locations were announced. In addition, about 400 scattered earthquakes were located in the United States with the aid of sensitive seismographic data from 60 Bureau and independent stations. About 3,200 descriptive reports were furnished by volunteer observers.

An important part of the Bureau's seismologic program is the maintenance of strong-motion seismographs, for recording the movements of local damaging earthquakes. This furnishes data of basic value in the development of structural design in earthquake areas. During the year 42 such instruments were in operation in the Pacific coast area, 4 in Montana, 4 in Nevada, 1 in Utah, and 7 in South and Central America. Eight earthquakes were recorded and 35 records obtained, but none of these were of major intensity.

A chain of seismograph stations at various reservoir sites was maintained on a reimbursable basis for the Bureau of Reclamation. The records obtained are processed in the Bureau and furnish basic data on the effects of reservoir loading on the earth's crust.

For the investigation of microseismic-meteorological relations, a mass analysis was made of 30,000 seismograph and 2,000 barometric readings, covering North America and the North Atlantic and Pacific Oceans, and a 3-year program of compiling surf and meteorological data obtained at Coast Guard stations was completed. Reports were obtained from 75 key stations in all parts of the world on 6-hour microseismic readings for the year 1947.

As part of the seismic sea wave warning system for the Hawaiian Islands, new visible-recording seismographs were installed in three Pacific stations. This is a joint undertaking of the Bureau with the Army, the Navy, and the Coast Guard.

The Bureau extended aid and technical advice to various scientific and engineering operations. Among these were: Aid to the Finne Ronne Antarctic Expedition, which resulted in new information on earthquakes in the Southern Hemisphere and new data on the relation between antarctic storms and microseisms; cooperation with the Montana School of Mines in investigating a major shock in southwestern Montana; cooperation with leading seismologists in the preparation of an earthquake probability map of the United States for use in a building code published by the Pacific Coast Building Officials Conference; close contact with the Advisory Committee on Engineering Seismology, a west-coast group engaged in the study of engineering design in earthquake areas. An Earthquake Engineering Research Institute is being formed under the committee's guidance, and the Bureau will contribute materially to its studies. Conferences on a wide variety of seismological problems were held with emissaries from India, China, Iceland, Ecuador, Peru, and Venezuela.

As a byproduct of the Bureau's seismologic program, new scientific discoveries occasionally emerge from analyses of the large volume of seismographic records processed in the Washington office. A new seismograph designed in the Bureau and operated near Honolulu, T. H., recorded clearly, for the first time, a water-borne sound wave originating at a submarine earthquake in the Aleutian Islands 2,300 miles away. Records from similar equipment installed at two stations in Oahu, T. H., indicated that microseismic activity is less in the plateau area of the island than on the coast, an important factor in connection with the use of modern high-sensitivity instruments. Through study of seismograms from the Lake Mead area, evidence was found of the existence of a variation in earth structure at a depth of about 160 kilometers, where some authorities postulate a structural boundary between crystalline and vitreous strata.

IMPROVEMENTS IN INSTRUMENTS, EQUIPMENT, AND TECHNIQUES

The Bureau has from its inception recognized the need for developing new and improved instruments, equipment, and techniques in order that better results might be obtained at reduced costs. It has kept abreast with the current findings of science and has adapted them to its own specialized needs. To this end, it has been found necessary to maintain a radiosonic laboratory for electronic development, and a photogrammetric laboratory for the development of aerial photographic mapping. The Bureau also maintains a modern repair shop for servicing all instruments and equipment used in its field and office work.

During the year several important improvements were made that will result in higher accuracy and greater efficiency in our work.

In the field of hydrographic surveying, additional refinements were made in the Shoran operating equipment. This method of fixing the position of survey ship has been adopted as the standard control system for surveys extending 50 to 100 miles from shore. The electronic position indicator, designed for use beyond the limits of Shoran, was given

further field testing. A large area was surveyed, in which control was carried to distances of 225 statute miles from shore. Modifications and improvements were incorporated in a second model, which was nearly completed at the end of the year.

Improvements were made in the Bureau's nine-lens aerial camera and its associated stereoscopic plotting equipment to give greater accuracy to the compilation of topographic maps from aerial photographs. Standardized procedures were established in the photogrammetric field operations with a resultant increase in the over-all production.

Further laboratory tests have been made of the seismic sea wave detector, and some mechanical improvements added. As now constructed, the detector should operate satisfactorily in a system for warning of an impending seismic sea wave in the Hawaiian Islands.

Improvements in our seismologic instruments and techniques included the following: Satisfactory calibration of the Neumann-Labarre high-magnification vibration meter by using a device which measures movements of the base plate to an accuracy close to one-millionth of an inch; the development and construction of an electronically operated torsion pendulum analyzer to facilitate determination of dynamic forces in buildings due to destructive ground motions recorded on the Bureau's earthquake accelerographs; the development of equipment for visible recording of seismograms; the construction of a heavy duty shaking table for making dynamic tests of seismometers and vibration instruments; and investigations with visible-recording shock recorders.

In the field of geomagnetism, a visible recording variometer, using Helmholtz coils around a standard variometer, with photocells and amplifier, is being developed. Experimental work has also been started on an induction-type magnetometer, patterned after a Canadian development, which will give results comparable to those obtained with conventional instruments but which will reduce the time required for a set of observations to about one-tenth.

Several improvements were made in our geodetic instruments, and others are under study. The tangent screw assembly in first- and second-order theodolites was redesigned for easy replacement and for an improved method of adjustment for wear. Proper functioning of the tangent screw is important in the rapid pointing of the telescope.

A photographic method of producing precise level rods has progressed to the point where a number of rods have been manufactured and are in use in the field. The method materially reduces the time required to graduate a rod without in any way impairing its quality. A cloth made of glass fibers, recently developed in the motion-picture industry, will now permit photographing the entire 10-foot rod at one time instead of in three stages, as formerly. The same photographic method will also produce the graduations on the wooden section of the rod, which was formerly done by decalcomania transfers.

Considerable testing of instruments for use in Arctic regions was made at temperatures of −30° F. Tests so far indicate that invar will be required for a number of parts heretofore made of brass.

A new level testing instrument was designed to insure a more accurate check of new level vials. All elements of this device have been

carefully manufactured and the micrometer screw has been checked for accuracy by the National Bureau of Standards.

Several innovations were made in chart reproduction methods. In the intricate Boston Harbor chart, the conventional symbolized dotted line depth curves have been replaced by fine continuous lines. This not only reduces the engraving time but makes the underwater features and dangers stand out more clearly. Many favorable comments have been received regarding this new practice.

There has been an increasing use of vinylite plastic sheets in our lithographic and cartographic work, with a correspondent elimination of certain reproduction steps. In the preparation of color printing plates, the use of vinylite eliminates negative making; in making duplicate positives or negatives, intermediate prints are eliminated. Success has also been achieved in making a plastic negative from a transparent original and from the negative a standard albumen printing plate. Vinylite has also been coated with an engraving ground so that the grid system could be engraved on it in the Bureau's projection ruling machine, and used as a negative for making black-line prints.

Detailed studies were made of methods of computing with high-speed calculating machines and their adaptability to the office processing of field data. Punched-card methods were found applicable to our specialized activities and, as a result, special equipment is being installed in the Bureau to take advantage of these methods. This will be used in the adjustment of extensive triangulation networks, in the harmonic analysis of tidal records, and in the computation of hourly values of magnetic components. The innovation will not only save many man-hours, but will also relieve personnel of much of the nerve-taxing computing that is characteristic of a good deal of our work.

COOPERATION WITH AMERICAN REPUBLICS

The Bureau participated for the eighth consecutive year in the Cooperation with the American Republics program which is sponsored and financed by the Department of State. Our participation embraces two major activities—a Scientific and Technical program, under which the Bureau acts in a consultative and advisory capacity to Latin-American countries, and an Exchange of Persons program, which is an in-service training activity for representatives from these countries.

The results obtained from this program have been beneficial not only in establishing good will and friendly relations with the various military, naval, and civil departments or agencies of the American Republics, but also in the valuable scientific data that have been exchanged. Interest in developing and executing surveying and mapping programs in the various countries has been stimulated through the in-service training program, and has resulted in increased purchases of material and equipment through special missions and the individual trainees. The adoption of Coast Survey methods has contributed materially to the establishment of standards of accuracy and procedure on a hemispheric basis which is being sponsored by the Commission on Cartography of the Pan American Institute of Geography and History.

Under the Scientific and Technical program, Bureau experts have visited the various countries now engaged in carrying on or planning to undertake programs of work in the fields of tides and currents, geomagnetism and seismology, geodetic surveying, hydrographic surveying, and map and chart production.

During the year tide stations were operated on a cooperative basis at the following 11 ports in Central and South America: Habana, Cuba; Tampico, Puerto Mexico, and Progreso, Mexico; Puntarenas, Costa Rica; Talara, Callao, and Matarini, Peru; and Valparaiso, Puerto Montt, and Punta Arenas, Chile. The Coast and Geodetic Survey furnishes the instrumental equipment and installs the stations, and the cooperating countries furnish the sites, the housing for the instruments, and the observers. The tide-gage records are forwarded to the Bureau for analysis and processing, and the results are forwarded to the respective cooperating agency. The observations are supplying valuable data for use in tide tables, for the construction of nautical charts, for engineering construction along the coasts, and for studies of changes in the relation of land to sea.

The results of the magnetic observations made last year in Argentina, Bolivia, Brazil, Chile, Ecuador, Peru, and Uruguay are being compiled and analyzed for inclusion in reports of these areas. These data will be used in the various studies and practices now being undertaken to determine magnetic variations which affect navigation, radio communication, and related scientific activities. A former member of the group from Uruguay has translated into Spanish a manual on magnetic observations. This Spanish edition of the Bureau's Direction for Magnetic Measurements, will be published under this program.

The Bureau assisted in the maintenance of strong-motion seismographs installed at Chile, Colombia, Costa Rica, Ecuador, Guatemala, and Peru, and the results obtained are being used in the development of earthquake studies and further research. The Seismological Institute of the University of Chile constructed a number of seismographs from specifications furnished by the Coast and Geodetic Survey, and made installations at Copiapo, Santa Lucia, Panimavida, and Punta Arenas. Periodic seismological bulletins have been sent to the United States and other countries. In Venezuela, plans were well advanced toward establishing a first-class station at Chinchina, using equipment manufactured in the United States.

Two officers were assigned to liaison duty with the Caribbean Command of the Department of the Army to advance geodetic surveys in the Central and South American countries. Another officer was assigned as tidal consultant. Reports indicate that the advice of these officers is bringing about a unified program among the American Republics.

The Bureau took part in the special mission of the Department for the inspection of CAA aviation facilities in South America by the assignment of a cartographer to lend assistance and advice regarding aeronautical chart facilities. The following countries were visited: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guatemala, Mexico, Peru and Uruguay. Occasion was taken to confer with offi-

cials in each country regarding the training program and the results obtained therefrom.

The survey of existing aids to navigation, made at the request of the Dominican Republic, was completed during the first part of the fiscal year. A comprehensive report embracing a 5- to 10-year plan of operation and construction of navigational aids was submitted by the lighthouse engineer specially engaged for this project. According to official information, the plan was adopted and operations were to be initiated shortly after January 1, 1948.

Under the Exchange of Persons program, qualified technicians and engineers from the American Republics are awarded training grants in the fields in which they are interested, and are brought to the United States for specialized studies and practical training in the methods and procedures adopted by the Coast and Geodetic Survey.

This in-service training program includes awards in three categories, namely: Type A, financed entirely by the United States; type B, financed by the foreign government; and type C, financed jointly. During the year 28 grants were awarded as follows: In map and chart production—Cuba (3), Ecuador (3), Guatemala (4), Mexico (3), and Peru (3); in geodetic surveying—Argentina (1), Brazil (1), Ecuador (1), Mexico (2), and Venezuela (2); in tides and currents—Argentina (1), Colombia (1), and Peru (2); in geomagnetism and seismology—Argentina (1). Of these, 12 grants were of type A, 14 of type B, and 2 of the type C. In addition, 5 trainees (from Bolivia, Cuba (2), Ecuador, and Paraguay) under the 1947 program continued their training in 1948.

The in-service training period varies from 6 to 8 months, depending on the activity followed. The emphasis is on practical application of methods and procedures. Trainees in geodetic and hydrographic surveying spend most of their time in the field, studying the techniques involved, operating the instruments, and learning the methods of party operation, after which they return to the Washington office to study office procedures involved in the processing of field data. Under tides and currents, and geomagnetism and seismology, the trainees are given an opportunity to operate the instruments and to become familiar with the various procedures. The trainees in map and chart production receive specialized instruction to meet their particular needs and interests with a general review of the entire field. They work on charts of their own countries, employing all the modern techniques of chart construction and reproduction. Special training in photogrammetric methods is given to those interested in this branch of map production and they are offered an opportunity of becoming familiar with the latest equipment and techniques.

One of the means used by the trainees to keep abreast of the latest developments and techniques in the surveying and mapping field, particularly of the Federal mapping agencies, is the Journal of the American Congress on Surveying and Mapping, to which the Bureau has lent its support. Through the Journal, and by attendance at the annual meetings of the congress, held in Washington, D. C., trainees have an opportunity to become familiar with the latest instrumental equipment and practices. Sixteen countries now have representation in the congress, with over 135 members.

REPRESENTATION ON COMMISSIONS, BOARDS, AND PANELS

To keep abreast of scientific and technical developments, both national and international, in the fields of activity in which it is interested, and to contribute its specialized knowledge to the study of future national needs, the Bureau has maintained representation and membership on a number of commissions, boards, panels, and committees. In some of these, membership is defined by law or by Executive order, while in others the cooperation of the Bureau is voluntarily sought. Some of the more important and active of these groups are the following:

Mississippi River Commission.—The Director of the Bureau continues to serve as the Coast and Geodetic Survey member of the Mississippi River Commission. The commission is responsible for the improvement and maintenance of the Mississippi River, from Cairo, Ill., to the Gulf of Mexico, for flood control, for promoting navigation, and for facilitating commerce on the river.

Research and Development Board.—The Chiefs of the Divisions of Photogrammetry, Coastal Surveys, Geodesy, Geomagnetism and Seismology, and Tides and Currents; and the Chief of the Section of Seismology are members or deputy members on various panels of the Committee on Geophysical Sciences of the Research and Development Board of the National Military Establishment.

Air Coordinating Committee.—The Chief of the Aeronautical Chart Branch represents the Department of Commerce and is chairman of the Subcommittee on Aeronautical Charts, Technical Division, Air Coordinating Committee. This commitee was established by Executive order to coordinate the aviation activities of the Federal Government and deals with such matters as standardization of symbols and specifications for aeronautical charts.

International Civil Aviation Organization.—An officer of the Bureau, on detached service, is the United States representative on the Council of the International Civil Aviation Organization (ICAO). This organization deals with all phases of civil aviation on an international level, particularly with regard to promoting safety, developing standards, and encouraging uniform procedures. The Bureau is also represented on the committee making recommendations to the ICAO Council on Dimensional Standardization.

Pan American Institute of Geography and History.—The Director of the Bureau is a member of the United States Advisory Committee on American Cartography for the Commission on Cartography of the Pan American Institute of Geography and History. The Bureau is represented on several of the technical committees of the Commission on Cartography. The Commission was set up in 1941 for the purpose of facilitating and expediting progress in map making in the nations of the Western Hemisphere, through the interchange of ideas, the exchange of information, and the promulgation of standards for the various classes of maps and surveys.

Miscellaneous representation on boards, etc.—The Bureau has official representation on a number of scientific and technical associations and committees, among which are the Governmental Advisory Committee on Oceanography; Advisory Committee for Research on Lithographic Papers of the Lithographic Technical Foundation; United States Board on Geographic Names; Federal Specifications Board; American Standards Association; California Advisory Committee on Engineering Seismology; Federal Inter-Agency River Basin Committee; Federal Inter-Agency Committee on Development of Alaska; Inter-Agency Safety Council; Missouri Basin Inter-Agency Committee; National Research Council Committee on Paricutin Volcano; Radio Technical Commission for Marine Services; and Joint Map and Photo Committee of the Joint Chiefs of Staff.

In addition, there are other scientific and engineering groups in which membership is voluntary, but which the Bureau encourages because they provide a forum for the mutual interchange of ideas and for bringing the Bureau's activities and progress to the attention of scientists, engineers, and others. Many of our personnel hold executive positions or head technical committees in these organizations, among which are the American Geophysical Union, American Congress on Surveying and Mapping, American Society of Photogrammetry, Institute of Navigation, International Union of Geodesy and Geophysics, Central Bureau of the International Association of Terrestrial Magnetism and Electricity, International Society of Photogrammetry, and International Seismological Association.

PERSONNEL AND FINANCES

The number of persons in the service of the Coast and Geodetic Survey at the close of the fiscal year was 2,529.

Civilian personnel actions during the year included 1,765 appointments, 1,546 separations, 14 retirements, 380 line promotions, and 966 within-grade promotions. Of the 1,765 appointments effected, 29 were employees who returned to duty from military furlough and 629 were veterans, making a total of 658 veterans placed in the Bureau during the year.

Commissioned personnel changes included 9 retirements, 4 resignations, and promotions as follows: 7 deck officers to ensigns, 1 ensign to lieutenant (jg), 51 lieutenants to lieutenant commanders, 34 lieutenant commanders to commanders, and 10 commanders to captains.

At the end of the fiscal year one officer was serving as instructor in surveying at the Field Artillery School, Fort Sill, Okla. Another officer was assigned as survey expert with the Field Artillery Test Section of Army Ground Forces Board No. 1 at Fort Bragg, N. C. One officer completed the 5-months' course at the Armed Forces Staff College at Norfolk, Va., the third officer to complete such course. Three officers were attached to the Caribbean Defense Command of the Army for liaison duties in surveying and mapping in South and Central American countries. One officer, based at Honolulu, was assigned to a project for obtaining systematic tide observations in the western Pacific in cooperation with the Corps of Engineers.

One officer was serving as representative of the United States on the Council of the International Civil Aviation Organization, and also as the United States representative on the Air Navigation Committee.

One cartographic engineer continued as liaison officer between the Bureau and the Civil Aeronautics Administration.

Four officers, two mathematicians, and one cartographic engineer continued on duty in the Republic of the Philippines under the Philippine Rehabilitation Program.

Personnel work was noticeably increased by (1) the passage of the Langer-Chavez-Stevenson Retirement Act, (2) the Loyalty Program as required by Executive Order 9835, (3) the Displacement Program as required by the Civil Service Commission in connection with replacing war-service employees with displaced career employees, and (4) the Employe Suggestion Program. Under (4) 35 awards have been made totaling $1,110 with an estimated savings of $23,875 during the first year after adoption.

The following table is a break-down of the number of people in the Bureau by regular appropriations and other funds as of June 30, 1948. Part-time fixed-fee employees and dollar-a-year men have been omitted from this table.

Distribution of personnel by appropriations, June 30, 1948

Appropriation	Commissioned	Civilian	Total
Washington office:			
Regular appropriations	24	742	766
Working funds		210	210
Philippine rehabilitation		5	5
Total, Washington office	24	957	981
Field service:			
Regular appropriations	133	1,291	1,424
Working funds		24	24
Philippine rehabilitation		98	98
Total, field service	133	1,413	1,546
On duty with military forces	2		2
Total	159	2,370	2,529

Collections covering miscellaneous receipts, including nautical and aeronautical charts and related publications, totaled $422,677 as compared with $441,927 during the preceding year.

The following funds, from the sources indicated, were made available to the Bureau during the fiscal year 1948:

Available funds

Regular appropriation:	
Salaries and expenses, departmental	$3,300,000
Salaries and expenses, field	5,000,000
Supplemental, salaries and expenses, field	152,000
Pay and allowances, commissioned officers	1,250,000
Total appropriations	9,702,000

Available funds—Continued

Reimbursements from other departments to credit of appropriation for:	
Salaries and expenses, departmental	$186,450
Salaries and expenses, field	33,308
Total reimbursements	219,758
Working funds received from:	
Department of the Army:	
Triangulation net of Western Europe	$37,500
Surveys at Proving Ground, Utah	16,000
Bamberg astronomic transits	5,000
Processing tidal records	25,000
Meteorology equipment for aircraft production	64,516
Department of the Navy:	
Hydrographic Office (magnetic data and charts)	7,800
Hydrographic Office (combat and approach charts)	15,000
Bureau of Supplies and Accounts (hydrographic survey of Pend Oreille Lake, Idaho)	21,000
Naval ordnance test station (base measurements and triangulation to locate ballistic ground ranges, Inyokern, Calif.)	20,000
Department of the Air Force:	
Classified project	13,750
Surveys in vicinity of Albuquerque, N. Mex	6,000
Aeronautical charts	200,000
Department of the Interior:	
Survey of Franklin D. Roosevelt Lake	15,000
Leveling for Santa Barbara conduit	2,500
Seismological stations at Hoover, Grand Coulee, Shasta, and Hungry Horse Dams	17,200
Atomic Energy Commission (special maps and charts)	20,000
Total working funds	486,266
Transfer from: Department of State (Philippine rehabilitation)	236,555
Allotments from:	
Department of State (Cooperation with American Republics)	75,277
Department of Commerce (printing and binding)	117,645
Total funds received	10,837,501

PUBLICATIONS

The results of the Bureau's work are disseminated to the public in the form of charts, special publications, and processed material. Marine and air charts are the principal publications of the Bureau and are printed at the Washington office. Other publications are generally printed at the Government Printing Office.

Charts and related publications are sold to the public at the various field stations of the Bureau, at the Washington office, and at authorized agencies located at strategic places throughout the country. Other publications of the Bureau are sold by the Government Printing Office.

In the field of related nautical chart publications, a new edition of the Atlantic Coast Pilot, Section C, was released for issue. Editions of the Alaska Coast Pilot, Part II, and the Atlantic Coast Pilot, Section D, were in press. Supplements for seven other coast pilot volumes

were published and issued. These volumes supplement the nautical chart and contain a wide variety of information for the benefit of the marine navigator.

A new Nautical Chart Manual has been prepared for the use of the cartographers and negative engravers. This manual embodies instructions designed to secure uniformity, completeness, and simplicity in the nautical charts.

Tide and current tables, giving information on the rise and fall of the tide and the ebb and flow of the current for numerous ports and waterways throughout the world, are published annually in advance. In addition to the regular tables, two new tide tables, one for the east coast of North and South America and the other for the west coast of North and South America, were prepared for the year 1949 to give more efficient service to users on our Atlantic and Pacific coasts. New tidal current charts for the northern and southern parts of Puget Sound, and a revised edition of Tidal Current Charts, San Francisco Bay were issued. At the end of the year a new publication, Tidal Current Charts, Delaware Bay and River, was in process of reproduction. These charts consist of a series of 12 and depict the direction and velocity of the tidal current for each hour of the tidal cycle.

Also completed during the year were index maps of tidal bench marks and loose-leaf compilations of descriptions and elevations of tidal bench marks for tide stations in Maryland, Virginia, Pennsylvania, Delaware, and Florida. This information is required by surveyors and engineers in coastal construction and other engineering projects.

In the field of geomagnetism, Serial 664, Magnetic Declination in the United States, 1945, was issued, and Serial 667, U. S. Magnetic Tables and Magnetic Charts for 1945, is in press. Processed report MO-25, Magnetic Observatory Results at Honolulu, T. H., for 1937–38, was also issued, as were six of the new MG reports for the various observatories. Each of these reports contains quarter-size reproductions of the magnetograms obtained at one observatory over a 6-month period.

Seismological publications issued during the past year included United States Earthquakes, 1946, the monthly Seismological Bulletins for 1945, and the quarterly Abstracts of Earthquake Reports for 1947. Epicenter notes on all important current shocks were also issued to the various collaborators and institutions cooperating with the Bureau in this phase of its program.

In the field of geodesy, Special Publication No. 237, Manual of Geodetic Astronomy, and Special Publication No. 239, Manual of Geodetic Leveling, were published during the year. These publications, which give standard specifications and detailed instructions, will make for uniformity in results of our field observations and maintenance of high standards. Special Publication No. 238, Air-Line Distances Between Cities in the United States, was also published. Nearly 125,000 distances were involved covering 492 cities. Computations were made on high-speed calculating machines.

A Handbook of Technical Services for the State of New Jersey, including New York and vicinity, was processed and issued during the

year. This publication describes and illustrates the kind of data and services which are available in the Bureau to engineers, surveyors, and the chart- and map-using public.

The first number of The Journal of the Coast and Geodetic Survey was issued during the year for distribution to the Bureau personnel. The Journal contains technical articles and serves as a medium for the presentation of new methods and new developments in both field and office.

A number of leaflets, pamphlets, articles, lectures, and miscellaneous items were prepared for the purpose of describing and interpreting the methods and activities of the Bureau to scientific and engineering societies and to the general public.

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