

WORLD WAR II HISTORY OF THE DEPARTMENT OF COMMERCE

PART 5 US COAST AND GEODETIC SURVEY

UNITED STATES DEPARTMENT OF COMMERCE
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WORLD WAR II HISTORY Of the COAST AND GEODETIC SURVEY

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INTRODUCTION	1
LEGISLATION AND REGULATIONS GOVERNING WAR DUTIES	2
TRANSFERS, RECRUITING, AND TRAINING OF PERSONNEL	3

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INTRODUCTION

The normal work of the Coast and Geodetic Survey, carried on throughout the United States and its possessions, includes (1) surveys of the coastal waters and adjoining land areas; (2) observation, study, and prediction of ocean tides and currents, and of the earth's magnetic elements; (3) geodetic control surveys and related gravity and astronomical observations; (4) production of nautical and aeronautical charts; and (5) seismological observations and investigations.

These activities provide information essential for water and air navigation, for mapping, and for many other strategic purposes, and thus assume vital importance in time of war. Personnel engaged in this work acquire training and experience invaluable in many phases of military activities.

Beginning during the period when preparations were being made for national defense and continuing throughout the war the Coast and Geodetic Survey was called upon to furnish, in increasing volume, a great variety of products and services which were required for virtually all classes of war operations. Activities of the Bureau carried on for these purposes were principally in the following three categories:

1. Transfer of personnel, ships, and equipment to the Army, Navy, and Marine Corps.
2. Utilization of personnel and facilities remaining with the Bureau for surveys and other investigations required for military and naval operations.
3. Expansion in the production of marine and air navigation charts, special charts and maps, and related material, to meet the needs of the Army, Navy, and Merchant Marine.

Over half of the Survey's corps of commissioned officers was transferred by Executive Order to the Army, Navy, and Marine Corps. A great number of civilian employees, both in the field and office, joined the military forces. Six of the Bureau's nine major survey ships were transferred to the Navy, and a large amount of miscellaneous navigational and surveying equipment was provided for use by various branches of the armed forces.

The numerous projects accomplished in the field and office, at the specific requests of the armed forces and other war agencies, involved activities in all branches of the Survey's work. Field operations varied widely in nature and volume, ranging from extensive surveys for charting or mapping strategic areas to vibration measurements for the installation of high-precision machine-tool equipment in war plants. Important office

projects included the preparation of comprehensive information on tides and currents for the planning and execution of naval and amphibious operations in all war theaters, the collection and dissemination of magnetic data for charts and maps of all parts of the world, and the development of geodetic formulas and tables for special use by the armed forces.

One of the most striking effects of the war upon the operations of the Coast and Geodetic Survey was the enormous increase in requirements for nautical and aeronautical charts and related publications, resulting from the rapid expansion of the nation's Navy, Air Forces, and Merchant Marine.

From an annual prewar issue of some 800,000 nautical and aeronautical charts the demand for charts of United States areas rose to a peak of about 13,500,000 copies in each of the fiscal years 1944 and 1945. Production of aeronautical charts of foreign areas, which was not carried on before the war, reached a maximum of nearly 4,000,000 copies in 1945. Special charts of various kinds were produced to the extent of about 6,000,000 copies annually.

An extensive project of major importance was the production of target charts for aerial bombing. During the war over 1,800 different target charts were prepared, chiefly for the Army Air Forces, with a maximum annual production of over 2,000,000 copies in 1944. Included in this group were charts covering such important objectives as the Romanian oil fields at Ploesti, and the atom-bombed cities of Hiroshima and Nagasaki. Target charts portraying simulated radar-scope views were provided for the first B-29 raids on Japan when the industrial area of Yawata was bombed. Target charts were also produced for training bomber crews in the United States.

An idea of the growth in requirements for charts under war conditions is afforded by a comparison of the quantities of chart paper consumed. The sheets of paper used in printing charts of United States areas in 1939, the last normal peacetime year, if stacked in a single pile would have reached a height of 335 feet. A similar stack of paper to meet the demand in 1945 would be 5,990 feet high—over ten times the height of the Washington Monument.

Under normal conditions the work of the Coast and Geodetic Survey is carried on chiefly in the interests of commerce and industry. With the advent of war it is necessary to re-channel all activities in order to concentrate on projects essential for war purposes, and to make adjustments in the volume of work to enable the Bureau to meet the strategic needs for its products and services. This involves no major changes in basic organization or functions. It does, however, require extensive changes in details of operations and the solution of many problems such as replacement of personnel transferred to, or inducted into, the armed services; procurement of additional chart production equipment and space for expanded activities; operation of certain facilities on a multiple-shift basis; and the safeguarding of a considerable amount of highly confidential information.

All activities carried on and procedures followed as described in this report were planned for maximum contribution to the war effort. It is believed that they were effective in achieving the purpose sought and provide a definite and logical pattern indicating the services which a national charting agency is equipped to perform in time of war.

LEGISLATION AND REGULATIONS GOVERNING WAR DUTIES

Provision for the cooperation of the Coast and Geodetic Survey with the armed forces in time of war is made in the Act of May 22, 1917 (33 U.S.C. 855-858). This authorizes the President, whenever in his judgment a sufficient national emergency exists, to transfer to the service and jurisdiction of the War Department, or of the Navy Department, such vessels, equipment, stations, and personnel of the Coast and Geodetic Survey as he may deem to be in the best interests of the country.

This Act also provides that the Secretary of War, the Secretary of the Navy, and the Secretary of Commerce shall jointly prescribe regulations governing the duties to be performed by the Coast and Geodetic Survey in time of war, and for cooperation with the War and Navy Departments in time of peace in preparation for its duties in war.

Shortly after the outbreak of hostilities the Secretary of each of the three departments concerned appointed a representative to assist in formulating the necessary regulations. The resulting regulations (see Appendix I) were approved by the three Secretaries on January 20, 1942. They include a provision for the establishment of an Interdepartmental Board to consider and recommend to the several Secretaries transfers of personnel and equipment to the War and Navy Departments, and the activities to be undertaken by the Coast and Geodetic Survey in connection with the war effort.

This board, composed of one representative of each department, was organized immediately and continued to function throughout the war. Changes in membership were made from time to time as members were transferred from duty in Washington or became unavailable for other reasons. Meetings of the board were held as required to prepare recommendations for consideration by the Secretaries of the three departments, and to draft Executive Orders for carrying out the recommendations.

Prior to the organization of the Interdepartmental Board a few transfers of personnel and ships were affected through conferences and correspondence between the departments concerned.

Early in the war the need became apparent for additional legislation affecting the status of the Bureau's commissioned officers. For this purpose, legislation (33 U.S.C. 854a-1 and 855a) was enacted in December 1942, providing (a) for temporary promotions of transferred officers upon recommendation of the Secretary of the department having jurisdiction; (b) for temporary promotions of officers remaining in the Survey to fill vacancies in ranks and grades resulting from transfers; (c) for temporary commissioning of officers to fill vacancies in the authorized number of commissioned

officers resulting from transfers; and (d) for affording to officers remaining in the Survey, assigned during World War II to projects for the War or Navy Departments in areas determined by the department concerned to be of immediate military hazard, the same rights and privileges as those provided for officers transferred to the armed forces.

This legislation was of great value in maintaining the efficiency of the Coast and Geodetic Survey under war conditions, but did not meet the complete needs of the Bureau. The Bureau was considerably handicapped in its dealings with the armed forces by the fact that its commissioned officers as a group do not have military status in time of war or emergency. Under present law only officers actually transferred to the armed forces have such status.

All commissioned officers of the Survey, without option on their part, are subject by law to transfer to combat duty in the armed forces, or to duty with the Bureau in areas of military hazard. The possibility of assignment to combat service for officers of the Bureau is exactly the same as for officers of the armed forces.

It is believed that, as a matter of justice, legislation should be enacted providing military status in time of war or emergency for all commissioned officers of the Coast and Geodetic Survey.

TRANSFERS, RECRUITING, AND TRAINING OF PERSONNEL

TRANSFER OF COMMISSIONED OFFICERS

During the war, 94 of the 171 commissioned officers of the Coast and Geodetic Survey were transferred to the armed forces—48 to the Army and 46 to the Navy. Of the latter, 17 were assigned to duty with the Marine Corps.

Between January 2, 1942, and January 20, 1944, transfers were affected by a series of 9 Executive Orders which transferred 38 officers, by name, to the Army and 39 to the Navy, and returned 4 officers from the Navy to the Coast and Geodetic Survey. After the latter date, additional transfers of 10 officers to the Army and 7 to the Navy were made under provisions of Executive Order No. 9468 of August 22, 1944, which authorizes transfers upon mutual agreement between the Secretaries of War, Navy, and Commerce; and the return of officers when so directed by the Secretary of War or the Secretary of the Navy. This latter Executive Order was issued in order to establish a simplified procedure for the return of officers to the Coast and Geodetic Survey and for their replacement in the armed forces by other officers of the Bureau.

Officers transferred to the Army served principally in the Air Forces, the Field Artillery, and the Corps of Engineers. In the Air Forces, they were engaged in mapping isolated regions of Africa, Asia, Alaska, and South America, and in the development and application of electronic methods for distance determinations. One officer was placed in charge of the mapping depot of the Army Air Forces at St. Louis, Missouri.

In the Army and Marine Corps artillery forces officers generally served in observation units, some in command of their battalions. Their work included development of methods and instruction of personnel in surveying and map construction as applied to artillery operations, procurement of control and magnetic data in combat areas, location of battery emplacements and of enemy installations, and other similar duties. One officer served throughout the war at the Field Artillery School at Fort Sill, Oklahoma, as head of the survey department. For a part of the war period, two Coast and Geodetic Survey officers were assigned as his assistants.

Most of the officers transferred to the Corps of Engineers were engaged in amphibious landing operations, including development of methods and equipment for navigation, instruction of personnel, and actual participation in landings on enemy shores. Two officers, one with considerable experience in the procurement and use of electronic equipment and the other with special knowledge of ocean tides and currents, were detailed to duty with the Corps of Engineers, without formal transfer, for work of this nature.

The majority of officers transferred to the Navy served on the Coast and Geodetic Survey ships which were transferred and on other naval survey ships, some as commanding officers, and others as executive officers or survey officers. Their duties included the carrying on of surveys in enemy areas under combat for immediate use, establishment of aids and removal of dangers to navigation, piloting, salvage operations, and the layout of anchorages.

Several brief reports from officers transferred to the armed services giving details of duties performed are included in Appendix II. Many reports were received from military commanders relating to the valuable services rendered by commissioned officers of the Coast and Geodetic Survey. A number of these reports are included in Appendix III.

PEACETIME TRAINING OF OFFICERS

Service of Coast and Geodetic Survey officers with the armed forces indicated the desirability of some preliminary training, particularly in administrative duties and in general military procedures. Several officers were assigned to the Field Artillery and participated in maneuvers before the war but there was no opportunity for training with other branches of the Army or with the Navy. Peacetime training of officers in preparation for their duties in time of war is undoubtedly desirable and it is believed that suitable arrangements should be made therefore.

Since the termination of hostilities, several branches of the Army have requested the continued assignment of officers to their services for special duty, such as survey experts and consultants with artillery regiments, instructors in field artillery schools, and in connection with the development of survey optical instruments. Officers on these assignments will be able to render valuable technical assistance to the military and at the

same time receive training in military procedure. Such arrangements should prove mutually beneficial.

TRANSFERS AND INDUCTIONS OF CIVILIAN PERSONNEL

At the beginning of the war, 18 employees of the Coast and Geodetic Survey held reserve commissions in the various branches of the military services. During the war, 1,020 men were drafted, or requested military furlough in order to enlist. Twenty women employees left to join the women's service units.

In many cases these members of the Bureau were able to render highly valuable specialized services by reason of their training in the work of the Survey. At the request of various branches of the Army and Navy, in urgent need of qualified personnel, arrangements were made to provide notification when persons trained in cartography and related lines of work were inducted, so that they could be assigned to their specialties and thus make the maximum contribution to the war effort.

The Chief of the Geomagnetism Section of the Division of Geomagnetism and Seismology was transferred on loan to the Navy Department where he rendered important service throughout the war in the development of magnetic devices and in the design and use of airborne electronic equipment for antisubmarine detection.

A geophysicist from the same Division was assigned to the Magnetic Division of the Navy's Bureau of Ships. During his war service he was personally responsible for the development of a successful technique for detecting and locating hurricanes thousands of miles away. The development included instrumental practices for proper observation of microseisms and the analysis and evaluation of the results. This is among the more significant developments of recent times in the fields of seismology and meteorology.

SELECTIVE SERVICE SYSTEM

Operations of the Coast and Geodetic Survey throughout the war were handicapped by loss of civilian personnel through induction into the armed services. Much of the Bureau's work is highly specialized and is carried on by no other agency in the United States, so that it was impossible in the majority of cases to obtain suitable replacements for experienced employees. This condition was especially serious with respect to crews on the Bureau's survey ships who, in addition to competence in seamanship, must be trained in a considerable variety of surveying operations.

Some relief in personnel conditions was afforded by deferments granted to key employees and by the action of the Bureau of the Budget in assigning Class I priority to the greater part of the Bureau's operations.

It is realized that operation of the selective service system was necessary during the war and that the difficulties encountered by the Coast and Geodetic Survey were shared by many other agencies and are to some extent unavoidable. However, on account

of the essential nature of the Bureau's work for war purposes, and the highly specialized character of its operations, it is believed that selective service legislation should include provisions for the exemption of ship personnel and of certain key employees, rather than leave such determinations to the uncertain action of individual boards throughout the country.

This seems particularly justifiable with respect to crews of vessels. In World War II, as doubtless will be the case in any future wars, the Bureau's ships were engaged in surveys required for military operations. In the majority of cases they operated under the direct orders of naval authorities.

PERSONNEL CASUALTIES

The Bureau was extremely fortunate in that there was no loss of life among commissioned officers who were transferred to the armed services although most of these officers were actively engaged over long periods in combat operations both on land and sea. By an odd chance of fate the only commissioned officers to lose their lives as a result of war activities were serving under jurisdiction of the Survey.

Commander George D. Cowie, in charge of the Bureau's office in Manila, was killed December 24, 1941, during the bombing of that city by the Japanese. Lieutenant Joseph W. Stirni, who was first imprisoned in the Santo Tomas Internment Camp, was killed in the bombing of the vessel in which he was being transferred from the Philippines to Japan as a prisoner of war. Lieutenant (j.g.) Joseph A. Sosbee was killed in an airplane crash in Alaska on July 18, 1943, while engaged in photo-topographic surveys.

Commander Charles Shaw, Commander Carl A. Egner, and Lieutenant George E. Morris were held prisoners by the Japanese in Manila. Lieutenant Morris was later transferred as a war prisoner to Japan. These officers were returned to the United States upon liberation by American forces. Commander Shaw died shortly thereafter.

The following civilian members of the Bureau were either killed in action or died as a result of wounds received:

Henry F. Bain
Robert E. Barger
William Bolsaver
Levin R. Brown
Ray B. Elliot

Calvin Farney
Philip A. McAdam
Lawrence Mater
Ormand E. May
Charles H. Rodgers, Jr.

John Ronsheim

RECRUITING AND TRAINING OF PERSONNEL

To provide the additional staff needed, and to replace employees who joined the armed forces, many changes in personnel were made during the war. Since very few experienced persons were available for employment, considerable effort was made to formulate a program of training and in so arranging duties that a new employee could begin productive work with a minimum amount of training. In most cases new employees were persons not subject to induction. These were women, physically handicapped men, married men with families, and personnel made available through the Civilian Public Service Camps, commonly known as conscientious objectors. The latter were employed on geodetic control surveys in the field.

Women were placed in positions which formerly had been filled almost exclusively by men. In the Washington office they were employed as offset-printing-press helpers, folding-machine operators, binders and finishers, photographers, hand-type compositors, draftsmen, cartographic engineers, lithographers, mathematicians, and computers. In the field they were used as recorders and engineering aids on survey parties and in photogrammetric officers, and as accountants and watchmen on triangulation and leveling parties.

Except in the case of draftsmen, the new employees were given "on the job" training, since the number at any one time was small enough to be absorbed gradually and trained under the direct supervision of an experienced employee.

Because of the large number of topographic draftsmen needed, special measures were required to obtain and train recruits. Persons skilled in other types of drafting, such as statistical and mechanical, and later, those with art and design experience, were hired and assigned to a training unit where they could be trained in a group. This procedure relieved the various supervisors from time-consuming "on the job" training.

Later, when this source of recruitment was exhausted, the Civil Service Commission, with knowledge of the successful results obtained in the Bureau's training unit, established a trainee draftsman examination to meet the needs of all Federal agencies. Since the examination was limited to eligibles within a radius of 50 miles of Washington, personal interviews were possible and a mechanical aptitude device was constructed in the Bureau to test the applicant. This device determines steadiness of hand, the coordination of hand and eye, and depth perception or the ability to see stereoscopically. Its value was demonstrated by the fact that employees who completed the training courses with the highest marks invariably had received the highest ratings in the aptitude test.

Many employees were obtained as a result of the trainee examination. Since most of them had no drafting experience it was necessary to give them about 4 weeks training. Each employee was graded upon completion of the training and in general the grades agreed very favorably with those obtained in the Civil Service examination. Up to the end of the war, about 700 persons, mostly women, had been successfully trained as topographic draftsmen.

The work of map making in the Bureau on which these draftsmen were engaged was organized into what might be called an assembly line; that is, rather than have one person carry along a complete job, the work was subdivided into a number of operations such as projections; selection and evaluation of source material; compilation of culture, drainage, and relief; nomenclature; smooth drafting; assembly; and review.

The employees assigned to the training section were given training in each phase of this work. Upon completion of the course they were assigned duties for which they showed the greatest aptitude.

As an additional item of training, and for incentive purposes and morale building, a series of 20-minute weekly lectures was inaugurated covering each phase of the Bureau's activities. This was supplemented by guest speakers from the Army and Navy who, in telling of the importance of the Bureau's products in actual warfare, brought realization to the employees of the direct contribution they were making to the war effort.

TRANSFER OF SHIPS TO NAVY

During the period from July 1941 to September 1942, six of the Bureau's nine major ships were transferred to the Navy by Executive Orders. The first ships to be transferred were the *Guide*, *Discoverer*, and *Pioneer*. These vessels were naval mine sweepers which had been transferred to the Coast and Geodetic Survey after World War I and were subject to recall if and when needed. These ships were recalled from survey duty in Alaska and transferred to the Navy in the order named on July 24, August 26, and September 17, 1941. To replace them the Navy provided the Survey with three small vessels which were later required for special duty and, after executing surveys required for naval operations in Puget Sound and San Francisco Bay, were returned to the Navy in March 1942.

Two of the Bureau's ships operating on the Atlantic coast, the *Oceanographer* (formerly the J.P. Morgan yacht *Corsair*), and the *Hydrographer*, were transferred to the Navy on April 7 and April 15, 1942, respectively. The last vessel to be transferred was the *Pathfinder*, a modern survey ship which was under construction in Seattle at the beginning of the war. Upon completion, it was transferred to the Navy on September 3, 1942. These three ships were used for surveying and related duties in various combat areas. Brief accounts of their activities during the war are included in Appendix IV.

TRANSFER OF OTHER EQUIPMENT

Throughout the war the Coast and Geodetic Survey assisted the various branches of the armed forces by supplying a large number and variety of navigating and surveying instruments and other equipment. This material was furnished for use in the several war theaters and for experimental work in connection with the development of instrumental equipment, or the adaptation of standard articles, for specific war purposes.

After the attack on Pearl Harbor, all available radio and hydrophonic equipment at the Bureau's magnetic observatory at Honolulu and on the ship *Explorer*, then at that port, was turned over to the Navy to relieve the temporary shortage of such equipment.

FIELD AND OFFICE OPERATIONS

COASTAL SURVEYS

Hydrographic and topographic surveys, accomplished by ships and shore-based units, are the principal sources of data for the compilation and revision of nautical charts. These are supplemented by local control surveys, magnetic surveys, and tide and current surveys. The conduct of these activities for military purposes was begun in the national defense period and continued throughout the war.

From November 1940 to March 1941, comprehensive surveys were made at the request of the Navy Department at the sites of proposed naval bases in the British West Indies. Detailed hydrographic, wire-drag, and topographic surveys were completed at Port of Spain, Trinidad, by the ship *Oceanographer*; at Antigua by the *Lydonia*; at Mayaguana by the *Hydrographer*; and in the Portland Bight area of Jamaica by the *Hydrographer* and *Gilbert*.

Extensive coastal surveys were executed along the coast of Maine. Early in the war the Navy Department requested the compilation of large-scale charts of Casco Bay and approaches in anticipation of the use of that area as an anchorage and base for a part of the Atlantic fleet. Under normal conditions the facilities of the Coast and Geodetic Survey are insufficient to maintain adequate surveys throughout the extensive water areas under jurisdiction of the United States and it is necessary to give priority to commercially important regions. For this reason the surveys of Casco Bay and vicinity were not up to date and it was found that extensive new surveys were required for the production of the charts requested.

The work was undertaken in the spring of 1942 by the *Oceanographer*, and, after transfer of that ship to the Navy, was continued by the *Lydonia* and *Gilbert*, assisted by several smaller vessels and by shore-based units engaged in wire-drag and photo-topographic surveys. The use of modern methods and equipment resulted in the discovery of a startling number of rocks and reefs dangerous to navigation, indicating the urgent need for the work and the desirability of maintaining adequate surveys of all coastal waters as a preparedness measure.

Casco Bay and adjacent waters were used extensively as anchorages for naval vessels, and particularly for ships engaged in convoy duty. The surveys accomplished contributed materially to the safety of these ships.

After completion of the Casco Bay area, surveys were extended to cover the approaches to the important shipbuilding port of Bath and were continued throughout the war in other nearby regions where modern surveys were needed. In addition to affording

information for naval operations, this project provided a large amount of data for the general revision of the charts of this region, which will be of value for peacetime use.

Enemy submarine operations along the Atlantic coast caused hundreds of wrecks, many of which constitute dangers to navigation. Although it was necessary to defer a general program for locating these wrecks until after the war, there were certain areas where immediate examinations were considered essential. Such work was accomplished off Delaware and Chesapeake Bays and along the coast of Florida by the Bureau's wire-drag vessels *Hilgard* and *Wainwright*, and by several navy and Coast Guard ships to which Coast and Geodetic Survey officers were temporarily assigned.

In connection with a project for ferrying seaplanes across the United States, involving the use of inland lakes and reservoirs for emergency landings, the Coast and Geodetic Survey was requested by the Navy Department to make wire-drag surveys of 10 such bodies of water in order to locate subsurface obstructions which might endanger planes when landing or taking off. This project was begun in April 1942 and completed in February 1943. The areas examined were Roosevelt Reservoir in Arizona; Salton Sea, California; Elephant Butte and Red Bluff Reservoirs in New Mexico; Lake Worth, Texas; Cross Lake, Louisiana; Mitchell and Jordan Reservoirs in Alabama; and Lloyd Shoals and Catawba Reservoirs in Georgia.

Just before the outbreak of war the ship *Explorer* had completed hydrographic and topographic surveys at Midway Island in the Pacific and at the time of the attack on Pearl Harbor was en route to take up similar work at Johnston Island. She returned to Honolulu and later led a convoy to San Francisco where she arrived in February 1942. While proceeding to Honolulu the ship rescued the personnel and armament of an American warplane which had been forced to land on the water.

A major contribution to the war effort was the survey of the Aleutian Islands to Attu, and of the Alaska Peninsula. Operations in these regions had been planned as a part of the prewar program of the gradual extension westward of suitable surveys and charts. With the advent of war and the occupation of islands in the Aleutians by the Japanese, these waters became of great strategic importance and surveys were carried on to the maximum possible extent throughout the war.

The ships *Explorer*, *Surveyor*, *Derickson*, *E. Lester Jones*, and *Patton* were engaged in this work. To meet military needs the normal program for extending surveys along a continuous area was abandoned and numerous projects at widely scattered points were executed along the chain of islands.

To insure effective cooperation with the Navy, a Coast and Geodetic Survey liaison officer was assigned to duty on the staff of the Commander, Alaska Sector. The ships operated under general orders from the Washington headquarters of the Survey but were under the immediate direction of the liaison officer who was authorized to issue orders for the execution of projects desired by the naval authorities and to arrange for the prompt dissemination of the results of surveys. This arrangement proved to be very

satisfactory and is recommended for use under any similar conditions which may occur in the future.

Surveys were accomplished at the request of various branches of the Army and Navy at a number of other places in Alaska by the above-mentioned ships between their seasons in the Aleutians, and by the *Westdahl*. Fairly extensive surveys were made in the vicinity of Sitka and in the approaches to Army bases in Cold Bay and in Cook Inlet. Near the end of the war a shore-based unit carried on surveys required by the Navy in the vicinity of Point Barrow. These surveys were necessary for safe navigation in the approaches and anchorages and alongside the docks and for the installation of coastal defense and other equipment.

Among other surveys accomplished for the Army and Navy were the wire dragging of areas for deep submergence tests of submarines, hydrographic surveys of special anchorages for naval use, hydrographic and topographic surveys of military and naval bases at various places along the coasts, surveys of approaches to shipyards, topographic surveys in Puerto Rico, and the establishment of speed-trial courses in connection with ship construction. Data obtained from hydrographic surveys were used for laying submarine nets on all coasts.

Since they were operating to a considerable extent in waters where contact with the enemy was likely, all ships except the smaller vessels were provided with armament furnished and installed by the Navy, and officers and men were trained in gunnery. Fortunately, it was necessary to use this armament only on one occasion when the ship *Explorer*, operating in the vicinity of Attu Island in the Aleutians, repelled an attack by Japanese planes. One advantage of the installation of armament was that it permitted the use of these ships for emergency convoy duty. They were used for this purpose in several instances when other ships were not available, particularly in Alaska.

TIDE AND CURRENT WORK

The Coast and Geodetic Survey is the only agency in the United States engaged comprehensively in the observation, study, and prediction of tides and tidal currents. Tide observations are necessary for the processing of hydrographic surveys, and tables of predicted tides and currents are essential for all navigation in coastal waters. In connection with its tide observations the Bureau established bench marks, the elevations of which are determined with respect to the datum planes of low water, mean sea level, high water, etc. Information concerning the range of tide and the maximum heights to which the tide rises is of great practical value in the construction of piers, docks, marine railways, seawalls, and other waterfront improvements.

The tremendous expansion in ship operation and in waterfront construction occasioned by the war increased very greatly the demand for information regarding tides, currents, tidal datum planes, and related phenomena.

The principal field work involved in the investigation of tides is the operation of automatic gages at numerous points along the coasts where continuous records of the rise and fall of the tides are obtained. Since peacetime needs for tidal data for navigational and other purposes require fairly complete coverage of all coasts, no material change in the volume or character of this work was necessary to meet wartime conditions.

Actual observations of the tidal currents provide data from which the times, strengths, and directions of the currents can be predicted. At the request of the Navy, surveys were made in six areas on the Atlantic coast and three areas on the Pacific coast for use in connection with the launching of vessels, testing torpedoes, and construction of port facilities.

During the period from November 1944 to March 1945, at the request of the Chief of Engineers, U.S. Army, the Chief of the Bureau's Division of Tides and Currents was detailed to the European Theater to study special problems relating to tides and currents. He was able to render material assistance in the procurement of accurate tidal data required to operate military ports in that area.

Under normal conditions the principal office activity in this work is the preparation of annual tables of predicted tides and of predicted currents. As was to be expected, there was a large growth in the demand for these tables during the war. The annual issue of tide tables increased from 25,600 copies in 1940 to 72,000 copies in 1945, while the issue of current tables increased from 11,500 to 48,500 copies. Many thousands of special tide and current tables for various combat areas were also prepared.

Tide tables contain predictions for numerous foreign ports for use by United States ships in foreign waters. These predictions are normally obtained on an exchange basis from the governments concerned. With the outbreak of war such exchange with the Axis nations and countries overrun by them was impossible, making it necessary for the Bureau to compute the predictions formerly furnished by those nations.

Accurate information with regard to the stage of the tide is especially important in connection with landing operations on hostile shores. To supplement the usual tide tables which give only the times and heights of the high and low waters, special predicted tide curves were prepared for combat areas which permitted the height to be determined graphically for any time of the day. They were printed to show a complete month on a sheet. The first ones prepared were for strategic locations in the Philippine Islands, followed by curves for 10 localities chosen for landings in China, Japan, and Island approaches. In all, 160 station-months of these predicted tide curves were prepared.

An especially important and extensive project was the preparation of 68 reports of tide and current conditions for various areas throughout the world. This work was sponsored and funds provided by the Director of Weather, Army Air Forces, and later by the Hydrographic Office of the Navy. It involved the collection and correlation of detailed information from material in the files of the Bureau, from captured enemy

documents, and from various libraries. Translations were made from Japanese, German, French, Russian, Dutch, and other foreign nautical and scientific publications.

As these reports were used for both planning and naval and amphibious operations they required the fullest information available for the different areas, with detail for even obscure beaches. They contained the following information:

1. A brief characterization of the tides and currents in the area, with notation of any unusual features such as swells, seiches, or tidal bores.
2. Table of tidal constants and differences with explanations and examples for using the data. The table listed the names of the places, latitude and longitude, tidal differences to be applied to the reference stations
3. Graphs showing typical tide curves for all types of tide in the area. This permitted ready determination of the height of tide at any time or the change in height during any desired period of time.
4. Daily tide predictions for the reference station or stations best suited for the area. This frequently necessitated predicting for stations which in normal peace times were not of sufficient importance to warrant such special predictions.
5. Tide and Light Diagrams were included in the later reports.
6. Detailed descriptions of tidal and other currents affecting navigation, particularly in passages and near shore.
7. Daily current predictions for important passages were included whenever possible.
8. Index charts showing the location of each place for which tide and current information was given.
9. A bibliography, giving source or authority from which information was obtained.

The reports for the various areas were prepared when requested, frequently meeting very short deadlines. They covered areas in all theaters of the war, from the Aleutian Islands to the East Indies and from Hudson Strait to the coast of Africa and the shores of the Indian Ocean. They varied in length from a few pages to more than a hundred pages. Report No. 48, for Japan, contained 122 typed pages.

The Tide and Light Diagrams which formed a part of the reports were found to be an especially effective form of presenting a large amount of information, both for planning and for operation. Each diagram contained data for a particular place for one month and footnotes extended the coverage to nearby places. They showed graphically the height of each high and low tide, the times of all tides and their relationship to light conditions, day and night. Daylight, three stages of twilight, and darkness were shown as well as periods of dim moonlight and bright moonlight.

Thus, at a glance one could determine at what time during the month high tide would occur near evening twilight when there would be no moon, or when low tide would occur during moonlight nights. Mean temperatures of air and sea were included

together with a monthly wind rose. They were useful not only for operations on land and sea, but also for aerial surveying and bombing missions.

Diagrams for strategic points in France, Belgium, and the Netherlands were constructed, but the largest demand was for areas in the Pacific. Operations in the Marshall and Caroline Islands and at Saipan, Guam, Iwo Jima, and other Pacific islands were prepared for, as well as the landings in Dutch New Guinea and Halmahera. There were special diagrams for the Leyte invasion and for the Luzon landings and many diagrams for other less publicized operations in the Philippines. The Asiatic coast from Korea to Singapore was well covered. A large number of diagrams were prepared for Japan from Hokkaido to Formosa. The Okinawa campaign was covered well in advance and diagrams were available for the proposed Kyushu and Honshu invasions.

In all, there were over 1,150 monthly diagrams for 112 places. More than 100,000 copies were printed in the Bureau's plant and many diagrams were reproduced in military publications.

MAGNETIC INVESTIGATIONS

Investigations to provide information concerning magnetic declination (the angle at which the compass needle points with reference to true north) and other elements of the earth's magnetism are essential for navigation on the sea and in the air, as well as for a number of other military and scientific purposes.

Before and during the war the Coast and Geodetic Survey operated five magnetic observatories, at Cheltenham, Md.; Tucson, Ariz.; Sitka, Alaska; San Juan, P.R.; and Honolulu, T.H. During the war, continuous magnetic records obtained at these observatories were supplemented by field surveys throughout the United States, Alaska, the American Republics, and in the Caribbean area, and the results furnished to the armed forces of the United States and its allies.

Many special field projects were accomplished at various times during the war. These included magnetic investigations at compass testing stations at airports and airplane plants; detailed vertical intensity surveys at sites for use by the Navy in connection with the degaussing of ships; and intensive surveys at seaports and other places for use by the Bureau of Ships and the Ordnance Laboratory of the Navy. The individual projects were not extensive and were financed by the Bureau's regular funds. In the aggregate, however, they required the expenditure of virtually all appropriations provided for magnetic work.

Facilities at the Cheltenham and Tucson observatories were used by the Navy for experimental work on various types of magnetic measuring instruments.

Demands for magnetic information occasioned by the war required a considerable expansion of the office force of the division handling this work, as well as the curtailment of some regular activities. The most extensive office work carried on was the furnishing

of magnetic data for charts and maps, mostly in the form of isogonic lines (lines joining places having the same magnetic declination) for all parts of the world. To derive this information, including estimates of annual change, an intensive study was made of all available records. These included data from the Bureau's observatories and field surveys, records of other governmental agencies and of the Carnegie Institution of Washington, and publications of foreign governments and institutions.

In all, magnetic data were furnished for 93 aeronautical planning charts; 74 isogonic charts; 87 long-range air navigation charts; 1,334 pilotage charts; 1,279 nautical charts; 731 aeronautical approach charts; 69 flight strips; 11 survival-guide charts; 84 instrument approach and landing charts; and 1,066 Army topographic maps.

Isogonic lines for the aeronautical charts of the United States published by the Coast and Geodetic Survey were revised at intervals of 6 months. Information concerning magnetic declination was also furnished in connection with the establishment of radio facilities.

For use in predicting radio transmission conditions, daily information on magnetic disturbance was furnished to the Navy, the British Admiralty, the National Bureau of Standards, and the Carnegie Institution of Washington.

A special force was maintained to study the correlation between meteorology and fluctuations of the earth's magnetism. Results of this study are given in the Journal of Terrestrial Magnetism and Atmospheric Electricity. The project was financed at first by the Army Air Forces and later by the Weather Bureau.

Among other items worthy of mention was the assistance given Pennsylvania State College on studies to determine whether there is a connection between the homing instinct of pigeons and the earth's magnetic field.

GEODETIC CONTROL SURVEYS

Horizontal control determines the geographic positions (latitude, longitude, and azimuth) of monumented stations; vertical control determines the elevations of bench marks with reference to mean sea level. Together the two series of marks furnish a basic framework which is essential for the proper coordination of charting and mapping surveys and for many other engineering and industrial projects. The most extensive work of this nature carried on during the war was the establishment of control for the strategic mapping program.

Another large project, the extension of control surveys in Alaska, was accomplished in compliance with various requests of the War Department. These surveys eventually were extended from Skagway to Fairbanks along the White Pass and Yukon Railroad and the Alaska Military Highway, and thence to Valdez and Anchorage with connecting surveys along the Glen Highway and the Tok Cutoff; also from Fairbanks down the Tanana and Yukon Rivers to Norton Sound, Kotzebue Sound, Nome, Teller,

and Little Diomed Island, and along the Alaska Peninsula from Wide Bay to Chignik. One section of the work between Skagway and Fairbanks extends through Canadian territory from White Horse to Big Delta and was accomplished with the cooperation of the Canadian Government.

In general, these surveys followed the main routes of land and air transportation. They provided accurate locations of the principal military installations, airfields, air beacons, and radio range stations, and established geodetic positions in specific localities where required for other military purposes. Also, they extended into a considerable area of Alaska the basic and uniform control datum existing previously in Mexico, the United States, and Canada. Thus, in addition to meeting current military needs, these surveys provide data of great peacetime value in charting, mapping, and other activities for the future development of the Territory.

In connection with this work astronomic observations were made at various places on the Alaska mainland, in the western Aleutians, and on the Pribilof Islands, to provide locations required by the Navy for operation of the Loran position-finding system.

In order to determine the location of military installations and for other war purposes, control surveys were executed at off lying bases in Puerto Rico, the Virgin Islands, Trinidad in the British West Indies, Newfoundland, and Bermuda.

Numerous minor projects carried on throughout the war included the accurate location of battery emplacements, fire control centers, airplane spotting towers, and similar installations in a large number of defense areas along our coasts; establishment of airplane speed trial courses; determination of distances for testing and calibrating various types of distance finders; location of Loran stations and other Radar installations; establishment of control points for bombing ranges; installation of control systems for ballistic measurements and rocket experiments; and alignment surveys at a naval ship model basin.

For this work the annual appropriations of the Coast and Geodetic Survey were supplemented by substantial amounts transferred to the Bureau by the War Departments.

Besides processing and disseminating the results of control surveys executed for strategic mapping, and of the numerous special projects accomplished for various war purposes, the Bureau supplied a large volume of geodetic data resulting from prewar operations. Early in the war, at the request of the Chief of Engineers, U.S. Army, each of the nine service commands was furnished with copies for distribution of all geodetic data applying to the area under its jurisdiction.

A considerable amount of control data was furnished for purposes nonmilitary in character but essential to the war effort. An example of this is the use of geophysical methods in prospecting for oil. It is estimated that about half of the discoveries of petroleum deposits are now made by such methods, and geodetic control surveys provide

the essential basic data. During the war the Bureau supplied information for this purpose in response to many hundreds of requests from oil companies and oil exploration companies.

As a result of activities in geodetic work during the war some 39,000 adjusted geographic positions and 35,000 adjusted elevations of bench marks were added to the files.

Studies were made of formulas for computing the distance between the two points on the earth specified by latitude and longitude. The Hydrographic Office of the Navy required a formula for Loran work applicable to distances up to several thousand miles and accurate within a few feet. Such a formula was devised as a result of the studies. The Hydrographic Office and other agencies using this formula adapted it to mass computation by means of simple mathematical transformations and special tables.

A formula of greater accuracy applicable for distances up to three or four hundred miles was needed by the Army Air Forces for Shoran work. Several such formulas were devised. A study was also made of the effect of the curvature of the Shoran ray in its path through the atmosphere.

At the request of the 311th Photo Wing, Army Air Forces, a study was made of the factors affecting radio propagation velocity and a formula was derived for the velocity correction, taking into account the effect of temperature, pressure, and humidity. In the derivation of the original Shoran velocity correction formula, several approximations and assumptions were made with a view to simplicity in application. Errors introduced thereby were negligible for air navigation purposes, but when Shoran was adapted to precise distance measurement it was found necessary to revise the formula to attain the required accuracy.

An officer of the British Royal Artillery requested assistance in developing a device for the rapid computation of the sides of a triangle of the type that would be developed by sighting on a target from the ends of a short base line. It was found that a slide rule could be constructed which would solve the problem, using the angles in degrees at the ends of the base line and the length of the base line as known data. The necessary computations were made and scale diagrams were furnished. A few months later, at the request of the U.S. Marine Corps, working drawings were furnished that organization for a similar slide rule using the mil as the angular unit of measurement.

The U.S. Marine Corps, in need of azimuths accurate to 2 to 3 minutes for fire control purposes, requested that a procedure be developed whereby such azimuths could be obtained rapidly in equatorial areas. A method was devised for quickly determining the azimuth of a star to the east or west of the observer by observing the altitude of the star, scaling the latitude of the point of observation, and then referring to tables or graphs which give the azimuth corresponding to the altitude and latitude. Tables and graphs were prepared for 16 stars.

The first tables covered the area from latitude 15 degrees North to latitude 15 degrees South, while a similar set of tables prepared later covered the areas from latitude 10 degrees to 60 degrees North and latitude 10 degrees to 60 degrees South. A large supply of these tables was furnished by the Marine Corps and the Army. The Hydrographic Office reproduced a number of the graphs on Pilot Charts.

These tables and graphs were used in all theaters of war by both Allied and United States forces to determine azimuths used in directing field artillery fire, to establish lines of direction in reconnaissance mapping, and as a rapid check on azimuths of a higher order.

A graph for the determination of the azimuth of Polaris at any hour angle was prepared for areas in the Northern Hemisphere.

Eight special range and bearing grids were computed for the construction of a series of charts for the Naval Research Laboratory, Chesapeake Beach, Md., to be used with Radar and other experimental apparatus. Through the use of these charts movable apparatus can be set up at any point on the laboratory grounds and a fairly accurate range and bearing scaled to the eight fixed positions located near the opposite shore of Chesapeake Bay.

The Bureau collaborated with the office of the Chief of Engineers, U.S. Army, in the preparation of tables for the transformation of geographic coordinates to the military grid. These tables were developed to simplify and expedite the computation of military grid coordinates on the polyconic projection. The tables already available were too cumbersome to use because of the double interpolation involved. Supplemental tables were also prepared for the inverse operation, that is, the transformation of military grid coordinates to geographic coordinates. Through the use of these tables the time required to transform a coordinate is reduced by approximately two thirds.

Special systems of plane coordinates based on the Lambert conformal projection were developed and tables computed for several special survey projects requested by the Chief of Engineers for coastal defense purposes and for control of outlying island bases and other regions. Eight areas on the Atlantic coast were covered, two on the Gulf coast, two on the Pacific coast, four in Alaska, and one each on Puerto Rico, Trinidad Is., St. Croix Is., Bermuda, Newfoundland, and Oahu.

A number of special map projections were computed for use in constructing aeronautical charts for the Army Air Forces. Among these were five Lambert projections, each with a different pair of standard parallels; five gnomonic projections, each centered at different latitude, together with compass roses for various points on each; an oblique Mercator projection of the Western Hemisphere; and an Azimuthal Equidistant projection centered on Tokyo. The last-named projection affords an easy means of scaling accurately the distance and azimuth from the central point of the projection to any other point.

STRATEGIC MAPPING IN THE UNITED STATES

In the fall of 1941 the Chief Engineers, U.S. Army, requested the Coast and Geodetic Survey to participate in an extensive mapping program of the United States for strategic purposes. In this program the Bureau had two functions to perform: first, the execution of geodetic surveys to provide horizontal and vertical control for the entire project; and second, the actual production of topographic maps in certain areas.

Geodetic control surveys were started in northern New York in August 1941 and were continued until May 1944, the last work accomplished being in the Santa Clara and Salinas Valleys, California. They were conducted in the following 22 States: Michigan, Ohio, New York, Vermont, Connecticut, Massachusetts, New Jersey, Pennsylvania, Maryland, West Virginia, Virginia, North Carolina, South Carolina, Georgia, Florida, Mississippi, Alabama, Texas, New Mexico, California, Oregon, and Washington.

In these areas the geographic positions of 5,116 triangulation stations were determined, and the elevations of 40,250 bench marks were measured.

Topographic surveying operations were begun by the Coast and Geodetic Survey in the vicinity of Georgetown, S.C., in January 1942, and continued until June 1944. Other Federal agencies participating in this part of the work were the Forest Service, Soil Conservation Service, Geological Survey, and the Tennessee Valley Authority.

The Coast and Geodetic Survey was assigned areas in Maine, New Hampshire, Pennsylvania, Maryland, Virginia, North Carolina, South Carolina, and Florida, and included the lower reaches of the Potomac River, the entrance to Delaware Bay, and several areas on Chesapeake Bay.

The greater part of the planimetric mapping was done by means of aerial photographs and the contouring was accomplished by planetable except in heavily wooded areas where hand level lines were run. All contours were drawn directly on the aerial photographs which served as planetable sheets.

Before the war, the Coast and Geodetic Survey designed and procured a nine-lens camera for aerial photography. In the early months of the mapping project, an airplane suitable for flying this camera was not available and a single lens camera was used. Progress with this equipment was very slow. In March 1942, the submarine menace became less acute and the Coast Guard found it possible to assign a plane for photography with the nine-lens camera. The rapid progress in photography made thereafter materially expedited the project and clearly demonstrated the value of the nine-lens camera for this class of work.

Small photogrammetric field offices in operation before the war at Baltimore, Md., and Tampa, Fla., were expanded and utilized for map compilation. They also served as headquarters for field parties engaged in identifying control points and other

operations required for the proper interpretation and clarification of the details shown on the aerial photographs, and for verification of the resulting maps.

All topographic mapping was done by the quadrangles, on paper 18 by 22 inches, each covering an area of 7.5 minutes of latitude and 7.5 minutes of longitude. The Coast and Geodetic Survey completed 323 quadrangles. These maps comply with national standard map accuracy requirements so that, in addition to meeting military needs, they contribute materially to the mapping of the United States and have a wide range of civilian uses. In coastal areas they provide valuable data for nautical chart revision. The cost of this work was defrayed by the War Department.

SEISMOLOGICAL INVESTIGATIONS

Seismological investigations are undertaken mainly to obtain information concerning the frequency and severity of earthquakes in various regions and to procure data on the effects of earthquakes for use in designing earthquake resistive structures. For the latter purpose special seismographs designed to record strong earthquake motions are operated in areas where such disturbances may occur. The importance of information of this character for the location and design of hospitals, barracks, and other military structures required the continuation of this work during the war.

Seismographs for recording and locating distant earthquakes are operated at observatories of the Coast and Geodetic Survey at San Juan, P.R.; Tucson, Ariz.; Ukiah, Calif.; Sitka and Fairbanks, Alaska; and Honolulu, T.H. Throughout the war these observatories cooperated with other stations in Australia, New Zealand, and Apia in British Samoa, in advising the Bureau immediately of any strong shocks recorded in order that the military authorities might be informed of any destructive earthquakes occurring in enemy territory.

During the period from September 1943 to June 1945 the occurrence of eight earthquakes, six near Japan, one on New Guinea, and one near Timor Island, was reported to military intelligence. One of these, occurring in December 1945 about 60 miles off the southeast coast of Honshu Island, Japan, was moderately destructive along the coast.

In connection with its seismological work the Coast and Geodetic Survey measures the vibration periods of various types of structures and ground areas. Extensive activities in this field included ground vibration tests for construction purposes at Navy yards, at sites of hospitals, and in the Panama Canal Zone; and investigations of the vibration effects of gunfire, blasting, operation of heavy machinery, and other disturbances on pipelines, foundations and structures, and on machinery used for the manufacture of precision tools at a number of war plants.

In addition to its normal seismological office work the Coast and Geodetic Survey furnished to various agencies detailed information regarding earthquake risks for a large number of points in recognized seismic zones. From field tests and studies of other

records, advice was also given concerning the probable effects of bomb explosions and similar disturbances on various types of structures.

Agencies to which information was furnished included the War and Navy Departments, Panama Canal authorities (effects on locks and dams), American Red Cross, Federal Power Commission, Bureau of Reclamation (effects on large dams), and contracting firms engaged in military construction.

Another important activity was the Bureau's cooperation with the Navy Department and the Weather Bureau in setting up a project and developing techniques for detection and tracking of hurricanes by the immediate analysis of microseismic records produced by special seismographs.

The Survey also assisted in the maintenance of Danish seismological stations in Greenland which were isolated from Europe during the war.

INSTRUMENT WORK

By reason of its long experience, the Coast and Geodetic Survey was able to render substantial assistance to the military services in the design, construction, and use of precision instruments. Early in the war the Bureau's Instrument Division trained a number of enlisted men of the Corps of Engineers, U.S. Army, in the repair and adjustment of surveying instruments, these men serving later as instructors for other Army personnel.

Expert advice was given to various branches of the armed services on the design of a wide variety of instruments. Details of instruments used by the Survey, such as signal lamps, tide gages, slotted templates, etc., were furnished for use in procuring stocks of such items for military use. Tests were conducted on instruments purchased from contractors and on surveying instruments captured from German and Japanese forces. On several occasions the Bureau's instrument shop facilities were made available to members of the Corps of Engineers for emergency work on the construction of instrumental equipment.

A reserve officer of the Division of Geodesy, while on active duty with the Ordnance Department of the Army conceived the idea of a bore sighting instrument for artillery and tank warfare use, for which he was awarded the Legion of Merit. The instrument has saved considerable material and man-hours in the development and inspection for acceptance of ordnance material, and greatly improved the technique in jump-firing used in gathering data for firing tables. The instrument was also adapted to provide greater safety in sighting tank guns under fire. The Bureau's Instrument Division developed the design details and constructed several pilot models for Aberdeen Proving Ground and Erie Proving Ground.

The Division of Geomagnetism and Seismology rendered considerable assistance in instrumental work. This included inspections and investigations of special magnets for use in magnetic mines, advice in the design of aircraft and marching compasses, cooperation in the design and construction of special magnetic instruments, tests of the magnetic properties of helmets (non-magnetic helmets are required for use when using marching compasses to determine azimuth), and the design and testing of seismological instrumental equipment for use by the Navy in the establishment of microseismic stations.

Before the war the Division of Coastal Surveys developed a device known as a "sono-radio buoy" for use in its radio-acoustic method of position-finding in hydrographic surveys. The essential elements of this apparatus are a hydrophone and a radio unit which, when actuated by under-water noises picked up by the hydrophone, automatically dispatches a radio signal. Details of this device and the methods involved were furnished the Hydrographic Office of the Navy for use in surveys of foreign waters. During the war the Navy adapted this apparatus for use in detecting submarines and in other military operations.

ACTIVITIES IN THE PHILIPPINE ISLANDS

For many years before the war the surveying and charting of the Philippine Islands was carried on under a cooperative agreement whereby a part of the cost of the work was paid by the United States Government and a part by the Insular Government.

Two ships, under command of Coast and Geodetic Survey officers, were engaged in field surveys, the *Fathomer*, owned by the Insular Government, and the *Research*, an old vessel which was the property of the United States but which had been transferred informally for operation by the Insular Government. An office was maintained in Manila from which field surveys were directed and where the charts of the archipelago were compiled and printed.

At the outbreak of the war the two ships were engaged in surveys requested by the Navy in Coron Passage, north of Palawan, and off Bataan. After the attack on Pearl Harbor they returned to Manila where their personnel assisted the office force in supplying the armed forces with charts, maps, and other material required for war operations. The *Research* was damaged by a bombing attack on Manila and later both ships proceeded to Corregidor where they suffered further damage from bombs. Finally the *Research* was so badly damaged that she was beached in a sinking condition on January 30, 1942. The *Fathomer* was captured by the Japanese with the fall of Bataan.

The officer in charge of operations in the Philippines was killed during a bombing raid on Manila. Two commissioned officers were interned in Manila and released when the islands were recaptured. The civilian technical assistant was called to active duty as a Major in the Army Reserves. He and one commissioned officer of the Bureau were captured on Corregidor and after imprisonment in several camps in the Philippines was

transferred to Japan and Korea where they were released after the surrender of Japan. The remaining officer was killed while being transported to Japan as a prisoner of war.

An attempt was made by the military authorities to transfer to Corregidor some of the charting equipment at the Manila office but this was prevented by the rapid advance of the Japanese. All facilities and material were captured but these provided virtually no information which was not available through general distribution before the war. During the reoccupation of Manila by United States forces the Manila office, including the chart-printing plant, was entirely destroyed. Fortunately, no basic data were lost as specially prepared copies of all finished surveys and other charting material had been forwarded to the Washington office before hostilities began.

CHART AND MAP PRODUCTION

The Coast and Geodetic Survey is responsible for the production and distribution of nautical and aeronautical charts of the United States and its possessions. From the attack on Pearl Harbor until the surrender of Japan, the Bureau was faced with the task of meeting the enormous and constantly expanding charting needs of the armed forces. More than 90 percent of the production was supplied directly to the Army, Navy, and Merchant Marine. To meet these requirements, the personnel of the Bureau's Chart Division was expanded over 700 percent, the hours of work lengthened, and the major portion of the facilities of the division placed on a two- or three-shift basis.

In addition to meeting all charting demands made upon it by the armed forces, the Bureau collaborated extensively with other war agencies in furnishing maps, charts, and other compilations to meet their needs. When special surveys were made, attention was given to the immediate verification, review, and publication of the information obtained so that the results could be furnished promptly to the agencies needing them.

NAUTICAL AND AERONAUTICAL CHARTS AND COAST PILOTS

The demand for the regular nautical charts of the Bureau increased from an annual issue of 400,000 in 1940 to over 4,000,000 in 1945. The greatest consumers of these charts were the Navy and the Merchant Marine, these two services alone taking 75 percent of the total issue. The demand for the regular aeronautical charts of the Bureau increased from 464,000 in 1940 to 9,500,000 in 1945. The principal consumers of these charts were the Army and the Navy Air Forces. Tables showing the distribution of charts by fiscal years are included in Appendix V.

To supplement the nautical charts the charting agencies of all nations provide volumes, generally called Coast Pilots. These publications contain information required for navigation and ship operation which cannot be shown conveniently on charts--- such as descriptions of the coasts and harbors, port regulations and facilities, sailing directions, and general information as to weather conditions, radio service, etc. The annual issue of Coast Pilots increased from 11,000 copies in 1940 to over 70,000 copies in 1945.

The need for charts for operational and training purposes reached such proportions at the height of the war that it was necessary to obtain assistance from commercial lithographic companies in order to meet the heavy demand. The four concerns with which contracts were made, namely, Rand McNally & Company of Chicago, Williams & Heintz of Washington, A. Hoen & Company of Baltimore, and Eastern Offset Company of Baltimore, rendered splendid service.

The lithographic printing done under contract consisted largely of multicolor aeronautical charts. When contract work was first started, it was customary to provide the contractors with the Bureau's printing plates for use in preparing plates for their own presses. This procedure proved to be unsatisfactory due to difficulties encountered in copying color plates where rulings and half-tones supplement the solids to provide various color tones. It was found far more satisfactory to process the work from Coast Survey negatives directly to the printing plates of the contractors. This procedure is recommended if similar needs arise in the future.

While the primary responsibility of the Bureau was the production and distribution of charts of the United States and its possessions as required by the armed forces, many other charting and mapping projects involving chart production of large portions of the world were undertaken for the military services and other war agencies.

An extensive series of world aeronautical charts on a scale of 1 : 1,000,000 and 22 by 29 inches in size was required by the Army Air Forces. The charts produced in this series conformed in the selection and treatment of detail, as well as in scale and placement of aeronautical data, to the standard aeronautical charts of the United States developed and published by the Coast and Geodetic Survey. The new series was designed to provide world-wide coverage and called for 1,200 charts, of which some 300 were of water areas. Of the 900 charts covering land areas, the Coast and Geodetic Survey produced about 550, with funds provided by the War Department. When the new series was completed the regional charts formerly published by the Coast and Geodetic Survey were withdrawn from circulation.

Sectional aeronautical charts, on a scale of 1:500,000, were produced for the Army Air Forces for specific areas including charts of central Europe and several special charts of the Channel area required by the invasion forces. In general, these charts were produced in accordance with the style and character employed in the sectional charts of the United States. About 110 charts of this series were produced, of which the Coast and Geodetic Survey published about 50.

As military requirements expanded, the Bureau was called upon to assist in producing flight charts for air routes that were being used consistently by the Air Forces. In general, these charts conformed with the world aeronautical chart series in treatment and detail, but were produced in strips measuring approximately 14 inches in width and of varying length, depending on distances between major air terminals. The charts were used by the Army Air Forces and the Air Transport Command on regularly scheduled runs.

SPECIAL CHARTS

In the early stages of the war a critical need developed for detailed target charts for use in bombing military and industrial objectives. The prime requirement involved in charts of this character as the speed with which they could be produced. Charts for 1,812 different targets were produced and delivered to the Army and Navy Air Forces during the war.

In connection with target chart production, considerable research was done in developing a target perspective chart for portraying a perspective approach to the target. Conventional charts and maps depict the area covered as it would appear from a point directly overhead. The perspective charts were designed to show the aviator the appearance of the terrain as seen ahead when coming in over a target. These charts were prepared for approaching each target from several different directions.

A program for making instrument approach and landing charts to assist the aviator in landing during unfavorable weather was undertaken in 1941 in cooperation with the Civil Aeronautics Administration. The program was greatly accelerated at the request of the Army, with War Department funds. At the end of the war, the Coast and Geodetic Survey had published approximately 600 of these charts, embracing major civil and military airports.

Early in the war a series of 43 planning charts, scale 1 : 5,000,000, having world-wide coverage, was started for the Army Air Forces for planning long-range flights. By using the same bases it was possible to produce efficiently a similar series of world outline charts and world isogonic charts, all of which were in considerable demand by the military forces.

A series of weather plotting charts, also providing world-wide coverage, was produced for the Air Forces. The charts of this series varied widely in scale, size, and treatment. In some cases they showed relief by hachures, while in others they were produced in outline form without relief data. Weather stations were indicated by conventional symbols, accompanied in many cases by an indexing system referring to supplemental data.

Other special charts produced included several types of planning charts, celestial navigation recording charts, the Link trainer graticule used in conjunction with Link trainers, time zone charts, Japanese city plans or mosaics for planning bombing missions and for determining the selection of targets, damage plans showing the devastated areas resulting from bombing missions, instrument flying training charts developed for use in the various Army Air Forces training centers, air defense grids developed as special overprints on sectional charts and used for target location and artillery-air bombardment control, direction-finding charts used in instrument flying, gnomonic tracking charts for position finding and tracking by radio, and azimuthal equidistant charts for quick determination of mileages to important strategic targets or areas.

During the latter part of the war, the Hydrographic Office called on the Bureau for the reconstruction of numerous captured Japanese nautical charts. These provided detailed navigational information as well as a considerable amount of source material for the construction of target charts that had not been available previously.

SURVEYS AND CHARTS OF THE PHILIPPINE ISLANDS

The surveys and charts of the Philippine Islands made by the Coast and Geodetic Survey continuously over a period of 40 years proved to be of much value to the armed forces in the Pacific theater of war. The surveys on which the charts are based show in detail the character and extent of the off lying reefs which too often in areas improperly surveyed had cost the lives of many American soldiers. In addition to the tremendous advantage to our Navy of having accurate navigational charts of this region, the detailed surveys provided excellent source material for the construction of 537 special large-scale quadrangle maps for the use of the Army in planning and executing the re-occupation of the Philippines.

Information available on the original surveys and in the accompanying descriptive reports was also of great value to a number of war agencies working in specialized fields. An especially important use was in the production for the Hydrographic Office of 38 bombardment charts of critical areas in the Philippines for use in softening objectives prior to the landing of forces. So rapidly did our forces advance in the region that on one occasion it was necessary for the Bureau to produce 25 different bombardment charts in 25 days to meet an emergency request.

SPECIAL TECHNICAL SERVICES

The modern facilities and equipment of the Coast and Geodetic Survey made it possible to contribute many special technical services to the war effort. Use of the Bureau's precision projection ruling machine was in such demand that it had to be operated through most of the war period on a two- or three-shift basis. Many other projects were accomplished for various war agencies, ranging from the construction of 175 war mapping quadrangle projections for the War Department and the Forest Service, to 967 projections for combat and bombardment charts for the Navy.

Other services included development of specifications for fluorescent chart paper for military use; preparation of special plotting tables, navigation tables, and catalogs; the preparation of pilot handbooks, air route and airfield indexes; the indexing of hundreds of thousands of aerial photographs; and the compilation and printing of gazetteers of the Philippine Islands, Alaska, and the Pacific coastal regions. The Philippine Islands volume alone required investigation and checking of 45,000 geographic names.

REPRODUCTION EQUIPMENT

Addition and replacements of equipment were continually necessary in order to maintain production schedules. New presses obtained were as follows: Three single-color presses, size 36 by 59 inches, one of which replaced an obsolete flatbed press; two two-color presses, size 36 by 39 inches; and two small single-color presses, size 22 by 30 inches. This brought the total press equipment to 11 offset presses- 9 large presses and 2 small ones.

Other equipment included a 40-by 40-inch precision camera equipped with a full-size 133-line halftone screen. Two large photographic contact printers and a large revolving contact printer enabled the photographic laboratory to produce as many as 39,261 positive films during the last year of the war. Two new Craftsman layout tables proved an asset in expediting work on many different types of reproduction. A new vacuum process printing frame and two new whirlers were obtained for the process room and a new offset proving press for the transfer room. An ozalid photographic printer was obtained to replace an obsolete blueprint machine. Two new continuous Photostat machines provided adequate facilities for changing the scale of the thousands of copies of source material, as well as handling normal requirements for this type of work.

The installation of two knife folders and two buckle folders and a third cutter made possible the rapid and efficient trimming and accordion folding of all aeronautical charts supplied the Army Air Forces. Trimming and folding of as many as 70,000 charts in 1 day was not uncommon with this equipment.

Numerous small instruments were designed for use in engraving glass negatives. These increased the accuracy and simplified the process. They included the graver holder for engraving single, double, or triple lines; the swivel graver for similar purposes; the contour graver; the rigid graver; a special graver for subdividing borders and projection lines; a building graver for engraving solid squares of any desired size with one movement of the tool; a mechanical letter engraver; and an electric dot engraver.

In general, the equipment acquired and developed during the war provided the Bureau with a well-balanced plant. Production difficulties resulted from shortage of personnel rather than from inadequate equipment.

NEW PROCESSES

To provide maps and charts in the quantities required and to meet the delivery schedules imposed by wartime demands, it was necessary to devise new methods of cartography and reproduction. So successful was the research that most of the new processes developed will permanently replace those formerly used.

APPENDIXES I TO VII

REGULATIONS GOVERNING THE DUTIES TO BE PERFORMED BY THE
COAST AND GEODETIC SURVEY IN TIME OF WAR, AND FOR THE
COOPERATION OF THAT SERVICE WITH THE WAR AND NAVY
DEPARTMENTS IN TIME OF PEACE IN PREPARATION FOR ITS DUTIES IN
WAR

1. PREAMBLE.—In accordance with section 16 of the Act of May 22, 1917 (40 Stat. 88), the following regulations will govern the duties to be performed by the Coast and Geodetic Survey in time of war, and the cooperation of that service with the War and Navy Departments in time of peace in preparation for its duties in war.

INTERDEPARTMENTAL BOARD

2. ORGANIZATION OF BOARD.— In time of war or whenever a national emergency exists during which, in accordance with the provisions of section 16 of the Act of May 22, 1917, personnel, vessels, equipment, and stations of the United States Coast and Geodetic Survey may be transferred by the President to the service and jurisdiction of the War Department or the of the Navy Department, a board shall be organized, consisting of one member appointed by the Secretary of War, one member appointed by the Secretary of the Navy, and one member appointed by the Secretary of Commerce. This board shall be known as the “Interdepartmental Board for Cooperation of the Coast and Geodetic Survey with the Armed Services.”
3. DUTIES OF BOARD.—a. The board shall investigate and consider the need for the continued supply to the military forces of the products and services of the Coast and Geodetic Survey during the emergency and shall submit for approval of the Secretary of War, the Secretary of the Navy, and the Secretary of Commerce:
 - (1) Recommendations as to personnel, vessels, equipment, and stations of the Coast and Geodetic Survey to be transferred to the jurisdiction of the War and Navy Departments.
 - (2) Recommendations as to modification of the normal activities of the Coast and Geodetic Survey in order to correlate them with military activities.
 - (3) Recommendations as to new activities to be undertaken by the Coast and Geodetic Survey.
- b. The board shall continue in existence for the duration of the emergency for the purpose of investigating and recommending, from time to time, such further disposition of the facilities of the Coast and Geodetic Survey as may appear desirable to meet developments.

c. Any questions which may arise between the departments concerning the effect or execution of the Act of May 22, 1917, shall be referred to the board for recommendation.

4. DUTIES OF THE COAST AND GEODETIC SURVEY.—a. In time of war the Coast and Geodetic Survey shall:

1. Continue its normal activities subject to such restrictions or modifications as may be agreed on jointly by the Secretaries of War, Navy, and Commerce as necessary in the prosecution of war.
2. Perform such special assignments consistent with its facilities as the War or Navy Department may request.

b. In time of peace the Coast and Geodetic Survey shall:

1. Maintain such liaison with the War and Navy Department as may be necessary to assure prompt and orderly disposition of its facilities in time of war.
3. Undertake such training programs as may be considered desirable by Secretaries of War, Navy, and Commerce.

TRANSFER OF PERSONNEL

5. COMMISSIONED OFFICERS.—Commissioned officers of the Coast and Geodetic Survey transferred to the War or Navy Departments shall serve under their commissions in the Coast and Geodetic Survey. While so serving they shall be deemed to have proper military status and shall be subject to the laws, regulations, and orders for the government of the Army or Navy.

6. SHIP PERSONNEL.—If a Coast and Geodetic Survey ship is transferred to the Navy Department, civil service officers without commissions (such as engineers, deck officers, chief radio technicians, and radio technicians, etc.) serving thereon shall be given opportunity to apply to the Navy Department for commission or warrants in the Naval Reserve in ranks commensurate with their age, experience, and qualifications. Petty officers and nonrated members of the crew shall be given opportunity to apply to the Navy Department for enrollment in the Naval Reserve in ratings determined by the Navy Department.

7. PHYSICAL EXAMINATIONS.-- The physical qualifications of each officer and employee under consideration for transfer shall be determined by the War or Navy Department before his transfer.

TRANSFER OF PROPERTY

8. PROPERTY RECEIPTS.—Any vessel or other Government property belonging to the Coast and Geodetic Survey when transferred to the War or Navy Department shall be receipted for by an authorized agent of the department to which transferred. Such receipts shall contain an inventory of all property conveyed.
9. CONDITION OF VESSELS AND EQUIPMENT UPON RETURN TO THE COAST AND GEODETIC SURVEY.—Any vessel belonging to the Coast and Geodetic Survey transferred to the War or Navy Department shall, when returned to the Coast and Geodetic Survey, be in as good condition as when transferred, ordinary wear and tear excepted, subject to inspection of the Coast and Geodetic Survey. All expenses necessary to alter a vessel to fit it for the service required by the War or Navy Department and to change it back to a condition suitable for survey work shall be paid for by the department to which such vessel had been transferred.
10. RETURN OF EQUIPMENT.—All Coast and Geodetic Survey equipment transferred to the War or Navy Department shall be returned to the Coast and Geodetic Survey, or similar equipment furnished to replace it.

MISCELLANEOUS

11. COMMUNICATION BETWEEN BUREAUS.—There shall be direct communication between appropriate representatives of the Army, Navy, and Coast and Geodetic Survey on all matters affecting the details of carrying out the provisions of the Act of May 22, 1917, and of these regulations.
12. DATE OF TRANSFERS. — The date on which the War or Navy Department assumes authority over and responsibility for personnel, vessels, equipment, or stations, and the date on which the Department of Commerce relinquishes authority and responsibility shall be the date the actual transfer is affected, in accordance with the President's Executive Order.
13. REPORTS.—Personnel reports and correspondence necessary to preserve the continuity of administrative records of the Coast and Geodetic Survey shall be furnished the Director of the Coast and Geodetic Survey by the War or Navy Departments.

Henry L. Stimson
Secretary of War
Frank Knox
Secretary of the Navy
Jesse H. Jones
Secretary of Commerce

January 20, 1942

U.S. COAST AND GEODETIC SURVEY APPENDIX II

REPORTS OF DUTIES PERFORMED BY OFFICERS TRANSFERRED TO THE ARMED SERVICES

From the Commanding Officer of the Survey Ship HYDROGRAPHER,
Serving with the Navy:

Hydrographic surveys, particularly those of anchorage areas and their approaches, were the main function of the HYDROGRAPHER. These surveys were sometimes made under combat conditions, and were always made under considerable pressure, as time was the important element.

The survey ships were expected to furnish charts and hydrographic data on the spot-Oxalic prints of boat sheets were much in demand for navigation prior to compilation of a regular chart. On one occasion a preliminary sheet showing buoy age, known dangers, and anchorage berths was completed and prints made after a large convoy of transport was within sight and distributed to the ships as they entered the anchorage. A reproduction machine of some kind is an absolute necessity on a ship which has to supply navigational information in forward areas.

Many special-purpose surveys were made, such as the following:

- (a) Surveys across tide flats and small channels in connection with establishment of barricades to stop enemy troops or boats attacking at night.
- (b) Surveys across tide flats and small channels in connection with establishment of other harbor and channel improvement activities, installation of anti-submarine nets, installation of submarine-detection devices, mining operations, establishment of degaussing ranges, field artillery, fire control (assisted Marines in this connection), seaplane anchorage and landing areas (including marking of such areas), and engineering activities of Seabees and Army Engineers.

At Shemya Island in the Aleutians, surveys were made to determine landing possibilities of large landing ships and obstructions were buoyed. A tide staff was established, and advice furnished as to the proper time for beaching and unleashing, and the distance from the beach at which ships would ground at the selected time. The ships were piloted to the beach by Coast and Geodetic Survey officers.

I was told some months later by the officer in command of the Shemya Task Force that for the first time in LST (Landing Ship Tank) history, the technical services of hydrographic engineers were used in a coordinated landing operation at Shemya and that the results were considered so satisfactory that

similar procedure was established for the landings in the Mediterranean and whenever possible in the Pacific.

On one occasion the ship was sent to Roe Anchorage at the north end of Kwajalein Atoll with orders to "survey and improve the anchorage." Diving equipment and divers were obtained, members of the crew were trained in diving and in handling explosives, and 75 coral heads, some of which were awash, were blasted out to a depth of 30 feet. After the operation, ships were able to anchor from 1 to 2 miles closer to the beach.

The establishment and maintenance of aids to navigation, both floating and fixed, and the installation of mooring equipment were among other duties of the survey ships. Buoys were often of an improvised type, made from oil drums or anything at hand. On one occasion we were called upon to place lights on buoys and beacons in Apra Harbor, Guam, for use by the ships in the event that it became necessary to clear the harbor at night due to a typhoon.

I was frequently called into consultation by Seabees, Army engineers, and others regarding problems on which hydrographic, geodetic, tidal, or oceanographic or navigational experience was of value, and was placed in command of convoys on numerous occasions. Officers attached to the ship were often called upon the pilot ships into anchorages, and at times to pilot landing craft to beaches.

We were often called upon to engage in such miscellaneous activities as assisting in salvage operations, including piloting a sinking vessel through the reefs, and rescue work. On one occasion it was necessary to make a quick survey to select a place to beach a sinking ship. On another occasion it was necessary to make a quick survey through a foul area, mark a channel, and select anchorage site for a floating drydock which had to be moved immediately to smoother water to drydock a sinking destroyer. Special investigations were once made and advice furnished in connection with salvage of several vessels stranded in foul areas by a typhoon.

From an officer serving with the field artillery, U.S. Army:

The mission of the Field Artillery Observation Battalions of the U.S. Army is to gain intelligence of enemy artillery installations by sound and flash ranging, and to furnish survey control for the artillery of the corps to which they are attached.

Coast and Geodetic Survey officers attached to the F.A. Observation Battalions were designated as Corps Artillery or Observation Battalion Survey Officers. The following activities are representative of the duties performed:

During the training period, I instructed and trained Observation Battalion and other artillery personnel in surveying; instructed in map construction, evaluation, and map reading; instructed in navigation; secured triangulation, leveling, and magnetic data for use of the artillery; acted as survey adviser and staff officer to the Observation Battalion Commander and Corps Artillery Commander; and engaged in pre-invasion planning.

During combat, I acted as Observation Battalion Survey Officer; as Corps Artillery Survey Officer; as Reconnaissance Officer, Corps Artillery and Observation Battalion; as Observation Battalion (S3) Plans and Training Officer; as Observation Battalion Executive Officer; and as Observation Battalion Commanding Officer.

During the post-combat period, my duties were as for the combat period. In addition I served as Provost Marshal of various occupied towns; commanded detachments engaged in the operation of prisoner-of-war camps; commanded detachments engaged in the operation of camps for displaced persons; and directed recreation centers, entailing the operation of numerous hotels, recreation facilities, and the Corps football team.

From an officer serving with the Marine Corps Artillery:

Prior to the outbreak of hostilities, the Marine Corps Artillery was organized into small tactical units with the mission of direct support for combat teams which would normally require observed fire only. With the large-scale amphibious operations planned for the Pacific, it was necessary that their organization include larger tactical units capable of operation against large enemy forces equipped with modern weapons. This necessitated certain technical services, such as survey, meteorological observations, and special counter-battery operations, which would permit the employment of artillery against targets which could not be observed.

To provide these technical services, it was necessary either to recruit or train personnel to carry on these operations. The normal training and experience of a Coast and Geodetic Survey officer included everything required except the operating procedures used by artillery units.

The survey for artillery consists of establishing horizontal and vertical control for the location and orientation of the guns which will permit the placing of fire on targets described by geographic coordinates, and the location of targets by survey. The methods of survey include triangulation, traverse, leveling, and determination of astronomic azimuths, all of which are routine in the work of the Coast and Geodetic Survey. While the degree of accuracy required for artillery survey is not high, thorough training in all types of surveying is desirable to permit the best selection or improvisation of methods to be used under the conditions encountered in combat.

Flash ranging and sound ranging are two standard methods used to locate enemy artillery in order that counter-battery fire can be directed against it. Flash ranging is the location by triangulation methods when the flash of the propelling charge can be seen. Sound ranging is a method of locating the point of origin of a sound, such as the firing of a gun, by determining the differences in time of the sound's arrival at various points which have been located by survey. This is a survey problem and similar to the one encountered in the radio acoustic ranging method of controlling hydrographic surveys, as developed by the Coast and Geodetic Survey.

The meteorological data required for artillery consist of the determination of the temperature and density of the air, the direction and velocity of the wind at various elevations, and their effect on the ballistics of the projectiles. The methods and instruments used to obtain this information are similar to those used in survey operations.

My schedule of assignments in the Marine Corps was generally typical of those of Coast and Geodetic Survey officers transferred for duty with Marine artillery units and was as follows:

Upon transfer to the Marine Corps, I was ordered to Quantico, Va., for the Field Artillery Course, with additional temporary duty as instructor in surveying and mathematics. Upon completion of this course it had been planned that I would join a combat unit but, as reports from the theaters of operations requested the development of special sound-ranging equipment suitable for use in amphibious operations, I was assigned to the Equipment Board to assist in its development.

Subsequently this work was turned over to another Coast and Geodetic Survey officer, and I was assigned to the artillery regiment of the Fourth Marine Division as Assistant Operations Officer in charge of survey, meteorology, and sound and flash ranging.

During training periods my duties consisted of instructing in surveying and map reading, training the personnel in the survey, meteorological, and sound-ranging sections, directing the work of these sections in connection with artillery training problems, and supervising any engineering work carried on by the organization. In preparation for an operation it was my responsibility to prepare the orders for the employment of survey and procedures to be followed and to compute data on tides, light conditions, and magnetic factors to be used for the various fire-direction and survey instruments.

During combat operations I directed the work of the sections noted above to furnish data on (1) the accuracy of available maps and necessary correction factors to be applied to map data, (2) control for location and orientation of the guns, and (3) the location of targets.

APPENDIX III

REPORTS OF THE VALUE OF THE BUREAU'S WORK FOR WAR PURPOSES

The value for war purposes of the services of Coast and Geodetic Survey personnel and of the Bureau's field and office operations is evidenced by numerous statements from various sources which were received from time to time during the war. Following are extracts from statements of this character:

FROM THE COMMANDER IN CHIEF, UNITED STATES FLEET:

On 7 April 1943, a heavy air attack was made by the Japanese on our ships in the Solomon Island area. The U.S. Coast and Geodetic Survey ship *Pathfinder* was in this area at the time. In commenting on this action, the Commander in Chief, Pacific Fleet, stated as follows:

"The performance of the *Pathfinder* on 7 April is noteworthy. Preceding the attack this vessel was conducting survey operations off Brandi Point, Guadalcanal. Despite warning of approaching planes and the departure of most of our large ships from the area, her personnel continued hydrograph until enemy planes were near. Leaving her ship boats with one quarter of the crew at their assigned survey duties, the commanding officer then went to maximum speed and maneuvered close aboard *Aaron Ward*. Two planes dived on her and were shot down. Her boats brought off wounded from *Aaron Ward* who were cared for on board during the night. Early the next morning these men were disembarked for hospitalization and at 0700, 8 April local time, the ship resumed its survey operations. It is a pleasure to report on the efficient and businesslike conduct of duty under fire of this USC&GS ship operating under my command.

"I wish to extend my sincere admiration and appreciation for the splendid work being performed by this and other U.S. Coast and Geodetic Survey ships."

FROM THE COMMANDER, ALASKAN SECTOR, NORTHWEST SEA FRONTIER:

Upon being relieved as Commander, Alaskan sector, I wish to express my appreciation for the cooperation and the invaluable results obtained by the vessels of the Coast and Geodetic Survey in the western Aleutians during 1943. Although additional and urgent work remains to be done next year, these vessels have accomplished a major work during the year just passed. They have carried on the previously existing surveys to points farther west and have, with minor exceptions, made it possible to navigate safely throughout the whole of the Aleutian chain.

Some of these vessels carried out survey work preliminary to the Attu and Kiska operations, establishing safe routes and making it possible for the heavy vessels of the Task Force to carry out their assigned missions. Some of the work was carried on in

conjunction with landing operations and furnished invaluable assistance to vessels of the Task Force. During these operations your ships were subject to the same hazards and enemy action as were combatant ships.

By copy of this letter the commanding officers of the various Survey vessels are requested to bring to the attention of their personnel the foregoing appreciation.

FROM THE HYDROGRAPHER, U.S. NAVY:

I take pleasure in enclosing herewith a copy of a letter from the Commander in Chief, U.S. Pacific Fleet and Pacific Ocean Areas, expressing his thanks and appreciation to the personnel of the Hydrographic Office for their expeditious and efficient action in meeting fleet requirements.

I desire you and the personnel of the U.S. Coast and Geodetic Survey to share with us in the Hydrographic Office in this expression of appreciation from CinCPOA and COMINCH, inasmuch as your organization has been of assistance to this Office in meeting many of the demands of urgent nature which we have had to fulfill during the past few years.

I particularly wish to convey through you my deep appreciations to the members of your staff who have cooperated to the utmost and whose loyalty, enthusiasm, and efficiency in expediting vital war work are worthy of commendation.

FROM THE COMMANDANT OF THE MARINE CORPS:

The officers of the U.S. Coast and Geodetic Survey who have been temporarily transferred to the Marine Corps have rendered invaluable service. Please permit me to take this opportunity to express appreciation of your action and cooperation in making the services of these officers available for survey duties with the Marine Corps.

FROM THE COMMANDING GENERAL OF THE ARMY GROUND FORCES:

With the relief from assignment to the War Department of the great majority of the officers of the United States Coast and Geodetic Survey made available to Army Ground Forces during the war, I wish to express to you and to the officers of your splendid organization my appreciation for the great contribution made by these officers to the success of the sound-and-flash ranging phase of artillery action in the operations in all theaters of war.

Following the initial assignment of officers of the Coast and Geodetic Survey to a limited number of field artillery observation battalions in the early part of the war, their value was immediately recognized in the resulting increase in efficiency of the united, particularly in regard to their survey functions.

The rapid expansion of the number of field artillery observation battalions required the return of combat-experienced officers to command and train new units. These officers who had served in combat with officers of the Coast and Geodetic Survey placed the utmost stress upon the necessity of obtaining additional officers of your service to assist in the training and operation of these battalions.

Your cooperation in making your officers available for duty with the War department and the accomplishments of these officers while so assigned reflect great credit on the United States Coast and Geodetic Survey.

FROM THE COMMANDING GENERAL OF THE 2D ENGINEER SPECIAL BRIGADE:

Today the first of the seven Coast and Geodetic Survey officers detailed to the 2d Engineer Special Brigade is being transferred to the depot for return to the States. I cannot allow him to depart without again inviting your attention to the superior work done in the western Pacific by all your officers who served with this brigade.

These officers were invaluable in assisting this brigade in successfully making 87 combat landings and winning 7 Presidential Unit Citations.

On behalf of the Army and especially of the 2d Engineer Special Brigade, I wish to express our sincere thanks for your cooperation in detailing us such valuable officers. Their contribution to the new field of amphibian engineering was noteworthy.

FROM THE COMMANDING OFFICER, BERMUDA BASE COMMAND, U.S. ARMY:

Receipt of triangulation survey data of the harbor defenses of Bermuda is hereby acknowledged.

It is obvious that great care was exercised in the compilation of the very complete data furnished. This survey will serve a most useful purpose not only for the U.S. Army but also for the U.S. Navy as well as the British Military Forces here.

This Command is most appreciative of the excellent work accomplished by the U.S. Coast and Geodetic Survey.

APPENDIX IV ACTIVITIES OF SURVEY SHIPS TRANSFERRED TO THE NAVY

U.S.C. & G.S.S. Oceanographer

During the first part of her war service the OCEANOGRAPHER was under the command of a Coast and Geodetic Survey officer transferred to the Navy. After a short period of duty in Alaska, this ship, under regular naval command, proceeded to the

western Pacific where she was engaged in surveying and charting operations until June 1944. important and extensive surveys required for war operations were accomplished in the vicinities of New Caledonia, Guadalcanal, the Solomon Islands, and the Treasury Islands.

The largest project executed was a survey of Indispensable Strait, an area about 5,800 square miles in extent between Guadalcanal, Florida, and Santa Isabel Islands on the west and Malaita Island on the east. Another important survey was made near Munda, New Georgia Island, in the Solomon Islands, when our forces first invaded the island.

In June 1944 the ship returned to the west coast for repairs, but because of her age and the cost of the extensive repairs required, it was decided that the vessel should be scrapped. She was decommissioned on September 22, 1944.

U.S.C. & G.S.S. HYDROGRAPHER

The HYDROGRAPHER served throughout the war under the command of Coast and Geodetic Survey officers transferred to the Navy. Her first assignment was in Newfoundland waters where she surveyed the approaches to the Naval Base at Argentia. After completion of this work, the ship was ordered to duty in the Aleutian Islands, where she operated for 7 months during the period of maximum military activity in that area.

Surveys were accomplished in the vicinities of Atka Island, Adak, Kanaga Pass, Attu, Shemya, and Kiska Harbor. In May 1943 the commanding officer was awarded the Legion of Merit for surveying and charting the unknown and dangerous waters surrounding Attu Island during the assault and occupation of that island. During the landings in Massacre Bay survey parties from the ship located and marked safe channels and anchorages which were used by the transports and task force which captured Attu.

Upon completion of her work in the Aleutians, the HYDROGRAPHER proceeded to the central and western Pacific where she carried on surveys during the remainder of the war. Projects were accomplished at various places in the Gilbert, Marshall, and Palau Islands, and in the waters surrounding Guam and Wake Islands, in spite of frequent enemy attacks. The commanding officer was awarded the Bronze Star Medal for surveys in the western Pacific.

After the close of the war the HYDROGRAPHER was ordered to return to the United States. The vessel reached Norfolk, Va., in March 1946 and was returned to the Coast and Geodetic Survey on July 1, 1946.

U.S.C. & G.S.S. PATHFINDER

This ship operated in the western Pacific throughout the war. Surveys were accomplished in the waters surrounding New Caledonia, Guam, and Guadalcanal and at numerous points in the Ellice, New Hebrides, Russell, Treasury, Admiralty, Caroline, and Philippine Islands.

The largest single operation undertaken was in the Russell Islands, which became a tremendous staging point for Army equipment and troops. This ship was equipped with a chart-printing plant which enabled her to utilize the results of surveys for the rapid production of a large number of charts required immediately for war operations.

During the latter part of the war the PATHFINDER was engaged in surveying the waters around Okinawa. On this mission she sustained the only damage resulting from a considerable number of attacks by enemy planes which were experienced on her various assignments. On May 6, 1945, she was attacked by two Kamikaze planes, one of which crashed into a gun platform, killing one man and setting fire to the vessel. The fire was extinguished without serious damage.

After the surrender of Japan, the PATHFINDER completed surveys at Okinawa and then proceeded to the Yokosuka Naval Base in Tokyo Bay. During October and November 1945, she executed several surveys in Tokyo Bay and was then ordered to return to the United States. The vessel reached Seattle late in December 1945 and was returned to the Coast and Geodetic Survey on August 22, 1946.

Officers and crew of the PATHFINDER were commended by the Commander in Chief, U.S. Pacific Fleet, and the Commander of South Pacific Forces for their excellent performance of survey duties and chart production in forward areas.

U.S. COAST AND GEODETIC SURVEY

APPENDIX V

DISTRIBUTION OF CHARTS

Nautical Charts

	1940	1941	1942	1943	1944	1945
Hydrographic Office	140,041	279,940	571,754	1,222,115	2,217,958	3,257,957
Coast Guard	14,124	15,652	33,480	61,785	25,867	7,980
War Department			65,313	76,710	65,491	27,664
Coast and Geodetic Survey	14,730	12,973	17,458	19,133	18,695	18,321
Other Executive Departments	16,342	40,948	9,529	17,575	15,464	9,083
Special to Armed Forces		10,618	93,212	94,508	112,933	1,845
Miscellaneous	8,648	9,480	19,184	36,077	40,320	80,808
Foreign Governments	1,018					
Sales	184,672	210,561	237,723	360,673	389,245	655,747
Condemnations	14,772	26,204	36,872	28,023	27,693	95,332
Total:	395,540	606,376	1,084,525	1,916,599	2,913,666	4,154,737

1 Does not include Manila Field Station.

The rapid changes in important navigational information make it necessary to apply hand corrections to the charts in order to keep them corrected to date of issue. The number of such corrections averaged 4.9 per chart, and the totals are tabulated below:

	1940	1941	1942	1943	1944	1945
Charts corrected	313,492	314,754	947,734	1,636,624	1,426,242	1,279,511
Corrections	1,603,186	1,848,553	3,685,074	7,680,944	6,380,693	5,870,289

Aeronautical Charts

	1940	1941	1942	1943	1944	1945
War Department	116,753	301,009	1,689,046	10,537,041	9,033,433	7,575,284
Navy Department ¹	37,533	55,841	157,221	800,389	1,009,846	1,168,272
Civil Aeronautics Administration	24,326	31,808	40,672	144,536	46,084	46,932
Coast and Geodetic Survey	5,941	6,182	9,803	42,981	20,482	27,116
Special to Air Corps		274,801	344,732			
Miscellaneous	5,414	13,675	8,730	19,133	10,193	16,847
Foreign Governments	336	3,010				
Sales	268,239	223,063	240,314	173,133	183,218	397,608
Condemnations	5,375	2,950	9,982	56,251	168,878	251,621
Totals:	463,917	912,339	2,500,500	11,773,464	10,472,134	9,483,680

¹ Includes U.S. Coast Guard

WORLD WAR II HISTORY

APPENDIX VI

Appropriations and Other Funds

Tabulated below are the regular appropriations and other funds (special appropriations and working funds) available for the work of the Coast and Geodetic Survey in the fiscal years immediately preceding and during the war:

Fiscal year	Regular and Supplemental Appropriations	Other Funds	Total
1940	\$3,125,000	\$174,394	\$3,299,394
1941	\$5,041,000	\$142,104	\$5,183,104
1942	\$4,402,705	\$310,677	\$5,713,382
1943	\$4,455,200	\$4,458,370	\$8,913,570
1944	\$5,266,000	\$3,677,610	\$8,217,638
1945	\$5,938,953	\$2,278,685	\$8,217,638

Working funds were transferred chiefly by the War Department for aeronautical charting in foreign areas and or war mapping, and a lesser extent by the Navy Department and Civil Aeronautics Administration for various special projects.

U.S.COAST AND GEODETIC SURVEY

APPENDIX VII

Transfer of Commissioned Personnel

Coast and Geodetic Survey Officers Transferred to Army

Name	Transfer to Army			Rank	Release from Army		
	Army File No.	Authority Ex. Order No.	Date		Authority Ex. Order No.	Date	Rank
Aslakson, Carl I.	K100017	9113	28 Mar 42	Lieut.	9468	30 Aug 47	Capt
Beyma, Chester J.	K100035	9415	20 Jan 44	Lieut.	9468	27 Feb 46	Lt. Comdr
Boothe, Glendon E.	K100027	9236	19 Sept 42	Lt. Comdr	9468	9 Apr 46	Comdr
Brown, Edward B., Jr	K100042	9510	8 Jan 45	Lt. Comdr	9468	17 Dec 45	Lt. Comdr
Bryant, Fair J.	K100001	9072	24 Feb 42	Ens.	9468	2 Mar 46	Lt. Comdr
Bull, John C.	K100005	9113	28 Mar 42	Lieut. (jg)	9468	18 Feb 46	Comdr
Chenworth, Charles F.	K100036	9415	20 Jan 44	Lieut.	9468	1 Dec 45	Lt. Comdr
Deane, William F.	K100037	9415	20 Jan 44	Lieut.	9468	15 June 46	Comdr
Deily, Earle, A.	K100028	9236	3 Sept 42	Lt. Comdr	9468	5 Apr 47	Comdr
Doran, Philip C.	K100012	9113	28 Mar 42	Lieut.	9468	5 Apr 47	Capt
Ellerbe, John C., Jr.	K100023	9187	30 Jun 42	Lieut.	9468	1 Oct 44	Comdr
Garber, Harry F.	K100026	9236	3 Sept 42	Lieut.	9468	23 July 45	Comdr
Gilmore, Ross A.	K100030	9305	23 Feb 43	Lieut.	9468	4 Mar 46	Comdr
Hecht, Maurice A.	K100003	9072	24 Feb 42	Lieut. (jg)	9468	13 May 46	Comdr
Hoskinson, Albert J.	K100011	9072	24 Feb 42	Lieut.	9468	12 Oct. 46	Comdr
Johnson, Frank G.	K100002	9072	24 Feb 42	Lieut.	9468	13 Feb 46	Comdr
Jones, Don A.	K100014	9113	28 Mar 42	Ens.	9468	15 Jan 46	Lt. Comdr
Karo, H. Arnold	K100006	9072	24 Feb 42	Lieut.	9468	10 Nov 45	Capt.
Konichek, Dorland H.	K100029	9236	1 Dec 42	Lieut.	9468	30 Jan 46	Lt. Comdr
Latham, Ector B.	K100025	9236	3 Sept 42	Lieut.	9468	18 Dec 44	Lt. Comdr
Lewey, Ernest B.	K100031	9305	23 Feb 45	Lieut.	9468	18 Mar 46	Comdr
Lushene, Joseph P.	K100015	9113	28 Mar 42	Lieut. (jg)	9468	1 Apr 46	Comdr
Maxwell, Eugene L.	K100049	9510	8 Jan 45	Lieut. (jg)	9468	21 Feb 46	Lieut. (jg)
McCarthy, Edward R.	K100021	9187	30 Jun 42	Lieut.	9468	20 Jan 47	Comdr
Moore, Glenn W.	K100032	9305	23 Feb 43	Lieut.	9468	20 Jan 48	Comdr
Paton, Hubert A.	K100007	9072	25 Mar 42	Lieut.	9468	3 Jan 46	Comdr
Paulson, Marvin T.	K100045	9510	8 Jan 45	Lieut.	9468	9 July 48	Lt. Comdr
Popper, Francis X.	K100024	9187	30 Jan 42	Ens.	9468	18 Apr 46	Lt. Comdr
Reed, Harry D.	K100038	9415	20 Jan 44	Lieut. (jg)	9468	17 Jan 46	Lieut
Ricketts, Max G.	K100043	9510	8 Jan 45	Lt. Comdr.	9468	15 Jan 46	Lt. Comdr
Russel, William C.	K100016	9072	24 Feb 42	Lieut. (jg)	9468	22 Jun 46	Comdr
Schank, Charles A.	K100034	9415	20 Jan 44	Lt. Comdr.	9468	6 Feb 46	Comdr
Seaborg, Harold J.	K100046	9510	8 Jan 45	Lieut.	9468	6 Dec 45	Lieut
Shinn, Columbus M.	K100039	9415	20 Jan 44	Ens.	9468	10 Jan 46	Lieut. (jg)
Sipe, Riley J.	K100018	9072	24 Feb 42	Lieut.	9468	11 Nov 46	Comdr
Sobieralski, V. Ralph	K100047	9510	8 Jan 45	Lieut.	9468	17 Jan 46	Lieut
Taylor, Paul	K100041	9468	20 Sept 44	Lieut.	9468	10 Jan 46	Lt. Comdr
Thorson, Alvin C.	K100004	9072	24 Feb 42	Lieut.	9468	20 Apr 46	Comdr
Thurmond, James D.	K100022	9187	30 Jun 42	Lieut.	9468	13 Jan 42	Lt. Comdr
Tison, James C., Jr.	K100009	9113	28 Mar 42	Lieut. (jg)	9468	1 Dec 49	Capt
Tryon, Raymod H. Jr.	K100048	9510	8 Jan 45	Lieut.	9468	10 Jan 46	Lt. Comdr
Tucker, William R.	K100013	9113	28 Mar 42	Ens.	9468	12 Mar 46	Comdr
Ulm, Kenneth S.	K100044	9510	8 Jan 45	Lt. Comdr.	9468	23 Nov 45	Lt. Comdr
Weber, Philip A.	K100033	9305	23 Feb 43	Lieut.	9468	13 Feb 45	Lt. Comdr
Wennermark, Maurice E.	K100040	9468	1 Sept 44	Lt. Comdr.	9468	6 Dec 45	Comdr
Whipp, David M.	K100010	9113	28 Mar 42	Ens.	9468	27 Mar 46	Lt. Comdr
Wilder, Leo C.	K100020	9187	30 Jun 42	Lt. Comdr.	9468	23 Feb 43	Lt. Comdr
Woodworth, Ralph W.	K100008	9072	24 Feb 42	Lieut.		10 Jan 45	Comdr

WORLD WAR II HISTORY

APPENDIX -- Continued

Coast and Geodetic Survey Officers Transferred to Navy

Name	Transfer to Navy Authority		Rank		Release from Navy Authority		
	Army File No. Date	Ex. Order No.			Ex. Order No.	Date	Rank
Anderson, George L.	122219	9007	2 Jan 42	Lieut.	9468	24 Apr 45	Comdr
Baum, Edwin C.	167947	9113	15 Apr 42	Lieut. (jg)	9236	3 Aug 42	Lieut
Bean, George L.	23396	9072	24 Feb 42	Lt. Comdr.	9305	22 Feb 43	Lt. Comdr
Campbell, Herry B.	146531	9113	7 Apr 42	Comdr.	9374	2 Sep 43	Comdr
Chovan, Walter J.	136758	9072	24 Feb 42	Lieut. (jg)	9468	16 Feb 45	Comdr
Clark, Charles W.	146530	9113	15 Apr 42	Ens.	9468	7 Jun 45	Comdr
Gibson, William M.	136759	9072	24 Feb 42	Lieut.	9468	1 Oct 46	Capt
Gossett, Franklin R.	122220	9007	2 Jan 42	Lieut. (jg)	9468	1 Feb 45	Comdr
Graham, Lyman D.	136755	9072	24 Feb 42	Lt. Comdr.	9468	22 Oct 45	Capt
Guthrie, John t.	199056	9284	1 Jan 43	Ens.	9468	21 Feb 46	Lieut
Hicks, Edgar F., Jr.	136760	9072	24 Feb 42	Lieut. (jg)	9468	3 Jan 45	Comdr
Jarman, Junius T.	167945	9072	2 Mar 42	Lieut. (jg)	9468	16 May 45	Comdr
Laskowski, John	167946	9113	15 Apr 42	Lieut. (jg)	9468	9 Mar 45	Lt. Comdr
Marshall, Robert A.	146532	9113	7 Apr 42	Lieut. (jg)	9468	14 Dec 44	Lt. Comdr
McCarty, Robert W.	168376	9113	7 Apr 42	Ens.	9468	7 Mar 46	Lt. Comdr
Pfau, Ralph L.	122221	9007	2 Jan 42	Lieut.	9468	7 Feb 45	Comdr
Riddell, Fred A.	168377	9187	1 July 42	Lieut.	9468	9 Apr 46	Comdr
Sanders, Ira T.	122222	9007	2 Jan 42	Lieut. (jg)	9468	6 May 46	Capt
Scaife, William M.	146533	9113	15	Lieut.	9468	19 Apr 45	Comdr

