U. S. DEPARTMENT OF COMMERCE

R. P. LAMONT, Secretary

COAST AND GEODETIC SURVEY

R. S. PATTON, Director

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ANNUAL REPORT

OF THE

DIRECTOR, UNITED STATES COAST AND GEODETIC SURVEY

TO THE

SECRETARY OF COMMERCE

FOR THE

FISCAL YEAR ENDED JUNE 30, 1930

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National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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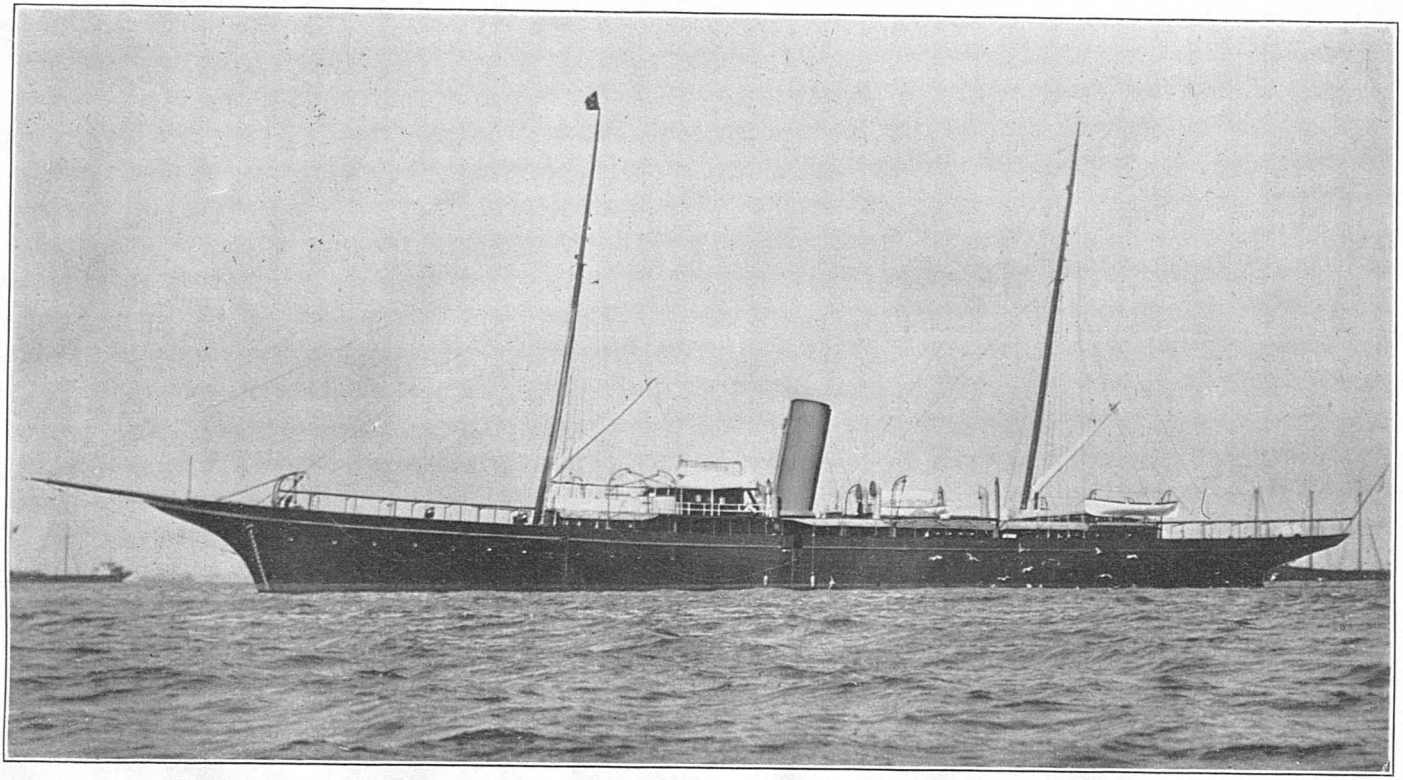


Surveyship "Oceanographer, "formerly "Corsair II," donated to the Government January 1, 1930, by Mr. J. P. Morgan

CONTENTS

	Page
Introduction	1

Part I.—FUNCTIONS OF THE BUREAU, ITS PROGRESS AND NEEDS

The chart	3
Control surveys	7
Tides and currents	10
Terrestrial magnetism and seismology	12
Airway maps	14
Instruments	16

Part II.—AIR PHOTOTOPOGRAPHY

Part III.—IN THE FIELD

Hydrographic and topographic work	21
Geodetic work	25
Magnetic and seismological work	27
Tide and current work	28

Part IV.—THE WASHINGTON OFFICE

Chief clerk	32
Division of hydrography and topography	32
Division of geodesy	33
Division of charts	34
Division of terrestrial magnetism and seismology	35
Division of tides and currents	36
Division of accounts	38
Instrument division	38
New charts	39

Part V.—DISTRIBUTION OF PARTIES DURING THE FISCAL YEAR ENDED JUNE 30, 1930

Division of hydrography and topography	42
Division of geodesy	45
Division of tides and currents	46
Division of terrestrial magnetism and seismology	47

ILLUSTRATIONS

Frontispiece.	
1. Comparison of results—airphototopography and ground methods	18
2. Organization chart	32
3. Airway mapping progress	47
4. Airway mapping program	47
5. Condition of field work to June 30, 1930, approaches to Panama Canal	47
6. Condition of field work to June 30, 1930, Porto Rico and Virgin Islands	47
7. Condition of field work to June 30, 1930, Hawaiian Islands	47
8. Condition of field work to June 30, 1930, Philippine Islands	47
9. Condition of field work to June 30, 1930, Alaska	47
10. Condition of field work to June 30, 1930, United States	47

REPORT OF THE DIRECTOR
UNITED STATES COAST AND GEODETIC SURVEY

DEPARTMENT OF COMMERCE,
COAST AND GEODETIC SURVEY,
Washington, July 1, 1930.

The honorable the SECRETARY OF COMMERCE.

DEAR MR. SECRETARY: There is transmitted herewith my second annual report. This report is for the fiscal year ended June 30, 1930, and is the ninety-ninth annual report of this bureau.

INTRODUCTION

This report marks the completion of 114 years of active service of the Coast and Geodetic Survey. Although created by act of Congress in 1807, field work was not begun until 1816. Its scope was limited at first to surveys and the subsequent operations necessary to the production of charts for the guidance of mariners traversing the waters adjacent to our Atlantic coast. That scope has gradually been expanded with the growth of the Nation.

The present functions of this bureau, defined in terms of the products given to the public for its use, consist of—

A. The nautical chart.
B. Related nautical publications.
C. Control surveys in the interior.
D. Tidal and current surveys and data.
E. Terrestrial magnetism; investigations and data.
F. Seismology; investigations and data.
G. Airway maps.
H. Technical work for other Federal agencies.

Each of these projects is an important one, and most of them will continue indefinitely at the determined rate of progress. The interests served by this bureau are in the fields of (1) maritime commerce, (2) aviation, (3) engineering, and (4) applied science as devoted to certain practical fields of industry and commerce. The relationship of this bureau to each of these interests is one to promote development and render service.

Two items of outstanding interest for the past year are significant; not of past achievement, but because of the opportunities they afford for greater future accomplishment.

1. The administration and Congress united in the decision to give practical effect to the so-called Temple Act, passed in 1925, which authorized the completion of the topographic map of the United States, including the necessary control surveys, in a period of 20 years. The amount appropriated for 1931 to be expended for control surveys was increased from $88,600 to $316,624. This project is

a definite, measurable one, which will be substantially completed in 12 or 13 years if appropriations equal to the present one are continued. Thereafter, a much smaller sum will be adequate for annual revisions and replacement of destroyed stations.

2. Last fall Mr. J. P. Morgan donated his yacht, the *Corsair II*, to the Government, stipulating that it be used for the work of the Coast and Geodetic Survey. The vessel is now in service, renamed the *Oceanographer*. It is a stanchly built, able seagoing yacht, in excellent condition throughout. Although 30 years old, it is still good for perhaps 10 years of minimum cost operation, and a further period at gradually rising costs of upkeep. It will be used to expedite the urgently needed resurvey of our Atlantic continental shelf. This donation obviates the necessity of building a vessel for this offshore work, and saves the Government approximately half a million dollars.

The past 10 years have been a period of unprecedented national progress, which has multiplied the demands for service from the bureau. During the same period bureau methods and processes have been thoroughly overhauled, and an effort has been made to bring all operations up to a maximum efficiency. This internal modernization, combined with moderate increases in some appropriations, has enabled the bureau reasonably well to meet the increased demands upon it.

Lack of an adequate number of technical employees is by far the most serious situation which confronts the bureau to-day. Some relief was afforded for 1931, but this was not enough, and it is earnestly hoped that the Budget for 1932 may carry funds adequate to meet the present critical situation.

Part I.—FUNCTIONS OF THE BUREAU, ITS PROGRESS AND NEEDS

THE CHART

This is the most important product of the bureau's work. Some 700 different charts are published covering the navigable tidal waters under the jurisdiction of the United States, including the Philippine Islands. Extensive portions of these waters, and as a rule the most important areas, are subject to constant changes resulting either from the works of man or from the operation of natural forces. Artificial channels and basins are dredged, or subsequent to dredging are shoaled by wave and current action; terminal facilities are built or altered; aids to navigation are in a constant state of flux due to changing requirements or the destructive action of storms; wrecks occur, to become a menace to shipping; improvements in the art of navigation require additional charted information; and on a sandy or alluvial shore, such as our Atlantic and Gulf coasts, natural changes are in constant progress.

In consequence the new chart, which may have been perfect when delivered from the printing press, tends quickly to become obsolete with respect to some details of the information shown. The charts must be revised constantly to keep them up to date. The most important ones are reprinted from four to six times a year. Others covering areas of less importance, or where the changes are slower, are reprinted less frequently, but the average for all charts is two reprintings a year. In so far as possible, all new information received since the last issue is incorporated in each reprinting. However, every copy of any chart, before it is allowed to leave the Washington office, is corrected by hand to show such changes as aids to navigation, depths in important channels, and dangers to navigation. During the past year 1,166,891 such hand corrections were made to the charts issued.

Field surveys.—For the bureau to attempt, by its own independent field work, to resurvey all the areas in which changes are known to have occurred would be an unnecessary duplication of effort. Reliable data from every available source are accepted and applied daily to our charts; but their application is only possible because, at some time or other, our field parties have supplied the comprehensive surveys which serve as the framework to which this supplemental information can be fitted.

In the course of years and after continued applications of such material, the framework itself becomes unable to support the burden properly, and complete new construction is necessary. The period through which a basic survey will remain adequate as a background depends on the quality of the data and workmanship involved, changing needs, and variation in shore lines.

The bureau either has comparatively recent or is making sufficient progress on new surveys of the Pacific coast, inclusive of Alaska, Hawaii, and the Philippines, almost to meet the present needs of commerce. These surveys, which for the most part are along rocky coasts, and consequently stable, are being made with modern equipment and methods.

On the Atlantic and Gulf coasts, however, the situation is quite different. Here, along a tidewater shore line of approximately 18,000 miles, where both natural and artificial changes are rapid, the original surveys for the most part date back at least 50 years. Furthermore, these surveys were made by methods long since considered obsolete and with no idea of the rigid requirements of the present-day navigator or of the varied purposes for which modern hydrographic and topographic surveys are used.

It is obvious, therefore, that existing surveys along the greater portion of the Atlantic and Gulf coasts can no longer be used as basic surveys. This not only seriously affects the adequacy of charts but also handicaps the bureau in supplying information and data to the public as required by law.

To illustrate the present inadequacy of one Atlantic coast chart, the bureau received during the previous year more than 40 letters from masters of vessels and fishing companies requesting a resurvey of the water areas in the vicinity of Georges Bank. The ships *Lydonia* and *Oceanographer* were assigned to this project and a successful start had been made at the close of the fiscal year.

The size of the undertaking and the difficulties which will be encountered throughout by our survey ships on this single assignment can be partially realized when it is visualized that the region being surveyed extends seaward off the New England coast for a distance of over 200 miles and comprises an area of approximately 15,000 square miles. It lies partly in one of the principal steamship tracks of the world and partly on one of the world's most important fishing banks. It is enveloped in fog over 50 per cent of the surveying season and is in a locality of strong and irregular currents as well as of frequent storms.

The employment of echo sounding and radio acoustic range finding, methods making practical use of the accurate timing of sound in water, coupled with the recent acquisition of the ship *Oceanographer*, will make it possible, despite handicaps and hazards, to accomplish this survey with an accuracy and dispatch that was impossible five years ago.

The development of echo sounding has likewise presented the mariner with a very valuable instrument, particularly when navigating in localities adequately charted. Without reducing the speed of his vessel it is possible for him to have a continuous record of the depths over which he is passing. If the chart shows the configuration of the bottom accurately, and in sufficient detail, these records can be used in fixing the position of his ship even under weather conditions which render other methods of no avail. On the other hand, if the chart does not portray a true contour of the bottom, the position of his ship becomes uncertain. This doubt means greater precautions, slower voyages, and increased operating ex-

penses. It can readily be understood, then, why the development of echo sounding has accelerated the demand for more accurate and more detailed surveys, as well as the extension seaward of such surveys.

Additional facilities required.—Congress has recognized the need for speeding up our offshore hydrographic surveys in recent appropriation bills. It is believed the *Oceanographer* (recently acquired) and the *Hydrographer* (under construction) will care for the increased work so far as they can execute it economically; that is, offshore surveys in exposed localities. There is, however, urgent need for a smaller, shallow-draft vessel for work in the many bays, harbors, rivers, and sounds along the Atlantic coast. As stated, the greater proportion of these are badly in need of new basic surveys.

There is also needed an additional seagoing tender of 70 to 90 tons for use as an offshore radio acoustic ranging station in conjunction with the larger ships engaged in offshore surveys on the Atlantic coast. For maximum economy the tender should be large enough only to provide good seagoing qualities. This type of boat is also suitable for small-area surveys or resurveys on the outer coast.

Finally, there is urgent need for additional field engineers. The authorized number of these engineers stood at 141 from July 1, 1919, to July 1, 1930. This number was hardly adequate in 1919. Since that date the demands on the bureau have increased materially. This increase was met in part by provision of larger modern ships requiring increased officer complements for economical operation. While needed officers were supplied the ships in part by discontinuing wire-drag and small revision surveys, yet every ship and other major party operating remains undermanned.

Each of our major ships costs about $12,600 a month to operate. Two additional officers costing $179 a month each would add 15 to 20 per cent to the productivity of a ship with no appreciable increase in other costs. A new ship is now approaching completion, but to man it will seriously increase present shortages elsewhere unless additional personnel is provided.

A minimum of 21 additional officers was required to meet the situation. For 1931 an increase of 11 of these officers was granted, as well as a further increase of 12 for the specific purposes of manning the newly acquired ship *Oceanographer* and carrying on the enlarged program of control surveys. This leaves a shortage of 10 officers, which it is earnestly hoped will be supplied in the next appropriation.

Chart publication.—There flows into this bureau a constant stream of information resulting from its own surveys in the field or furnished by the scores of cooperating agencies—Federal, State, municipal, and private—engaged on work to which the collection of data of value to the chart is an incidental by-product. The primary purpose of the division of charts is to fill all orders for the 576 charts of the coasts of the United States, Porto Rico, Canal Zone, Alaska, and the Hawaiian Islands now published, with charts corrected to date from all available information affecting them. As surveys are extended into sections where more detailed charts are required, they are prepared and published.

During the past year 282,000 charts were distributed to Government agencies and the public, an increase of 13 per cent over the previous year. Of this number, 154,000 were sold, the receipts totaling over $80,000—a 50 per cent increase over the sales of five years ago and the largest number sold in the history of the bureau. These figures show the rapidly increasing demand for our products and the ever-expanding service rendered to the public.

Charts are a basic implement of water-borne commerce, as essential to the ship as the compass, the radio, or the rudder. As our ports and harbors grow, the charts must grow with them. The millions spent annually on harbor improvements, port works, lighthouses, and buoys, as well as the elaborate hydrographic and topographic surveys by the field force of this bureau, would be partly wasted if these changes and improvements were not shown on the charts.

To constantly revise the 576 charts of our coasts—to study, digest, and finally apply to them the elaborate surveys continuously being made by this bureau, the harbor improvements by the Corps of Engineers, the thousands of changes in lights and buoys by the Lighthouse Service, hundreds of reports on all kinds of subjects, such as wrecks, newly discovered dangers, changes in names, changes in anchorage limits, fishing limits, and the like—this is a job requiring men familiar with the needs of the mariner and trained in the technicalities of chart construction and production. It demands experienced cartographers, who digest, verify, and compile these records and reports; photographers, engravers, and lithographers, who produce the plates with exacting accuracy; pressmen, who print the chart with the perfection commensurate with so important a document; draftsmen, who make the final additions to each copy, by hand, of information received after printing just before it is issued; and the distributing organization which has an inviolable rule that all orders must be filled before close of the day's business, if the chart is not out of print.

Seventeen new charts were issued during the past year, as compared to 16 during the previous year. A list of 14 new charts, urgently demanded, which have been tentatively approved, faces the bureau at this time, but there is need for many more. In addition, requests have been made for the charting of new kinds of information involving additional work, to say nothing of special work of various kinds for other bureaus and departments, and the preparation of maps and various illustrations for the publications of this bureau. It has been necessary to subordinate all this work to more urgent requirements in order to meet the demand for charts already published.

With every indication that there will be a large increase in the amount of material to be charted, the organization faces a truly critical situation. Unless a sacrifice in the quality of the charts is made, the situation can not be met except by an increase in personnel and equipment. A personnel increase involving an additional expenditure of approximately $32,000 per annum has been proposed, and it is hoped that the urgency of this increase will be recognized.

The increase in quantity of charts distributed probably falls heaviest on the distributing organization. This section has kept up to a high standard of efficiency in spite of the increased burden. One

item alone will demonstrate the amount of the increase—correspondence increased during the year from 25,118 letters and circulars to 34,992, an increase of almost 40 per cent.

CONTROL SURVEYS

It has already been stated that one of the items of outstanding interest during the year was the adoption of a program for expediting completion of the control surveys of the United States.

The layman may be in some doubt as to just what control surveys actually are and the purposes they serve. To him the chart or the coast pilot is a definite, tangible product. He can handle it, examine it, and understand its uses. The meaning and value of the control survey, however, are not so readily grasped, because that survey is not a tangible thing; not an end in itself, but rather a means toward many different ends. It is a tool for reducing the cost and insuring the accuracy of all those engineering operations which involve an exact knowledge of the relationships between points located throughout an extensive portion of the earth's surface.

All surveying and numerous engineering operations not usually classed as surveying consist essentially in the measurements of directions and distances, horizontal or vertical, or in various combinations of all four. Each of these measurements necessarily is only an approximation of the absolute value, from which it differs by an unknown amount which may be called the error of observation. If the work be very carefully done, the error will be relatively small; if hastily and carelessly executed, the error will be correspondingly large.

If a survey starts at a single point of origin and by repetitions of such measurements proceeds indefinitely into the unknown, these errors gradually accumulate and in time may attain to such proportions as seriously to detract from the value of the work. The difficulty may not be apparent at the time the survey is made, but later it will make trouble, as when an attempt is made to join together two contiguous surveys. It will then be found that instead of the two fitting together, there are gaps, overlaps, and offsets which throw doubt on both surveys and require extensive revision work before they can be reconciled.

Now, suppose that instead of starting a survey at one point of origin and proceeding indefinitely therefrom, we have two widely separated points of origin and know very accurately the distance and direction between them. We start the detailed survey simultaneously at each point and work toward a junction midway between them. We then accomplish a number of important things:

1. We reduce by one-half the total errors which can accumulate.
2. We obtain an accurate measure of the errors which actually have accumulated and can either distribute them throughout the surveys or revise the latter, as the facts may warrant.
3. In making the surveys we took only moderate precautions against excessive errors, because we knew that such errors would be detected before we proceeded very far. Therefore the work proceeded faster and cost less than would have been the case had it been necessary to take superprecautions to guard against errors which thereafter could not have been detected.

The foregoing briefly suggests rather than adequately explains the functions of the control surveys. Under the project on which the Coast and Geodetic Survey has been working in a moderate way for many years, and which is now to proceed at an accelerated rate, two separate networks are being spread over the whole of the United States. The first consists of many thousands of permanently marked points whose latitudes and longitudes are very accurately determined. Knowing these, the distance and direction between any two points can be readily computed. The second network consists of similarly marked points whose elevations above mean sea level have been determined with comparable accuracy. The purpose of these two networks is to control the accuracy of such detailed surveying or engineering operations as are thereafter executed.

Every map, regardless of its purpose or accuracy, must have control. Even the barest sketch of a newly discovered island, or a similar representation of a man's farm or an isolated mining claim, must be referred to some starting point, which is in reality a control point regardless of the accuracy of its determination. It follows clearly that the more accurately determined the control points are, as regards their location and elevation, the more valuable and important become the surveys based on them, especially in important areas of development or commerce. Control surveys are essential in the determination of political boundaries not only of the Federal Government but of States, counties, and municipalities as well, and for a number of years triangulation has been employed by many of the large cities of this country in city-planning projects.

Consider for a moment the practical use of control surveys as they affect the individual. All history of the human race records innumerable disputes and a great amount of litigation between property owners arising from questions regarding property lines and boundaries. While it is not conceivably possible to eliminate entirely such litigation in the future, there is no doubt that it can be reduced in amount wherever people are disposed to undergo the small expense necessary to connect their property boundaries with near-by permanent control stations. A single mark is naturally subject to change or destruction, but with thousands of such marks distributed over the country, nothing short of a cataclysm would permanently efface any considerable number of them at the same time. As long as only a few are destroyed it is always possible to go back to some undisturbed stations and from these redetermine the lost position of a boundary mark. The property lines of farm property, mining claims, or any area properly surveyed and coordinated to the control system of this bureau can be relocated at any time, even though all the corners or original landmarks of the property may have been destroyed. It is reasonably certain that the cost of relocating such property lines would be only a small percentage of the amount annually spent in boundary litigation.

The economic use and importance of maps to the commercial development of a country is constantly becoming better known. Maps are of great value to practically every enterprise that concerns land areas. They effect economies in the extension of railroads, highways, water power and irrigation projects, drainage and flood control, reforestation, in the study of evaporation and

precipitation of moisture, aviation, and in the endless enterprises where changes are brought about by the hand of man.

The demand for charts of this bureau has increased 13 per cent during the past year, and there is constantly a more insistent demand for maps of all kinds and for all purposes. Owing principally to the rapid commercial development of this country, to constantly increasing property values, and also to aviation and faster and more luxurious methods of travel, both on land and sea, the demand is not only for more maps but for more accurate maps as well.

The triangulation system of this country was first started on the Atlantic coast for the particular purpose of controlling surveys of the coast and off-lying shoals, but with the development of other sections and the extension of our boundaries, requiring similar control, there soon resulted a number of isolated sections of triangulation, each independent of the others. These arcs of triangulation were gradually extended and connected into a single framework. The triangulation in the western half of the United States has been extended sufficiently to permit the final adjustment of positions for that part of the country west of the ninety-eighth meridian. Work is now progressing along a number of arcs east of the ninety-eighth meridian, which, with existing triangulation, will be used for a similar adjustment in the eastern half of the United States. With the completion of these adjustments positions for the control of maps and charts in this country should remain fixed indefinitely.

Through international agreements with Mexico and the Dominion of Canada, the control surveys of those two countries and the United States are based on one datum, known as the North American datum. This arrangement is particularly advantageous to this country, as it is desirable to coordinate the surveys of Alaska into the same system. Through cooperation with the Dominion of Canada, control surveys in southeast Alaska are now adjusted to the North American datum by means of a connection through Canadian surveys of the same order of accuracy in British Columbia. For interior and western Alaska, however, the control necessarily must remain based on independent datums until such time as it is possible to extend triangulation through the interior, again through cooperation with Canada.

The advantages of vertical control should be obvious. Indescribable confusion always results when elevations are referred to different datums, a natural and inescapable result where there is no central agency to extend standard elevations over the country. With the development of the country, engineering projects are eventually brought together and require the adoption of a standard datum, based preferably on mean sea level, and the extension of this datum over the country. It is the only means whereby great confusion and useless expenditure of funds can be avoided.

In any work of this highly scientific character it is necessary to conduct investigations, both in the field and in the office, for more efficient and economical methods of procedure and for the development of better instruments. An instrument has been designed in the shops of this bureau for use on triangulation which is more safely portable, less liable to damage in field use, and which can be handled

more rapidly than any instrument previously used. As a result, the number of stations at which the observations must be repeated to secure the prescribed accuracy has been considerably reduced during the last two years, as has also the average length of time required to occupy a station. New steel towers recently adopted to elevate instrument and observer above the tree tops, or to overcome the curvature of the earth's surface, have proved their usefulness and economy to a greater degree than ever before in the extension of the belt of triangulation along the Mississippi River during the past winter. Owing to the generally flat character of the country and to the large areas of tall timber, the instrument had to be elevated at every station. Sixteen steel towers, costing a total of $9,600, were used on the 190 stations of this work with practically no deterioration or damage. The average height of these towers was 116 feet, and the cost of a lumber tower would have amounted to approximately $600 per station, not including the extra amount of labor necessary for erecting the wooden towers or the fact that the lumber could not be used a second time.

Worthy accomplishments in this field during the past year include the completion of an arc of first-order triangulation along the Mississippi River from Cairo, Ill., to New Orleans, La., which is a part of the regular triangulation net of the United States of particular value in its relation to flood-control surveys. Gravity values were determined at a number of stations in the Bahama Islands in cooperation with an international scientific expedition. A large number of important triangulation stations in the western half of the United States were adjusted to the 1927 general western adjustment. The first-order level net is in the process of an adjustment which should be held for an indefinite time. For the first time in our history geographic positions of first-order triangulation stations in Alaska are adjusted to the North American datum and issued in printed form. A large number of Laplace stations has been added to the eastern net of triangulation of the United States for the purpose of adjustment within the near future.

TIDES AND CURRENTS

The demands made upon the bureau for information based on tide and current observations are ever increasing. In response to the insistent calls of shipping and fishing interests, hydrographic operations are expanding. More ships and more men are being employed in this work, and improved methods of sounding are adding to the volume of work accomplished.

The tidal control for this work involves the establishment of an increasing number of primary and secondary tide stations. The locations of these stations must be carefully planned, the records from the gages reduced and verified, reference planes for soundings derived and verified, and the tide reducers in every volume of soundings substantiated. Tidal constants must be determined from each series of observations and the results correlated, compiled, and published in the annual tide tables.

To preserve the reference planes derived from the various tidal series, bench marks are established at the tide stations and connected

by levels to the tide staffs. The leveling records must be verified and the descriptions and elevations of the bench marks prepared for permanent file and published to meet the demands of engineers for this information. For each primary tide station the plane of mean sea level must be determined, from all the observations, for use as a reference plane for leveling work. Information from the tide records which is of special importance to the navigator is furnished for publication in the Coast Pilots.

All of the above work is of great economic importance and it is vitally necessary to engineering and commercial interests and to the public at large that it be kept up to date.

Engineering projects of all kinds which are executed on or near tidewater must take into account the rise and fall of the tide and the velocity and direction of the tidal current, and a full knowledge of these phenomena may be worth thousands of dollars to the individual or firm engaged in such engineering work.

Many channels can be navigated safely by deep-draft vessels only at or near high water, and accurate predictions of the times of the high waters as given in our tide tables are an absolute necessity for the navigation of such channels. Current tables are at least equally important to the navigator, for in places the currents are so swift and treacherous that a safe passage can be made only at slack water, and the times of the slack waters must be definitely known in advance. Apart from the question of safety, a favorable current often means a great saving in time and money. Predicted currents furnish the only means for taking full advantage of this saving.

To meet in an efficient manner the varied demands of many interests desiring data on tides, currents, datum planes, and related subjects, the division is preparing, as rapidly as the pressure of urgent routine work will permit, three series of publications in addition to the annual tide tables, current tables, and occasional miscellaneous publications.

1. A series of publications on tides and currents in the important harbors and waterways of the United States and its possessions. One or more of these publications are being prepared each year. They contain all the available tide and current data for the areas involved, including the results from a recent current survey for each area.

2. A series of tidal bench-mark publications giving for the use of engineers and surveyors the descriptions and elevations of the tidal bench marks in the States along our coasts. The publications of this series are being issued at the rate of about two a year.

3. A series of tidal-current charts giving for the more important harbors of the United States the details of the current movement for each hour of the tidal cycle, and at the same time presenting a comprehensive view of the movement for the harbor as a whole. One of this series has already been issued and others are in process of preparation.

Each of the above-mentioned series of publications is filling a long-felt need in its particular field and the insistent calls for similar information for additional areas prove the value of each series.

The harbor publications are at present being issued about two years after the completion of the corresponding current surveys. The

bench-mark publications now cover about one-half of our coastwise stations. The remainder of the coast line should be covered by these publications, and the older bench-mark publications are already in need of revision. The preparation of several tidal-current charts has been delayed for some months by the pressure of other work.

Owing to a great increase in the work of the division and the attempt to supply the increased requirements of the public for authentic tide and current information by means of publications and otherwise, the office work of the division has for years been steadily increasing with no increase in personnel. To take care properly of this increase of work there will be required the services of an additional associate mathematician and at least one subprofessional grade employee. This need for increased personnel is becoming more and more urgent, and the reduction and publication of valuable data are being delayed considerably in spite of increased efforts and increased efficiency on the part of the personnel.

TERRESTRIAL MAGNETISM AND SEISMOLOGY

Magnetic work.—The magnetic work of the Coast and Geodetic Survey, begun as one of the essential steps in the preparation of nautical charts, has been broadened to meet the needs of the land surveyor, the aviator, the prospector for oil and magnetic iron ore, and the radio engineer.

When no landmarks or heavenly bodies are visible the navigator of the sea or of the air depends on the compass to guide him. The compass does not in general point true north, however, nor is its direction at any place constant. The mariner's chart and the airway map must therefore give information regarding the compass variation (the amount by which the compass needle points east or west of true north).

The surveyor's compass was one of the earliest forms of surveying instruments, and for nearly all of the early land surveys in the United States the boundaries were defined in the deeds by compass bearings. Even at the present time it is in general use where land values are low and more accurate and expensive methods are not justified. When a surveyor is called upon to retrace the lines of an old compass survey, he must know how much the direction of the compass needle has changed in the interval since the original survey.

The prospector making use of magnetic methods in his search for oil requires a knowledge of the general distribution of the earth's magnetism in the area under investigation. Departures from this general distribution shown by his observations may serve to indicate irregularities in underground geological formations which are associated with the presence of oil.

The transmission of messages by telegraph and cable is frequently interrupted by currents of electricity in the earth, and electricity in the air has a material effect on the transmission of radio waves, and these electrical manifestations are in turn closely allied with the earth's magnetism and its fluctuations.

To meet these various needs the bureau has made a magnetic survey of the country involving observations at about 5,000 places. At many of these places permanent marks were set and the true

bearings of a number of prominent objects were determined in order to provide local surveyors with means for testing their compasses. Similar observations have been made in Alaska and the various insular possessions. To keep track of the change of the earth's magnetism with lapse of time, about 200 repeat stations are occupied at intervals of about 5 years, and 5 magnetic observatories are maintained at which continuous photographic records of the changes are made.

The results of these observations are published from time to time in various forms to meet the varying needs.

During the past year the field work in terrestrial magnetism has been devoted primarily to observations at repeat stations in order to determine the change of the earth's magnetism with lapse of time. In addition, a considerable number of lost stations were replaced at the request of local surveyors, to provide them with means for controlling their surveys. With the close of the present field season, the 5-year program of repeat observations will have been completed and the necessary results will be available for bringing our magnetic charts and secular-change tables up to 1930.

The five magnetic observatories have continued in operation. Working conditions at the San Juan observatory have been much improved by the erection of an office building to replace the one destroyed by hurricane in 1928. At the Tucson observatory, through the cooperation of the department of terrestrial magnetism of the Carnegie Institution of Washington, atmospheric electric observations have been made continuously since September, 1929. The building and instruments were supplied by that institution, and the work is being carried on by the observer in charge of the magnetic observatory.

Special attention is being given to the improvement of the instrumental equipment of the observatories, by replacement or modification. Most of the variation instruments have been in continuous use for 25 years or more and have necessarily deteriorated. Moreover, in that time there have been many new developments of which it is important to take advantage.

Seismology.—In 1925 this bureau was charged by law with the making of seismological investigations, and the work in this comparatively new field is being developed gradually.

The coming of an earthquake can not be foretold, but from a knowledge of the general geologic structure of the earth and of where and when earthquakes have occurred in the past it is possible to indicate in a general way that earthquakes are more likely to occur in some places than others and that destructive shocks may be expected only in certain limited regions. These are factors which enter into the selection of a dwelling place, the erection of buildings, the construction of dams, laying of water pipes, and other public works, and the placing of insurance.

An earthquake history of the country has been compiled by this bureau as a basis for such an estimate, but back of the past century the information is very fragmentary. Arrangements have been made for collecting more detailed reports regarding future earthquakes as they occur, with the aid of numerous cooperative observers

all over the country. Records of other than purely local minor shocks are secured on seismographs operated at the magnetic observatories at Tucson, Ariz., and Sitka, Alaska; at Honolulu in cooperation with the University of Hawaii; and at Chicago in cooperation with the University of Chicago. Provision has been made in the new office building at the San Juan, P. R., observatory for the installation of a modern seismograph to replace the inferior one destroyed by the hurricane of 1928. More stations are needed, however, to cover the country adequately, and arrangements have been made for establishing three additional stations to be operated by State educational institutions.

These instrumental records serve to determine the time and place of occurrence of earthquakes in inaccessible regions, particularly in the ocean areas, and furnish a most important contribution to our knowledge of the structure of the interior of the earth.

These instrumental and personal earthquake records are not sufficient, however, for the structural engineer who is called upon to design buildings or other structures that may be expected to withstand an earthquake shock. He wants to know more accurately what happens in the region of greatest disturbance; the amount of ground movement, the velocity of the motion, the period of vibration, and how these factors are related to the nature of the subsoil.

Plans for supplying this information are being made, involving the design of suitable instruments to be installed in regions where earthquakes are most likely to occur, and laboratory studies with model structures mounted on a platform to which motions simulating an earthquake may be given.

Additional requirements.—The outstanding need is for additional office force to keep pace with the development of the work. This would be met by the addition of four scientists. In the field the important needs are for an additional office building at the Cheltenham, Md., observatory, where the space at present available was never sufficient and with increased activity has become wholly inadequate, and the replacement of one of the observatory buildings at San Juan, P. R., which has proved unsatisfactory because built too cheaply. Additional instruments are needed in connection with the current program. For carrying out the proposed investigations in the central region of an earthquake there will be needed provision for both additional personnel and instrumental equipment.

AIRWAY MAPS

Just as the mariner needs charts to guide him along the waters of our coasts, so the aviator needs maps to guide his cross-country flights. Congress has recognized this need and, in the air commerce act of 1926, charged the Secretary of Commerce among other duties with the function of providing such maps. Because of the basic similarity between charts and maps, the Secretary of Commerce delegated the function to the Coast and Geodetic Survey.

The first task undertaken was the mapping of the strips designated as United States airways. These maps cover strips of territory 80 miles wide extending, individually or in series, from one important airport to another. The present program embraces 42

such maps, of which 22 have been completed, 7 are now in hand, and 13 remain to be undertaken. This program supplements others adopted by the Army and Navy, primarily to meet military requirements.

Although the preparation of these maps has barely emerged from the experimental stage, the demand is increasing at a rate far beyond expectations. Each edition now printed is four times as large as the editions printed in 1927–28.

As aviation has developed it has tended more and more to deviate from these few specific routes. Planes now fly everywhere, and at present about 80 per cent of all flying is over routes which do not follow the airways. It has therefore become necessary during the past year to start work on a new project. This consists of a map of the entire United States, divided for convenience into 92 sections. Each section joins exactly with those surrounding it, so that the pilot, by selecting the proper sections, can have a continuous map covering any flight he may wish to make within the United States.

The first of the sectional maps is now being printed. They are in many respects an innovation, and require exhaustive study and experiment to determine the features to be shown, the best way to show them, to say nothing of the methods of production. Both the prospective users of the maps and those having knowledge of map construction have been consulted frequently in order to obtain the best possible results. While production may have been delayed to some extent, a firm foundation has been laid for increased production in the future.

The Government is spending millions in marking and lighting the airways, yet the maps lag far behind. With the small force now available for this work, the number of strip maps has been doubled during the past year, and considerable progress has been made in the preparation of six of the series of sectional maps, yet the supply does not begin to meet the demand.

Production of these flight maps is greatly hampered and made exceedingly difficult and time consuming by the lack of the standard topographic map of the United States. The flight map is essentially a small-scale topographic map to which certain information of particular importance to aviators has been added. If the standard topographic map were available, it would be an easy matter to simplify and reduce it to the proper scale and add the special aeronautical details. Under such conditions both projects could be completed by a small force in a few years.

However, only about 40 per cent of the country has been covered by the standard topographic map, and of that 40 per cent about half was done so long ago that great difficulty is experienced in attempting to use it. With respect to the remaining 60 per cent the situation is even more serious. Material is secured from every available source, largely from the States; highways from one source, railroads from another, drainage and relief from a third, and so on. It then is necessary to fit all these separate items of information into one properly coordinated whole. It is a difficult task, because the relationships between the various items, which are the thing of maximum importance to the aviator, are usually the feature subject to the greatest relative uncertainty.

Under these conditions a flight check of the compiled map is required. By this method, an experienced officer can verify the more important features and detect omissions in a comparatively short time. The number of maps now ready for flight check will require the exclusive use of a plane during the coming year. This work has been hampered by the lack of any provision for the payment of traveling expenses to a commissioned officer engaged on this duty.

The need for airway maps to meet the requirements of commercial flying is urgent. The map-producing force should be augmented to complete the present program in the shortest possible time.

INSTRUMENTS

The work of this bureau is such that the quantity and quality of the results obtained are directly affected by the quality of the instruments used. In many cases the instruments are of a highly special nature and many have been developed by the bureau itself, as they could not be obtained elsewhere, the work of the bureau being unusual in its nature and procedure. The instrument division of the bureau has therefore always played an important part in the bureau's activities.

In recent years this division has developed a number of new instruments which have resulted in increased accuracy in the field work and in considerably greater output. In other cases it has been able appreciably to reduce the cost of such instrumental equipment. Among the more important developments are:

1. A first-order theodolite, used in primary triangulation survey. The use of this instrument has permitted the completion of a set of observations in a considerably shorter period of time than has been possible heretofore.

2. A second-order theodolite, similar in design to the first-order instrument, but smaller and lighter and with slightly lower accuracy, will be used to increase the accuracy of certain types of work without additional increase in time of observation.

3. A vertical collimator, for centering the surveying instrument over a permanent station mark, where take-down steel towers are used in triangulation surveying. This is a much more convenient instrument for the purpose than the one previously available, and centering can be accomplished with as great a degree of accuracy as is required.

It is essential to the work of this bureau that its instrument division should function with a high degree of efficiency in order that an adequate supply of the great variety of instruments which we use shall at all times be available. The cost of operating field parties is such that delay in receiving equipment is an expensive matter to the Government. It is also essential that this division should be in a position to develop such new instruments, and to make such changes in design in them, as may be found desirable and in keeping with advances in the scientific knowledge upon which these instruments are based.

Many attempts to obtain development of these special instruments through private firms have almost always been unsuccessful,

as the engineering knowledge necessary to produce them is not available elsewhere in this country, nor do foreign firms understand the conditions under which the work is carried on. Instruments are developed by the bureau through the combination of the engineering knowledge and experience in the field, which dictates the requirements of the instruments to be developed, and the scientific and engineering knowledge in the office which is requisite to produce them. The bureau has been greatly handicapped in this work by lack of personnel.

The recent increase in appropriation for geodetic work will further handicap this division and development of new instruments will be practically at a standstill unless an increase in its force is authorized. In order properly to maintain our regular stock of instruments and to design and produce a number of improvements which are even now being held up, five additional instrument makers are required. The cost of such an increase is so small as compared with the value of the services to be rendered that every consideration of sound business principles dictates its adoption.

Part II.—AIR PHOTOTOPOGRAPHY

During the past year the bureau has made an intensive study of the relative merits, for the topographic surveys necessary to chart production and correction, of the present ground methods and of surveys by aerial photography.

For several years lack of adequate personnel and funds has compelled the bureau to abandon its long-established practice of engaging regularly in revision of topographic surveys of the coasts. Comparatively little topographic work has been done, and that little has been confined largely to mapping those features which it is particularly important to show correctly on the charts, leaving unmapped the surrounding features which could have been included at a moderate additional cost, and which would have added greatly to the general value of the work. The cumulative effect of this policy, applied over a series of years, is that the charts are becoming seriously deficient in topographic information, and a method by which this deficiency could be supplied at a minimum cost is urgently needed.

With the cooperation of the Army and Navy air services a number of surveys in recent years by the aerial photographic method have been made. Until recently these surveys indicated that the accuracy required for charts on large scales could not be obtained by this method without extensive measurements on the ground for control of the photographs. This added so greatly to the cost of the work as to make it comparable with that of the ground method of survey.

The bureau is convinced, however, that this need for extensive ground control resulted largely from deficiencies in the photographic equipment used, and that it is practicable to build equipment of higher precision which will give the required results with few ground measurements. If a photo survey with the proposed equipment be made in conjunction with the sounding of the adjacent waters, the control points which are established on the ground for use in locating the soundings will serve with very little supplementing to insure the necessary graphic accuracy in both surveys. Experience indicates that in this manner a basic air-photo survey of the coast can be made for less cost than a ground survey limited to revision along the shore line only.

By this method, therefore, it should be possible gradually to restore to the charts an adequate amount of topographic detail This one fact does not exhaust the values of the method. Other agencies make similar partial surveys along the coast, each selecting those details necessary to its own particular purpose, with a resulting duplication of effort. The air-survey camera can eliminate such duplication. Its photographs show not only the details needed for one particular map but also with equal accuracy practically unlimited information in detail sufficient for compiling almost any

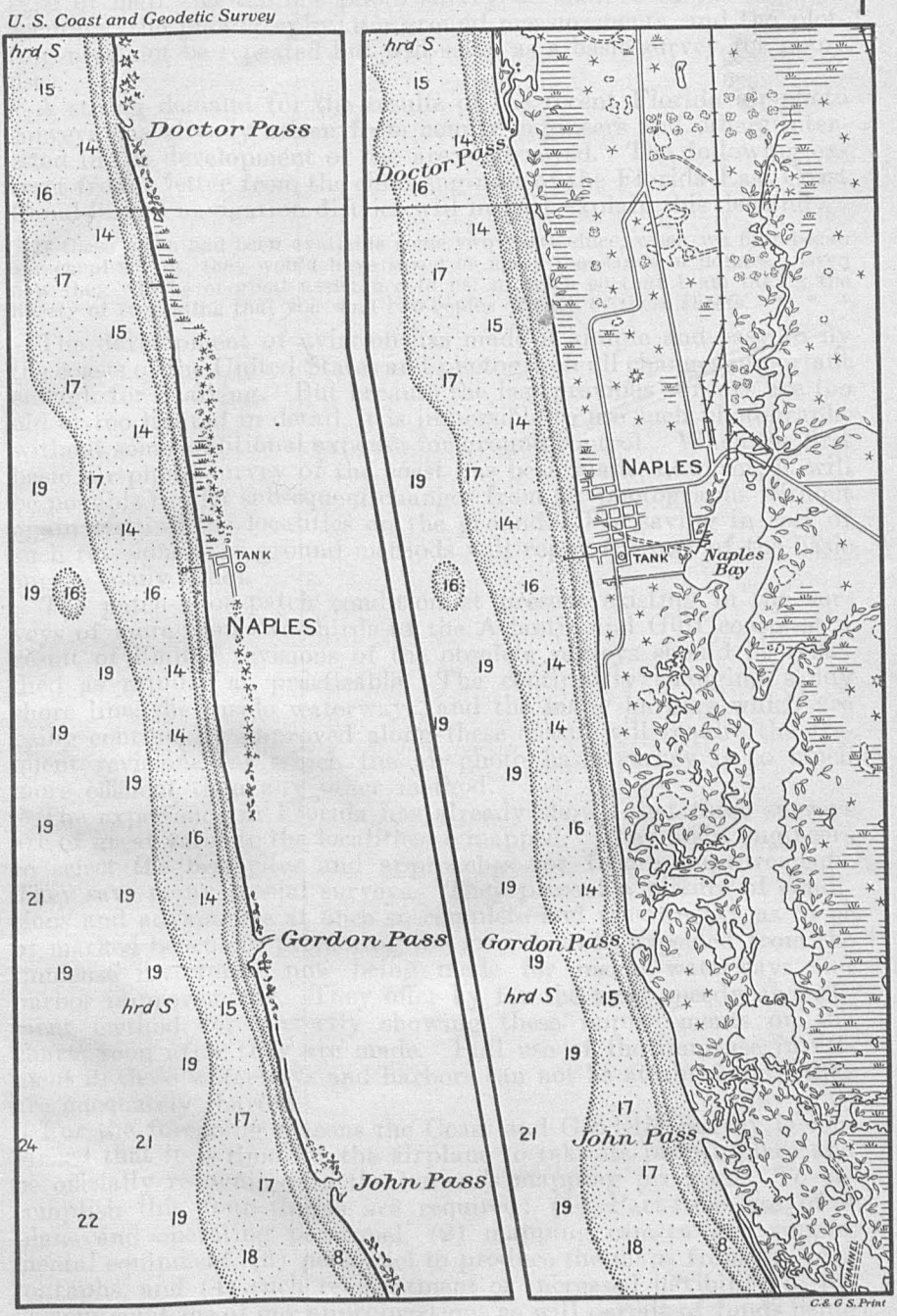


CHART OF SAME COAST BEFORE AND AFTER AIR PHOTO RESURVEY

It has become possible, by air photo methods, to obtain the topography shown on the right at no greater cost than the limited ground survey shown on the left.

type of map. If the one photo survey be made with the required accuracy, the photography, the ground measurements, and the plotting need not be repeated but will serve as a basic survey for many uses.

A strong demand for the results of the recent Florida air-photo surveys has already arisen from county engineers and others interested in the development of the areas surveyed. The following extract from a letter from the chief engineer of the Florida East Coast Canal inland navigation district will in part explain this demand:

> If these maps had been available some two years since, when we first began our canal survey, they would have saved us many thousands of dollars. Even now they will be of great assistance to us, so much so that I am taking the liberty of requesting that you send two copies of each of these sheets. * * *

The development of aviation has made it simple and easy to fly the coasts of the United States and photograph all changes important enough for charting. But because the last previous surveys are too old or too limited in detail, it is impossible to use such photographs without some additional expense for ground control. When the first basic air-photo survey of the coast has been made, however, it will be possible to plot subsequent changes from air photographs without again visiting the localities on the ground. The saving in cost of such revisions over ground methods will repay the cost of the basic survey many times.

The patch-upon-patch condition at present existing in the surveys of more than two-thirds of the Atlantic and Gulf coasts as a result of limited revisions of the obsolete surveys should be remedied as rapidly as practicable. The continually changing sandy shore line, the inside waterways, and the many harbors which are being continually improved along these coasts will require the frequent revisions for which the air-photo basic survey is so much more efficient than any other method.

The experience in Florida has already shown that these surveys are of great value to the localities so mapped. They assist engineers to select the best sites and approaches for future improvements. They save many special surveys. They present a picture of conditions and advantages at once so complete and trustworthy as to be of marked benefit in promoting the growth to be expected from the immense investment now being made for inside waterways and harbor improvements. They offer by far the most speedy and efficient method for correctly showing these improvements on the charts soon after they are made. Full use of the immense investment in these waterways and harbors can not be attained until they are adequately charted.

For the foregoing reasons the Coast and Geodetic Survey is convinced that it is time for the airplane to take its proper place and be officially recognized in the bureau's mapping program. To accomplish this four things are required: (1) Part-time use of a plane and operating personnel, (2) mapping camera and supplemental equipment, (3) personnel to produce the maps from the photographs, and (4) such readjustment or increased flexibility in the various subitems of our appropriations as will permit of funds being used for the new method.

None of these requirements should present any serious difficulty. Beginning July 1, 1931, the Aeronautics Branch of the Department of Commerce plans to furnish a plane and pilot for this bureau's exclusive use on the flight checks of the airway maps.

General plans for the photographic equipment have been worked out; and detailed specifications can be ready by the time funds become available.

The fourth requirement necessitates some explanation. At present separate appropriations are made for different items of work; for operating expenses of field parties in different localities engaged on different kinds of work; for the repair and upkeep of ships; for the crews of ships; for commissioned officers; for office personnel, etc. No part of funds appropriated for any one item can be used for any of the others.

The mapping of a 100-mile strip of coast by the present ground method would require a topographic party working in the field for five or six months. At the end of the time the party would deliver to the office a finished product, ready for application to the chart. Its cost would be about $5,000, all chargeable to appropriations for field expenses and for pay of field engineers. To survey the same strip from the air would require less than a day of actual flying time. The product, however, would consist of some hundreds of photographs, requiring three or four months' work by a small office force, at a total cost of about $4,000 to finish a much more detailed and therefore a better product than that produced by the field party. About 30 to 35 per cent of this cost would be chargeable to a field appropriation and the remainder to that for pay of office force.

Since justification for the new method rests on the conviction that more and better work can be done for the same money, it is illogical to request additional funds to put the new method into effect. On the other hand, it is only by experience that the exact amounts of the transfers which should be made among the different appropriation items can be determined. The most satisfactory procedure, therefore, for the few years which will constitute the developmental stage of the new method will be for Congress to grant a limited authority to spend funds from the existing appropriations, and this authority is being sought in connection with the 1932 Budget.

Part III.—IN THE FIELD

HYDROGRAPHIC AND TOPOGRAPHIC WORK

During the fiscal year 1930, hydrographic, topographic, and control surveys were made along various sections of the Atlantic, Gulf, and Pacific coasts, including Alaska, Hawaiian Islands, and the Philippines. To perform these surveys, which comprise 41 separate projects, 27 survey units were employed.

A brief summary of the surveys accomplished or in progress at the close of the year is given below:

Atlantic coast.—The necessary surveys were completed to make possible the construction of two new general charts between Cape Canaveral and Jupiter Inlet, Fla. These charts, Nos. 1246 and 1247, will replace Nos. 162 and 163 of the old series. In connection with this project the ground control necessary for the reduction of air photographs was established and the new charts will include the phototopography. The work on this project was accomplished by the parties on the *Lydonia*, *Ranger*, and *Natoma*.

From July to November the parties on the *Lydonia* and the *Ranger* were engaged on new surveys off the Delaware and Maryland coasts. This work extended offshore to the edge of the continental shelf and represents part of a general resurvey of the section of the coast lying between the Delaware and Chesapeake Bays. Air photographs have also been recently taken of this region and the necessary ground control was established for that section along which the parties worked. During this same period the party on the *Natoma* made several surveys in Chesapeake Bay necessary in the investigation of reported changes in the charts.

The first assignment of the *Oceanographer*, which was acquired in January, was on the Gulf coast of Florida. Work was started here on a comprehensive survey of the region east of Pensacola. This project was discontinued in May in order to take up work with the *Lydonia* on Georges Bank during the summer months. Work will be continued on the Gulf project during the winter.

A wire-drag survey of Long Island Sound was started near the end of the fiscal year. The necessity for this work has been recognized for several years, but it was not until this year that funds have been available. A wire-drag examination was made of a reported shoal area in the vicinity of Ambrose Lightship.

Inland waterway surveys were made in Chesapeake Bay, in Lynnhaven Roads, Norfolk Harbor, Elizabeth River, Va., and in St. Andrews Bay, Fla.

A field examination was made of Delaware and Chesapeake Bays for a revision of the Atlantic Coast Pilot, Sandy Hook to Cape Henry. An examination was also made of the inland route through New Jersey for a new edition of the Inside Route Pilot, Coast of New Jersey.

A party in the launch *Elsie* made an examination of the inside route from Charleston, S. C., to New York.

Owing to the increased interest in yachting, the demand for information concerning the inside route from New York to Key West has materially increased. There has also been a big increase in the sale of Coast Pilots covering the coast from St. Croix to Sandy Hook. This is also probably accounted for by the increased demands of the yachtsman.

Pacific coast.—Complete new offshore surveys were extended along the California coast from the vicinity of Cape Mendocino southward to Pigeon Point by the parties on the ships *Discoverer* and *Pioneer*. The same parties also completed the inshore work except for the section between Bowens Landing and Point Reyes and between Halfmoon Bay and Pigeon Point. Work on the former of these two sections was taken up near the end of the fiscal year by an independent party using the chartered launch *Rogue*.

The party on the ship *Guide* having returned from a 2-year assignment in the Hawaiian Islands took up, near the end of the fiscal year, an extensive project on the Washington coast. This consists of complete new offshore and inshore surveys from a junction with previously completed work in the vicinity of Cape Elizabeth northward to Juan de Fuca Straits. The control was established and the topographic work completed for a considerable portion of this project earlier in the fiscal year by an independent shore party.

The party on the motor vessel *Westdahl* took up, as the first assignment of this new vessel, complete new surveys in Santa Barbara Channel and completed the work contemplated in time to join the *Discoverer*, as a tender, for work in southwest Alaska.

A party using the chartered launch *Rogue* completed topographic and inshore hydrographic surveys inside of completed offshore work from the vicinity of Crescent City southward to Cape Mendocino. This project also included a wire-drag survey of the anchorage in, and the approaches to, Crescent City Harbor, as well as revision surveys in Humboldt Bay.

Two parties were engaged during several months of the year in extending new schemes of coastal triangulation for the control of hydrographic and topographic surveys between Cape Mendocino and Rockport and between Point Reyes and Fort Bragg, the intermediate section between Rockport and Fort Bragg having been accomplished earlier in the year by subparties from the ship *Discoverer*.

Alaska.—The party on the ship *Surveyor* accomplished a large amount of field work along the northwest and west coasts of Kodiak Islands. Detailed surveys were made of Zachar, Spiridon, Larsen, Uganik, South Arm, Alitak, and Deadman Bays, as well as that portion of Shelikof Strait which had not been adequately surveyed. During the present season the *Surveyor* is continuing operations on the west coast of Kodiak Island. Its season's work will include a complete and detailed survey of Sitkinak Strait. The results of the surveys around Kodiak Island will be published on new charts on a scale of 1 to 80,000.

The party on the ship *Discoverer* is engaged during the present season in making new surveys along the south coast of the Kenai

Peninsula between Aialik Bay and Chugach Islands. These will include detailed surveys of Nuka Island Pass, Port Dick, and Windy Bay and will furnish the data for the construction of new and more detailed charts of that locality.

The party on the ship *Explorer*, cooperating with the United States Army Engineers and with the United States Lighthouse Service, accomplished a new survey of Wrangell Narrows. This project included the location of all the permanent aids to navigation in the narrows and the extension of surveys through Beecher Pass and Duncan Canal southward into and along the north coast of Sumner Strait as far west as Mitchell Point. This party also completed the surveys necessary to obtain data for the construction of large-scale charts of Keku Strait and extended control surveys from that locality southward along the west coast of Sumner Strait. During the present season the party on the *Explorer* is engaged in obtaining the data necessary for the construction of larger-scale charts of Behm Canal and its tributaries. Demands for such charts have increased with the proposed extension of steamer routes to include these scenic passages.

During the past year three connections were completed between the first-order scheme of triangulation through southeast Alaska and the Alaska-Canada boundary triangulation. These connections, which rigidly fix the Alaska-Canada boundary on the North American datum, were made through Taku Inlet, Stikine Strait, and Behm Canal.

Hawaiian Islands.—The party on the ship *Guide* (July to September) and the party on the ship *Pioneer* (April to June) continued work on the project which calls for a survey of the entire region between the main group of the Hawaiian Islands and Midway Island. This area, embracing a chain of shoals, reefs, and islets, which have never been properly charted, is over 2,000 miles in length and parallels the main steamship tracks between Honolulu and the Orient. The new charts resulting from the detailed surveys being made will undoubtedly shorten the steamship tracks and effect considerable saving in time and expense to trans-Pacific shipping. More than 50 per cent of this project had been completed at the end of the fiscal year. During the month of September the party on the *Guide* made detailed surveys of the anchorages and approaches to Honuapo and Punaluu, Island of Hawaii, to meet the demands for large-scale charts of these roadsteads.

Philippine Islands.—The parties on the ships *Pathfinder*, *Fathomer*, and *Marinduque* continued work throughout the year in the following localities: North and east coasts of Luzon Island; south coast of Palawan Islands; Tawitawi Island, Sulu Archipelago; south coast of Mindanao Island.

Hydrography, topography, and triangulation (second and third order) performed during year

Locality	Hydrography			Topography		Triangulation (second and third order)		
	Miles of sounding lines	Area, in square miles	Number of soundings	Length of shore line surveyed, in miles	Area surveyed, in square miles	Length of scheme in miles	Area covered, in square miles	Number of geographic positions determined
Georges Bank, Mass	863	900	2,460					
Entrance to Ambrose Channel, N. Y.	3	1	140					
Cape Henlopen to Fenwick Island, Del. and Md	823	85	18,604					
Lewes to Ocean City, Del. and Md	1,148	1,235	13,512	49	11	10	10	12
Chesapeake Bay, Md. and Va	669	52	16,177	25		20	26	24
District of Columbia					1			
Little Creek and vicinity, Va	100	2	10,233	23	7	8	49	26
Norfolk, Va	158	8	8,971	128		14	14	33
Cape Canaveral to Sebastian, Fla	2,543	653	29,879	37	9	40	89	50
Sebastian to Fort Pierce, Fla	2,054	1,118	62,645	50	9	10	35	38
Fort Pierce to Jupiter Inlet, Fla	2,910	766	50,859	39	1	36	95	59
East coast of Florida (air photo reduction)				574	752			
Shark River and Whitwater Bay to Naples, Fla	1,413	137	55,744	5	2			
St. Andrews Bay, Fla	181	9	7,655	31	8	5	5	7
East of Pensacola, Fla	237	47	5,265	15	3	12	17	9
Santa Barbara Channel, Calif	1,612	564	6,448					17
Point Reyes to Pigeon Point, Calif	7,277	4,380	57,206	68	46	7	35	9
Point Arena to Point Reyes, Calif	6,847	6,309	42,244	81	20	6	5	10
Gualala, Calif	89	7	1,755	11	4			
Point Reyes to Fort Bragg, Calif						108	250	150
Rockport to Punta Gorda, Calif						60	128	98
Crescent City to Cape Mendocino, Calif	734	113	25,989	187	69			
Cape Elizabeth to Cape Johnson, Wash				59	115	42	115	18
Cape Elizabeth to Destruction Island, Wash	1,044	225	10,113					
Behm Canal and Stikine River, Alaska						64	188	132
Behm Canal, Alaska	864	79	20,258	154	56	35	96	35
Taku Inlet and Stikine River, Alaska						36	203	21
Wrangell Narrows, Duncan Canal, and Sumner Strait, Alaska	1,231	74	40,406	79	24	58	106	171
Kenai Peninsula, Alaska	1,452	977	8,032	45	14	37	231	41
Kodiak Island, Alaska	3,951	1,578	51,736	224	315	60	157	81
Do	2,068	980	16,932	61	36	78	471	84
Oahu, westward and vicinity of Hawaii, Hawaiian Islands	11,289	48,654	28,901	8	1		1	2
Oahu Island to Gardner Island, Hawaiian Islands	6,820	42,600	21,760					
North of Luzon and Mindanao, P. I.	7,200	6,409	41,504	66	90	71	1,025	18
East coast of Luzon and Palawan, P. I	1,349	1,076	20,429	93	235	46	300	19
Sulu Archipelago and Mindanao, P. I	4,504	1,361	104,192	161	85			
Total	71,433	120,399	780,049	2,273	1,913	863	3,651	1,164

GEODETIC WORK

[July 1, 1929, to June 30, 1930]

	Length of scheme	Area covered
Triangulation, first-order:		
New York, Pennsylvania, and New Jersey, Buffalo-Trenton arc	*Miles* 325	*Sq. mi.* 3,450
Illinois, Missouri, Kentucky, Arkansas, Tennessee, Mississippi, and Louisiana, Mississippi River arc	615	4,900
Georgia, Alabama, and Mississippi, Atlanta-Shreveport arc	340	4,300
California, Bear Lake to thirty-fifth parallel arc	105	2,000
California, Point Reyes to Great Valley	45	1,450
Total	1,430	16,100
Traverse, first-order:		
Louisiana, LaBarre to Torras	23	------
Louisiana, Kentucky, and Arkansas, connections to Mississippi River Commission stations	10	------
Total	33	------
Base lines, first-order:		
Ohio, Portsmouth	5.3	------
California, Lucerne Valley	8.7	------
New Jersey, Princeton	5.3	------
Pennsylvania, Knoxville	3.8	------
Missouri, East Prairie	10.3	------
Mississippi, Stovall	7.2	------
Arkansas, Chicot	5.8	------
Louisiana, Mounds	5.4	------
Louisiana, New Roads	6.8	------
Louisiana, Gramercy	7.5	------
Louisiana, New Orleans	4.7	------
Missouri, Rogersville	12.1	------
Iowa, Corydon	5.0	------
Total	87.9	------

	Length of scheme	Area covered
Reconnaissance, first-order triangulation:		
Pennsylvania and New Jersey, Canton to Trenton	*Miles* 160	*Sq. mi.* 2,260
Iowa and Nebraska, forty-second parallel arc	175	2,100
Wisconsin, La Crosse to Fond du Lac	140	1,500
Illinois, Cairo to thirty-ninth parallel arc	110	1,440
Missouri, Cairo to Charleston	20	180
Illinois, Kentucky, and Tennessee, Cairo to Nashville	160	1,700
California, Lucerne Valley to thirty-fifth parallel arc	75	1,600
California, Point Reyes to Great Valley	45	1,450
Total	885	12,230
Leveling, first-order:		
Taylor Springs, N. Mex., to Pueblo, Colo., in progress at the beginning of the fiscal year (162−14=148)	148	------
Colorado Springs to Denver, Colo	80	------
Colorado Springs to Cheyenne Wells, Colo., 171 miles of single line	86	------
Philadelphia to Harrisburg, Pa.	117	------
Shelbyville to Vincennes, Ind	149	------
Washington to Petersburg, Ind	16	------
Wabash to Huntington, Ind	19	------
Washington to Indianapolis, Ind.	112	------
Total	727	------
Summary:		
First-order triangulation	1,430	16,100
First-order traverse	33	------
First-order base lines	87.9	------
First-order triangulation, reconnaissance	885	12,230
First-order leveling	727	------

It can be seen from the preceding table that a large part of the control surveys executed during the fiscal year 1930 were in the eastern half of the United States. This is in accordance with the statement made in the 1929 report that additional arcs of triangulation would be extended in the eastern part of the United States during the fiscal years 1930 and 1931, in order to adjust the triangulation in that region in one unit, in a manner similar to that of the western adjustment made three years ago. When completed, the two adjustments will give all triangulation stations in the United States permanently fixed geographic positions to which all future surveys will be coordinated. It seems certain that the triangulation necessary for the eastern adjustment will be completed in the fiscal year 1931.

The important arc along the Mississippi River was executed at the request of the Corps of Engineers of the United States Army and under financial cooperation with that organization. The purpose of this arc is to serve as a basis for the detailed topographic and flood-control surveys along the river. It also forms a part of the network of first-order triangulation over the eastern half of the United States.

A double observing party was used on the Mississippi arc and excellent progress was made in spite of difficult terrain, poor roads, and exceptionally high trees. The arc extends from Cairo to New Orleans, a distance of 615 miles, and was completed in six months. Connections were made at intervals of approximately 15 miles to stations of the Mississippi River Commission in order that the old surveys could be coordinated with the new ones. Because some of the stations were difficult to recover and almost inaccessible, five of these connections were made by traverse.

Another important arc of first-order triangulation was the one extended across New York and Pennsylvania, from Buffalo, N. Y., to Trenton, N. J. This divided a large loop of the eastern network of triangulation into two smaller loops, in preparation for the adjustment of the triangulation of the eastern half of the country. A double observing party was used on this arc also.

On both of the arcs mentioned above the Bilby portable steel towers were used. The Mississippi River arc was an especially severe test of the towers, as the high trees made necessary an average height of tower of 126 feet, and at one station a height of 156 feet was used.

In connection with earthquake studies in California two arcs of triangulation were completed in that State. In order to have the stations rather close together in the fault zones, where the larger earth movements are likely to occur, each of the arcs is a combination of a large first-order scheme with a smaller connected second-order scheme running through it. This gives exceptionally accurate positions for the stations near the faults, and it should be possible, in the future, to detect rather small earth movements by reobserving the triangulation after the lapse of several years or following an earthquake in the region.

Thirteen bases were measured during the year, of which 7 were along the Mississippi River arc of triangulation, 2 on the ninety-third meridian arc, 2 on the Buffalo-Trenton arc, 1 in California, and 1 in Ohio near the southern end of the first-order arc extending from the thirty-ninth parallel to Lake Erie. The observations for horizontal directions on the last-named arc were completed early in the fiscal year 1930.

In preparation for an unusually extensive program of triangulation for the fiscal year 1931, reconnaissance surveys were made over several projected new arcs of triangulation, mostly in the eastern half of the United States. One of these arcs is along the forty-second parallel from the ninety-eighth meridian to a point south of Chicago, one is an east-and-west arc across the central part of Wisconsin and three of them are short arcs radiating north, east, and west from Cairo, Ill.

A number of Laplace stations needed for the eastern adjustment were provided by an astronomical party which made observations for longitude, azimuth, and latitude in eight States in the northern part of the country, east of the Mississippi River.

About 725 miles of first-order leveling were run during the year. Two lines were run in Colorado, one in Pennsylvania and four

rather short lines in Indiana. The work in Indiana was requested by the Corps of Engineers of the United States Army, for use in flood-control operations, and was financed from flood-control funds.

Only one gravity party did field work during the year. Six stations were occupied in the Bahama Islands and one in Florida, in cooperation with the international expedition to the Bahamas under the auspices of Princeton University.

The international variation of latitude station at Ukiah, Calif., was continued in operation during the year.

MAGNETIC AND SEISMOLOGICAL WORK

Magnetic stations occupied during the fiscal year

Alabama	5	Montana	2
Alaska	23	Nebraska	6
Arizona	5	New Hampshire	1
California	21	New Jersey	1
Colorado	2	New Mexico	4
Connecticut	2	New York	5
Delaware	2	North Dakota	6
Florida	4	Oregon	1
Hawaii	9	Pennsylvania	2
Kansas	9	Philippine Islands	3
Maine	5	Texas	10
Maryland	4	Wyoming	1
Massachusetts	3		
Minnesota	5	Total	141

The primary object of the year's magnetic work has been the occupation of repeat stations in order to determine the change of the earth's magnetism with lapse of time. The special aim has been to complete during the calendar year 1930 the secular change data covering the period 1925–1930 needed to prepare the publication entitled, "Magnetic Declination in the United States in 1930." Incidentally, a considerable number of stations which had ceased to be available have been replaced to meet the needs of local surveyors.

Continuous photographic records of the variations of the magnetic elements were made at the five magnetic observatories, together with the necessary absolute observations and scale value determinations. Considerable progress was made in improving the instrumental equipment. At Cheltenham (Md.) field instruments have been standardized and variometers have been tested and adjusted. Working conditions at San Juan (P. R.) have been much improved by the erection of an office building and garage to replace those destroyed by the hurricane of 1928. At Tucson (Ariz.) atmospheric electric observations have been made continuously since September, 1929, with the cooperation of the Carnegie Institution of Washington and the United States Army Signal Corps. At Sitka (Alaska) special auroral observations have been continued. There has been cooperation with the Alaska Agricultural College and School of Mines at Fairbanks (Alaska), where a station for the observation of auroras has been established through a grant from the Rockefeller Foundation.

Seismology.—Seismographs were operated continuously at the Sitka and Tucson observatories, at Honolulu in cooperation with the University of Hawaii, and at Chicago in cooperation with the University of Chicago. Provision was made in the new office building at San Juan for the installation of two Wenner seismometers, and observations at this station, which were stopped by the 1928 hurricane, will be resumed early in the next fiscal year. At Sitka a Wood-Anderson seismometer has been in use temporarily, to find whether a Wenner seismograph could be operated without serious interference from microseisms. Cheltenham has been used merely as a station for experiment and test, because of the nearness of the well-equipped station at Georgetown University.

Arrangements for the systematic collection of reports of visible and felt effects of earthquakes have progressed very satisfactorily. The National Research Council, through its division of geology and geography, the Jesuit Seismological Association, and other organizations are cooperating efficiently in the eastern part of the country, and the collection of information for the Pacific coast region has been centralized at the San Francisco field station of this bureau. Considerable study has been given to two important earthquakes, the one of September 12, 1929, in western New York, and the one of November 18, 1929, on the Grand Banks, which did great damage to trans-Atlantic cables.

TIDE AND CURRENT WORK

The tide and current work during the past year comprised the operation of a number of primary tide stations for the purpose of furnishing general tidal control for the various regions; the operation of numerous secondary tide stations for use in connection with hydrographic surveys; the establishment of basic bench marks at several of the primary tide stations; the carrying on of special tide and current surveys in Long Island Sound and the Hudson River; and the securing of additional current observations at a number of localities where the information was needed.

Primary tide stations.—Throughout the fiscal year 22 primary tide stations were in operation, 13 on the Atlantic coast, 3 on the Gulf coast, 4 on the Pacific coast, and 2 in Alaska. In September, 1929, an additional primary tide station was installed at Eastport, Me. In the operation of these stations it has been aimed to secure not only observations that would furnish data for hydrographic control but in addition furnish also data for the determination of accurate datum planes, for reducing the results of short series of observations to mean values, for furnishing the necessary data for court cases, and for determining secular changes in relation of land to sea. Particular attention was paid to the standardization of instruments and to the maintenance of fixed zeros of tide staff.

Of the 22 primary tide stations, 5 were operated on a cooperative basis with other governmental organizations, so that no expense for observers was incurred at any of these 5 stations. Under the arrangements made, these stations are functioning in a very efficient

manner. In the following list, primary tide stations which are operated on a cooperative basis are marked by an asterisk (*).

Primary tide stations

Eastport, Me.
Portland, Me.
Portsmouth, N. H.*
Boston, Mass.
New York, N. Y.
Atlantic City, N. J.
Philadelphia, Pa.
Annapolis, Md.*
Baltimore, Md.
Hampton Roads, Va.*
Charleston, S. C.
Mayport, Fla.*
Jacksonville, Fla.*
Daytona Beach, Fla.
Key West, Fla.
Pensacola, Fla.
Galveston, Tex.
La Jolla, Calif.
San Francisco, Calif.
Astoria, Oreg.
Seattle, Wash.
Ketchikan, Alaska.
Seward, Alaska.

At the end of the fiscal year arrangements were being made to establish a new primary tide station at Newport, R. I., on a cooperative basis.

Secondary tide stations.—In addition to the primary tide stations listed above, records for practically the entire year have been received from gages located at Prospect Harbor, Me.; Ocean City, N. J.; Fort Lauderdale, Fla.; Everglades, Fla.; San Diego, Calif.; Los Angeles, Calif.; Cordova, Alaska; Honolulu, and Hilo, Hawaii. During the year a gage was installed at Santa Barbara, Calif. Excepting Ocean City and Santa Barbara, the above gages are maintained through cooperative arrangements with other organizations. Short series of tide observations at 146 other tide stations have been taken in connection with hydrographic work.

Basic bench marks.—During the year basic bench marks were established at eight primary tide stations so that now such basic bench marks have been installed at the following primary tide stations:

Boston, Mass.
Atlantic City, N. J.
Baltimore, Md.
Norfolk, Va.
Charleston, S. C.
Key West, Fla.
Pensacola, Fla.
La Jolla, Calif.
San Francisco, Calif.
Seattle, Wash.

Arrangements are being made for the installation of basic bench marks during the coming year at New York City and at Daytona Beach, Fla.

Inspection of tide stations.—The following tide stations have been inspected during the fiscal year and levels run between tide staff and bench marks. The importance of frequent inspections in the operation of the primary tide stations is recognized and all opportunities afforded for such inspection by field parties at distant stations have been embraced.

Portsmouth, N. H.
Portland, Me.
Prospect Harbor, Me.
Boston, Mass.
New York, N. Y.
Atlantic City, N. J.
Philadelphia, Pa.
Ocean City, Md.
Annapolis, Md.
Charleston, S. C.
Hampton Roads, Va.
Pensacola, Fla.
Everglades, Fla.
Galveston, Tex.
San Diego, Calif.
La Jolla, Calif.
Honolulu, Hawaii.
Hilo, Hawaii.
Seattle, Wash.
Ketchikan, Alaska.

Current and tide surveys of harbors.—In continuing the program of tide and current surveys of important harbors, Long Island Sound and Hudson River were completed during the fiscal year, observations at 130 current stations and 30 tide stations being made. The results have been tabulated and reduced and the manuscripts for publication are nearing completion.

In the last month of the fiscal year 1930 a tide and current survey of Narragansett Bay was begun. This will be completed in the coming fiscal year.

Miscellaneous current observations.—In connection with the hydrographic work of the survey, observations at 14 current stations were made. These observations furnish data at places where no information was previously at hand.

Density and temperature observations.—At a number of our primary tide stations daily density and temperature observations are taken by the tide observer in connection with his other duties at the tide station. Density and temperature observations are also taken in connection with our special current and tide surveys of harbors.

Summary of tide and current records received.—The following is a summary of tide and current records received in the office during the year.

	Stations	Months		Stations	Months
Automatic tide-gage records	135	525	Density and temperature records	20	190
Tide books	44	17	Current records	295	[1] 1,120
Miscellaneous tide records	6	72	Leveling records	129	

[1] Days.

Cooperation.—In carrying on the tide and current work there is continued encouragement given to cooperation with other organizations because of the mutual benefits to be derived. At a number of our tide stations this office provides the instruments and instructions for operating the same, while the cooperative agency provides a shelter for the equipment and also supplies an observer to give daily attention to the tide gage. The cooperative stations are subject to the same inspection as stations maintained wholly by this survey. Copies of the records are available to both organizations and usually the original records are filed in the archives of this office. Another form of cooperation consists in the exchange of tide and current data which have been obtained independently by different organizations.

Cooperation with the Army engineers has been especially valuable to this survey because of the need of both organizations for tide and current data. During the past year a considerable amount of tide data for the Hudson River and Long Island Sound has been supplied by the district engineers in New York and Providence. Tide stations at Jacksonville and Mayport, Fla., are maintained cooperatively with the office of the district engineer at Jacksonville.

Valuable tide information is also received from time to time from the Navy Department and tide stations maintained cooperatively with that department are located at Portsmouth, N. H., Hampton

Roads, Va., and San Diego, Calif. A primary tide station at Annapolis, Md., is maintained in cooperation with the Naval Academy and in addition to serving as a primary tide station is also used for the purpose of instructing midshipmen in tidal work.

A tide station at Honolulu is maintained cooperatively with the surveyor of the Territory of Hawaii in charge, and one at Hilo, Hawaii, with the United States Geological Survey.

Other cooperative tide stations operated during the past year include 1 at Cordova, Alaska, by the chamber of commerce of that city; 1 at Los Angeles, Calif., by the harbor department; 1 at Prospect Harbor, Me., by Henry Southworth Shaw; 1 at Fort Lauderdale, Fla., by the authorities of that city; and 1 at Everglades, Fla., by the Florida Railroad & Navigation Corporation.

Part IV.—THE WASHINGTON OFFICE

The organization of the Washington office of the bureau is presented by the organization chart opposite. The accomplishments during the fiscal year by divisions and sections follow.

CHIEF CLERK

The principal duties of this division are the upkeep of the mechanical equipment of the Washington office of the bureau; the supervision of the expenditures for office expenses, including the purchase of supplies for the office and to some extent for the field; the care and custody of most of the original records of the field surveys, as well as the library of printed publications; the general supervision of all matters relating to the personnel work, including reports of leaves of absence; the custody and accounting for the receipts from the sale of charts, publications, etc.

In the library and archives 129 hydrographic and 116 topographic sheets, each representing new surveys made by the bureau, were received. Other additions were blue prints (mostly showing surveys made by Army engineers), 724; maps, 2,907; charts, 2,168; field, office, and observatory records, 4,601; photographs and negatives, 251; prints, 441; lantern slides, 133; and books, 583.

The total number of permanent and temporary employees in the office and field forces, which includes commissioned officers and all employees appointed through civil-service certification, is: Office force, 236; field force, 213; total, 449. These figures do not include the persons engaged as rodmen, chainmen, heliotropers, and others in the field parties, nor seamen on vessels.

The receipts from the sale of charts and nautical publications prepared by the bureau amounted to $80,093.75. The funds realized from the sale of old property, work done, and miscellaneous sources amounted to $1,890.49.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY

All plans for field work and instructions for surveys are prepared in this division. Plans and specifications for new vessels and surveying equipment as well as repairs are also prepared and the construction of new vessels and launches is supervised. The coast pilot section prepares manuscripts for new editions of the various Coast Pilots and gets out an annual supplement for each volume. This section also prepares answers to the many requests for information referred to the division.

The construction of the tender *Westdahl* was completed and the vesesl is now employed in surveys of the Alaska coast, operating as a tender to one of the larger vessels. Construction was continued on the motor vessel *Hydrographer* and the tender *Gilbert*.

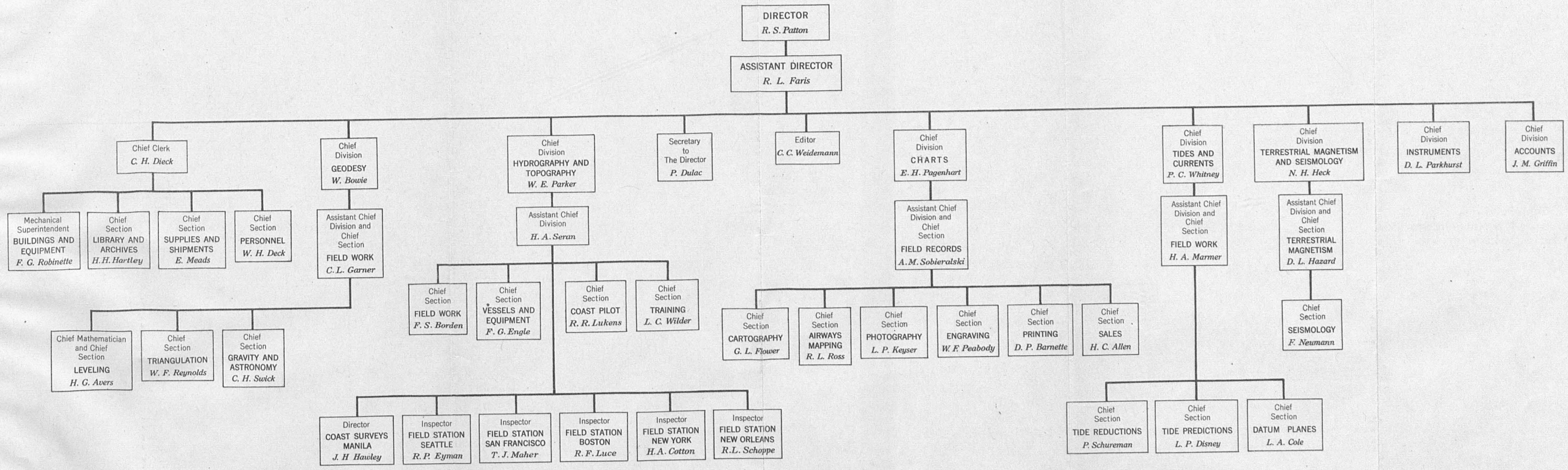
U. S. Coast and Geodetic Survey

Revised to July 1, 1930

CHART SHOWING ORGANIZATION OF THE

U. S. COAST AND GEODETIC SURVEY

1930



C. & G. S. Print.

The former yacht *Corsair* was taken over and put into service with practically no alteration except for the installation of surveying equipment. The vessel was renamed the *Oceanographer* and at the close of the fiscal year was actively engaged in the survey of Georges Bank. The training section is now quartered aboard the *Oceanographer* where the newly appointed officers are given practical and theoretical training to fit them as ships' officers.

Plans and instructions were prepared for a complete and accurate survey of Georges Bank. New equipment for radio acoustic sound ranging was designed and put in successful operation for this work. Extensive improvements were made in the echo-sounding instruments installed in the various vessels on both the Atlantic and Pacific coasts. Experiments were continued looking toward the development of a shallow-water echo-sounding apparatus.

Field examinations were made and new editions were brought out for two of the pilot volumes, and the manuscript for one of the Philippine Island Pilots was revised. Work was started on an office revision of the Alaska Coast Pilot, Part II.

Work was continued on the office reduction of the photographic topography along the east coast of Florida.

DIVISION OF GEODESY

The following important pieces of work were completed during the year or were in progress at the end of the fiscal year:

Computation and adjustment of the following pieces of triangulation.—

1. Southeast Alaska: Triangulation in the following areas: Mary Island to Port Simpson, Holkham Bay, Crawfish Inlet, Tlevak Strait, Stephens Passage, Chatham Strait-Salisbury Sound-Cape Ommaney-Cross Sound, Portlock Harbor, Warm Spring Bay, Red Bluff Bay, Tebenkof Bay, Port Lucy, Patterson Bay, Port Malmesbury, Port Walter, Table Bay, Port Conclusion, Port Armstrong, outside coasts of Baranof and Kruzof Islands, Davidson Inlet, Icy Strait, Meares Passage, Keete Inlet, Excursion Inlet, Cross Sound to Lituya Bay, Port Frederick, Stikine River, Revillagigedo Channel, Sumner Strait, Duncan Canal, and Behm Canal.
2. Readjustment of the first-order triangulation net east of the ninety eighth meridian; preliminary work only.
3. Preliminary computation of the triangulation along the Mississippi River between Cairo, Ill., and New Orleans, La.
4. Reduction of the triangulation in Haro Strait, Wash., to the North American datum of 1927.
5. Reduction of the triangulation in Los Angeles County, Calif., to the North American datum of 1927.

Computation and adjustment of leveling.—

1. Computation of 727 miles of first-order leveling located in New Mexico, Colorado, Pennsylvania, and Indiana.
2. The adjustment of the combined level nets of Canada and of the United States, involving nearly 70,000 miles of leveling.

Computation of the following astronomical and gravity work.—

1. Azimuths: 35 stations in the United States.
2. Longitudes: 16 stations in the United States.
3. Latitudes: 4 stations in the United States.
4. Laplace azimuths: Computation of true geodetic azimuths at 15 Laplace stations.
5. Isostatic reductions: Computation of the reduction for topography and isostatic compensation at 18 gravity stations in the United States, in the Bahama Islands, and in the West Indies. Computation of the deflections of the vertical in the meridian and prime vertical at 7 stations in the United States and along the Atlantic coast.

6. Gravity computations: Computation of 20 gravity stations in the United States, in the Bahama Islands, and in the West Indies, and of various standardizations and experimental work at Washington, D. C.

Investigations were carried on during the year in the following subjects: Interior of the earth, earth tides, methods of reducing gravity observations, and variation of latitude.

The following publications were issued by the division of geodesy during the fiscal year:

Special Publication 156, Triangulation in Hawaii.
Special Publication 8, Formulas and Tables for the Computation of Geodetic Positions (seventh edition).
Special Publication 158, Bilby Steel Tower for Triangulation.
Special Publication 159, The Bowie Method of Triangulation Adjustment as Applied to the First-Order Net in the Western Part of the United States.
Special Publication 160, Triangulation in Colorado (1927 datum).
Special Publication 161, First-Order Leveling in Hawaii.
Special Publication 164, First-Order Triangulation in Southeast Alaska.
Special Publication 166, Geodetic Operations in the United States, January 1, 1927, to December 31, 1929.
Special Publication 169, First-Order Leveling in Alaska.

DIVISION OF CHARTS

During the year 272,000 charts were printed and 264,000 distributed (sold or issued for official use). These are the biggest figures since the peak years of and immediately following the war. Chart sales have increased 50 per cent in five years. Tide Table distribution increased 44 per cent; Current Tables, 45 per cent; Coast Pilots, 33 per cent; Inside Route Pilots, 22 per cent, in the same period. The bureau's airway map work does not go back five years, but the past year shows proportionately larger increase in distribution.

For the program of sectional airway maps the general limits and nomenclature of the International Millionth Map of the World have been adopted. The first map of this series will soon be published.

Accomplishments, 1930

Charts, new	17
New editions	129
New prints	371
Reprints, no change	80
Airway maps, new	11
Reprints	11

Weekly Notices to Mariners, in collaboration with the Bureau of Lighthouses.

Charts and publications distributed

Year	Charts	Coast Pilot	Inside Route Pilot	Strip airway maps
1920	311,699	15,261	2,085	
1921	290,188	8,728	2,656	
1922	215,509	6,235	2,261	
1923	197,426	6,610	1,787	
1924	221,543	5,917	1,788	
1925	230,535	5,733	1,727	
1926	232,286	6,328	2,648	
1927	246,836	7,859	1,994	
1928	241,880	7,019	[1] 1,849	
1929	249,499	6,288	1,756	
1930	282,034	7,656	2,208	[1] 12,004

[1] Previously distributed by Aeronautics Branch.

Analysis of chart distribution, number of copies, and percentage of totals

Year	Sold	Per cent	Official distribution	Per cent	Condemned	Per cent	Total
1905	42,719	41.8	52,591	51.6	6,713	6.6	102,023
1910	52,068	43.6	58,307	48.8	9,019	7.6	119,394
1915	57,060	44.6	62,327	48.8	8,416	6.6	127,803
1920	124,845	40.1	173,929	55.8	12,925	4.1	311,699
1925	102,011	44.2	111,552	48.4	16,972	7.4	230,535
1926	132,605	57.1	85,171	36.6	14,510	6.3	232,286
1927	119,593	48.5	111,383	45.1	15,860	6.4	246,836
1928	122,242	50.5	106,654	44.1	12,984	5.4	241,880
1929	135,170	54.2	103,391	41.4	10,938	4.4	249,499
1930	153,995	54.6	110,151	39.1	17,888	6.3	282,034

Program, 1931.—In addition to maintenance of existing charts and maps and the publication of Notices to Mariners, there are projected 11 new charts, 4 reconstructed charts, 7 new strip airway maps, and 5 sectional airway maps.

DIVISION OF TERRESTRIAL MAGNETISM AND SEISMOLOGY

Terrestrial magnetism.—Good progress has been made in the preparation for publication of the observatory results. The results for 1923 and 1924 are now published for Cheltenham and Honolulu. The manuscript for Sitka, covering the same period, is in the hands of the printer, and that for Tucson and Vieques is nearly ready for publication. The work to be done on the results for later years has been much reduced by the adoption of the improved method of reading hourly values.

The results of field observations in 1929 have been submitted for publication, thus keeping this part of the work up to date. The publication entitled "United States Magnetic Tables and Charts for 1925" has been issued and preparation of the similar publication for Alaska for 1930 is well advanced. A paper on The Magnetic Declination in the Philippine Islands, prepared in this office, was published at Manila.

The preparation of publications giving information regarding the magnetic declination for individual States or groups of States was delayed by lack of personnel, but one covering the States of Delaware, Maryland, Virginia, West Virginia, Kentucky, and Tennessee was issued and correction sheets were prepared for some of those published previously.

A third edition of Directions for Magnetic Measurements was issued. It is being used extensively by the Carnegie Institution of Washington and by observers in other countries.

Much study has been given to the further improvement of instruments and methods of observation, involving design and testing of instruments and parts and the preparation of specifications for installation, housing, and operation.

Some attention has been given to the broad problems of terrestrial magnetism and there has been full cooperation with national and international organizations engaged in the study of these problems. Members of the division have participated in the activities of various scientific organizations, both as officers and in the presentation of papers.

Seismology.—The form of the principal seismological report issued by the bureau has been changed so as to bring about a considerable saving in the work of preparation, without detracting from its value to those making use of the results. This has been done after consultation with other organizations making instrumental investigations so that methods may be uniform in so far as this is desirable.

Thirty determinations of the position of earthquakes and the transmission of this information west to Manila and east to Europe were made during the year.

Plans have been made to modernize equipment at all stations as rapidly as possible. A seismograph intermediate in sensitivity between existing instruments has been developed and built, to meet a need which has been felt for some time.

Cooperation and advice have been given to universities and other organizations contemplating the installation of seismographs.

Study has been made of the problem of securing information as to what happens in the central region of an earthquake, to meet the needs of the engineers called upon to design structures for places subject to earthquakes.

DIVISION OF TIDES AND CURRENTS

Growing hydrographic activities and an ever-increasing demand on the part of the public for tide and current information have increased from year to year the office work of the division of tides and currents. Comprehensive current and tide surveys were begun in 1922 and have been continued each year since that date. The reduction, correlation, and publication of all tide and current data for the areas covered by these surveys, together with the preparation of tidal bench-mark publications and the increasing scope and number of the annual tide and current tables, have greatly increased the volume of work. For years the need for additional office personnel to meet the increasing demands made upon the division has been apparent. This need has now become imperative, as the reduction and publication of valuable data are being delayed by the lack of a sufficient force.

Special Publication No. 162, Tides and Currents in Chesapeake Bay, the seventh of a series on currents and tides in the important waterways of the United States, was issued during the fiscal year. Work has progressed during the year on two additional publications of this series, one covering Long Island Sound and the other the Hudson River. The publications of the series which have been issued to date are listed below:

Currents and tides in harbors

No. 111. New York Harbor, 1925.
No. 115. San Francisco Harbor, 1925.
No. 123. Delaware Bay, 1926.
No. 127. Southeast Alaska, 1927.
No. 142. Boston Harbor, 1928.
No. 150. Portsmouth Harbor, 1929.
No. 162. Chesapeake Bay, 1930.

Special Publication No. 163, Tidal Bench Marks, State of Oregon, received from the printer during the fiscal year, is the eighth of a series containing descriptions and elevations of tidal bench marks along the coasts of the United States. The ninth publication of the

series, covering the State of Washington, was in process of preparation at the end of the fiscal year. The following publications of this series have been issued:

Tidal bench mark publications

No. 83. New York, 1922.
No. 119. District of Columbia, 1925.
No. 128. Rhode Island, 1926.
No. 136. Connecticut, 1927.
No. 141. California, 1928.
No. 148. New Jersey, 1929.
No. 155. Massachusetts, 1929.
No. 163. Oregon, 1930.

Special Publication No. 154, Instructions, Primary Tide Stations, which was prepared as a supplement to Special Publication No. 139, was received from the printer during the fiscal year. This publication contains instructions pertaining to the operation of a primary tide station and the preliminary reduction of the records.

The list of annual tide tables was augmented during the year by the addition of a tide table for San Francisco Bay which was first issued for the year 1930. The table of subordinate stations in the Tide Tables, United States and Foreign Ports, was completely revised for all foreign ports. The table of subordinate stations in the Current Tables, Pacific Coast, was revised to include additional data.

The following table, showing the issue of the tide tables for each fiscal year for the 10-year period 1921–1930, is indicative of the demand for the tables:

Fiscal year	United States and Foreign Ports Tide Tables	Atlantic Coast Tide Tables	Pacific Coast Tide Tables	New York Harbor Tide Tables	Boston Harbor Tide Tables	San Francisco Bay Tide Tables	Total
1921	3,577	5,678	14,957				24,212
1922	3,067	5,704	14,902				23,673
1923	2,479	5,440	15,054				22,973
1924	2,509	7,097	15,234				24,840
1925	2,218	6,727	15,849				24,794
1926	2,730	6,707	15,347				24,784
1927	2,692	6,934	15,911				25,537
1928	2,377	7,225	16,990	1,992			28,584
1929	3,234	7,266	16,887	956	1,461		29,804
1930	2,605	8,457	16,889	1,134	1,470	5,024	35,579

The following table shows the number of copies of the current tables issued for the fiscal years 1923 to 1930, separate current tables having been issued in 1923 for the first time:

Fiscal year	Atlantic Coast Current Tables	Pacific Coast Current Tables	Total	Fiscal year	Atlantic Coast Current Tables	Pacific Coast Current Tables	Total
1923	2,029	1,780	3,815	1927	3,722	2,311	6,033
1924	3,124	2,002	5,126	1928	3,614	2,501	6,115
1925	2,452	2,474	4,926	1929	3,492	4,040	7,532
1926	3,014	1,763	4,777	1930	4,054	3,098	7,152

The United States and Foreign Ports Tide Tables for 1930 include daily predictions for 89 reference stations and tidal differences and constants for 3,803 subordinate stations. Three new

reference stations—Swatow, China; Southampton, England; and Cuxhaven, Germany—were included in the 1931 edition.

In accordance with a cooperative arrangement for the exchange of tidal predictions, daily predictions for the annual tide tables are now exchanged between the Coast and Geodetic Survey and the following organizations: British Admiralty, 20 stations; Canadian Hydrographic Office, 4 stations; Deutsche Seewarte, 6 stations; Service Hydrographique, France, 4 stations; geodetic branch, Survey of India, 5 stations.

During the fiscal year the second of the series of tidal current charts was prepared for publication.

DIVISION OF ACCOUNTS

The regular annual appropriation for the Coast and Geodetic Survey for the fiscal year 1930 amounted to $2,515,860, which amount was supplemented by transfers from other departments, special appropriations, etc., to the extent of $210,426.48, making a grand total of $2,726,286.48. The actual disbursements during the period of the fiscal year amounted to $2,677,281.31.

INSTRUMENT DIVISION

This division supplies all of the instrumental equipment and the major part of the general property used by the ships and shore parties in their field work. Its functions are varied in that it is required to design and develop such new instruments and equipment as are desired in order to maintain or increase the accuracy of the field surveys and to reduce the costs. In this work the bureau is recognized as a leader throughout the world and the inventive and development activities of this division are of the greatest importance to the bureau's well-being.

Because of the precision with which the bureau's surveys must be carried on, the instruments designed must embody correct scientific principles; and continuous care is exercised to keep in touch with all developments in the scientific and engineering world, to insure that any new development which might be applicable to the bureau's work will be made use of. This may be illustrated by the rapid increase in the use of radio and its allied mechanisms in the survey's work, which has resulted in the development of radio acoustic ranging for locating positions far offshore and in measuring the ocean's depth by electrosonic methods. A few years ago equipment of this sort was entirely foreign to the bureau's work.

The division also services and stores instruments and other equipment, has charge of recording transfers of material between parties and the Washington office, and also accounts for material at the bureau's headquarters.

These various functions were successfully carried on during the past year and a number of new and improved instruments were brought out, the more important being:

1. *Tide gage.*—This instrument has been under constant development for several years, and a number of decided improvements were made during this past year; more notably, a clock assembly which

can be removed without the use of tools and a new magazine and take-up rolls for the record sheet.

2. *Registering sheave.*—A new registering sheave for sounding was designed with a more easily read counter, which will allow measurements to be made directly to 0.1 of a fathom, and the position of this counter is so arranged that it can be read much more easily than those used in the past.

3. *Telescope cross-wire material.*—An interesting development during the year was the invention of a method of producing very fine fibers of glass which may be used to replace the conventional spider-web material previously used. Spider threads are weak and are apt to change their length when moistened, with the result that they lose their straightness. Similar threads of glass are very strong, very black in the field of view, and are practically unaffected by temperature and moisture. They are also much easier to install in the telescope than the spider thread.

4. *Graduated circles for theodolites.*—Experiments were conducted with the plating with chromium of the silver used on the graduated circles for theodolites. The silver used must be very soft and is easily scratched and tarnished. The plating with the hard material, chromium, gives a surface which does not tarnish and which is not easily scratched in the ordinary course of handling. The chromium also has a very pleasing appearance under the instrument's microscope.

5. *Tide-gage pulleys.*—Tide gages are connected to the sea by means of a wire passing over pulleys and connected to a large float. Friction in the pulleys, or other resistance due to them, causes an error in the measurement of the rise and fall of the tide. A new type of pulley was designed which has a large wheel, is very free-running, and is equipped with a device to prevent the jumping of the wire from the pulley and is so designed that new wire may be easily installed.

NEW CHARTS

[Published during the fiscal year 1930]

No.

579. Hempstead Bay, N. Y. November, 1929. Scale, 1:20,000. Dimensions, 20 by 30 inches. Price, 25 cents. This chart includes East Rockaway Inlet and Jones Inlet and extends from Far Rockaway to South Oyster Bay. It shows the results of surveys made by the Coast and Geodetic Survey in 1927, supplemented by data from other sources. It joins chart No. 578, Great South Bay, on the east and chart No. 542, Jamaica Bay, on the west. Soundings are in feet at mean low water.

681. Wando River, upper part, S. C. May, 1930. Scale 1:20,000. Dimensions, 14 by 26 inches. Price, 25 cents. This new chart covers the upper reaches of the Wando River extending from that portion of the river shown on chart No. 470 up to Wards Bridge. Soundings are in feet at mean low water.

923. Point Lima to Batata Cay, P. R., West Indies. August, 1929. Scale, 1:20,000. Dimensions, 22 by 24 inches. Price, 25 cents. The soundings are in feet and give the depths at mean low water. The chart includes Ports Humacao and Maguabo and gives the results of surveys made in 1927 supplemented by earlier surveys and other data.

924. Port Maunabo, P. R. September, 1929. Scale, 1:20,000. Dimensions, 19 by 20 inches. Price, 25 cents. The soundings are expressed in feet, reduced to the plane of mean low water, from surveys made by the Coast and Geodetic Survey to 1927.

No.

926. Point Petrona to Muertos Island, south coast, Porto Rico, November, 1929. Scale, 1:20,000. Dimensions, 33 by 38 inches. Price, 75 cents. This chart is issued to supply a demand for a chart of the area covered on a larger scale than was previously issued. It shows the results of surveys by the Coast and Geodetic Survey made in 1927, supplemented by surveys of 1899 and 1905.

934. West coast of Vieques Island, West Indies. October, 1929. Scale, 1:10,000. Dimensions, 23 by 24 inches. Price, 25 cents. The soundings are given in feet and referred to the plane of mean low water. Those between the western shore line and the 30-foot curve are from a survey made in 1927; the others from earlier surveys.

935. Christiansted Harbor, Saint Croix, West Indies. July, 1929. Scale, 1:10,000. Dimensions, 25 by 32 inches. Price, 50 cents. This new chart is on a scale of 1:10,000. The soundings are in feet, reduced to mean low water, from surveys made by the Coast and Geodetic Survey in 1925.

936. Vicinity of Point Palmas Altas, north coast of Porto Rico. November, 1929. Scale, 1:10,000. Dimensions, 26 by 36 inches. Price, 50 cents. This chart covers the landing of and approaches to Palmas Altas and shows the results of a survey by the Coast and Geodetic Survey in 1928.

3251. Inside Route, North River to Adams Creek, N. C. January, 1930. Scale, 1:80,000. Dimensions, 24 by 38 inches. Price, 25 cents. This new chart is an addition to the inland-route series and covers the inland route from North River to Adams Creek via the recently completed Alligator River-Pungo River Canal and the waterway connecting Pamlico River and Neuse River via Goose Creek and Bay River.

4118. Haena Point to Kepuhi Point, north coast of Kauai, Hawaiian Islands. March, 1930. Scale, 1:20,000. Dimensions, 28 by 44 inches. Price, 75 cents. The depths are expressed in fathoms at mean lower low water from surveys made by the Coast and Geodetic Survey in 1927. This chart includes Wainiha, Hanalei, Kalihiwai, and Kilauea Bays.

4122. Kaumalapau Harbor, Lanai, Hawaiian Islands. November, 1929. Scale, 1:2,500. Dimensions, 15 by 16 inches. Price, 25 cents. The soundings are in feet and give the depths below the plane of mean lower low water. The chart shows the results of a survey made by the Coast and Geodetic Survey in 1927–28.

8255. Crawfish Inlet to Sitka, Baranof Island, Southeast Alaska. August, 1929. Scale, 1:40,000. Dimensions, 33 by 44 inches. Price, 75 cents. This is one of the series of charts on a scale of 1:40,000 covering the outer coast of southeast Alaska. The soundings are in fathoms at mean lower low water. The area south of the latitude of the northern extremity of Biorka Island is from surveys made in 1924 and 1925. The rest of the chart is from earlier surveys. Charts Nos. 8237 and 8240 will be canceled.

8260. Yakobi Island and Lisianski Inlet, southeast Alaska. July, 1929. Scale, 1:40,000. Dimensions, 32 by 38 inches. Price, 75 cents. Soundings in fathoms at mean lower low water. This is one of the series of charts on a scale of 1:40,000 covering the outside coast of southeast Alaska. The area covered by this chart was surveyed in 1917 and 1926.

8528. Point Elrington to Cape Resurrection, Kenai Peninsula, south coast, Alaska. March, 1930. Scale, 1:80,000 in latitude 60° 35′, making the mean scale of chart 1:81,560. Soundings in fathoms at mean lower low water. Dimensions, 32 by 32 inches. Price, 75 cents. The chart includes Port Bainbridge, Puget Bay, Johnstone Bay, Whidbey Bay, and Bay Harbor, and affords a useful chart for making the passage between Prince William Sound and Resurrection Bay. From surveys made in 1927–28 by the Coast and Geodetic Survey supplemented by earlier surveys and other data.

8529. Cape Resurrection to Two Arm Bay, Kenai Peninsula, south coast, Alaska. April, 1930. Scale, 1:80,000 in latitude 60° 35′. Soundings in fathoms at mean lower low water. Dimensions, 28 by 36 inches. Price, 75 cents. This is one of a series of charts covering Prince William Sound and extending westward to Cook Inlet, all constructed on a scale of 1:80,000 in latitude 60° 35′. It overlaps and extends westward from chart No. 8528 and cancels Nos. 8538 and 8527.

No.

8531. Gore Point to Anchor Point, Kenai Peninsula, south coast, Alaska. June, 1930. Scale, 1 : 80,000 in latitude 60° 35′. Dimensions, 32 by 42 inches. Soundings in fathoms at mean lower low water. Price, 75 cents. This is the westernmost of a series of charts covering Prince William Sound and extending westward to Cook Inlet, all constructed on a scale of 1 : 80,000 in latitude 60° 35′. It covers the southwestern end of the Kenai Peninsula from Gore Point on the south to Anchor Point in Cook Inlet. It includes Kachemak Bay and Chugach Passage. The inshore area between Gore Point and Chugach Bay, inclusive, is not yet surveyed.

8574. Sitkalidak Strait, Cape Barnabas to Old Harbor, Kodiak Island, Alaska. September, 1929. Scale, 1 : 40,000. Dimensions, 24 by 38 inches. Price, 50 cents. This is a preliminary chart published to give the results of a survey made by the Coast and Geodetic Survey. Surveys in the vicinity of Kodiak Island are in progress, and when completed a series of charts on a scale of 1 : 80,000, covering Kodiak Island, will be constructed.

Part V.—DISTRIBUTION OF PARTIES DURING THE FISCAL YEAR ENDED JUNE 30, 1930

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY

[Abbreviations used: L=length in statute miles; A=area, square statute miles; P=number of geographical positions; M=miles of sounding lines; S=number of soundings; W. D.=wire drag; sta.=stations; mag.=magnetic.]

Locality and operations	Persons conducting operations
Massachusetts, Georges Bank; Hydrography, M863, A900, S2,460.	Ship Oceanographer, June 5–June 30, Lt. F. L. Peacock, comdg.; Lt. R. F. A. Studds, exec.; Lt. (J. G.) T. B. Reed; Ensign K. B. Jeffers; E. B. Brown, jr., D. O.; J. C. Tribble, jr., D. O.; H. Ely, ch. engr.
Massachusetts, Georges Bank: Serving as R. A. R. station in cooperation with ship Oceanographer; planting and locating buoys; astronomic, current, magnetic, radio compass, temperature, and salinity, observations.	Ship Lydonia, June 4–June 30, Lt. G. D. Cowie, comdg.; Lt. W. M. Scaife, exec.; Lt. (J. G.) K. G. Crosby, Lt. (J. G.) L. S. Hubbard; Lt. (J. G.) W. F. Malnate; O. B. Hartzog, jr., D. O.; M. A. Hecht, D. O.; C. N. Conover, ch. engr.
New York, Long Island Sound: Wire drag	Launches Ogden and Marindin, June 2–June 30, Lt. (J. G.) B. H. Rigg, in charge; Lt. (J. G.) H. E. Finnegan, from June 5; Fred Natella, D. O.; F. E. Okeson mate, from June 3.
New York, entrance to Ambrose Channel: Hydrography, M3, A1, S140; wire drag, A1.	Launches Ogden, Rodgers, and Marindin, Oct. 4–Oct. 11, Lt. (J. G.) H. E. Finnegan, in charge; Lt. (J. G.) J. C. Sammons; Ensign K. B. Jeffers; F. Natella, D. O.
New Jersey, Herford Inlet-Toms River: Searching for and marking triangulation stations.	Shore party, Oct. 1–Nov. 30, E. R. Martin, jr. engr., in charge.
New Jersey and Delaware: Coast Pilot revision.	Chartered launch, July 1–Aug. 21, Lt. G. D. Cowie, in charge.
Delaware and Maryland, Cape Henlopen, Fenwick Island: Hydrography, M823, A85, S18, 604; tide sta., 3.	Ship Ranger, Aug. 19–Nov. 1, Lt. Charles Shaw, comdg.; Lt. (J. G.) B. H. Rigg, exec.; Lt. (J. G.) W. M. Gibson; Ensign R. A. Earle, to Oct. 15; M. E. Wennermark, D. O.; J. S. Massey, D. O.; R. C. Overton, mate; F. L. Chamberlain, ch. engr.
Delaware and Maryland, Fenwick Island: Triangulation, L10, A10, P12; topography, L49, A11; hydrography, M1,148, A1,235, S13,512; tide sta., 1; current sta., 25; mag. sta., 4.	Ship Lydonia, July 24–Nov. 3, Lt. G. C. Mattison, comdg.; Lt. Charles Shaw, exec., Aug. 14; Lt. (J. G.) E. B. Roberts, exec., from Aug. 14; Lt. (J. G.) E. A. Deily, from Aug. 5; Lt. (J. G.) H. A. Paton; Lt. (J. G.) W. F. Malnate, from Aug. 17; Lt. (J. G.) E. R. McCarthy; M. G. Ricketts, D. O.; M. H. Reese, D. O.; F. E. Okeson, mate; C. N. Conover, ch. engr.
Maryland and Virginia, Chesapeake Bay: Triangulation, L20, A26, P24; topography, L25; hydrography, M669, A52, S16,177; tide sta., 4; current sta., 1.	Ship Natoma, July 1–Nov. 13, Lt. Jack Senior, comdg.; Lt. (J. G.) J. C. Bose, exec. to Oct. 26; Lt. (J. G.) H. A. Paton, exec., from Oct. 26; Lt. (J. G.) W. J. Chovan, to Oct. 20; Lt. (J. G.) W. R. Porter; F. A. Riddell, D. O.; I. R. Rubottom, D. O., to Nov. 8; Antone Silva, ch. engr.
District of Columbia, Bureau of Standards grounds: Topography, A1.	Shore party, Feb. 4–Mar. 10, Lt. (J. G.) L. C. Wilder, in charge; E. L. Jones, D. O., to Feb. 27; C. R. Reed, D. O.; W. C. Russell, D. O.
Virginia, Little Creek and vicinity: Triangulation, L8, A49, P26; topography, L23, A7; hydrography, M100, A2, S10,233; tide sta., 2.	Launch Mikawe, July 17–Oct. 5, Lt. F. L. Peacock, comdg.; R. A. Marshall, D. O., to Aug. 31; J. S. Morton, D. O.; H. C. Walker, D. O.; E. B. Brown, jr., D. O.; J. C. Ellerbe, jr., D. O.; J. C. Tribble, jr., D. O. O. B. Hartzog, jr., D. O.; J. C. Tison, jr., D. O.; M. A. Hecht, D. O., from July 16; K. S. Ulm, D. O., from Sept. 21.
Virginia, Norfolk: Triangulation, L14, A14, P33; topography, L128; hydrography, M158, A8, S8,971; tide sta., 4.	Shore party, July 24–Jan. 25, Lt. R. F. A. Studds, in charge, to Dec. 28; Lt. (J. G.) H. E. Finnegan, from and in charge from Dec. 28; Ensign L. W. Swanson; R. A. Marshall, D. O., from Sept. 1.
Virginia, North Carolina, and South Carolina: Coast Pilot revision, inside route.	Launch Elsie, May 31–June 15, Lt. (J. G.) G. E. Boothe, in charge.
Florida, east coast, Cape Canaveral–Sebastian: Triangulation, L40, A89, P50; topography, L37, A9; hydrography, M2,543, A653, S29,879; tide sta., 1; current sta., 11; mag. sta., 6.	Ship Lydonia, Feb. 4–May 9, Lt. G. D. Cowie, comdg.; Lt. W. M. Scaife, exec.; Lt. (J. G.) K. G. Crosby; Lt. (J. G.) L. S. Hubbard, from Mar. 28; Lt. (J. G.) W. F. Malnate; Ensign M. H. Reese; H. S. Walker, D. O., Apr. 12–Apr. 29; O. B. Hartzog, jr., D. O.; M. A. Hecht, D. O.; F. E. Okeson, mate, Apr. 27; C. N. Conover, ch. engr.

Division of Hydrography and Topography—Continued

Locality and operations	Persons conducting operations
Florida, east coast, Sebastian-Fort Pierce: Triangulation, L10, A35, P38; topography, L50, A9; hydrography, M2,054, A1,118, S62,645; tide sta., 4; current sta., 4; mag. sta. 1.	Ship Ranger, Jan. 1-June 30, Lt. Charles Shaw, comdg.; Lt. (J. G.) E. B. Roberts, exec.; Lt. (J. G.) W. M. Gibson, to June 14; Ensign M. E. Wennermark, to May 24; Ensign J. S. Massey, to June 21; H. C. Walker, D. O., to June 9; R. C. Overton, mate; F. L. Chamberlain, ch. engr.
Florida, east coast, Fort Pierce-Jupiter Inlet: Triangulation, L36, A95, P59; topography, L39, A1; hydrography, M2,910, A766, S50,859; tide sta., 4; current sta., 2; mag. sta., 3.	Ship Natoma, Dec. 19-June 30, Lt. C. A. Egner, comdg.; Lt. (J. G.) H. A. Paton, exec.; Lt. (J. G.) W. R. Porter, to Mar. 22; Lt. (J. G.) G. R. Shelton, from Mar. 18; Ensign F. A. Riddell, to May 26; Ensign M. H. Reese, from May 25; J. C. Tison, jr., D. O.; Antone Silva, ch. engr.
Florida, east coast: Air photoreduction, topography, L574, A752.	Office, July 1-June 30, Lt. O. S. Reading, in charge; Lt. (J. G.) W. J. Chovan, from Jan. 6; Ensign R. C. Bolstad; M. A. Hecht, D. O., from Nov. 16-Jan. 11; E. L. Jones, D. O., from Nov. 16-Feb. 3.
Florida, west coast, Shark River and White Water Bay-Naples: Topography, L5, A2; hydrography, M1,413, A137, S55,744; tide sta. 10.	Shore party, Dec. 9-Apr. 30, Lt. (J. G.) B. H. Rigg, in charge; Fred Natella, D. O., from Jan. 11; F. E. Okeson, mate, Dec. 16-Apr. 26.
Florida, west coast, St. Andrews Bay: Triangulation, L5, A5, P7; topography, L31, A8; hydrography, M181, A9, S7,655: tide sta., 1.	Chartered launch, Apr. 28-June 30, Lt. R. D. Horne, in charge; M. G. Ricketts, D. O.
Florida, west coast, east of Pensacola Bay, Santa Rosa Island and vicinity: Triangulation, L12, A17, P9; topography, L15, A3; hydrography, M237, A47, S5,263; current sta., 1; mag. sta., 2.	Ship Oceanographer, Mar. 21-May 9, Lt. F. L. Peacock, comdg.; Lt. R. F. A. Studds, exec.; Lt. R. D. Horne, to Apr. 26; Lt. (J. G.) T. B. Reed; Lt. (J. G.) C. A. Burmister; Ensign K. B. Jeffers; E. B. Brown, jr., D. O.; J. C. Tribble, jr., D. O.; H. Ely, ch. engr.
California, Santa Barbara Channel: Triangulation, P17; hydrography, M1,612, A564, S6,448; tide sta., 1.	Motor vessel Westdahl, Jan. 6-Mar. 31, Lt. L. D. Graham, comdg.; Lt. (J. G.) R. C. Rowse; Ensign R. A. Earle.
California, vicinity Point Reyes: Triangulation, L7, A35, P9; topography, L68, A46; hydrography, M7,277, A4,380, S57,206; tide sta., 2; current sta., 2.	Ship Pioneer, July 1-Dec. 6, Lt. O. W. Swainson, comdg.; Lt. R. P. Eyman, exec.; Lt. J. A. Bond; Lt. E. O. Heaton; Lt. (J. G.) K. G. Crosby, to July 20; Lt. (J. G.) R. C. Rowse, to Nov. 4; Lt. (J. G.) H. J. Healy; Lt. (J. G.) G. A. Nelson, from July 29; Ensign G. R. Fish, from Nov. 23; Ensign J. F. Fay, to Nov. 15; Ensign R. A. Gilmore; Ensign G. C. Mast; C. R. Jones, ch. engr.
California, Point Reyes-Rockport: Triangulation, L6, A5, P10; topography, L81, A20; hydrography, M6,847, A6,309, S42,244; tide sta., 2.	Ship Discoverer, July 1-Dec. 6, Lt. Comdr. F. G. Engle, comdg., to July 31; Lt. Comdr. F. B. T. Siems, comdg., from Aug. 1; Lt. L. D. Graham, exec., to Oct. 28; Lt. C. M. Durgin, from Sept. 3, exec. Oct. 28-Nov. 28; Lt. Herman Odessey; Lt. (J. G.) R. W. Knox, exec. from Nov. 28; Lt. (J. G.) G. L. Anderson; Lt. (J. G.) J. C. Bose, from Dec. 2; Lt. (J. G.) A. C. Thorson; Ensign Curtis Le Fever; Ensign C. J. Wagner; Ensign John Laskowski; J. L. McIver, ch. engr.
California, Gualala: Topography, L11, A4; hydrography, M89, A7, S1,755; tide sta., 1.	Chartered launch, June 5-June 30, Lt. (J. G.) L. C. Johnson, in charge; Ensign J. N. Jones; R. A. Marshall, D. O.
California, Point Reyes-Fort Bragg: Triangulation, L108, A250, P150.	Shore party, Nov. 17-June 30, Lt. (J. G.) Charles Pierce, in charge to Mar. 1; Lt. (J. G.) J. H. Brittain, in charge from Mar. 2; Ensign G. R. Fish, from April 7.
California, Rockport to Punta Gorda: Triangulation, L60, A128, P98.	Shore party, Dec. 17-June 30, Lt. (J. G.) H. A. Karo, in charge to April 7; Lt. (J. G.) Charles Pierce, in charge from April 8.
California, Crescent City-Cape Mendocino: Topography, L187, A69; hydrography, M734, A113, S25,989; tide sta., 3; current sta., 7; mag. sta., 4.	Shore party, July 1-Dec. 3, Lt. A. P. Ratti, in charge; Lt. (J. G.) G. R. Shelton; Ensign G. M. Marchand.
Washington, Cape Elizabeth-Cape Johnson: Triangulation, L42, A115, P18; topography, L59, A115.	Shore party, July 1-Oct. 26, Lt. R. D. Horne, in charge; Ensign G. R. Fish.
Washington, Cape Elizabeth-Destruction Island: Hydrography, M1,044, A225, S10,113; tide sta., 1; mag. sta., 3.	Ship Guide, May 26-June 30, Lt. K. T. Adams, comdg.; Lt. E. H. Bernstein, exec.; Lt. Herman Odessey; Lt. (J. G.) H. A. Karo; Lt. (J. G.) F. G. Johnson; Lt. (J. G.) H. J. Healy; Ensign J. C. Mathisson; Ensign A. N. Stewart; Ensign J. N. Jones; J. S. Morton, D. O.; Frank Seymour, ch. engr.
Alaska, southeast, Behm Canal and Stikine River: Triangulation, L64, A188, P132.	Shore party, chartered launch, July 1-Sept. 24, Lt. (J. G.) J. M. Smook, in charge; Lt. (J. G.) B. G. Jones.
Alaska, southeast, Behm Canal: Triangulation, L35, A96, P35; topography, L154, A56; hydrography, M864, A79, S20,258; tide sta., 3; mag. sta., 4.	Ship Explorer, Apr. 9-June 30, Lt. E. W. Eickelberg, comdg.; Lt. (J. G.) H. C. Warwick, exec.; Lt. (J. G.) P. C. Doran; Lt. (J. G.) J. C. Partington; Lt. (J. G.) B. G. Jones; Ensign H. O. Fortin; K. S. Ulm, D. O.; W. Weidlich, mate; A. N. Loken, ch. engr.
Alaska, southeast, Taku Inlet and Stikine River: Triangulation, L36, A203, P21.	Shore party, July 1-Sept. 27, Lt. W. M. Scaife, in charge; Ensign A. N. Stewart; cooperating with this party, Sept. 10-Sept. 24, Lt. (J. G.) J. M. Smook and Lt. (J. G.) B. G. Jones.

Division of Hydrography and Topography—Continued

Locality and operations	Persons conducting operations
Alaska, southeast, Sumner Strait, Wrangell Narrows, Duncan Canal, and Keku Strait; Triangulation, L58, A106, P171; topography, L79, A24; hydrography, M1,231, A74, S40,-406; tide sta., 3; mag. sta., 13.	Ship Explorer, July 1–Oct. 9, Lt. E. W. Eickelberg, comdg.; Lt. E. H. Bernstein, exec.; Lt. (J. G.) T. B. Reed; Lt. (J. G.) P. C. Doran; Lt. (J. G.) J. C. Partington; Lt. (J. G.) L. C. Johnson; Ensign J. N. Jones; W. Weidlich, mate; A. N. Loken, ch. engr.
Alaska, southwest, Kenai Peninsula: Triangulation, L37, A231, P41; topography, L45, A14; hydrography, M1,452, A977, S8,032; tide sta., 2.	Ship Discoverer, May 12–June 30, Lt. Comdr. F. B. T. Siems, comdg.; Lt. J. A. Bond, exec., from June 14; Lt. (J. G.) G. L. Anderson; Lt. (J. G.) R. C. Rowse; Lt. (J. G.) G. A. Nelson; Ensign G. W. Lovesee; Ensign John Laskowski; Ensign G. C. Mast; Ensign I. R. Rubottom; J. L. McIver, ch. engr.; F. J. Soule, surgeon. M. V. Westdahl, May 12–June 30, Lt. L. D. Graham, comdg.; Lt. (J. G.) F. B. Quinn; Ensign R. A. Earle.
Alaska, southwest, Kodiak Island: Triangulation, L60, A157, P81; topography, L224, A315; hydrography, M3,951, A1,578, S51,736; wire drag, A1; tide sta., 2; current sta., 1; mag. sta., 7.	Ship Surveyor, July 1–Oct. 19, Lt. R. R. Lukens, comdg.; Lt. C. A. Egner, exec.; Lt. C. D. Meaney; Lt. (J. G.) L. S. Hubbard; Lt. (J. G.) F. G. Johnson; Lt. (J. G.) P. L. Bernstein; Lt. (J. G.) R. J. Sipe; Ensign J. C. Mathisson; Ensign H. J. Oliver; Ensign C. A. George; Ensign H. F. Garber; R. W. Healy, mate; G. E. Johanson, ch. engr.; W. J. Leary, surgeon.
Alaska, southwest, Kodiak Island: Triangulation, L78, A471, P84; topography, L61, A36; hydrography, M2,068, A980, S16,932; tide sta., 3.	Ship Surveyor, May 8–June 30, Comdr. H. F. Hardy, comdg.; Lt. C. D. Meaney, exec.; Lt. (J. G.) R. W. Knox; Lt. (J. G.) R. J. Sipe; Lt. (J. G.) A. C. Thorson; Ensign L. W. Swanson; Ensign E. B. Lewey; Ensign C. A. George; Ensign G. M. Marchand; Ensign H. F. Garber; R. W. Healy, mate; G. E. Johanson, ch. engr.; W. J. Leary, surgeon.
Hawaiian Islands, Oahu, westward and vicinity of Hawaii: Triangulation, A1, P2; topography, L8, A1; hydrography, M11,289, A48,-654, S28,901; tide sta., 1; mag. sta., 2.	Ship Guide, July 1–Nov. 12, Lt. K. T. Adams, comdg.; Lt. F. L. Gallen, exec.; Lt. (J. G.) H. C. Warwick; Lt. (J. G.) G. E. Boothe; Lt. (J. G.) W. H. Bainbridge; Lt. (J. G.) F. B. Quinn; Ensign V. M. Gibbens; Ensign G. W. Lovesee; Ensign E. B. Lewey; Frank Seymour, ch. engr.; D. R. Kruger, surgeon, from July 31.
Hawaiian Islands, Oahu-Gardner Pinnacles: Hydrography, M6,820, A42,600, S21,760.	Ship Pioneer, Apr. 14–June 30, Lt. O. W. Swainson, comdg.; Lt. C. K. Green, exec.; Lt. E. O. Heaton; Lt. (J. G.) V. M. Gibbens; Lt. (J. G.) P. L. Bernstein; Ensign R. A. Gilmore; Ensign C. J. Wagner; J. C. Ellerbe, jr., D. O.; C. R. Jones, ch. engr.; D. R. Kruger, surgeon.
Philippine Islands, Babuyan Islands and vicinity: Topography, L2, A1; hydrography, M2,910, A2,016, S10,314; current sta., 61.	Ship Pathfinder, July 1–Sept. 30, Lt. H. B. Campbell, comdg.; Lt. (J. G.) R. W. Woodworth, exec.; Lt. (J. G.) I. E. Rittenburg; Lt. (J. G.) E. H. Kirsch; K. R. Gile, ch. engr.; J. V. Tormey, surgeon.
Philippine Islands, Claveria Bay, Luzon Island: Triangulation, L71, A1,014, P12; topography, L5; hydrography, M164, A227, S3,165; tide sta., 1.	Ship Pathfinder, May 1–June 30, Lt. G. C. Mattison, comdg.; Lt. C. M. Durgin, exec.; Lt. M. O. Witherbee; Lt. (J. G.) J. M. Smook; Ensign G. E. Morris; K. R. Gile, ch. engr.; J. V. Tormey, surgeon.
Philippine Islands, Luzon Island, east coast, Casiguran Sound, Cape San Ildefonso, etc.: Triangulation, P4; topography, L93, A235; hydrography, M1,335, A1,076, S19,856; mag. sta., 1.	Ship Fathomer, July 1–Oct. 15, Lt. G. C. Jones, comdg.; Lt. (J. G.) A. J. Hoskinson, exec.; Ensign C. A. Burmister; Ensign E. C. Baum; Ensign G. E. Morris; G. W. Hutchison, ch. engr.; W. R. Scroggs, surgeon.
Philippine Islands, Luzon Island, east coast, Palanan Bay: Hydrography, M14, S573; tide sta., 1.	Ship Fathomer, June 1–June 30, Lt. Jack Senior, comdg.; Lt. (J. G.) A. P. Ratti, exec.; Lt. (J. G.) E. A. Deily; Lt. (J. G.) J. C. Bose; Lt. (J. G.) E. R. McCarthy; G. W. Hutchison, ch. engr.; W. R. Scroggs, surgeon.
Philippine Islands, Cagayan Valley: Triangulation reconnaissance.	Shore party, Mar. 28–Apr. 22, and May 22–May 27, Lt. G. C. Jones, in charge, to Apr. 22; Lt. (J. G.) J. M. Smook, in charge, from Apr. 23; Lt. (J. G.) E. R. McCarthy, from May 22.
Philippine Islands, Mindoro Strait: Mag. sta. 7.	Ship Fathomer, Mar. 11–Mar. 19, Lt. G. C. Jones, comdg.: Lt. (J. G.) A. J. Hoskinson, exec.; Ensign E. C. Baum; Ensign G. E. Morris; G. W. Hutchison, ch. engr.; W. R. Scroggs, surgeon.
Philippine Islands, Davao Gulf, Mindanao Island: Triangulation, A11, P6; topography, L59, A89; hydrography, M4,101, A4,164, S27,386; tide sta., 2; current sta., 14; mag. sta., 4.	Ship Pathfinder, Oct. 19–Jan. 31, Lt. H. B. Campbell, comdg.; Lt. (J. G.) R. W. Woodworth, exec.; Lt. M. O. Witherbee, from Nov. 12; Lt. (J. G.) I. Rittenburg; Lt. (J. G.) E. H. Kirsch; K. R. Gile, ch. engr.; J. V. Tormey, surgeon.
Philippine Islands, Port Lamon, Mindanao Island: Hydrography, M25, A2, S639.	Shore party, May 20–June 2, Arthur Hunycutt, in charge.
Philippine Islands, Dumanquilas Bay, Mindanao Island: Topography, L32, A10; hydrography, M1,973, A1,206, S27,760; tide sta., 1; current sta., 3; mag. sta., 5.	Ship Marinduque, July 1–Sept. 13, Lt. W. D. Patterson, comdg.; Lt. (J. G.) C. I. Aslakson, exec.; Lt. (J. G.) S. B. Grenell; Ensign F. R. Gossett; H. Ely, ch. engr.; to Aug. 18; J. Wyer, ch. engr., from Sept. 6; F. J. Soule, surgeon.

Division of Hydrography and Topography—Continued

Locality and operations	Persons conducting operations
Philippine Islands, Tawitawi Group, Sulu Archipelago: Topography, L130, A75; hydrography, M2,531, A155, S76,432; tide sta., 5.	Ship Marinduque, Sept. 24–June 30, Lt. W. D. Patterson, comdg.; Lt. (J. G.) C. I. Aslakson, exec.; to Feb. 11; Lt. (J. G.) S. B. Grenell, exec., from Feb. 12; Lt. M. O Witherbee, Oct. 27–Nov. 10; Ensign F. R. Gossett; J. Wyer, ch. engr.; F. J. Soule, surgeon, to Jan. 6; A. W. Matschke, surgeon, from May 27.
Philippine Islands, Palawan Island, southwest coast: Triangulation, L46, A300, P15.	Ship Fathomer, Nov. 6–Dec. 8, and Mar. 27–May 11, Lt. G. C. Jones, comdg.; to Mar. 20; Lt. Jack Senior, comdg., from Mar. 21; Lt. (J. G.) A. J. Hoskinson, exec., to Mar. 20; Lt. A. P. Ratti, exec., from Mar. 21; Ensign E. C. Baum, to Mar. 22; Ensign G. E. Morris, to Mar. 20; Lt. (J. G.) E. A. Deily, from Mar. 20; Lt. (J. G.) J. C. Bose, from Mar. 20; Lt. (J. G.) E. R. McCarthy, from Mar. 20; G. W. Hutchison, ch. engr.; W. R. Scroggs, surgeon.

DIVISION OF GEODESY

[July 1, 1929, to June 30, 1930]

Locality	Operations	Persons conducting operations
Buffalo-Trenton arc, New York, Pennsylvania, and New Jersey.	Triangulation and base measurement, first-order 325 mi., 3,450 sq. mi.; 2 base lines, 9.1 mi., 1 base line, 5.3 mi., at Portsmouth, Ohio; 6 Laplace and 4 first-order azimuths.	Lt. (J. G.) C. M. Thomas, chief; Lt. (J. G.) E. J. Brown; Ensign C. A. Schanck; Ensign J. D. Thurmond; M. Braden, foreman hand.
Mississippi River arc, Illinois, Missouri, Kentucky, Arkansas, Tennessee, Mississippi, and Louisiana.	Triangulation, first-order; 615 mi., 4,900 sq. mi.; 11 Laplace and 4 first-order azimuths.	Lt. H. W. Hemple, chief; Lt. (J. G.) P. A. Smith; Lt. (J. G.) John Bowie, jr.; Lt. (J. G.) I. T. Sanders; Signalmen J. S. Bilby and W. J. Bilby.
Atlanta-Shreveport arc, Georgia, Alabama, and Mississippi.	Triangulation, first-order; 340 mi., 4,300 sq. mi.; 4 Laplace and 1 first-order azimuth.	Lt. (J. G.) P. A. Smith, chief; Ensign J. D. Thurmond; Signalman W. J. Bilby.
Bear Lake to thirty-fifth parallel, Calif.	Triangulation and base measurement, first-order; 105 mi., 2,000 sq. mi.; base line, 8.7 mi.; 3 Laplace azimuths.	Lt. G. L. Bean, chief; Lt. (J. G.) H. A. Karo; Lt. (J. G.) J. H. Brittain.
Point Reyes to Great Valley, Calif.	Triangulation, first-order; 45 mi., 1,450 sq. mi.	Lt. G. L. Bean, chief; Ensign H. J. Oliver.
Mississippi River arc, Missouri, Arkansas, Kentucky, Mississippi, and Louisiana.	Base and traverse measurement, first-order; traverse, 33 mi.; 7 base lines, 47.7 mi.	Lt. (J. G.) C. M. Thomas, chief; Lt. (J. G.) J. D. Thurmond; Lt. (J. G.) I. T. Sanders; M. Braden, foreman hand.
Ninety-third meridian, Missouri and Iowa.	Base measurement, first-order; 2 base lines, 17.1 mi.	Lt. (J. G.) I. T. Sanders, chief; M. Braden, foreman hand.
Canton, Pa., to Trenton, N. J.	Reconnaissance for first-order triangulation; 160 mi., 2,260 sq. mi.	W. Mussetter, chief.
Forty-second parallel arc, Nebraska and Iowa.	Reconnaissance for first-order triangulation; 175 mi., 2,100 sq. mi.	Do.
La Crosse to Fond du Lac, Wis.	Reconnaissance for first-order triangulation; 140 mi., 1,500 sq. mi.	Do.
Cairo to thirty-ninth parallel, Ill.	Reconnaissance for first-order triangulation; 110 mi., 1,440 sq. mi.	Do.
Cairo, Ill., to Charleston, Mo.	Reconnaissance for first-order triangulation; 20 mi., 180 sq. mi.	Do.
Cairo to Nashville, Illinois, Kentucky, and Tennessee.	Reconnaissance for first-order triangulation; 160 mi., 1,700 sq. mi.	Do.
Lucerne Valley to thirty-fifth parallel, Calif.	Reconnaissance for first-order triangulation; 75 mi., 1,600 sq. mi.	Lt. G. L. Bean, chief; Lt. (J. G.) H. A. Karo; Lt. (J. G.) J. H. Brittain.
Point Reyes to Great Valley, Calif.	Reconnaissance for first-order triangulation; 45 mi., 1,450 sq. mi.	Do.
Michigan, Wisconsin, Illinois, Kentucky, Ohio, New York, and Pennsylvania.	4 Laplace and 1 reobserved Laplace azimuths; 15 longitudes, 4 latitudes.	Lt. (J. G.) R. L. Pfau, chief; Ensign J. P. Lushene.
Missouri	1 longitude and 2 latitudes	Lt. (J. G.) J. P. Lushene, chief; Lt. (J. G.) E. B. Latham.
New Jersey and Pennsylvania	3 longitudes and 1 latitude	Lt. (J. G.) R. L. Pfau, chief; Lt. (J. G.) C. A. Schanck.
Bahama Islands and Florida	7 gravity stations	Lt. (J. G.) J. P. Lushene, chief.

Division of Geodesy—Continued

Locality	Operations	Persons conducting operations
Taylor Springs, N. Mex., to Pueblo, Colo.	First-order leveling; 148 mi	Lt. Charles Pierce, chief.
Colorado Springs, Colo., to Denver, Colo.	First-order leveling; 80 mi	Do.
Colorado Springs, Colo., to Cheyenne Wells, Colo.	Leveling (single line rerun over old first-order line); 171 mi. single line.	Do.
Philadelphia, Pa., to Harrisburg, Pa.	First-order leveling; 117 mi	Lt. (J. G.) J. D. Thurmond, chief.
Shelbyville, Ind., to Vincennes, Ind.	First-order leveling; 149 mi	Lt. (J. G.) John Bowie, jr., chief.
Washington, Ind., to Petersburg, Ind.	First-order leveling; 16 mi	Lt. (J. G.) John Bowie, jr., chief; Lt. W. R. Porter.
Wabash, Ind., to Huntington, Ind.	First-order leveling; 19 mi	Do.
Washington, Ind., to Indianapolis, Ind.	First-order leveling; 112 mi	Do.

DIVISION OF TIDES AND CURRENTS

Eastport, Me	Tide observations	J. J. Murphy.
Prospect Harbor, Me	do	H. S. Shaw.
Portland, Me	do	C. H. Hudson.
Portsmouth, N. H	do	U. S. Navy; C. A. Gerry.
Boston Harbor, Mass	Current observations, 10 stations	H. E. Finnegan.
Boston, Mass	Tide observations	R. F. Luce; H. F. Russell.
Cornfield Point Lightship, Conn	Current observations	Harry Eide, master.
Bartlett Reef Lightship, Conn	do	John S. Gundersen, master.
Long Island Sound and tributaries, N. Y. and Conn.	Current observations, 99 stations	H. E. Finnegan.
Do	Tide observations, 16 stations	Do.
New York, N. Y	Tide observations	H. A. Cotton; T. J. Lyons.
Hudson River, N. Y	Current observations, 31 stations	H. E. Finnegan.
Do	Tide observations, 12 stations	Do.
Atlantic City, N. J	Tide observations	S. S. Day.
Cold Spring Inlet, N. J	do	R. L. Schoppe.
Coast of Delaware	Tide observations, 2 stations	Charles Shaw.
Philadelphia, Pa	Tide observations	W. M. Miller.
Ocean City, Md	do	J. L. Quillen.
Chesapeake Bay, Md	Tide observations, 2 stations	Jack Senior.
Annapolis, Md	Tide observations	U. S. Navy; W. F. Graham.
Baltimore, Md	do	F. A. Kummell.
Hampton Roads, Va	do	U. S. Navy; J. C. Twaddle.
Vicinity of Norfolk, Va	Tide observations, 3 stations	R. F. A. Studds.
Little Creek, Va	Tide observations	F. L. Peacock.
York Spit Channel, Va	Current observations	Jack Senior.
Chesapeake Bay, Va	Tide observations, 2 stations	Do.
Charleston, S. C	Tide observations	L. C. Lockwood.
Mayport, Fla	do	U. S. Engineers; H. H. Williams.
Jacksonville, Fla	do	U. S. Engineers; W. P. Tisdale.
Cape Canaveral, Fla	do	G. C. Mattison.
Fort Lauderdale, Fla	do	A. J. Garten.
Fort Pierce Inlet, Fla	Current observations	Charles Shaw.
Fort Pierce, Fla	Tide observations, 2 stations	Do.
Jupiter Inlet, Fla	Tide observations	Jack Senior.
Daytona Beach, Fla	do	T. J. Wright.
Vicinity of Miami, Fla	Current observations, 3 stations	R. L. Schoppe.
Palm Beach, Fla	Tide observations, 2 stations	Do.
Key West, Fla	Tide observations	S. M. Goldsmith.
Everglades, Fla	do	D. G. Copeland; F. J. Nebiker.
Vicinity of Everglades, Fla	Tide observations, 10 stations	B. H. Rigg.
Pensacola, Fla	Tide observations	V. D. Holcomb.
Galveston, Tex	do	C. F. Southwick; L. T. Armstrong.
La Jolla, Calif	do	G. F. McEwen.
Santa Barbara, Calif	do	M. M. Hicks.
San Francisco, Calif	do	T. J. Maher; H. S. Ballard.
Bonita Channel, Calif	Current observations	O. W. Swainson.
Vicinity of San Francisco, Calif	Tide observations, 2 stations	Do.
Coast of California	Tide observations, 3 stations	F. G. Engle; F. B. T. Siems.
Do	Tide observations, 4 stations	A. P. Ratti.
Astoria, Oreg	Tide observations	A. M. Coleman.
Seattle, Wash	do	R. P. Eyman; E. E. David.
Ketchikan, Alaska	do	A. Anderson.
Southeast Alaska	Tide observations, 7 stations	H. W. Cotton; E. W. Eickelberg.
Vicinity of Kodiak Island, Alaska	Current observations, 2 stations	R. R. Lukens.
Do	Tide observations, 6 stations	Do.

Division of Tides and Currents—Continued

Locality	Operations	Persons conducting operations
Cordova, Alaska	Tide observations	Chamber of commerce.
Seward, Alaska	do	I. A. Leedom.
Honolulu, Hawaii	do	J. H. Peters.
Hilo, Hawaii	do	U. S. Geological Survey.
Hawaiian Islands	Tide observations, 3 stations	K. T. Adams.

DIVISION OF TERRESTRIAL MAGNETISM AND SEISMOLOGY

Cheltenham, Md	Observatory	George Hartnell, S. G. Townshend, magnetic observers.
San Juan, P. R	do	Lt. E. R. Hand.
Sitka, Alaska	do	F. P. Ulrich, magnetic observer.
Tucson, Ariz	do	A. K. Ludy, magnetic observer.
Honolulu, Hawaii	do	Lt. J. H. Peters.
Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania.	Repeat stations and replacements	W. M. Hill, magnetic observer.
Maryland	Replacement	H. E. McComb, John Hershberger, magnetic observers.
Alabama, Texas, New Mexico, Colorado, Arizona, California.	Repeat stations and replacements	W. M. Hill, magnetic observer.
South Dakota, Wyoming, Montana, North Dakota, Minnesota, Nebraska, Kansas.	do	S. A. Deel, magnetic observer.
Kansas, Nebraska, Colorado, Wyoming.	do	Do.

Very truly yours,

R. S. PATTON, *Director.*

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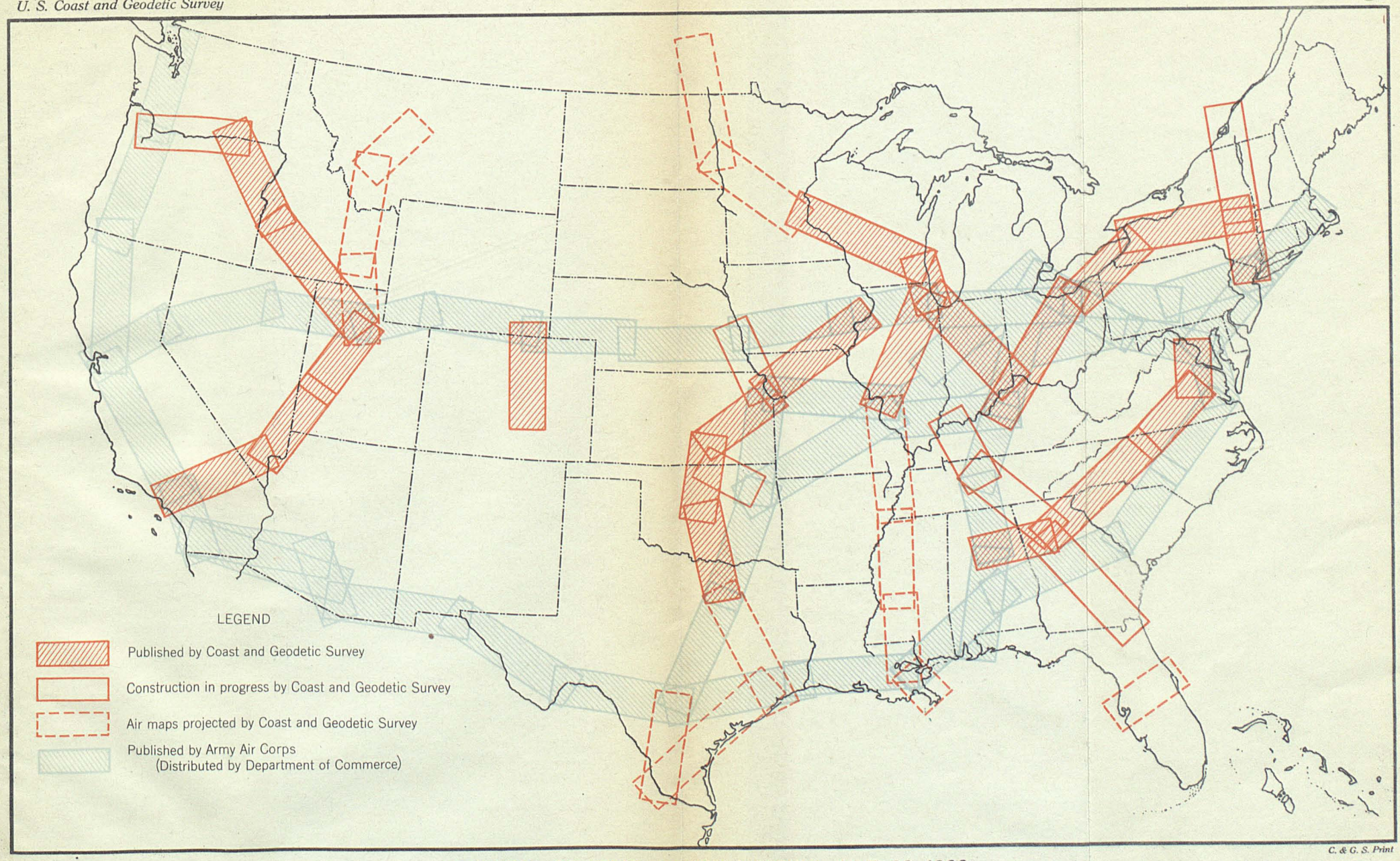
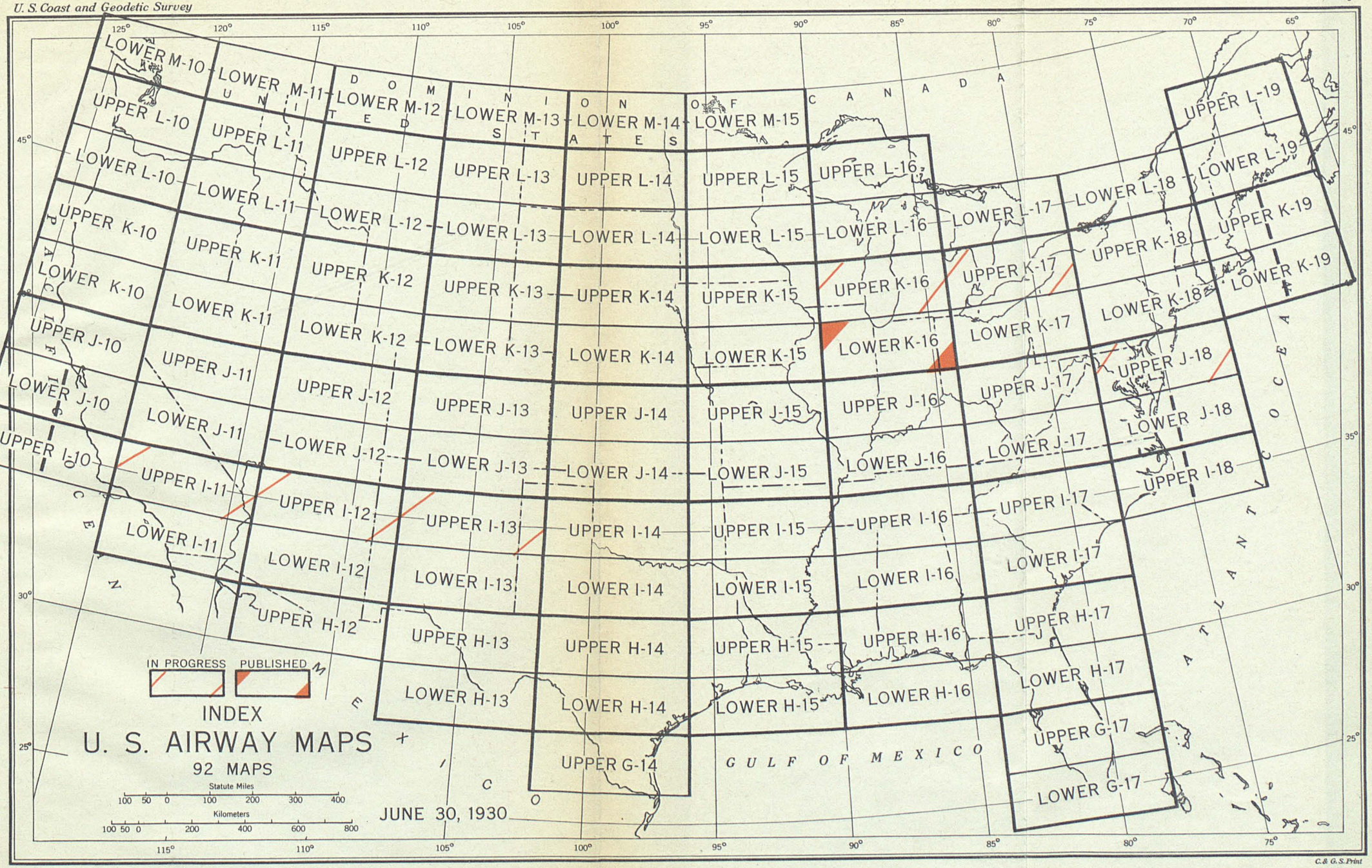


C. & G. S. Print

PROGRESS OF STRIP AIRWAY MAPPING JUNE 30, 1930
Coast and Geodetic Survey and Army Air Corps


LOWER M-10
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UPPER L-10
UPPER L-11
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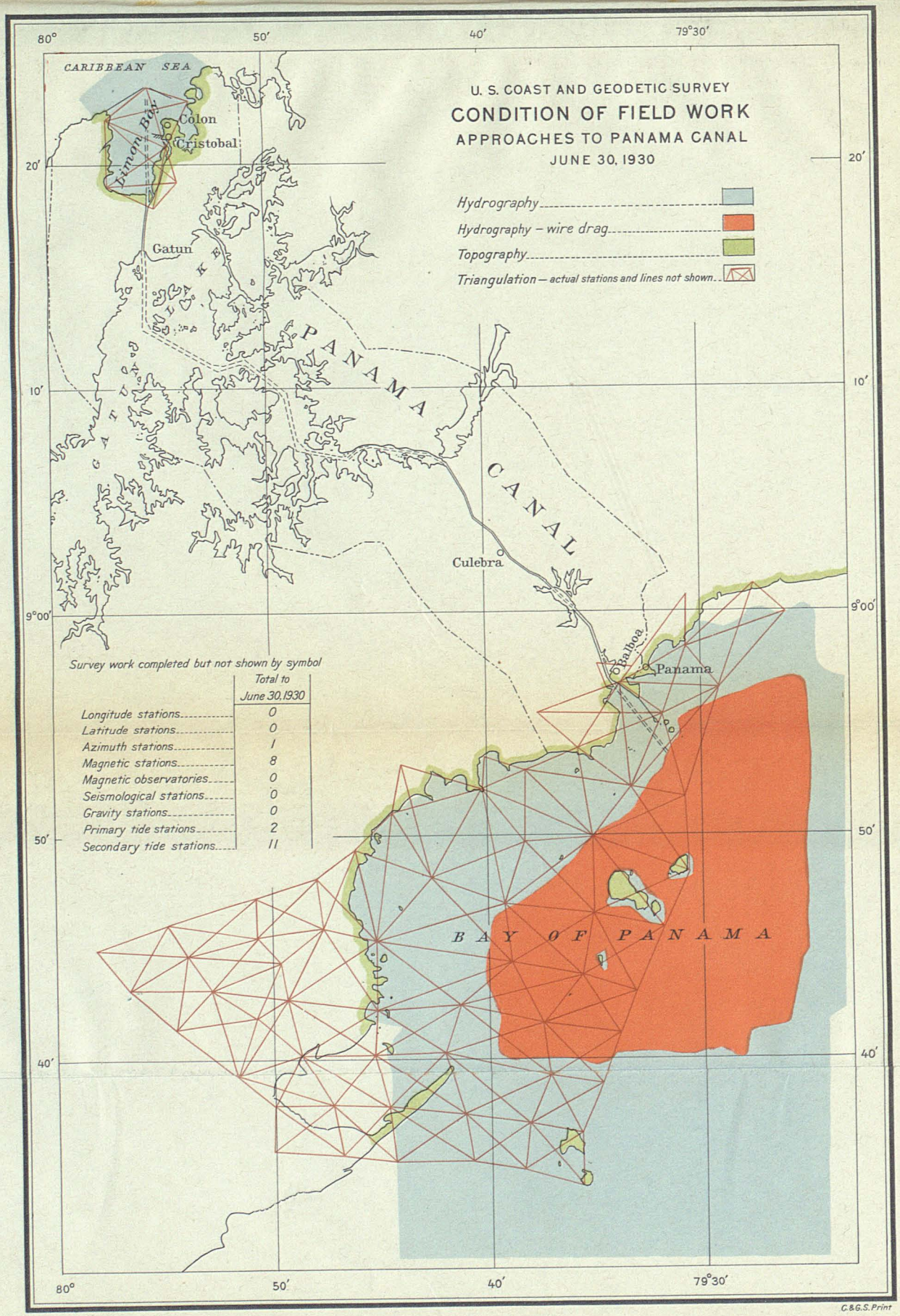
LOWER H-17
UPPER G-14
UPPER G-17
LOWER G-17
DOMINION OF CANADA
UNITED STATES
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
IN PROGRESS
PUBLISHED
INDEX
U. S. AIRWAY MAPS
92 MAPS
Statute Miles
100 50 0 100 200 300 400
Kilometers
100 50 0 200 400 600 800
JUNE 30, 1930
125° 120° 115° 110° 105° 100° 95° 90° 85° 80° 75° 70° 65°
45° 35° 30° 25°


U. S. COAST AND GEODETIC SURVEY
CONDITION OF FIELD WORK
APPROACHES TO PANAMA CANAL
JUNE 30, 1930
Hydrography
Hydrography – wire drag
Topography
Triangulation – actual stations and lines not shown
CARIBBEAN SEA
Limon Bay
Colon
Cristobal
Gatun
LAKE GATUN
PANAMA CANAL
Culebra
Balboa
Panama
BAY OF PANAMA
80°
50′
40′
79°30′
20′
10′
9°00′
Survey work completed but not shown by symbol
Total to June 30, 1930
Longitude stations 0
Latitude stations 0
Azimuth stations 1
Magnetic stations 8
Magnetic observatories 0
Seismological stations 0
Gravity stations 0
Primary tide stations 2
Secondary tide stations 11

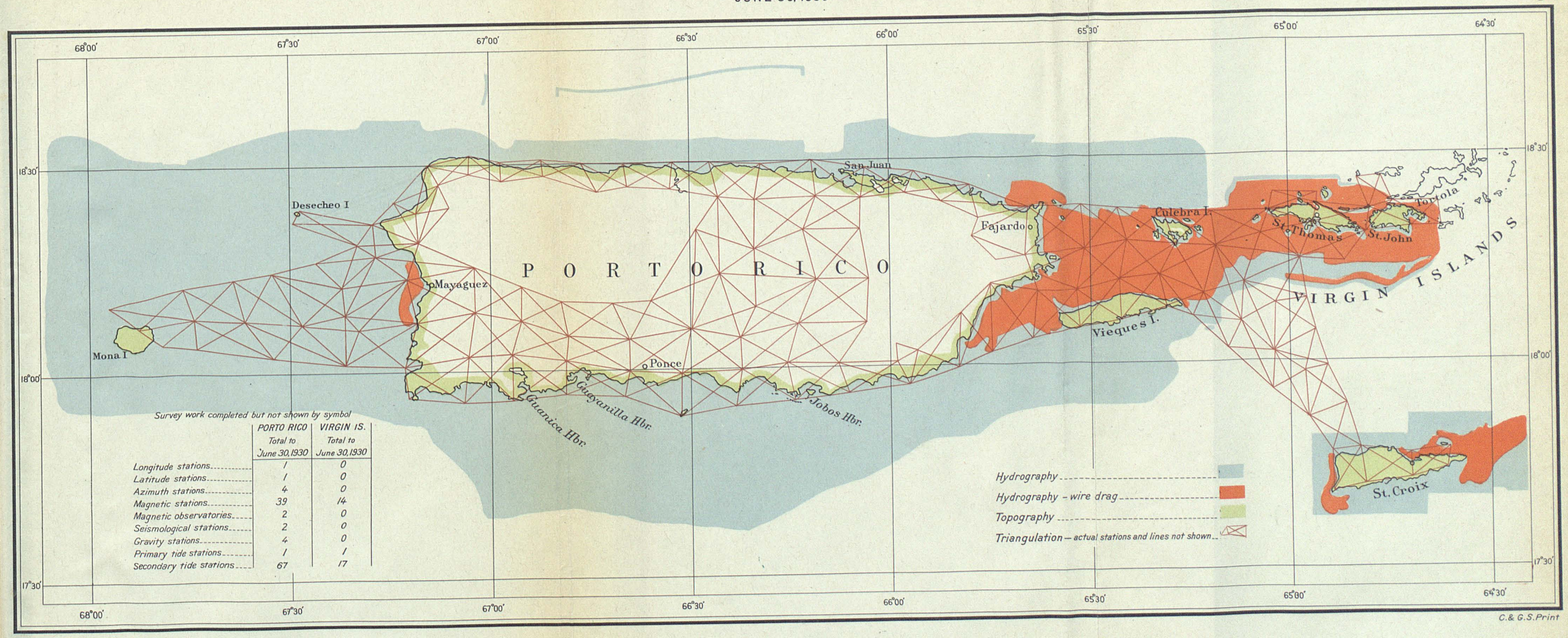
C.&G.S. Print

U. S. COAST AND GEODETIC SURVEY

CONDITION OF FIELD WORK

PORTO RICO AND VIRGIN ISLANDS

JUNE 30, 1930



Survey work completed but not shown by symbol

	PORTO RICO Total to June 30, 1930	VIRGIN IS. Total to June 30, 1930
Longitude stations	1	0
Latitude stations	1	0
Azimuth stations	4	0
Magnetic stations	39	14
Magnetic observatories	2	0
Seismological stations	2	0
Gravity stations	4	0
Primary tide stations	1	1
Secondary tide stations	67	17

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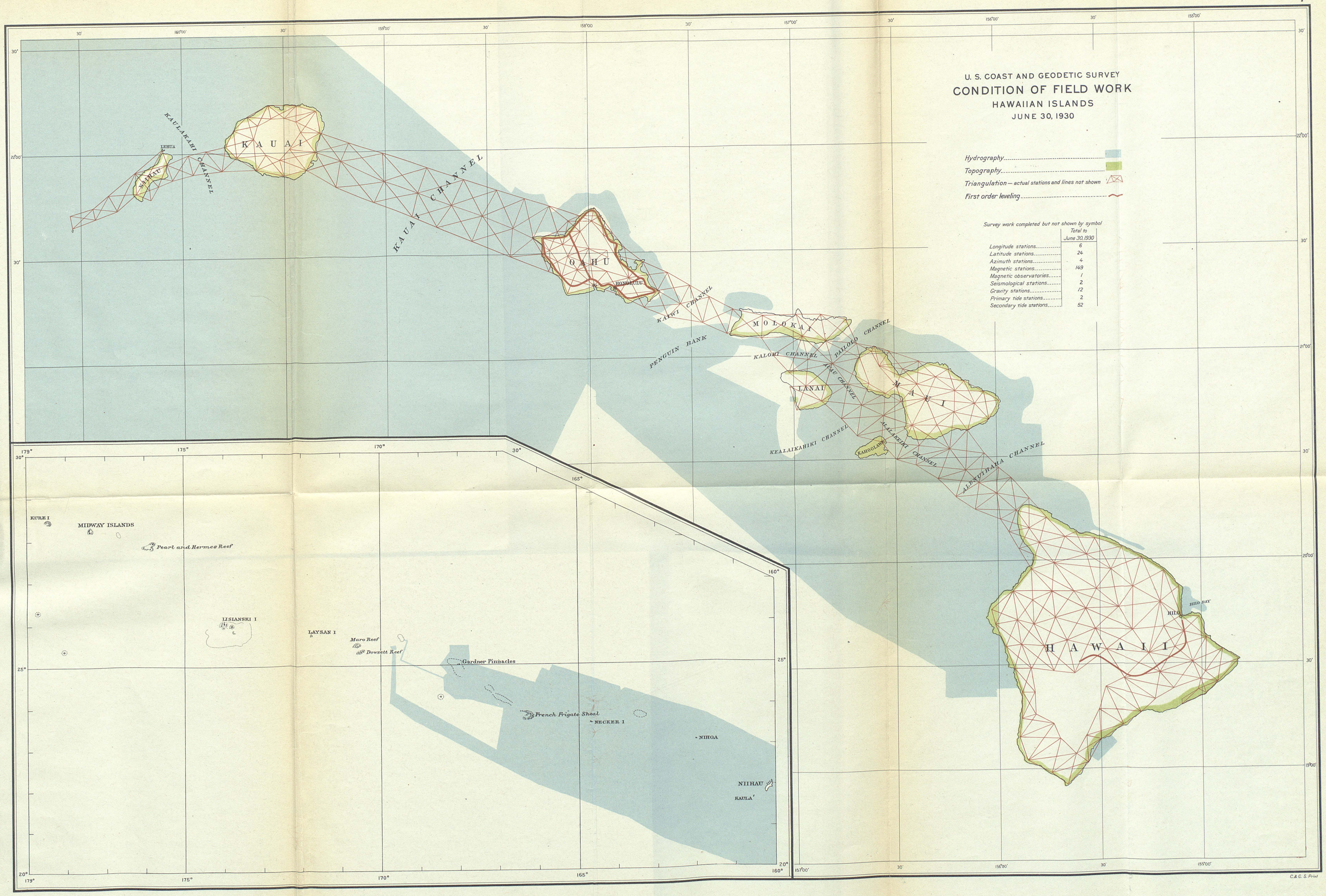
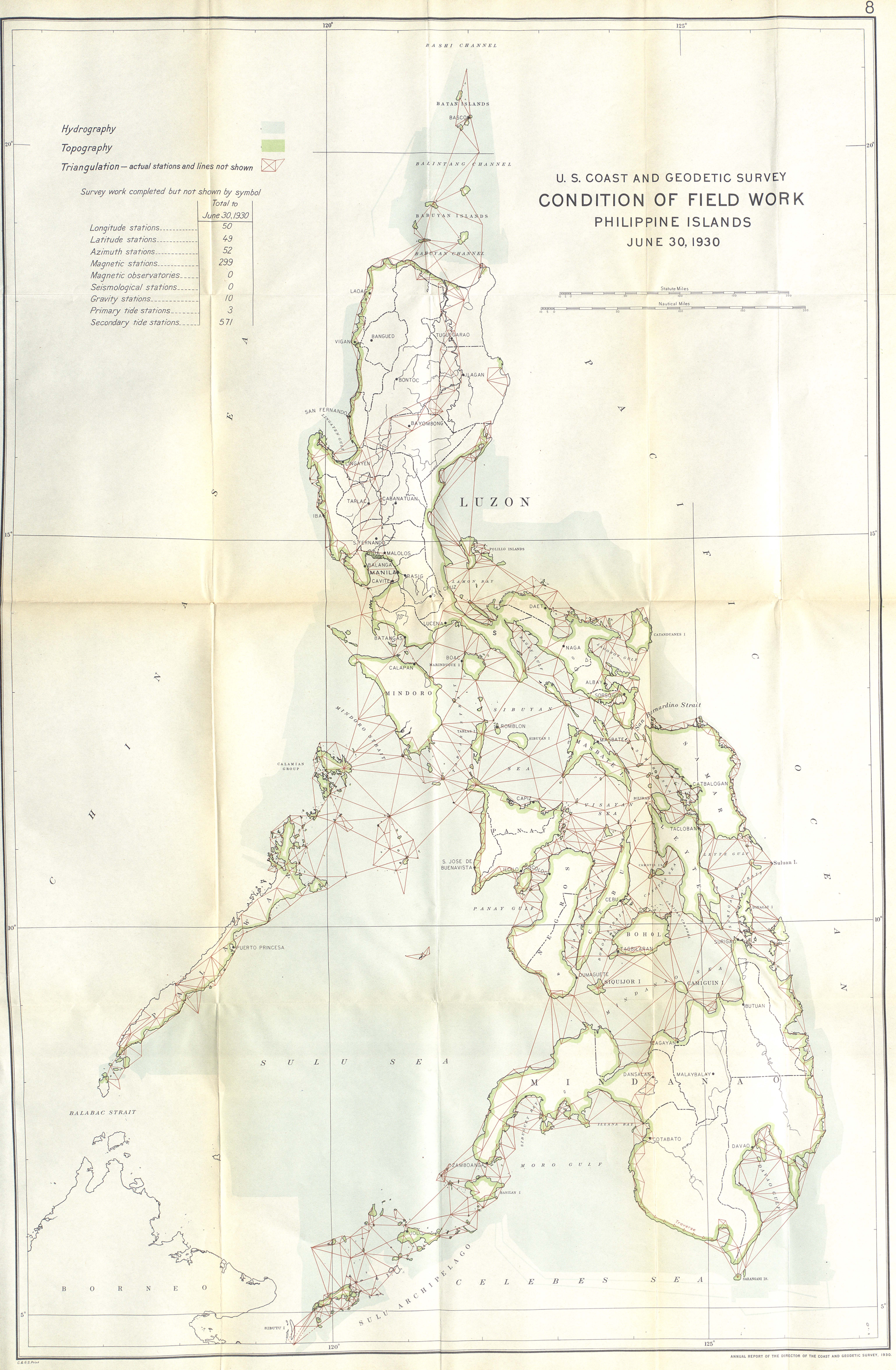
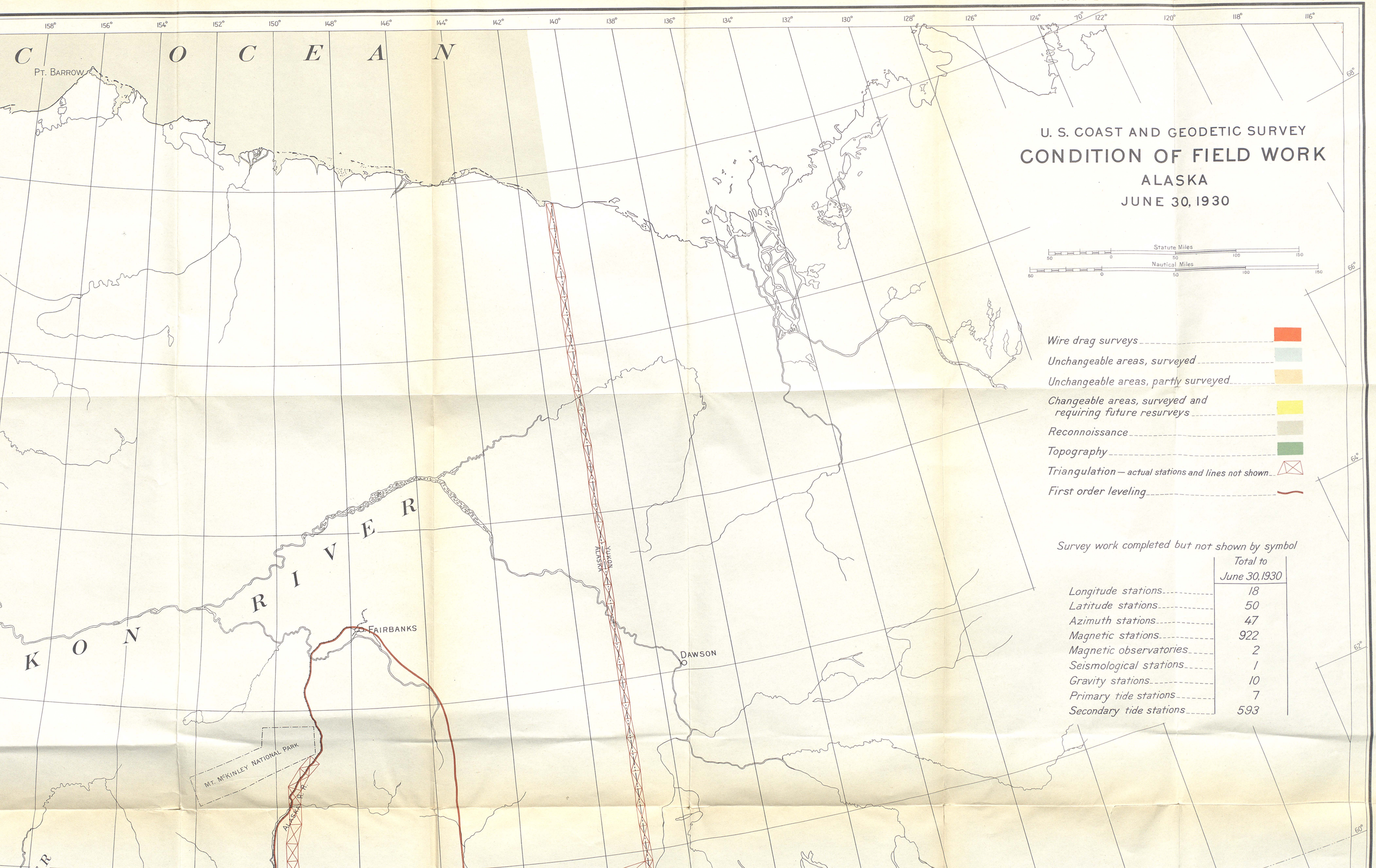
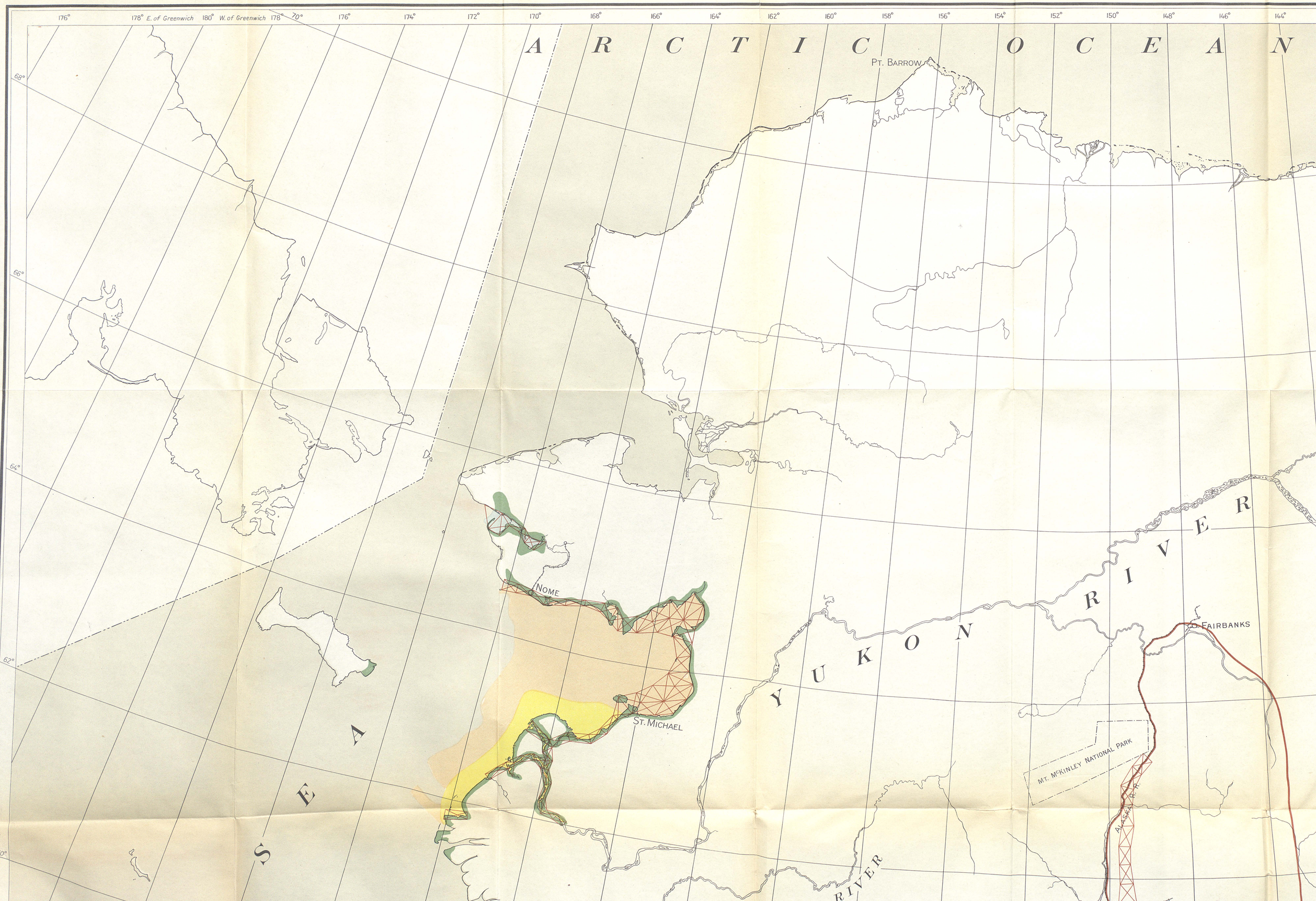

U. S. COAST AND GEODETIC SURVEY
CONDITION OF FIELD WORK
HAWAIIAN ISLANDS
JUNE 30, 1930
Hydrography
Topography
Triangulation — actual stations and lines not shown
First order leveling
Survey work completed but not shown by symbol
Total to June 30, 1930
Longitude stations 6
Latitude stations 24
Azimuth stations 4
Magnetic stations 149
Magnetic observatories 1
Seismological stations 2
Gravity stations 12
Primary tide stations 2
Secondary tide stations 52
KAUAI
NIHAU
LEHUA
KAULAKAHI CHANNEL
KAUAI CHANNEL
OAHU
HONOLULU
KAIWI CHANNEL
PENGUIN BANK
MOLOKAI
KALOHI CHANNEL
PAILOLO CHANNEL
AMAU CHANNEL
LANAI
MAUI
KEALAIKAHIKI CHANNEL
KAHOOLAWE
ALENUIHAHA CHANNEL
HAWAII
HILO BAY
HILO
KURE I
MIDWAY ISLANDS
Pearl and Hermes Reef
LISIANSKI I
LAYSAN I
Maro Reef
Dowsett Reef
Gardner Pinnacles
French Frigate Shoal
NECKER I
NIHOA
NIHAU
KAULA
C. & G. S. Print

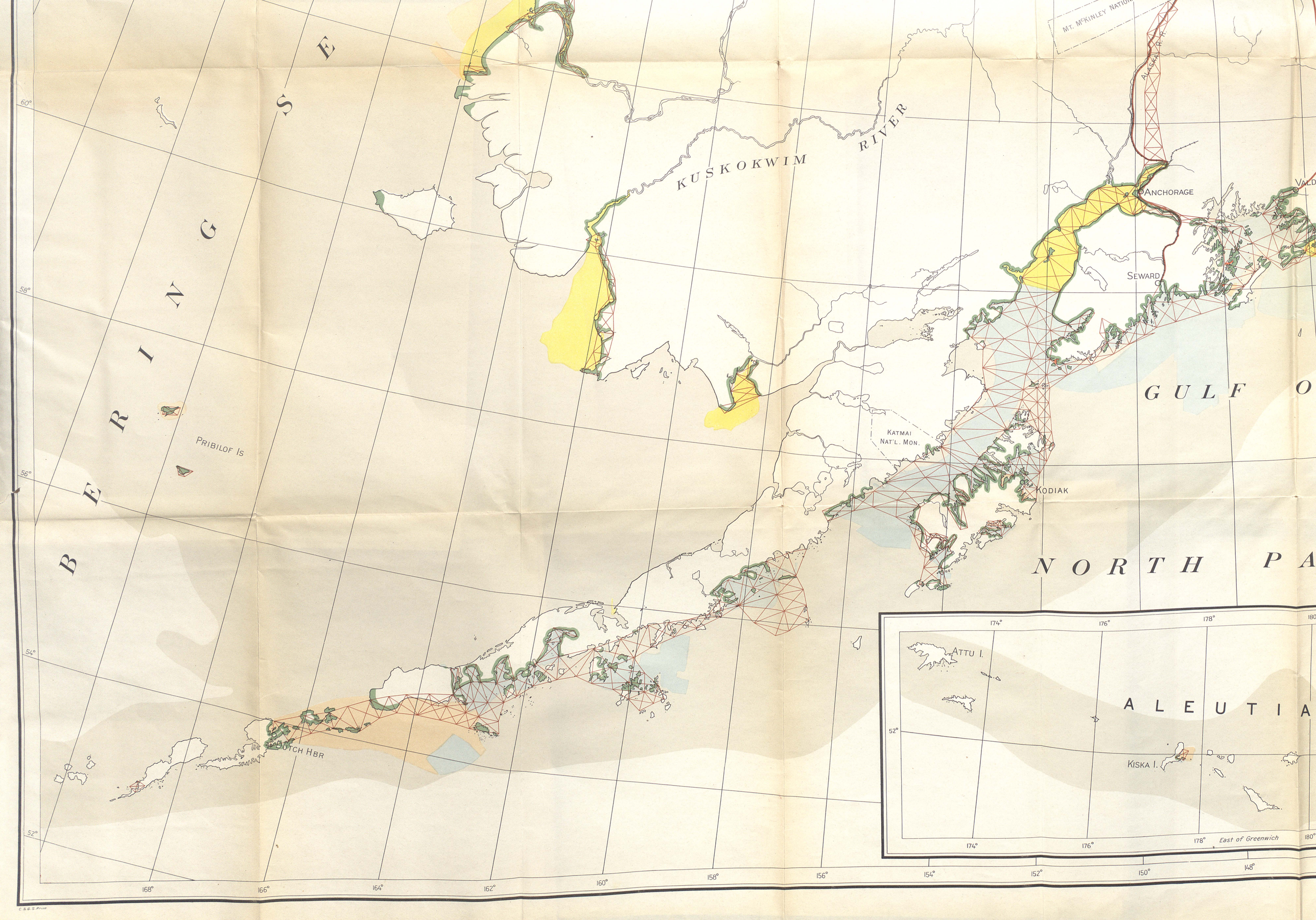

U. S. COAST AND GEODETIC SURVEY
CONDITION OF FIELD WORK
PHILIPPINE ISLANDS
JUNE 30, 1930
Hydrography
Topography
Triangulation — actual stations and lines not shown
Survey work completed but not shown by symbol
Total to June 30, 1930
Longitude stations 50
Latitude stations 49
Azimuth stations 52
Magnetic stations 299
Magnetic observatories 0
Seismological stations 0
Gravity stations 10
Primary tide stations 3
Secondary tide stations 571
Statute Miles
Nautical Miles
BASHI CHANNEL
BATAN ISLANDS
BASCO
BALINTANG CHANNEL
BABUYAN ISLANDS
BABUYAN CHANNEL
LUZON
LAOAG
VIGAN
BANGUED
TUGUEGARAO
ILAGAN
BONTOC
SAN FERNANDO
LINGAYEN GULF
BAYOMBONG
LINGAYEN
TARLAC
CABANATUAN
IBA
S. FERNANDO
MALOLOS
BALANGA
MANILA
CAVITE
PASIG
LAMON BAY
CRUZ
POLILLO ISLANDS
DAET
LUCENA
BATANGAS
CALAPAN
BOAC
MARINDUQUE I
NAGA
LAGONOY GULF
CATANDUANES I
ALBAY
SORSOGON
MINDORO
MINDORO STRAIT
SIBUYAN
ROMBLON
TABLAS I
SIBUYAN I
MASBATE
San Bernardino Strait
CALAMIAN GROUP
SEA
CAPIZ
VISAYAN SEA
BILIRAN
CATBALOGAN
TACLOBAN
LEYTE GULF
Suluan I.
S. JOSE DE BUENAVISTA
ILOILO
BACOLOD
PANAY
PANAY GULF
CEBU
CAMOTES SEA
DINAGAT I
BOHOL
TAGBILARAN
SURIGAO
DUMAGUETE
SIQUIJOR I
CAMIGUIN I
BUTUAN
CAGAYAN
DANSALAN
MALAYBALAY
MINDANAO
PUERTO PRINCESA
PALAWAN
SULU SEA
BALABAC STRAIT
BORNEO
ILLANA BAY
COTABATO
DAVAO
ZAMBOANGA
MORO GULF
BASILAN I
JOLO
SULU ARCHIPELAGO
CELEBES SEA
SARANGANI IS.
SIBUTU I
Traverse
PHILIPPINE SEA
120°
125°
20°
15°
10°
5°

Scale $\frac{1}{2\,500\,000}$ Lambert Conformal Conic Projection



MT. McKINLEY NATIONAL
ALASKA R.R.
ANCHORAGE
VALDEZ
C.R. & N.W. RY.
KENNICOTT
WHITEHORSE
YUKON
BRITISH COLUMBIA
CORDOVA
SEWARD
SKAGWAY
JUNEAU
BRITISH COLUMBIA
ALASKA
GULF OF ALASKA
SITKA
PETERSBURG
WRANGELL
KODIAK
KETCHIKAN
PRINCE RUPERT
NORTH PACIFIC OCEAN
ALEUTIAN ISLANDS
TTU I.
KISKA I.
East of Greenwich
West of Greenwich
60°
58°
56°
54°
52°
52°
174°
176°
178°
180°
178°
176°
174°
172°
170°
152°
150°
148°
146°
144°
142°
140°
138°
136°
134°
132°


176°
178° E. of Greenwich
180° W. of Greenwich
178°
70°
176°
174°
172°
170°
168°
166°
164°
162°
160°
158°
156°
154°
152°
150°
148°
146°
144°
68°
66°
64°
62°
60°
ARCTIC OCEAN
Pt. Barrow
Nome
St. Michael
Fairbanks
YUKON RIVER
Mt. McKinley National Park
Alaska R.R.
SEA


BERING SEA
PRIBILOF IS
KUSKOKWIM RIVER
MT. McKINLEY NATIONAL
ALASKA R.R.
ANCHORAGE
SEWARD
VALD
GULF O
KATMAI NAT'L. MON.
KODIAK
NORTH PA
DUTCH HBR
ALEUTIA
ATTU I.
KISKA I.
East of Greenwich
60°
58°
56°
54°
52°
168°
166°
164°
162°
160°
158°
156°
154°
152°
150°
148°
174°
176°
178°
180°

C.&G.S. Print

U. S. COAST AND GEODETIC SURVEY
CONDITION OF FIELD WORK
UNITED STATES
JUNE 30, 1930
Wire drag surveys
Unchangeable areas, surveyed
Unchangeable areas, partly surveyed
Changeable areas, surveyed and requiring future resurveys
Reconnoissance
Topography
Triangulation — actual stations and lines not shown
First order traverse
First order leveling
First order traverse and First order leveling
Statute Miles
Nautical Miles
DOMINION OF CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
NEVADA
UTAH
COLORADO
KANSAS
OKLAHOMA
TEXAS
CALIFORNIA
ARIZONA
NEW MEXICO
MINNESOTA
PACIFIC OCEAN
GULF OF CALIFORNIA
SEATTLE
OLYMPIA
PORTLAND
SALEM
HELENA
BUTTE
BISMARCK
FARGO
MINNEAPOLIS
SHERIDAN
PIERRE
SIOUX FALLS
SIOUX CITY
BOISE
POCATELLO
OGDEN
SALT LAKE CITY
RENO
CARSON CITY
SACRAMENTO
SAN FRANCISCO
CHEYENNE
OMAHA
LINCOLN
DENVER
PUEBLO
TOPEKA
KANSAS CITY
WICHITA
LOS ANGELES
SANTA FE
ALBUQUERQUE
OKLAHOMA CITY
MUSKOGEE
FORT
PHOENIX
TUCSON
DALLAS
AUSTIN
SAN ANTONIO
GALVESTON
Guadalupe I.

C.& G.S. Print

Survey work completed but not shown by symbol

	Total to June 30, 1930
Longitude stations	435
Latitude stations	627
Azimuth stations	865
Magnetic stations	4880
Magnetic observatories	6
Seismological stations	3
Gravity stations	312
Primary tide stations	44
Secondary tide stations	3487