U. S. Coast and Geodetic Survey

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United States Coast and Geodetic Survey

GENERAL STATEMENT

The fiscal year 1947 marked the first full year since the close of the war that the Bureau's activities were concerned primarily with its normal peacetime program. Certain delays in the process of returning ships and personnel from the armed forces delayed resumption of the work, but in the closing months of the year the program was in full operation.

If an over-all characteristic of the year's work were to be singled out, it would undoubtedly be the growing interest shown by the public in our products and the manifold ways in which the Bureau can serve commerce and industry. It is becoming recognized that there is need in the economic program of the country for fundamental surveys and maps to furnish the basis for engineering planning and for the development of natural resources, just as there is need for accurate charts to safeguard our water-borne and air-borne commerce.

Surveys for Economic Planning

Surveying and mapping are fact-finding operations, and intelligent national, State, or municipal planning is impossible without them. Modern reclamation, navigation, flood control, and multiple water-use projects, such as for the Ohio, Columbia, Mississippi, and Missouri River Basins, which must consider a river system as an integrated whole, require planning on an extensive area basis. Comprehensive horizontal and vertical control surveys must therefore precede the planning stage.

On a more local level, control surveys are essential to wise city and county planning and for the perpetuation of property boundaries in areas of high land values. It is in the national interest that all surveys, no matter how localized, should be integrated in the national network of geodetic control. This can be accomplished by a further break-down of our control surveys so that an economical tie-in may be made by local surveyors and engineers.

Progress in Survey Electronics and Technical Equipment

We have kept abreast with developments in the fields of electronics as applied to distance and angle measurements. These systems are not yet adapted to geodetic survey use, but improvements in instrumental equipment that will afford the degree of accuracy required in the work of the Bureau are being watched. The optimistic note

sounded in our last year's report regarding the use of electronics in hydrographic surveying has been fully justified by our experiences during the past year. Extensive use of Shoran for offshore control has been made in the western Aleutians and along the Atlantic coast, and enthusiasm is expressed for the method by those using it. We have redesigned and rebuilt the Coast and Geodetic Survey electronic position indicator, with which it will be possible to carry hydrographic surveys for about 200 miles beyond the limits of Shoran, thereby adding to the accuracy and efficiency of oceanographic investigations and surveys of the Continental Shelf and beyond.

Developments in instruments and processes in other fields of the Bureau's work will result in improved efficiency and greater economy. Among these were a mathematically accurate parabolic reflector, for use in triangulation, that increases the range of the signal lamp and improves its haze-penetrating power; a seismic sea-wave warning system; a new technique for measuring the magnitudes of earthquakes from instrument records; and a new process for making color proofs from photographic positives for use in deep-etch reproduction.

We have further experimented with certain of our nautical charts to develop a type that will best meet the needs of vessels using the Loran or Radar systems of navigation. The project begun toward the end of the last fiscal year of charting the Gulf Intracoastal Waterway was continued during 1947. There is an increasing demand for charts of this waterway and the Bureau is expediting the program. A new series of aeronautical charts for the United States was introduced—the Radio Facility Charts. Complete radio data to facilitate the planning and execution of cross-country flights are provided. These charts are finding wide use by commercial, private, and military airmen.

Cooperation With Other Agencies

The Bureau has continued to cooperate with various Government agencies and private organizations in furnishing information on our methods and techniques and in other ways. A large amount of cartographic and reproduction work was done on a reimbursable basis for the War Department, State Department, Bureau of Foreign and Domestic Commerce, and Civil Aeronautics Administration. An agreement was concluded with the Geological Survey whereby coastal topographic maps prepared by the Coast and Geodetic Survey will be turned over to the Geological Survey for publication. In turn, the results of the permanently monumented control surveys made by the Geological Survey will be turned over to the Coast Survey for publication. This arrangement is of primary significance and should result in a more logical definition of the functions of the two agencies and simplify the procedure of obtaining maps and survey data. An arrangement has also been concluded with the Hydrographic Office of the Navy Department which makes the Coast and Geodetic Survey the repository for magnetic and tidal data. All such information obtained by the Hydrographic Office will be sent to the Bureau for analysis and publication.

The Bureau participated in the Philippine Rehabilitation Program, authorized by the Seventy-ninth Congress. Under this program the

survey work interrupted by the war will be continued and 20 Filipinos will be trained each year until June 30, 1950. An officer of the Bureau has been placed in charge of the Manila Field Station and named director of Coast Surveys. Other Survey personnel have been assigned to duty at Manila to assist in the operation of the program. Technical assistance was also given to the Philippine Government in the matter of establishing a modern map reproduction plant. Recommendations and detailed specifications were furnished on all items of equipment and accessories necessary, with special consideration given to the availability and utility of the basic equipment.

Broadening Our Technical Services

The program of broadening the technical services of the Bureau discussed in our last annual report, progressed during the year, under very limited funds for needed personnel. It is axiomatic that a public-service bureau should endeavor to render the maximum of service to the public. The keynote of this program has therefore been to develop a better understanding, a more effective distribution, and a greater utilization of the products of the Bureau's activities. Apart from its function of making and publishing nautical and aeronautical charts, with which mariners and aviators are familiar, the work of the Bureau touches a variety of other fields which could have application in many scientific and engineering endeavors.

It is this availability of information and services that is being stressed by the Bureau in a number of ways. For example, a new series of State maps on a scale large enough to show the actual triangulation and leveling nets in the area, with appropriate references for obtaining the desired information from the Bureau, has been published.

Another means for the dissemination of Bureau information to the public has been through the medium of specially prepared exhibits. A number of these were on display in various parts of the country in conjunction with meetings and expositions of national scope and importance.

A third means has been through news releases, in the daily press and in technical magazines, announcing survey projects, new and revised charts issued, and new publications of the Bureau; through the issuance of pamphlets, manuals, and other publications describing Bureau practices; and through the publication of articles in technical and trade magazines, and the preparation of lectures describing and interpreting the methods and activities of the Bureau to scientific and engineering societies and to the general public.

A closer liaison has also been established with governmental and private agencies through representation on various scientific and technical boards, panels, and commissions, and through active participation by personnel of the Bureau in the programs of national and international bodies dealing with surveying and mapping or related fields.

The response to this program of broadened service has been a noticeable increase in requests for geodetic data and in the sale of nautical and aeronautical charts to the public; in addition, the Bureau is being consulted on a far greater variety of matters than heretofore.

Closer contact with the public is desirable, particularly with local surveyors and engineers who could benefit from the use of Survey data. This can be achieved by increasing our field stations and their personnel.

Needs of the Bureau

Our service to the public can be improved if certain activities or liaisons can be resumed or undertaken as early as possible.

One of these is the flight-checking of aeronautical charts. This is an important part of the charting program. Constant flight-checking should be maintained, and each chart should be inspected on the average of once every 3 years. Owing to the limited funds available for field work during the past year, it was possible to flight-check only two charts.

The rate of surveys in strategic sections of our coastal regions and of Alaska should be advanced. A stepped-up program would not only serve our military needs during any future emergency but would be of immediate benefit to our commerce and industry.

Our program of research and development should be accelerated. A specialized scientific organization advances in proportion to its success in research. Future requirements in the national security program will call for greater accuracy and speed in survey methods, computation, and reproduction, and further acceleration in planning for surveying our natural resources. We should begin now to lay the foundation for a broadened program of research.

Finally, a close liaison should be maintained, through the Department, with the National Security Council, and particularly with the National Military Establishment. The functions and responsibilities of the Bureau are closely allied to military planning and operations. This has been recognized by congressional enactment. A liaison, as proposed, will insure a maximum usefulness of the Bureau's technical services and products in time of national emergency.

FUNCTIONS OF THE BUREAU

The importance to our maritime commerce of a complete knowledge of our coast and the character of the sea bottom near it was recognized at an early period in the history of our country. In 1807 the Congress directed President Jefferson to cause a survey of the coast to be made, although, owing to certain delays, including the War of 1812, actual field work was not begun until 1816. This was the beginning of the Coast Survey.

An important extension of the Bureau's work was made in 1871, when a geodetic connection between the Atlantic and Pacific coasts was authorized. Since that time the Bureau has been actively engaged in extending triangulation and precise levels in the interior of the country for the control of topographic and geologic surveys and large engineering undertakings, and has been continuing the same work along our coasts for charting our water areas.

Two other activities, not contemplated in the original act, have been added to the functions of the Bureau in recent years—the investigation

of earthquakes, or seismology, transferred from the Weather Bureau in 1925, and the preparation of aeronautical charts, delegated to the Secretary of Commerce under the Air Commerce Act of 1926.

Through the years the importance of this undertaking 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 and the publication of the resulting data. Because of its unique organization, administered by a commissioned corps, its technically trained personnel, and its specialized equipment, the Bureau forms an effective reserve for service in the National Military Establishment.

Products of the Bureau

The Coast and Geodetic Survey today renders a considerable variety of essential services for the advancement of marine, aviation, commercial, and industrial interests of the country. The products of the Bureau invariably take the form of publications. Charts and maps and certain processed publications are produced in our own 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.

Topographic 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, waterfront 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

When the Coast Survey first began its charting work, our country consisted of a narrow coastal belt along the Atlantic coast and comprised about 15,000 statute miles of shore line. With the Nation's territorial expansion, the activities of the Bureau have grown until today its jurisdiction extends to all the waters of continental United

States, Alaska, the Philippines, Guam, the Hawaiian Islands, Puerto Rico, the Canal Zone, and the Virgin Islands—comprising a total shoreline of more than 100,000 statute miles.

To cover this extensive coastline, 892 different nautical charts are published. These range from large-scale harbor charts, used for close inshore navigation and requiring fullness of detail in topographic and hydrographic features, to small-scale sailing charts, used for offshore navigation and necessitating a greater generalization of detail.

The function of the nautical chart is to safeguard our seaways. It must keep commerce informed of changes in hydrographic conditions brought about by the forces of nature or by the works of man. The millions of dollars spent annually on harbor improvements, port facilities, lighthouses, and buoys would fail of their full purpose if these improvements were to be omitted from the charts. As our ports and harbors grow the charts must grow with them. They must be revised frequently to give an accurate picture of existing conditions.

The field surveys executed by the Bureau are the basic data used in the construction and revision of nautical charts. These surveys are supplemented by data from other organizations, especially data relative to channel and harbor improvements, and changes in aids to navigation.

Charts are brought up to date by periodic resurveys and by publication of new editions showing the changed conditions. In some of our seaports changes are so numerous that it is necessary to reissue the harbor charts four times a year by new and revised editions. 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

The Coast Survey came into being during a period when maritime countries began to recognize the governmental responsibility for surveying and charting their coasts. This concept has become basic. It was reaffirmed by the Air Commerce Act of 1926, because of the fundamental similarity between marine and air charting. Public safety requires the use of up-to-date and reliable charts. A constant flow of information must therefore go out to aviators regarding our civil airways and our airports. This information must reflect changes in culture, in aids to navigation, and in other vital aeronautical data. In some of the chart series, it is necessary to maintain a weekly revision schedule. Obviously, the ramifications of the program of preparing and maintaining aeronautical charts are such that only a Federal organization supported by the public can accomplish it satisfactorily.

Because of its trained personnel and the many years of experience in the preparation of nautical charts, the Bureau was assigned the task of preparing and publishing aeronautical charts. To date, 789 have been issued for the United States and possessions. As with surface navigation, charts of widely varying scales are required to meet the different needs of air navigation. 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.

Aeronautical charts are compiled from the basic survey data of the Bureau supplemented by the best topographic data from more than 50 miscellaneous sources. They are designed to be read easily by the pilot in a rapidly moving airplane and emphasis is given to features of aeronautical importance. Upon the basic chart, there are overprinted in color, usually magenta, airports, beacon lights, radio-range stations, and other aeronautical data. Before final publication, and to insure accuracy of the detail shown, the preliminary chart is flown by an experienced observer and details on the chart are compared with actual ground features. Necessary corrections and additions are noted. Some of the most important information is obtained from the flight-check.

CHART PRODUCTION AND DISTRIBUTION

During the fiscal year 1947 the Bureau faced a heavy backlog of revision data for its nautical and aeronautical charts. Efforts were concentrated on improving the quality of the charts by applying the most vital information to them. There still remains a heavy work load of compilation work on all types of charts. There was a greater demand from the public for charts, and efforts were concentrated on supplying the charts with more efficient and improved service.

To relieve the overburdened facilities of the Washington Office, regional chart distribution centers were established at New York and Baltimore. Nautical charts are now furnished to these offices uncorrected and hand corrections are made there. This has resulted in a saving in the number of personnel engaged on this work in the Washington Office.

The sale of nautical charts to the public increased approximately 40 percent over 1946, although the total demand decreased to some extent, because the requirements of the Navy Department were less in 1947. The demand for aeronautical charts also increased during the year, in spite of the fact that the requirements of the War Department decreased from 66.8 to 46.4 percent (including airport charts) of the total issue.

The relative annual output of navigational charts and related publications is given in the following table:

Charts and related publications issued

Type of chart or publication	1944	1945	1946	1947
Nautical charts	2, 913, 666	4, 330, 547	2, 235, 396	1, 225, 639
Aeronautical charts	17, 645, 892	16, 899, 049	9, 097, 817	7, 988, 426
Airport charts			2, 705, 446	4, 885, 703
Coast Pilots	16, 086	13, 884	14, 067	15, 993
Tide tables	81, 449	98, 016	80, 014	65, 767
Current tables	86, 038	40, 933	37, 856	45, 778

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

Distribution of nautical and aeronautical charts in 1947

NAUTICAL			
Free issue:		*Percent*	
Navy Department	503,369	41.6	
Coast Guard	3,621	.3	
War Department	41,301	3.4	
Coast and Geodetic Survey	17,407	1.4	
Other Department	6,587	.5	
	572,285	47.2	
Sales	529,876	42.7	
Condemned	123,478	10.1	
	1,225,639	100.0	1,225,639
U. S. AERONAUTICAL			
Free issue:			
War Department	2,851,495	40.0	
Navy Department	1,214,153	17.0	
Civil Aeronautics	66,922	.9	
Coast and Geodetic Survey	68,480	.9	
Other Departments	89,945	1.3	
	4,290,995	60.1	
Sales	1,644,105	23.0	
Condemned	1,209,298	16.9	
	7,144,398	100.0	7,144,398
U. S. AIRPORT			
Total issue			4,885,703
SPECIAL AND FOREIGN AERONAUTICAL			
Total issue			844,028
Total			14,099,768

The number of individual nautical charts on issue at the end of the year was 892. To produce the 1,225,639 copies issued, 644 printings were necessary, as follows: 13 new charts, 77 new editions, 502 new prints, and 52 reprints. A program of reconstruction and extensive revision of the nautical charts has been necessitated by the large accumulation of hydrographic and topographic data during the war years which could not be applied to the charts because of press of war work.

Approximately 8 million hand corrections were necessary to correct the charts to date of issue. Dangers requiring hand corrections and other navigational information were reported to the Coast Guard and Hydrographic Office for publication in the weekly Notice to Mariners. During the year a new practice was initiated of sending to eight district offices marked copies of Notice to Mariners to show the items being applied by hand correction to the charts. This will insure an agreement between nautical charts issued by the district offices and those issued from the Washington Office.

The project begun toward the end of the last fiscal year of charting the Gulf Intracoastal Waterway was continued during 1947. There

is an increasing demand for charts of this waterway, and the Bureau is expediting the program. 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 will run from Carabelle, Fla., to the Mexican border—a distance of 1,076 miles—and will require 33 large-scale charts, similar in design to the Atlantic intracoastal charts. Five of these charts have been published to date, and eight more are in various stages of completion.

A new chart for use with the Loran system of navigation has been developed. This new chart is printed on the reverse side of the conventional chart and carries the Loran curves superimposed upon a printing of the conventional chart, but with most of the soundings removed and more depth curves added. A navigator employing the Loran system may now use the Loran chart without reference to the standard chart.

Two special charts were produced for use in connection with the International Meeting on Marine Radio Aids to Navigation at New London, Conn., to demonstrate the use of Loran and Shoran. Six additional experimental charts for use in Radar navigation were produced. These show topography by gradient tints and should facilitate the correlation of the charted detail with the radarscope.

In the field of related nautical chart publications, the Bureau publishes a series of Coast Pilots to supplement the information shown on the charts. A program for expediting revision of these Pilots is progressing satisfactorily. Field inspection for the revision of the Atlantic Coast Pilots continued throughout the year. Inspection of Section C, Sandy Hook to Cape Henry, was completed; and the work on Section D, Cape Henry to Key West, had progressed south to Myrtle Beach, S. C.

The aeronautical charts of the United States and possessions were maintained. These include 226 standard aeronautical charts, 521 instrument approach and landing charts, and 42 radio facility charts, a total of 789. The standard charts are revised generally every 6 months on schedule, and the remaining charts are revised weekly as necessary. To maintain these charts, 1,503 printings were necessary.

During the year a new series of aeronautical charts was introduced—the Radio Facility Charts. Forty-two charts, each measuring 8 by 10½ inches, cover the entire United States. These charts provide complete radio data to facilitate the planning and execution of cross-country flights and are similar to the data formerly published in Air Navigation Radio Aids, which was discontinued toward the end of the last fiscal year. The special type of information necessary for aeronautical operations, by use of radio facilities, is depicted on these charts, which are finding wide use by commercial, private, and military airmen. Under the maintenance program for these charts, revisions will be made on a weekly schedule to provide users with the latest changes in radio facility data with a minimum of delay. These charts are distributed in quantities of 20 or more copies of each sheet on a yearly subscription basis which includes automatic distribution of all revisions for the entire year. Single copies of any of these charts may be purchased without revision service.

A new route chart, Chicago, Ill., to Gander, Newfoundland, was published in January. This chart was primarily designed to meet the requirements of air carriers operating over the North Atlantic and using high-speed, high-altitude, long-range aircraft. It covers all international air routes originating in the United States and extends to transoceanic take-off points in Newfoundland and Labrador so that only one chart is necessary for all such operations on this side of the Atlantic.

To fill the requirements of the principal commercial air carriers that operate certificated overseas routes, and of the military forces, the Bureau published the second of a series of aircraft position charts, covering western Europe and northwestern Africa. These charts are designed for selected areas that require a special type of air navigation chart. The construction of the third chart of this series, which will cover the Caribbean area, is in progress.

In addition to the production of the standard aeronautical charts special work was accomplished for the War Department and other governmental agencies. These included route charts, azimuthal equidistant charts, gnomonic tracking charts, grid navigation overprints, link trainer charts, and miscellaneous charts.

Owing to the limited funds available for field work, flight-check operations during the year consisted only of the flight-checking of two local aeronautical charts. Constant flight-checking should be maintained, and each chart should be inspected on the average of at least once every 3 years.

A new field station was established in September 1946 at Chicago, Ill. This is the fourth station established by the Bureau for liaison with the Civil Aeronautics Administration for the distribution of aeronautical charts and for the dissemination of survey data to the public. Other stations previously established are at Kansas City, Mo., Atlanta, Ga., and Fort Worth, Tex.

The Kansas City field office was enlarged and now supplies all aeronautical chart agencies west of the Mississippi River. It is planned to establish a new distribution office in San Francisco or Los Angeles, Calif., for the west coast. The issue of charts from these offices results in a saving in the amount of space needed for storing charts in the Washington Office and the accompanying processing of orders for charts, and also furnishes more efficient service to the chart users and chart agents, owing to their closer proximity to the distribution center.

During the year, 22 new nautical chart agents and 123 aeronautical chart agents were appointed. More than 40 agencies were canceled as a result of certain inefficiencies disclosed on inspection. At the end of the year there were 181 nautical and 364 aeronautical chart agencies.

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 begun.

SURVEYS OF COASTAL WATERS

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

Before the war, the annual progress of surveys along our coasts proceeded at an economical rate without attempting to advance too far ahead of commercial needs. Main seaports and approaches were surveyed, as well as the more important inlets. With the advent of war this work ceased, ships were transferred to the Navy, and hydrographic parties assigned to areas of strategic importance.

When the war closed preparations were made to resume our program of surveying and charting and to extend it into regions of partially undeveloped natural resources, where oil, fishing, and mining operations are either being carried on or are contemplated. Owing to the delay in the retransfer of ships back to the Survey and to the needed alterations and repairs, it was not until the closing months of the fiscal year that the program was in full operation.

During the year 19 survey vessels and several shore-based units were engaged on coastal surveys along the Atlantic, Gulf, and Pacific coasts of the United States, and in Alaska. In the Philippines the Bureau operated one vessel in conjunction with the Philippine Government. A summary of the surveys accomplished is given in the following table:

Statistical summary of coastal surveys

Locality	Hydrography				Topography		Triangulation		
	Sounding lines	Area	Wire drag	Area	Shore line	Area	Length of schemes	Area	Geographic positions
	Miles	*Square miles*	*Miles*	*Square miles*	*Miles*	*Square miles*	*Miles*	*Square miles*	*Number*
Coast of Maine	9,048	1,199	------	------	------	------	------	------	------
Massachusetts to Cape Charles	113	1	42	5	------	------	------	------	5
Chesapeake Bay	2,322	90	56	23	1	1	2	4	2
Cape Charles to Florida	3,728	671	------	------	------	------	------	------	------
Gulf Coast	5,346	826	------	------	23	------	------	------	------
California and Oregon	2,804	371	------	------	39	32	55	177	119
Puget Sound	727	38	------	------	40	15	7	5	12
Alaska	23,458	49,350	------	------	88	23	213	1,244	360
Philippines	310	16	------	------	------	------	------	------	7
Total	47,856	52,562	98	28	191	71	277	1,430	505

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

The *Lydonia* made Shoran-controlled hydrographic surveys off the New Hampshire and Maine coasts during the summer months and off the coast of South Carolina during the winter months.

The *Cowie* was engaged throughout the year on hydrographic surveys in the James River and Chesapeake Bay areas, many of which were of particular interest to the Corps of Engineers.

The *Faris* made coast pilot investigations along the coast between New York and Norfolk until November 1946, when the vessel was disposed of because of its age and the excessive cost of needed repairs.

The *Gilbert* accomplished hydrographic surveys along the coast of Maine. The vessel was prevented from doing field work during the winter because of the installation of a new engine and delays incident thereto.

The *Hilgard* and *Wainwright* made hydrographic and wire-drag surveys in Boston Harbor and hydrographic surveys in the Chickahominy River, Va. From November 1946 to January 1947 the *Hilgard* was engaged on coast pilot inspection in the Chesapeake Bay area. During the last quarter of the fiscal year both vessels made a current survey in Delaware Bay.

The *Sosbee* was engaged on hydrographic surveys off the coast of Maine until the end of October 1946, when coast pilot investigations were begun in Chesapeake Bay and continued south from Norfolk, Va., via the Intracoastal Waterway, to the vicinity of Myrtle Beach, S. C.

The *Parker*, *Bowen*, and *Stirni* made wire-drag surveys in the lower Chesapeake Bay area and at its entrance to search for, locate, and determine the least depths over numerous wrecks.

The *Hydrographer*, returned from the Navy toward the end of the last fiscal year, was reconverted and began hydrographic surveys in the Gulf of Mexico on November 2, 1946. This vessel also conducted field tests with newly designed electronic position-finding equipment.

On the Pacific coast and in Alaska, the survey vessels *Explorer*, *Surveyor*, *Pioneer*, *Pathfinder*, *Derickson*, *Patton*, *Lester Jones*, *Westdahl*, *Hodgson*, and *Bowie* were engaged on hydrographic, topographic, triangulation, or current surveys.

The *Explorer*, in conjunction with the *Pioneer* and *Surveyor*, made Shoran-controlled hydrographic surveys, and topographic and triangulation surveys in the vicinities of Attu, Aggatu, and Buldir Islands, in the western Aleutians, with work progressing in an eastwardly direction. During the winter months the *Explorer* was engaged on hydrography and triangulation in the vicinity of the San Juan Islands, Wash.

The *Pioneer*, the former *Mobjack*, was transferred from the Navy Department in August 1946, and sailed for Alaska in April 1947, after conversion for survey duty.

The *Surveyor*, in addition to assisting the *Explorer* in the Aleutians, later began hydrographic surveys along the south side of the Alaska Peninsula, between Shelikof Strait and Cold Bay. During the winter the *Surveyor* was engaged on hydrography and triangulation in Hood Canal, Wash.

The *Pathfinder*, after conversion for survey duty, was recommissioned on August 23, 1946, and assigned to hydrographic and topographic surveys in the vicinity of Naknek, Bristol Bay, Alaska. During the winter months hydrography was accomplished in the vicinity of the San Juan Islands, Wash.

The *Derickson* made hydrographic and triangulation surveys at Adak Island in the Aleutians, as well as in the northerly part of Prince William Sound, between Valdez and Whittier. During the winter months, the vessel established triangulation control in the San Juan Islands, Wash.

The *Patton* made hydrographic and triangulation surveys in the vicinity of Sitka, Alaska, and assisted the *Explorer* in the development of shoal areas in the approaches to Massacre Bay, Attu Island. During the winter, the *Patton* and *Lester Jones* completed radio-current-meter surveys in Puget Sound, Wash.

The *Lester Jones* was engaged on air photographic inspection along the south side of the Alaska Peninsula, in the vicinity of Stepovak Bay, and furnished water transportation to a geodetic party in Cook Inlet.

The *Westdahl* made hydrographic surveys in the Columbia River until decommissioned in October 1946. The vessel was sold in January 1947.

The *Hodgson*, the former PCS–1450, was transferred from the Navy Department and converted for survey duty, replacing the *Westdahl* on hydrographic surveys of the Columbia River on October 28, 1946. A hydrographic survey was completed for the Navy Department at Cathlamet Bay, Astoria, Oreg.

The *Bowie*, the former PCS–1405, was transferred from the Navy Department in August 1946, and made hydrographic surveys in San Francisco Bay.

At the request of the Navy Department, an Arctic shore party accomplished reconnaissance and control surveys along the Arctic coast, from Point Barrow to Peard Bay.

A shore-based party was engaged on combined operations in Bristol Bay, Alaska, in the vicinity of the Egegik River, which area is of interest to the fishing industry.

A shore party began surveys in Pend Orielle Lake, Idaho, at the request of the Navy Department.

A shore party under the direction of the Supervisor, Southwestern District, completed a scheme of second-order triangulation on San Clemente Island, Calif., and a second-order base measurement at Muroc Air Base to serve as an aircraft speed-trial course.

In the Republic of the Philippines, the Manila office of this Bureau was returned to the jurisdiction of the Coast and Geodetic Survey by Public Law 370—Seventy-ninth Congress. This law authorized the Philippine Rehabilitation Program, which provides for the continuation of the survey work interrupted by the war and for the training of not to exceed 20 Filipinos each year until June 30, 1950. A commissioned officer of the Bureau was appointed Director of Coast Surveys of the Philippine Islands, and three commissioned officers and three civilian employees were assigned to the Manila Office to assist in field operations, revision of obsolete charts, and training. The *Tulip*, a 200-foot steel twin steam-engine vessel, was transferred from the United States Navy to operational control of the Director of Coast Surveys. Funds for carrying out the program, with the exception of the pay of commissioned officers, are being transferred from appropriations made to 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 render 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 expedites the application of field surveys to the finished nautical charts and permits close cooperation between the field engineer and the office cartographer.

PHOTOGRAMMETRIC SURVEYS

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

All topographic surveys based on aerial photographs are considered photogrammetric surveys. These surveys may generally be subdivided into the following phases of work: The taking of the aerial photographs, the laboratory processing of the photographs, field inspection of the photographs and the necessary supplemental ground surveys, office compilation, and the office review and drafting.

As in past years, the United States Coast Guard cooperated with this Bureau in furnishing airplanes and crews for aerial photography. The principal areas photographed were: Bristol Bay, Alaska; Puget Sound, Wash.; Roosevelt Lake, Wash., from Grand Coulee Dam to the Canadian Border; Columbia River from Vancouver to Bonneville and from The Dalles to the Snake River; Willamette River, Oreg., from Portland to Salem; the Gulf Intracoastal Waterway from Houma, La., to Corpus Christi, Tex.; and various scattered sections of the coastline for revising the nautical charts. In addition some 200 airports scattered throughout the United States were photographed for use in making airport surveys.

During the year photogrammetric field surveys were in progress in the following areas: Eastern Maine; Delaware River; the Potomac River along the District of Columbia-Virginia boundary; the Cape Hatteras-Neuse River area in North Carolina; the Florida east coast from Homestead to Wabasso; Portland, Oreg.; the Willamette River, Oreg., from Portland to Salem; Roosevelt Lake, Wash.; and the Alaska Peninsula in the vicinity of Cape Fox.

The photography along the Gulf Intracoastal Waterway, a project begun during the previous fiscal year, included 480 statute miles from Houma, La., to Corpus Christi, Tex., preparatory to field surveys and

photogrammetric compilation to provide the location of aids to navigation and up-to-date topographic details for the new Intracoastal Waterway charts.

The survey of Roosevelt Lake, Wash., is a cooperative project with the Bureau of Reclamation and the Geological Survey. Large-scale photogrammetric surveys of the shore line and adjacent details are being made to provide the basic data for detailed hydrographic surveys and to provide vertical control for contouring by the Geological Survey. The original survey sheets prepared by both agencies will be used by the Bureau of Reclamation for silting studies. Nautical charts of the Lake will be compiled and published by the Coast and Geodetic Survey.

Photogrammetric offices continued in operation at Baltimore, Md., and Tampa, Fla., where topographic and planimetric maps were compiled of coastal areas in eastern Maine; Delaware Bay and Delaware River, New Jersey and Delaware; the coastal area of North Carolina; and the east coast of Florida. The combined field and office party organized in Portland, Oreg., during the previous fiscal year was continued under the direction of the Supervisor, Midwestern District. The compilation of planimetric maps in the vicinity of Portland was completed and compilation was started on new projects of the Willamette River, Oreg., and Roosevelt Lake, Wash.

Work in the Washington Office included compilation of large-scale planimetric maps of the District of Columbia-Virginia boundary line by means of the stereoplanigraph; compilation of topographic maps of the Alaska Peninsula by means of the nine-lens stereoscopic plotting instruments; and compiltaion of new planimetric maps and revision of others by graphic methods for use in nautical chart revision. Revision of 440 statute miles of the Gulf Intracoastal Waterway from Carrabelle, Fla., to Houma, La., was completed for use on the new Intracoastal Waterway charts. Review and drafting of planimetric and topographic maps prior to publication were continued.

Five airport survey parties operated throughout the United States during the fiscal year and 87 fields were surveyed. These surveys are used in the production and maintenance of aeronautical instrument approach and landing charts and obstruction plans. The latter are used by the Civil Aeronautics Administration in administering regulations regarding the allowable pay load of various aircraft.

Seventy-one obstruction plans were published during the year, bringing the total published to date to 88. This is part of a program for the construction of plans for some 550 airports requested by the Civil Aeronautics Administration. Thus far all work has been on new plans. During the next fiscal year, however, resurveys to insure adequate maintenance will be required. This will necessitate an increase in the number of airport survey parties.

With the removal of wartime restrictions on the distribution of aerial photographs, there has been an increasing demand for copies of these by the general public. This has noticeably increased the work load of the air photographic laboratory.

A summary of the photogrammetric mapping of coastal areas for the fiscal year 1947 is given in the tabulation on the following page.

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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 shoreline surveys		Topographic maps			
	Square miles	*Miles*	*Square miles*	*Square miles*	*Square miles*	*Square miles*	*Number*	*Square miles*	*Number*	*Square miles*	*Number*
Alaska:											
Glacier Bay	1,065										
Alaska Peninsula		146	200		500			300	9		
Bristol Bay	3,100	27	300								
California (San Francisco Bay)						60	3				
Delaware, New Jersey, Pennsylvania (Delaware River)		305	440	465		113	4	257	7		
District of Columbia, Virginia (D. C.-Va. boundary)	20	29	21			21	7				
Florida:											
Stuart to Fort Myers to Tampa										840	37
East coast, Florida Bay to Vero Beach		408	457	457				684	19		
Florida, Alabama, Mississippi, Louisiana, Texas (Gulf Intracoastal Waterway)	2,520	272	875			[1] 766	[1] 57				
Maine (Portland to Canadian boundary)		688	404		152	168	21	48	1	325	13
Maryland (Patuxent River)						34	1				
Massachusetts (Cape Cod)										380	17
North Carolina (Cape Hatteras-Neuse River area)		398	250	250							
Oregon (Columbia River and Willamette River)	1,500	132	229			431	60			97	13
Virginia (Rappahannock River to James River)					240			460	8		
Washington:											
Lake Roosevelt	1,450	40	275								
Puget Sound	1,600										
Total	11,255	2,445	3,318	1,172	892	827	96	1,749	44	1,642	80

[1] Project includes revision of existing maps and compilation of data for nautical charts. No new maps to be published. Figures are not included in totals at bottom of this summary.

GEODETIC CONTROL SURVEYS

Geodetic control surveys consist of triangulation to establish horizontal control (latitude and longitude), leveling to determine elevations above mean sea level, astronomic observations, base line measurements, and determinations of the value of gravity, throughout the country.

For accurate surveys for land development projects covering large areas, the earth's curvature must be taken into account. Geodetic surveys serve this purpose and provide a homogeneous network of locations and elevations for use in the planning and construction phases of flood control, irrigation, drainage, water supply, hydroelectric development, navigation, and other large-scale engineering and mapping projects; and in the planning and building of transmission lines, highways, railroads, canals, tunnels, and airports.

To encourage and enable local engineers and surveyors to connect their surveys to the Federal network of control, the present policy of the Bureau provides for triangulation stations spaced at intervals of about 4 miles in agricultural areas and from 2 to 3 miles in metropolitan areas. For elevations, bench marks are located at 1-mile intervals along the lines of leveling which run along highways and are spaced approximately 6 miles apart.

The major activities during the past year have been concerned with the continuation of geodetic control surveys in the Columbia River Basin and the Missouri River Valley. These surveys, requested by the Corps of Engineers and the Bureau of Reclamation, will permit the coordination of the maps and the many local detailed engineering surveys and plans needed in studies for the development of multiple water uses and for other natural resources of these regions.

The Missouri Valley project has as its primary objective the control of floods by the building of dams at various points along the rivers, impounding the waters in reservoirs, and regulating the flow in the lower reaches of the rivers. The impounded waters will in some instances be used for irrigation purposes to reclaim vast areas of submarginal farm lands. The areas being surveyed, under a priority schedule established by the Corps of Engineers, are along the main stem of the Missouri River from Kansas City upstream and on various tributaries, such as the Gasconade, Blue, Osage, and Niobrara Rivers. In connection with this project, triangulation was also accomplished in Nebraska, in an area northwest of North Platte, for mapping control for the Geological Survey.

Other control surveys made at the request of the Bureau of Reclamation were: Triangulation along the Rio Grande from Brownsville to Rio Grande City, Tex., for the Valley Gravity Reclamation project; triangulation in Arizona in connection with the investigation of diversion routes for the Colorado River for the central Arizona project; triangulation along the Green River southeast of Salt Lake City, Utah, for the central Utah project; leveling along two lines on each side of the San Joaquin Valley from Bakersfield to Red Bluff, Calif., with several cross lines. There is evidence of subsidence in the valley, and periodic leveling is planned to determine the extent and characteristics.

Additional surveys requested by the Corps of Engineers included triangulation and leveling in the Trinity Valley of Texas for the development of the Trinity River Watershed, and for the canalization of the river channel to provide barge transportation from the Gulf of Mexico to Dallas and Fort Worth.

As an adjunct of the Trinity River project and at the request of local officials, detailed control was provided in Dallas and Johnson Counties for planning purposes.

An extensive program of leveling was also initiated in Alabama for areas along the Black Warrior and Tombigbee Rivers where the Corps of Engineers have a number of river-improvement projects.

Geodetic control surveys for mapping by the Geological Survey included triangulation and leveling in Indiana, and triangulation in Mississippi, between Jackson and McCombs, where recent oil discoveries have enhanced property values. The survey monuments established will be of value not only for the mapping project but also for use of local engineers and surveyors in coordinating their individual surveys for boundary and property demarcation.

Miscellaneous control surveys accomplished during the year at the request of various Federal agencies include the following: Leveling to establish elevations of water gages along the Kentucky Reservoir in Tennessee and Kentucky for the Tennessee Valley Authority; triangulation in the Tonto National Forest, Ariz., and triangulation and leveling in the Mount Hood National Forest, Oreg., for the Forest Service; and gravity observations on several of the Hawaiian Islands, the Palau Islands, Admiralty Islands, and the Solomon Islands for the War Department. Cooperative projects accomplished provided control in the vicinity of El Paso, Tex., and Salton Sea, Calif., for the Army, and near Camp Davis, N. C., for the Navy.

There was increasing evidence during the year of the growing interest in more detailed urban control surveys to provide a permanent base for the tie-in and coordination of local surveys. In the East Bay region of San Francisco, 11 county, municipal, and utility organizations requested a detailed scheme of triangulation and base measurement over the area to correct chaotic local survey conditions and to coordinate them for planning and construction. This was a cooperative project for which the Bureau furnished the supervision, the instrumental equipment, the portable steel triangulation towers, and accomplished the mathematical treatment of the results. The local agencies provided the greater number of employees and paid the costs of the field operations. A similar cooperative project, including leveling, was under way to accomplish urban control for Cincinnati, Ohio, at the request of the City Engineer's Department.

A cooperative leveling project was completed for San Antonio, Tex. Precise elevations were established for about 60 bench marks, placed systematically throughout the city and marked with concrete markers set to a depth of 30 feet. The new leveling revised the elevations of old marks, provided additional data to study vertical movements of bench marks, and placed various local detached level surveys on a common datum.

At the request of the Highway Department of Nevada, the State Planning Board, and various municipal and local engineers, detailed

triangulation and base measurements were made for the cities of Reno, Sparks, Winnemucca, and Las Vegas. Triangulation was also provided in northeastern Nevada along the Utah and Idaho boundary lines and in the Minidoka National Forest.

A triangulation survey northwestward of Aberdeen, Md., to the vicinity of Delta, Pa., was completed during the year at the request of local officials and engineers.

In California detailed triangulation was completed between Santa Cruz and San Francisco Bay. A comparison of the recent work with observations made a number of years ago will determine whether land movements have occurred in this area during the past 65 years. Triangulation, traverse, and leveling were also accomplished at the earthquake fault line near Palmdale, Calif. It is proposed to repeat this work periodically to determine whether earth movements can be detected before a disastrous earthquake occurs.

Astronomic observations for latitude, longitude, and azimuth were made in Idaho, Oregon, North Dakota, Nebraska, Missouri, and Indiana. for use in the adjustment of the triangulation.

The variation of latitude observatories at Ukiah, Calif., and Gaithersburg, Md., continued in operation throughout the year. These are two of five observatories located on the same parallel of latitude (39°08′N.) and operated on an international basis, the other three being in Italy, Japan, and the Soviet Union. Each observatory makes observations on the same groups of stars. During the year 1,560 star pairs were observed at Gaithersburg and 1,431 at Ukiah.

A triangulation and base measurement party operated in southwestern Alaska to provide an arc from Portage Bay, Alaskan Peninsula, to Egegik on Bristol Bay, thence eastward straddling Iliamna Lake and connecting to established marks at Kamishak Bay, Cook Inlet. This will provide control for photogrammetric and hydrographic surveys for the charting of Bristol Bay.

Through the leadership of Bradford Washburn, director of the New England Museum of Natural History, a cooperative mapping project of the Mount McKinley Range was carried out. Aerial photographs were taken by the Army Air Forces and directions were observed by Mr. Washburn to supplement observations made by the Coast and Geodetic Survey. Elevations of the highest peaks have been determined. The information will furnish control for the mapping of Mount McKinley National Park.

Control surveys to mark the Virginia-District of Columbia boundary line were made. Monuments were established at approximately 1-mile intervals and connections in distance and direction made to the high water line, which marks the boundary. The demarcation of the boundary line is specifically assigned to the Coast and Geodetic Survey by act of Congress.

During the year levels were run to 86 airports, making a total of 712 airports at which sea-level elevations have been determined and connected to the Federal network of levels.

The field activities during the year are summarized in the table on next page.

Area triangulation—first- and second-order

Locality	Number of stations	Length of scheme	Area
		Miles	*Square miles*
Henrys Fork, Snake River, Idaho	100	115	4,090
Southern Indiana	314	320	3,645
Stanley to Devils Lake and Portal to Halliday, N. Dak	210	195	2,260
Willamette River, Newberg to Oregon City, Oreg	49	35	165
Salmon River, Idaho	28	90	1,470
Portage Bay to Bristol Bay to Cook Inlet, Alaska	102	340	7,060
Fort Bliss Base Net, N. Mex	12	10	50
Idaho Falls, Idaho to Dubois, Wyo	82	210	6,280
Vernal to Provo, Utah	30	90	2,000
John Day River, Oreg	164	235	3,660
Wind River, Wash	20	30	345
Lebanon to Rolla, Mo	97	110	1,100
Rio Grande Valley, Tex	53	125	1,390
Northwestern Nebraska	121	375	8,950
Northeastern Indiana	176	205	2,100
Vicinity of Winnemucca, Nev	9	15	55
District of Columbia—Virginia boundary	28	10	10
Salton Sea, Calif	9	10	35
Cowlitz and Klickitat Rivers, Wash	62	125	2,000
Salinas Valley, Calif	10	40	420
Trinity River, Tex	191	105	2,545
Tonto National Forest, Ariz	75	215	5,895
Vicinity of Sparks and Reno, Nev	30	25	675
Fort Worth to Dallas, Tex	164	90	1,185
Southwestern Mississippi	97	165	1,890
Vicinity of Camp Davis, N. C	16	25	65
Santa Clara Valley, Calif	67	195	2,215
East Bay Cities, Calif	97	130	1,365
Vicinity of Marble Canyon, Ariz	20	15	95
Vicinity of Las Vegas, Nev	29	25	250
Montello, Nevada to Twin Falls, Idaho	23	105	2,370
Phoenix to Parker, Ariz	39	50	1,345
Maupin to Oregon City, Oreg	33	85	1,875
Vicinity of Broad Pass, Alaska	5	30	1,110
Gasconade and Osage Rivers, Mo	109	90	1,850
Big Blue and Nemaha Rivers, Kans	101	60	3,035
Conowingo, Md. to Holtwood, Pa	23	25	480
Vicinity of Cincinnati, Ohio	13	20	335
Total	2,808	4,140	76,665

First-order base-line measurement

Locality	Length of scheme	Locality	Length of scheme
	Miles		*Miles*
Egegik, Alaska	4.3	Gordon, Nebr	6.8
Iliamna, Alaska	4.0	Humboldt, Nev	2.0
Naknek, Alaska	2.1	Las Vegas, Nev	3.1
Beehive, Ariz	1.5	Reno, Nev	2.4
Lee, Ariz	.2	Fort Bliss, N. Mex	5.2
Phoenix, Ariz	4.2	Camp Davis, N. C	1.9
Livermore, Calif	3.8	Balta, N. Dak	6.1
Berkeley, Calif	2.4	Prairie City, Oreg	5.2
Muroc (extension), Calif	.6	Euless, Tex	5.0
San Leandro, Calif	2.4	Garland, Tex	5.3
Vega, Calif	2.2	Kerens, Tex	5.5
Menan, Idaho	1.0	Teton, Wyo	4.7
Fort Wayne, Ind	4.8		
Jasper, Ind	2.5	Total	93.1
Dixon, Mo	3.9		

Traverse measurement

Locality	Number of stations	Length of scheme
FIRST-ORDER TRAVERSE		*Miles*
Earthquake Area, Palmdale, Calif.		9
Alameda, Calif.	120	30
Total	120	39
SECOND-ORDER TRAVERSE		
Treasure Island, Calif.	11	3
Gaithersburg, Md.	2	1
Total	13	4

Reconnaissance

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

Locality	Length of scheme	Area
	Miles	*Square miles*
Flaxton to Halliday, N. Dak.	100	1,000
Portage Bay to Bristol Bay to Cook Inlet, Alaska	220	4,300
Northwestern Nebraska	210	5,235
Wind River, Wash.	30	345
Northern Indiana	615	7,985
Upper Cowlitz River, Wash.	85	1,365
Gros Ventre and Buffalo Rivers, Wyo.	100	2,150
Big Blue and Nemaha Rivers, Nebr. and Kans.	410	7,240
Salmon River, Stanley to Salmon, Idaho	95	1,435
Vicinity of Winnemucca, Nev.	15	55
Reno-Sparks area, Nev.	10	45
Lemhi River Valley, Idaho	50	650
Mount Hood National Forest, Oreg.	110	1,870
Vicinity of Conowingo, Md., and Holtwood, Pa.	30	505
Vernal to Provo, Utah	150	4,160
Osage River and Pottawattomie Creek, Kans.	245	3,870
Osage River, Mo.	290	4,625
Western Arizona	550	12,305
Rio Grande Valley, Tex.	125	1,300
Carson City to Fallon, Nev.	100	1,240
Central Indiana	300	5,270
Reno to Carson City, Nev.	50	1,365
Vicinity of Las Vegas, Nev.	25	250
Athens to Kaufman, Tex.	35	390
Corsicana area, Tex.	40	720
Hillsboro to Forth Worth, Tex.	50	865
Marble Canyon, Ariz.	15	95
Tombigbee River, Miss. and Ala.	570	8,200
Pasco to Wenatchee, Wash.	375	6,270
Black Warrior River, Ala.	130	2,560
Missouri River, Kansas City, Mo., to Sioux City, Iowa	455	4,700
Saltillo Base Net, Nebr.	10	50
Annapolis to Kent Island, Md.	7	35
Northeastern California	105	7,140
Bristol Bay, Alaska	50	1,000
Vicinity of Camp Davis, N. C.	25	65
East Bay Cities, Calif.	130	1,365
Vicinity of Cincinnati, Ohio	50	600
Total	6,052	102,800

Leveling

State	First-order	Second-order	State	First-order	Second-order
	Miles	*Miles*		*Miles*	*Miles*
Alabama	79	851	North Carolina	7	24
California	1,416	60	North Dakota	53	390
Idaho	83	22	Ohio		212
Illinois	115	2	Oregon	6	459
Indiana	256	3,035	South Dakota	4	146
Iowa	3		Tennessee	218	11
Kansas		79	Texas	397	1,397
Kentucky	146	1	Washington	103	264
Missouri	292	311	Wyoming		116
Montana	129				
Nebraska	187	219	Total	3,494	7,599

Astronomy

State	Determinations			State	Determinations		
	Latitude	Longitude	Azimuth		Latitude	Longitude	Azimuth
Idaho	3	3	2	Oregon	2	2	1
Indiana	1	1		Texas	0	0	1
Missouri	1	1	1				
Nebraska	1	1	1	Total	10	10	9
North Dakota	2	2	3				

Gravity

Location	Determinations
Hawaiian Islands	2
Palau Islands	1
Solomon Islands	1
Admiralty Islands	1
Total	5

Summary of geodetic work, June 30, 1947

Work	July 1, 1946, to June 30, 1947	Total to June 30, 1947
	Miles	*Miles*
Triangulation, first- and second-order, length of arc	4,140	103,710
Leveling	11,093	349,109
	Number	*Number*
First-order base lines	27	306
Second-order base lines	0	56
Latitude stations	10	1,002
Longitude stations	10	804
Azimuth stations	9	1,290

In the Washington Office and in the computing office in New York City, work was continued on the processing of the geodetic field surveys and in preparing the results for dissemination to Government agencies and the general public. Computations and adjustments were completed for 92 triangulation projects, involving 6,625 stations for which geographic positions (latitudes and longitudes) were determined. A new method of adjusting area and complex schemes of triangulation was introduced during the year, which makes use of the variation of coordinates principle instead of the more complicated method of condition equations. Further improvements in this method are anticipated.

Preliminary computations were made for 4,589 miles of leveling, and 17 level nets were adjusted. One of these, in the Pacific Northwest, will serve to place on a consistent basis all elevations in Oregon, Washington, most of Idaho, and parts of California, Nevada, Utah, and Wyoming, as well as in Canada. Another noteworthy accomplishment was the adjustment of the network of leveling (475 miles) in the vicinity of Los Angeles and Long Beach, Calif.

Maps for each State on an approximate scale of 1:600,000 were issued during the year on which the triangulation schemes are indicated. Similar State maps are issued showing the level lines. The distribution of these maps has resulted in increased requests from the public for geodetic survey data. These include requests for descriptions of triangulation stations and bench marks, and lists of geographic positions, plane coordinates, and elevations. During the year there were lithoprinted 2,772 pages of descriptions of triangulation stations, 1,116 pages of descriptions of bench marks, and 4,392 pages of geographic positions and plane coordinates.

Legislation authorizing the use of the State Plane Coordinate Systems for property descriptions was adopted by the following States during the year: Maine, Tennessee, South Dakota, and California. This brings the total number of States with such legislation to 24. Surveys of property so described are connected to the Federal network of control, and are preserved for future recovery.

A set of tables was prepared for the computation of plane coordinates in the Republic of the Philippines using a transverse Mercator projection. The zones for the systems were determined after consultation with the Board of Surveys and Maps of the Philippine Islands.

The Bureau has cooperated with the 311th Reconnaissance Wing, United States Army Air Forces, in investigating and recommending computation procedures for Shoran triangulation, and has kept abreast of investigations of other electronic means of distance and angle determination. These systems are not yet adapted for field geodetic survey use, but it is essential to have all available information on these new methods. Investigations as to accuracy, practicability, economy, and efficiency of operation compared with conventional methods will be made as electronic methods develop.

TIDE AND CURRENT SURVEYS

The Coast and Geodetic Survey is charged with the function of obtaining and publishing tidal data. Observations and investigations of tides and currents are carried on to provide basic data for the surveying activities of the Bureau as well as to supply essential information for safeguarding maritime commerce and aiding the industrial development of coastal property. Soundings taken during hydrograhpic surveys must be corrected for the height of the tide, so that the nautical chart will show all depths referred to a uniform datum. Similarly, the datum of mean sea level must be determined from tide observations at various points along our coasts for the control of the network of leveling extending over the country. The results derived from long series of tide observations also furnish the only quantitative data for determining the slow change taking place in the relation of land to sea, that is, whether any given coastal region is rising or sinking relative to the sea.

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 published by the Bureau. Although designed primarily as an aid to navigation, tide and current predictions now have wide application to practically every activity associated with coastal waters. There is an increasing demand for this information for such diverse purposes as the launching of ships, schedules for arriving and sailing, harbor construction work, yachting, and fishing. In the industrial development of coastal property, these data are used for the location and design of piers, bridges, and factories; for the determination of boundaries of water-front property; for offshore oil production projects; and for the solution of problems of sewage disposal and water pollution.

Aside from the published tables, which are sold at the major ports through sales agencies and field offices of the Bureau, the information is disseminated through newspapers, radio stations, and publishers of almanacs and calendars.

A related field of work is that of investigation of the temperature and density of sea water along our coasts and in our harbors, the results of which are also available in the form of publications. This information is required by the shipping industry, industrial plants using sea water, the fishing industry, and for various scientific purposes, such as determining the strength of a radio signal after it passes over a body of water.

To obtain the data for tide and current information, the Bureau had in operation, during the year, 40 primary and secondary tide stations on the Atlantic and Gulf coasts; 31 stations on the Pacific coast, in Alaska, and in the Hawaiian Islands; 9 stations in foreign countries; and, under the State Department program of cooperation with the American Republics, 11 stations in Central and South America. Fifty-four of these stations were maintained in cooperation with other agencies, including the Governments in Central and South America,

the various units of the Army, Navy, and Coast Guard, and municipal and research organizations. Nine new stations were established and four stations were discontinued.

Observations of the temperature and density of sea water were obtained at 67 of the tide stations and at 3 stations established for observing temperatures and densities only. Of these stations, 8 were in operation in Alaska, 8 in the Pacific Islands, and 6 in Central and South America.

Tidal bench-mark recovery operations were carried on along the Pacific coast, in Alaska, and in the South Atlantic States.

A project was initiated in cooperation with the Corps of Engineers for establishment of tide stations in the western Pacific area. Standard tide gages have been established on several islands, and a detailed program for extending systematic tide observations has been worked out. Apart from providing much-needed original tidal data for the prediction of tides in this area, the project will be a major contribution to the development of tidal knowledge in the entire Pacific. The data will also be of material help in the study of seismic sea waves.

Data accumulated from current surveys extending over a number of years by parties basing at Seattle during the winter season were incorporated in a new publication, Tidal Current Charts, Puget Sound (northern part), which presents a comprehensive view of the complex tidal current movement in that area. Work preliminary to the preparation of similar charts for the southern part of the Sound is now in progress. A tidal current survey of Delaware Bay and River was in progress at the end of the fiscal year. Through a cooperative arrangement with the United States Coast Guard, continuous hourly observations of the current to cover a period of a year or more were inaugurated at Overfalls and Five Fathom Bank Lightships in the vicinity of Delaware Bay.

The preparation of special tide and current reports for particular areas for the use of the Joint Army-Navy Intelligence Service was continued at the request of the Hydrographic Office, and three reports were completed during the year. A seismic sea-wave warning system has been devised and will be installed as soon as the necessary equipment is obtained. A local seismic sea-wave warning device has been built and will be placed in operation at Honolulu in the near future. Special sheets of predicted tide curves for Bikini Atoll for the months of September and October, 1946, were prepared for the after-effect studies of Operation "Crossroads."

Arrangements for the exchange of tidal information between the Bureau and England, Canada, India, Argentina, France, and the Netherlands were in effect during the year. Daily tide predictions, together with a roll of predicted tide curves for Bangkok Bar for the year 1948, were supplied to Siam. A compilation of the tidal harmonic constants for 214 stations derived from analyses made by the Bureau since 1938 was furnished to the International Hydrographic Bureau at Monaco for its archives, and for distribution to the hydrographic offices of the various member states.

GEOMAGNETIC SURVEYS

The geomagnetic work of the Bureau was begun in 1843 as one of the essential steps in the preparation of nautical charts. As long as the navigator steers his vessel by the magnetic compass, he must have data on the amount the compass needle deviates from true north at any given locality. Both the nautical and aeronautical charts of the Bureau provide this information. The Survey is able to furnish such information as a result of its continuing magnetic survey of the United States and the regions under its jurisdiction.

Magnetic surveys are important to land surveyors in retracing property lines surveyed many years earlier with the magnetic compass, and frequent use is made of our data on the secular change of magnetic declination. In addition, the space and time variations of the magnetic field are important to geophysical prospectors who use magnetic methods in their search for oil-bearing structures and other mineral wealth. Knowledge of transient changes in the magnetic field is useful to activities dependent on radio communications and radio aids to navigation; and all the aspects of geomagnetic science are significant in various types of basic research.

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 24° east to 22° west of true north, or a total range of 46° between the northwestern and northeastern corners of the Nation. Because of the constantly changing direction and strength of the earth's magnetic forces, observations are necessary at periodic intervals. The present program of the Bureau calls for the determination of the magnetic elements at about 200 repeat stations at 5-year intervals in order to determine the annual change.

During the year, continuous photographic records of the principal magnetic elements were obtained at the magnetic observatories at Cheltenham, Md.; San Juan, P. R.; Sitka, Alaska; and Tucson, Ariz. At Honolulu, T. H., the recording was continuous except for a short period in March when the magnetograph was transferred to a site a few miles distant on account of excessive vibration transmitted from low-flying aircraft at the old site.

A departure from past practice has been inaugurated at the magnetic observatories that will afford more nearly up-to-date information at all times. Mean values are no longer scaled for each hour but only the values for the twenty-fourth hour of each day are scaled. Approximate monthly and annual mean values are derived from the abridged scalings. The first number of a new and trial form of report (MG–report) was issued, for the Cheltenham Observatory. It contains quarter-size reproductions of the magnetograms, together with approximate monthly and annual mean values derived from

abridged scalings. This report presents the results in their entirety, thus providing information not previously published, although lacking a great mass of numerical evaluation formerly furnished. If this form of report is adopted finally, it will supersede for all Coast and Geodetic Survey observatories the series of biennial volumes heretofore issued containing numerical results.

The automatic declination recording station at Gatlinburg, Tenn., was reactivated in July 1946. Active steps have been taken toward the establishment of two similar stations, one in northern Florida and one at Logan, Utah.

Two regular field parties were in operation during the year, one in central and northern Alaska and one in South America.

Special magnetic projects were undertaken in the Arctic and Antarctic in cooperation with the Navy Department. Magnetic observations were made near the north geomagnetic pole; one station was at Thule, Greenland, and seven were on Devon Island and neighboring islands in Canada. In addition to the observations at Little America IV, advantage was taken of the opportunity to observe at Old Panama (Panama) and at Amberly, Christchurch (New Zealand). Several Navy observers who participated in this expedition received preliminary training by the Coast and Geodetic Survey.

The training of a Canadian observer was begun, for another Arctic magnetic survey, and an observer was trained for, and instruments loaned to, the Finn Ronne Antarctic Expedition.

As in past years, current revisions of data for the use of the compass in navigation were accomplished with respect to several hundred nautical and aeronautical charts issued or revised during the year. Magnetic conditions based on records at the Cheltenham Observatory were reported daily to the National Bureau of Standards in connection with its program of forecasting radio transmission conditions. In addition, magnetic data were furnished other Government agencies. A weekly report on magnetic conditions (Cheltenham K-indices) was instituted in January.

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

A contract has been awarded for the construction of a new magnetic observatory near Fairbanks, Alaska. Because of the possibilities of future air travel over the north polar regions, the obtaining of continuous magnetic observations in this important area will contribute to the safety of such flights.

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

Distribution of magnetic observations

Location	Repeat stations				Other stations	Total
	New		Old			
	Complete [1]	Declination only	Complete [1]	Declination only		
California					1	1
Indiana					1	1
Tennessee				1		1
Vermont					1	1
Virginia					2	2
Washington					2	2
Alaska	7		5		11	23
Canada					7	7
Greenland					1	1
Panama			1			1
Argentina			1			1
Bolivia			3			3
Brazil			7			7
Chile			3			3
Ecuador			1		1	2
Peru			1			1
Uruguay			1			1
Antarctica	1				1	2
New Zealand			1			1
Total	8		24	1	28	61

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

SEISMOLOGY

Seismological investigation in the Coast and Geodetic Survey 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. The Bureau maps earthquake areas and evaluates earthquake risk through the operation of seismographs and the systematic collection of earthquake information; it operates seismographs of a special type to furnish the structural engineer with accurate records of destructive earthquake motions and analyzes the records for practical application to engineering problems; and, finally, it investigates the scientific aspects of earthquakes to obtain a better understanding of the principles underlying their cause, frequency, and distribution. The Bureau's program is directed to the improvement of building codes and the safeguarding of lives and property.

The earthquake program of the Bureau is a highly cooperative one and close contacts are maintained with business, engineering, and scientific agencies which are concerned with this specialized activity in the interest of public safety and scientific research. Voluntary cooperation is obtained from thousands of individuals, many of them meteorological observers, and from State collaborators, who are willing to aid earthquake research by submitting reports on their activities. Current earthquake catalogs are prepared from these reports. Immediate information on strong shocks everywhere in the

world is made possible through the cooperation of Science Service and the Jesuit Seismological Association at St. Louis University.

In recent years there have been increasing demands on the Bureau because of greater interest in seismology on the part of universities which are inaugurating courses in seismology, by scientific and engineering organizations which are becoming increasingly active in various fields of related research, and by National Defense units which find seismology and other branches of geophysics playing an increasingly important part in their programs.

During the year seismographs were operated at four magnetic observatories and at the Ukiah Latitude Observatory. Fifty-two seismographs designed to register destructive motions were maintained in the western part of the United States and seven outside the country. Three tiltmeters measuring the microscopic motions of basement rock were operated on the west coast to detect minute movements which may occur in advance of a major earthquake. Vibration measurements were made during the controlled detonation of large quantities of unserviceable munitions in Idaho.

About 240 earthquakes were accurately located from instrumental data, and about 150 were less accurately located from 1,800 descriptive reports collected in the United States. In one instance a special questionnaire coverage was made. Immediate information on the location and magnitude of 58 earthquakes was made possible through 900 telegraph and radio messages sent by key stations in the Western Hemisphere and Pacific areas. Strong-motion seismographs yielded 46 records registered by 6 moderately strong earthquakes. Two similar records of minor shocks were obtained at South American stations. Seismograms of the destructive earthquake of August 4, 1946, in the Dominican Republic were collected from stations all over the world; these are being analyzed to determine the exact origin of the earthquake and other technical features.

Aid was extended to 22 cooperating stations located at various universities in analyzing their records and publishing results. In most instances valuable information obtained at such stations would be lost without this assistance. Three proposed sites for private seismological stations were tested to determine their suitability for operating highly sensitive seismographs.

The furnishing of technical and statistical information on earthquakes is an important part of the Bureau's activity. Information on earthquake risk in Alaska and our newly acquired Pacific islands was furnished contractors, public utility companies, and the Army and Navy. Data on earthquakes in the United States were furnished insurance and business concerns and other Government departments. In the Puget Sound area, which was shaken badly by two earthquakes in the spring of 1946, the operators of large factories employing many persons were advised on methods of mitigating injury and loss of life during earthquakes.

Seismograph records of several important earthquakes were sent to seismologists in Italy and Russia for special study. Seismographic data, in the form of periodic bulletins, were prepared and sent to stations and organizations throughout the world, and similar publica-

tions were received in exchange. The Survey obtained the cooperation of about 75 foreign and domestic seismologic stations in making a special tabulation of microseismic data to determine their possible connection with world-wide weather conditions. Seismographs were loaned to the Finn Ronne Antarctic Expedition.

The Coast and Geodetic Survey cooperated with the Bureau of Reclamation in maintaining the latter's seismologic projects at Lake Mead, Shasta Dam, and Grand Coulee Dam. The primary objective is to investigate possible seismic activity due to the impounding of great masses of water within limited areas.

Plans were made to test the practicability of broadcasting seismic sea-wave warnings, and a new list of seismic sea waves was compiled.

To advance the engineering-seismological program of the Bureau, an advisory committee of California engineers was organized to advise on ways and means of solving the many technical problems which lie between the recording of seismic data and the successful application of such data to engineering problems.

IMPROVEMENTS IN INSTRUMENTS, EQUIPMENT, AND TECHNIQUES

Because of its highly specialized activities, the Bureau has from its inception recognized the importance of developing new and improved instruments, equipment, and techniques, and of adapting the current findings of science to its own needs in order that better results could be obtained at reduced costs. Frequent requests are received from Federal, State, and municipal agencies, as well as from private enterprise, for technical details on new instruments, methods, and practices. Correspondence with foreign interests, both governmental and private, has increased since the war, and many representatives have visited the Bureau to observe the new processes and acquire data on their performance.

The Bureau services the equipment and instruments used in its work. It maintains radiosonic and photogrammetric laboratories for the development and improvement of instruments and techniques used in these fields. Various wartime developments in instruments and processes were further improved and adapted to Bureau use during the year.

The Shoran electronic equipment was further improved for hydrographic surveying and changes were made in the operating techniques. The Coast and Geodetic Survey electronic position indicator, previously developed and tested, was redesigned and rebuilt. With this equipment it will be possible to determine accurately a ship's position at a distance of 250 or more statute miles from shore, or about 200 miles beyond the limits of Shoran. Laboratory calculations of the probable error in any one distance measurement is approximately 100 feet. This new distance-measuring device will make possible more accurate oceanographic investigations, particularly in the regions beyond the Continental Shelf.

Another hydrographic improvement was a special control developed for use with echo-sounding equipment. This device, which generates a small amount of accurately controlled 60-cycle power (accuracy

better than one second per day), eliminates the necessity of making laborious corrections to soundings for errors caused by off-frequency power supplies.

Other important improvements made during the year in instrumental equipment are the following:

A mathematically accurate parabolic reflector was designed for the 5-inch signal lamp used in triangulation. This furnishes a brilliant beam with approximately parallel rays, which increases the range and efficiency of the lamp and also improves its haze-penetrating ability. A small quantity of these are now undergoing field trial.

A smaller, lighter, and more effective heliotrope has been designed which makes use of square mirrors instead of round ones. An experimental model of a geodetic level provided with a coincidence type of level bubble reader has been partly completed. A new type interferometer for use with the gravity apparatus was designed to simplify the instrument and to prevent damage to the precision mirrors, which have been subject to frequent damage in the past.

Experiments have been conducted to adapt a wartime development in photographic reproduction to the application of graduations on our geodetic level rods. These experiments are promising and if successful will reduce by a very considerable amount the time required to graduate a rod. Another wartime development—a clear glazing compound which is tough, water-resistant, and quite hard—has been used on the rods in place of clear lacquer, and has shown no sign of deterioration or discoloring after exposure to the weather for more than 6 months.

The micrometer microscope for first- and second-order theodolites has been entirely redesigned to provide easier access to the moving parts, to reduce wear, and to provide a positive method for adjusting for focus and "run."

The bearing material for the leg joint of the tripods used on a number of our instruments has always been made of metal and wears out after one or two seasons' use. Experiments conducted in an accelerated wear test indicate that such bearings made of a fabric-base phenolic plastic give about eight times the length of service.

The clock case for the standard tide gage has been redesigned to enclose this unit. This will exclude dust and reduce corrosive action. The framework supporting and enclosing the gage has also been redesigned for better protection and to provide a sturdier gage. The portable tide gage has been modified to permit observing larger ranges of tide.

Several strong-motion accelerographs have been improved by the addition of 12-inch tape recorders and by the use of newly developed torsion suspensions on the accelerometers. A convenient portable photographic recorder for field use is nearing completion. Considerable development work has been completed on a low-cost pen-recording shock recorder for use in seismic regions.

A seismic sea-wave warning system has been devised and will be placed in operation as soon as equipment is received. A local sea-wave warning indicator has also been devised and tested and will be installed at Honolulu in the near future.

A recently developed technique for measuring the magnitudes of earthquakes from instrument records was adopted, and an analyzing machine to process records of destructive earth motions for engineering use was designed.

The making of instruments for geomagnetic work is a highly specialized activity, heretofore confined chiefly to a very few European firms. During the past year, however, domestic firms have contracted to build several variometers for recording magnetic fluctuations, using new designs developed in the Bureau. In addition, two large earth inductors of unique design have been received. Improved three-component tape recorders for use at secondary magnetic observatories are nearing completion. Some progress has also been made on the development of a pen-recording magnetograph for use in the Arctic.

An extra-wide-angle aerial lens covering a field of 120° and a projection lens to produce practically distortion-free prints are being manufactured by the Bureau of Standards. This lens will be useful for photographing airports and for small-scale surveys.

In the field of photolithography a new process for making color proofs from photographic positives, for use in deep-etch reproduction, has been developed. This process is an extension of the technique previously developed of preparing color proofs on plastic directly from negatives.

An improved ground or stain was developed for negative engraving which provides a better engraving surface and gives more consistent results.

A change in design of the compass roses used on charts presented the problem of replacing thousands of existing compasses on wet-plate negatives with the new style. A compass negative has been developed which permits mechanical adjustment to any desired magnetic variation. With this process only a relatively few negatives will be required.

The Bureau has continued to cooperate with various Government agencies and private organizations during the year, in furnishing information on our methods and techniques and in assisting in procuring such equipment as they needed. Four precise levels were inspected for the Army at the manufacturer's plant. Considerable interest has been shown in our tidal equipment. Instruments were loaned to the Finn Ronne Antarctic Expedition and to the Bradford Washburn Expedition to Mount McKinley, Alaska. Tests of the buoyancy, offset, and drift of various designs of temporary marker buoys used in minesweeping operations were made by two Survey vessels at the request of the Naval Bureau of Ships.

COOPERATION WITH AMERICAN REPUBLICS

During the past 7 years the Coast and Geodetic Survey has participated in the "Cooperation with the American Republics" program sponsored and financed by the Department of State. Two major activities or programs are included in the over-all program—the "Scientific and Technical" and the "Exchange of Persons." The first is a consultation program. Under it, Bureau experts in tidal surveys, geomagnetism, seismology, geodesy, hydrography, and map and chart production visit corresponding agencies in those countries which have

adopted our methods and procedures, or to those which are planning extensive surveying and mapping operations and are concerned with standardizing operations throughout the American Hemisphere. The second is an in-service training activity and consists of selecting qualified technicians and engineers from various Latin American countries and awarding them training grants or fellowships in the fields in which they are interested.

The cooperation program has produced important benefits to the United States as well as to the other American Republics. The consultations with the surveying and mapping agencies of the American Republics have continued to establish and maintain friendly relations with military, naval, and civil departments. In addition to creating good will, valuable scientific data were obtained for mapping, charting, earth movements, and horizontal and vertical control. The in-service training program provides an effective medium for the interchange of surveying and mapping developments and the wider adoption of our methods and equipment. The purchase of United States equipment and materials through special missions and the individual trainees has continued at an increased rate.

Under the consultation program, cooperative tide stations were operated at the following 11 ports in Central and South America during the year: Habana, Cuba; Tampico, Puerto Mexico, and Progreso, Mexico; Puntarenas, Costa Rica; Talara, Callao, and Matarani, Peru; and Valparaiso, Puerto Montt, and Punta Arenas, Chile. The Coast and Geodetic Survey furnishes and installs the instrumental equipment for these stations while the cooperating countries provide the maintenance. The gage records from each station are analyzed in this Bureau and a copy of the results forwarded to each cooperating agency. The observations are supplying valuable data for the calculation of tide tables, the prediction of tides, the construction of nautical charts, and the determination of various tidal datum planes required in the development of coastal areas and in the study of changes in the relation of land to sea.

Magnetic observations were made in Ecuador, Bolivia, Peru, Chile, Argentina, Uruguay, and Brazil. These surveys furnish information on the secular change of the magnetic elements and assist in the development of systematic observation practices to determine magnetic variations which affect navigation, radio communication, and related scientific activities.

A Bureau representative visited eight American Republics—Argentina, Brazil, Chile, Colombia, Ecuador, Peru, Uruguay, and Venezuela—as part of the State Department's project to develop closer cooperation between seismologists of the Western Hemisphere. A geophysicist was also sent to Guatemala and Costa Rica to install equipment for recording destructive earthquake motions.

An officer who had been assigned as a geodetic expert to four of the American Republics in the preceding fiscal year continued operations in Brazil for 5 months, observing, advising, and instructing personnel of geodetic survey organizations.

Another officer was detailed to Colombia, Ecuador, and Peru to follow up on the results of earlier training programs, to furnish technical recommendations to mapping agencies in those countries and to

encourage the adoption of uniform standards and modern methods for the reproduction of maps and charts.

A lighthouse engineer (specially engaged under this program) was assigned to the Dominican Republic, at its request, to make a comprehensive survey of existing aids to navigation. Technical advice was furnished and detailed recommendations were made for new installations and for modernizing old ones. A plan was submitted for an organization to operate and maintain all aids to navigation and for a 5-year plan of operation and construction. These improvements would be of great value to our commerce in the Dominican Republic through aid to the safe navigation of merchant ships in these waters.

Under the in-service training program grants are awarded under three categories: Type A—financed by the United States, type B—financed by the foreign government, and type C—financed jointly. During the year, 27 training grants were awarded as follows: In map and chart production to Bolivia (1), Chile (3), Colombia (1), Cuba (2), Ecuador (3), Mexico (4), and Peru (1); in geodetic surveying to Chile (3), Ecuador (1), El Salvador (2), Mexico (2), Paraguay (1), and Uruguay (1); in hydrographic surveying to Mexico (2). Of these, 19 grants were of type A, 7 of type B, and 1 of type C. In addition, four trainees (from Bolivia, Mexico, Paraguay, and Peru) under the 1946 program continued their training in 1947.

The in-service training period varies from 3 to 8 months, depending upon the field of activity pursued. The emphasis in this program is on practical application of methods and procedures rather than on formal lectures. Trainees in geodetic and hydrographic surveying spend part of their time in the Washington Office learning the office methods of processing field data, but the greater part of their time is spent in the field observing or performing the various activities. Those training in map and chart production receive specialized instruction to meet their particular needs and interests, with a general orientation in the entire field. Many of the trainees work on charts of their countries, utilizing all of the modern techniques of chart construction and reproduction. There appears to be a special need for the development of modern photolithographic reproduction in most of the Latin American countries, but extensive progress has been retarded because of the scarcity of United States equipment and materials available for purchase.

As part of the over-all program of cooperation with the American Republics, four experts from the Bureau in the fields of geodesy, aeronautical charts, photogrammetry, and hydrography, attended the Third Consultation of the Commission on Cartography of the Pan American Institute of Geography and History held in Caracas, Venezuela, in August 1946. This conference was attended by prominent leaders in the surveying and mapping fields from the 21 American Republics.

An indirect cooperative activity has been the encouragement and assistance given by the Bureau to the American Congress on Surveying and Mapping. The type of information contained in the official journal of the Congress appears to fill a need of private and governmental interests in the American Republics. Many of the former

trainees have found in it a means of keeping abreast of the latest developments in equipment, practices, and procedures, particularly of the Federal mapping agencies. Membership in the Congress from the American Republics now numbers approximately 100 with representation from 15 countries.

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.

Joint Research and Development Board.—The chiefs of the Divisions of Photogrammetry, Coastal Surveys, Geodesy, Geomagnetism, and Seismology and the chief of the Section of Seismology are members or deputy members on various panels of the Committee on Geophysical Sciences of the Joint 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 committee 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, represents the United States in several capacities with 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 Geographical Names; Federal Specifications Board; American Standards Association; California Advisory Committee on Engineering Seismology; Federal Inter-Agency River Basin Committee; and Joint Map 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, Institute of Navigation, International Union of Geodesy and Geophysics, Central Bureau of the International Association of Terrestrial Magnetism and Electricity, 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 2,380.

During the year, 1,231 appointments were effected, 1,080 separations occurred, 11 employees were retired, 5 were inducted into the armed forces, and 243 line promotions (including reallocations) and 1,033 within-grade promotions were made. Of the 1,231 appointments made, 115 were employees who returned to duty from military furlough and 701 were veterans who received new appointments, making a total of 816 veterans placed in the Bureau during the year.

Wage board employees of the Bureau were given an adjustment in salary averaging approximately an 8-percent increase in base pay as a result of the Commerce Department Wage Board order of August 30, 1946, and approximately a 9-percent increase as the result of Department order of March 7, 1947. In accordance with the Department's order of April 21, 1947, automatic promotions to and including the maximum rate within a level will be permitted annually to wage board employees with an efficiency rating of good or better.

An officer and a geophysicist were assigned to the Navy Antarctic Expedition to make geomagnetic observations at Little America IV. Another geophysicist was attached to the Navy's Arctic Expedition "Nanook" and made observations near the geomagnetic north pole. Four geophysicists participated in the atomic bomb experiments at Bikini.

Four officers, two mathematicians, and one cartographic engineer were assigned to duty in the Republic of the Philippines under the Philippine Rehabilitation Program, and will continue the surveying

and charting operations inaugurated while the islands were under Army jurisdiction.

A tidal specialist was assigned to the War Department for 3 months during the year to develop a program of systematic tide observations in the wetern Pacific in connection with Army survey projects.

Two officers have been assigned to the Caribbean Defense Command of the War Department as consultants in surveying and mapping for national defense plans in South American countries.

At the request of the Government of the Dominican Republic, three Bureau representatives visited that country after the destructive earthquake of August 4, 1946, to investigate the disturbed area and make recommendations for future seismologic investigations.

One officer was serving as alternate 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.

At the end of the fiscal year all of the 93 officers who had been transferred to the Armed Forces by Executive order during the war had been returned to the Coast and Geodetic Survey with the exception of 3 who were still serving with the Army and Navy. In addition two officers were serving as instructors in surveying, one at the Field Artillery School, Fort Sill, Okla., and one with the Marine Corps at Quantico, Va. 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.

On July 1, 1946, a Budget Unit was created in the Personnel Management Section.

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, 1947. Part-time fixed-fee employees and $1-a-year men have been omitted from this table.

Distribution of personnel by appropriations

Appropriation	Commissioned	Civilian	Total
Washington office:			
Regular appropriations	26	848	874
Working funds		29	29
Philippine Rehabilitation		3	3
Total, Washington office	26	880	906
Field service:			
Regular appropriations	132	1,249	1,381
Working funds		12	12
Philippine Rehabilitation		81	81
Total, field service	132	1,342	1,474
On duty with military forces	5		5
Total	163	2,222	2,385

Collections covering miscellaneous receipts, including nautical and aeronautical charts and related publications, totaled $441,927 as compared with $436.078 during the preceding year.

The following funds, from the sources indicated, were made available to the Bureau during fiscal year 1947:

Available funds

Regular appropriation	$8,814,000
First Deficiency Appropriation Act, 1947	510,700
Second Deficiency Appropriation Act, 1947	290,000
Total appropriations	9,614,700
Reimbursements from other departments to credit of appropriation for:	
Salaries and expenses, departmental	137,672
Salaries and expenses, field	63,421
Total reimbursements	201,093
Working funds received from:	
Bureau of Reclamation (seismological work, Boulder Dam)	10,200
Bureau of Reclamation (seismological work, Coulee Dam)	2,400
Bureau of Reclamation (seismological work, Shasta Dam)	2,400
Navy Department ("Crossroads" program)	2,150
Total working funds	17,150
Transfer from:	
Department of State (Philippine rehabilitation)	218,000
Allotments from:	
Department of State (cooperation with American Republics)	117,004
Department of Commerce (printing and binding)	84,000
Total allotments	201,004
Total funds received	10,251,947

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 and at the Washington Office, as well as at authorized agencies located at strategic places throughout the country. Other publications may be purchased from the Government Printing Office.

In the field of related nautical chart publications, manuscripts for new editions of the Alaska Coast Pilot, Part II, and the Atlantic Coast Pilot, Section C, were sent to the printer during the year. Supplements were published for eight other volumes of the Coast Pilots. These volumes contain a wide variety of information which cannot be conveniently shown on the charts. At the request of the Navy Department, a general supplement to the Pilots, Serial 693, Restricted, Danger, and Anchorage Areas, was published giving general warnings resulting from wartime activities.

New editions of the Nautical Chart Catalog and the Aeronautical Chart Catalog were issued. These have been printed for the first time as separate publications.

Tide and current tables, consisting of four volumes published annually in advance, give information on the rise and fall of the tide and the ebb and flow of the current for numerous ports and waterways along our coasts and in foreign areas. Four special tide and current tables for the western Pacific region were also published, and a new edition of Tidal Current Charts, Long Island Sound and Block Island Sound, was issued. At the end of the year a new edition of Tidal Current Charts, San Francisco Bay, and a new publication, Tidal Current Charts, Puget Sound (Northern Part), were in process of reproduction.

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 Washington, Oregon, California, and Maine. Similar material was nearing completion for Maryland. This information is used by surveyors and engineers in hydrographic operations, coastal construction, and other engineering projects.

A revised 1947 edition of the publication TW–1, Surface Water Temperatures, Atlantic and Gulf Coasts, which furnishes valuable information for shipping and fishing interests and for industrial plants using sea water, was published during the year.

Two special publications relating to tide and current work were reprinted: No. 196, Manual of Tide Observations, and No. 215, Manual of Current Observations.

In the field of seismology, manuscripts for Serial 699, United States Earthquakes, 1945, and for a revised edition of Serial 609, Earthquake History of the United States, Part I, were sent to the printer. The first publication is an annual statistical summary of the year's earthquakes; the second, a catalog of the stronger shocks of historical record through 1946. In addition, three quarterly processed reports were issued during the year. These included the Seismological Bulletin, a register of seismogram interpretations for all regular and cooperating stations of the Bureau; the Abstracts of Earthquake Reports for the Pacific Coast and the Western Mountain Region, containing summaries of earthquake information; and the Progress Report on Strong-Motion Earthquake Work, containing abstracts of important earthquakes, analyses of strong-motion seismograph records, and miscellaneous news items.

A chart of Seismic Sea Wave Travel Times to Honolulu was published, which gives the time required for a sea wave to reach Honolulu from an earthquake epicenter in the Pacific Ocean.

In the field of geomagnetism, Serial 166, Directions for Magnetic Measurements, was reprinted with slight corrections. Processed report MO–24, Magnetic Observatory Results at San Juan, P. R., for 1929–30, was also issued, and a similar report for the Honolulu observatory for 1937–38 is in press. The first number of the new MG reports, entitled "Magnetograms, Cheltenham, Md., January to June 1946," was issued. A similar report for the Sitka, Alaska, observatory was in

press. These reports contain quarter-size reproductions of the magnetograms obtained at the observatories.

In the field of geodesy, manuscripts for Special Publication No. 237, Manual of Geodetic Astronomy—Determination of Latitude, Longitude, and Azimuth, No. 239, Manual of Geodetic Leveling—Field Methods, and No. 238, Air-Line Distances Between Cities in the United States, were forwarded to the printer. The latter publication gives distances between each of 500 cities and will be of considerable use to the air-cargo transportation companies which determine costs on a weight-per-mile basis. Processed publication G–58, containing tables for the computation of geographic positions by calculating machines using the constants of the International Ellipsoid, was being printed at the end of the year. This publication will be particularly useful in the South American countries. Publication G–56, Elevations From Zenith Distances, was also prepared and printed within the Bureau.

Serial 685, Regulations of the Coast and Geodetic Survey, was issued during the year. This governs the operations of the Bureau, both field and office.

In addition to these formal publications, 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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