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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, 1923

WASHINGTON
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1923

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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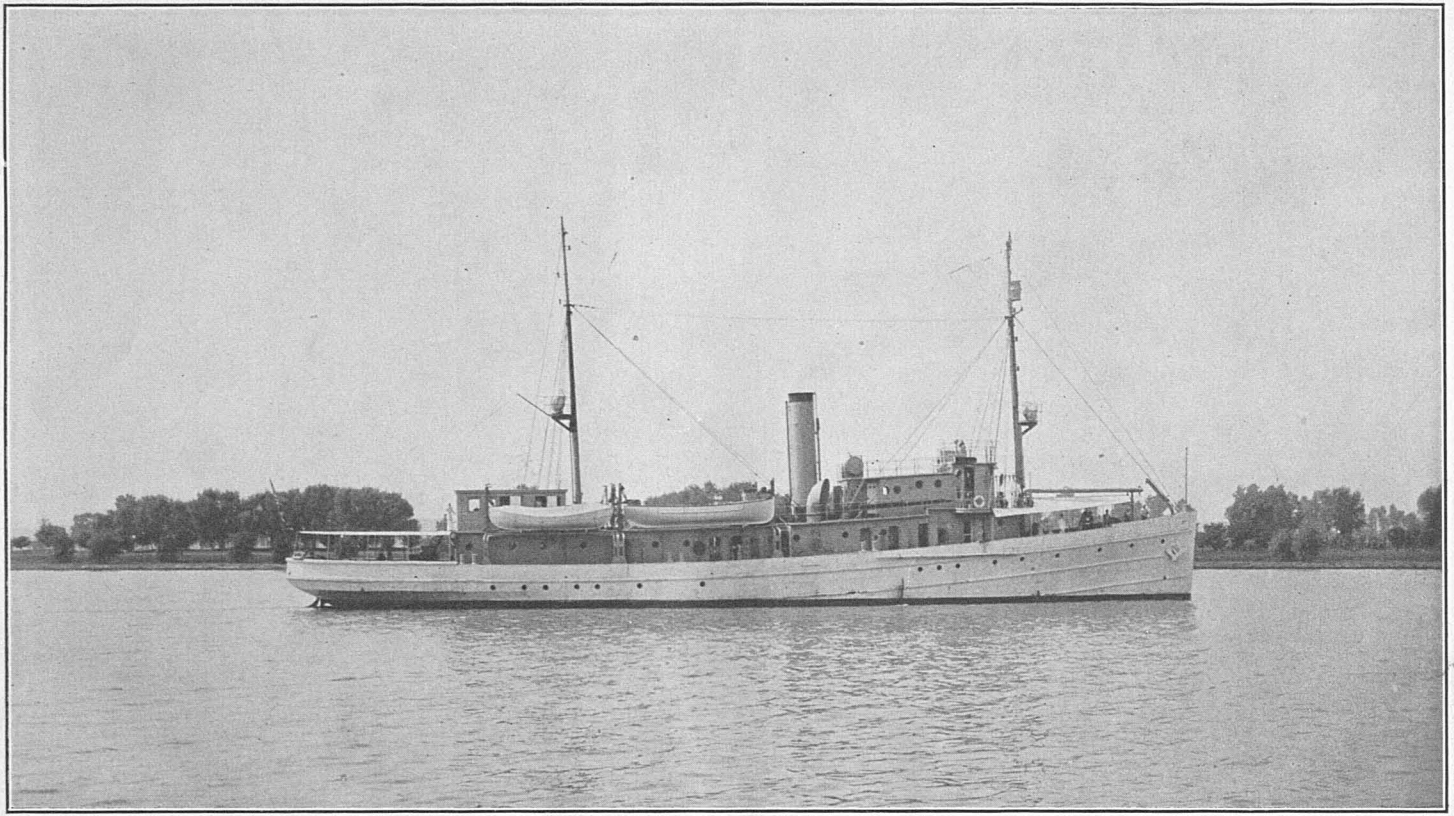


U. S. COAST AND GEODETIC SURVEY STEAMER "GUIDE," THE MOST MODERN AND FULLY EQUIPPED SURVEYING VESSEL AFLOAT.

(" PIONEER)

REPORT

OF THE

DIRECTOR, U. S. COAST AND GEODETIC SURVEY.

DEPARTMENT OF COMMERCE,
COAST AND GEODETIC SURVEY,
Washington, October 5, 1923.

SIR: There is submitted herewith my ninth annual report. This report is for the fiscal year ended June 30, 1923, and is the ninety-second annual report of this bureau.

INTRODUCTION.

PART I.—OUTSTANDING CONDITIONS OF THE BUREAU.

INTRODUCTION.

The Coast and Geodetic Survey has had during 1922–23 what is probably its most successful year since its creation more than a century ago. This is due to various causes, all of which have important bearing both on the welfare of the personnel of the service and on the providing of means for carrying on the work of the bureau in a bigger and more efficient manner. I feel that it is well to point out the reasons for these successful accomplishments, as well as to stress our more pressing needs, and I shall therefore enumerate them briefly.

RECLASSIFICATION AND SALARY INCREASES.

For many years this bureau, like many other establishments within the Government, has dragged along with a condition of dissatisfaction among its personnel, due to inadequate pay. This condition has caused a steady demoralization and general disintegration of the personnel throughout the bureau. As this situation grew steadily worse year by year, with little hope of relief in sight, the best men were constantly being drawn away from the service, leaving vacancies that were hard to fill, while those who remained were, in spite of their loyalty to the Government, unconsciously suffering in efficiency because of their constant agitation and concern over their future status and the question of whether or not there would be relief.

During this long period of unrest repeated efforts were made to secure more adequate salaries for the Government employees—salaries commensurate with the duties which they performed and also on a scale necessitated by the increased cost of living. These efforts met with only slight success until the past year, when the seriousness

of the situation seemed at last to loom up in its true magnitude, with the result that the reclassification bill, which had been pending in Congress for well over a year, was brought to the fore and its prospects toward the close of last February were very bright. With the increasing sympathy of Congress and the clear understanding and support of this all-important matter by President Harding, Congress at length actually passed the bill, and the President, on March 4, 1923, signed the important measure.

While it was well understood and known by many that the bill was not perfect nor entirely suited to everyone's needs and ideas, still it was such a big step in the right direction that its possible defects were more than compensated by the benefits that would accrue from its enactment. The whole tenor and purpose of this legislation will, I believe, remove the general and just dissatisfaction among the underpaid employees of the Government, thereby improving their morale and raising their standards, so that the most able workers will be attracted to and retained in the service, while those who fail to show their appreciation of what has been done by meeting the new standards will be gradually eliminated through the pressure of their more loyal and efficient associates.

It must be understood that the first undertaking of the reclassification board to put this legislation into effect is an extremely difficult and tedious task, viewed from every angle, and with regard to the tentative recommendations of the board it is believed and hoped that the people affected by them will accept them in good part, realizing that this preliminary interpretation of the law will later be adjusted to meet in every respect the just requirements of a proper reclassification and reallocation.

The passage of this momentous legislation unquestionably marks an epoch in the conduct of this phase of the Government business, as it will eventually result in a condition of uniform justice that will bring contentment to the workers, and thereby greatly increase their efficiency and productivity. But there is another outstanding phase of this classification legislation which to me is vital. Inasmuch as the departments are charged by Congress with the responsibility of handling their several affairs, and Congress in turn looks to them for the proper results, it is therefore in the interests of good administration that classification and salary matters which affect the internal activity of any department, whether in connection with employees in the District of Columbia or of the field forces which are next to be considered, should be adjusted by that department, and not by some commission or board which bears no responsibility for the conduct of the business of the department—this, of course, subject to whatever control and regulation Congress feels it is best to provide, including such advisory agencies as may be necessary to properly coordinate similar positions in different departments.

VALUE OF MODERN VESSELS.

The steamers *Discoverer* and *Pioneer*, mentioned in my report of last year as having been transferred to this bureau from the Navy Department, have been engaged in survey work during the entire

year. These vessels have proved economical and efficient surveying units and even better adapted for surveying purposes than was anticipated. The other vessel, the *Guide* (transferred in the same manner), has been altered to fit her for surveying duty and is now having her final trial before leaving for the Pacific coast. A sonic depth finder has been installed, as well as a subaqueous sound-ranging apparatus for the determination of the ship's position while sounding. These two devices will be subjected to thorough practical tests under actual working conditions, and if these tests meet our confident expectations combined use of the two devices will effect a tremendous reduction in the cost of our offshore hydrography.

The problem of making hydrographic surveys along the Pacific coast is difficult, as in the winter when clear weather prevails, gales are severe and frequent and a very small percentage of time can be utilized for survey work. During the summer fogs are prevalent and the work is greatly delayed and the unit cost increased thereby. Experiments in the past have been carried on for the determination of a ship's position from radio compass stations, but these positions, while adequate for navigation, did not meet the more exacting requirements in accuracy necessary in hydrographic surveying. An officer of this service who had experience in the Navy during the late war in the experiments carried on for the detection of submarines suggested the possibility of the determination of the ship's position by subaqueous sound ranging. This officer made an intensive study of the problem and, with the cooperation of the Bureau of Standards and the Army authorities at Fort Wright, devised an apparatus which has been constructed by the Bureau of Standards. It is believed that this equipment will serve the purpose of accurately determining a ship's position while engaged in sounding during foggy weather. This equipment is now completed and installed, and with it the *Guide* is the most complete and modern survey vessel afloat.

SPECIAL SURVEYS MADE AT THE REQUEST OF THE SECRETARY OF THE NAVY.

For many years the bureau has made special hydrographic, topographic, and other kinds of land surveys, at the request of the heads of other bureaus and departments of the Government, and a special appropriation has been made annually to this bureau to cover the cost of such work where it could not be charged to any of the appropriations for the support of the usual work of the bureau.

Much of such special work has been done for the Navy in recent years, including special surveys of naval bases and projected naval bases and naval rendezvous, determination of geographical positions of and azimuths from radio compass stations, and laying out and marking speed-trial courses for testing naval vessels and hydroplanes. Some of this work has been confidential and the data suppressed from publication at the request of the Navy. Some of the surveys have appeared on later charts and would have been made eventually even had they not been made the subject of a special request to be taken up immediately for the Navy, and some would never have been made by this bureau had they not been requested for a special purpose not in line with the usual work of the bureau.

During the past fiscal year the bureau has been engaged upon a larger amount of such work for the Navy than during any previous fiscal year, not excepting the years of the World War. The number of projects undertaken at the request of the Navy has not exceeded that of previous years, but the size of the projects, the personnel and equipment involved, and the cost of the work have exceeded those of any previous year. This work includes triangulation, topography, hydrography, both ship and launch, wire dragging, cadastral surveys, and other operations, and covers extensive areas in widely separated localities. Some of these projects will require another year or more for completion. Part of the work is of a confidential nature.

CONTINUED COOPERATION WITH CITY ENGINEERS, HIGHWAY ENGINEERS, COUNTY ENGINEERS, AND LAND SURVEYORS.

The new undertaking, as set out in my 1922 annual report, of extending cooperation in making precise surveys to municipalities, and cooperating with county engineers and local civil engineers is being received with more favor and is attaining more results than was anticipated.

The laws of a number of States of the Union require county surveyors to standardize their compasses periodically, and to enable this standardization this bureau, as a part of its function of making a magnetic survey of the country has established magnetic stations at most of the county seats of each State of the Union. In the past it has been the practice of this bureau to rely for information as to the state of preservation of these magnetic stations on periodic examinations by field officers of the bureau. Under the cooperative plan extensive correspondence has been carried on with the county surveyors and civil engineers of a number of States with the end in view of learning from such local surveyors and civil engineers the state of preservation of the magnetic stations that have been established and the need of additional stations in areas where there has been considerable local disturbance of the magnetic field. This correspondence has brought to the attention of numerous county surveyors and civil engineers the existence and use of these stations and has enabled this bureau to eliminate the examination of stations that have been reported by local surveyors to be in a proper state of preservation. As a result of this canvass a new publication has been prepared for the State of Arkansas which gives in condensed form a great deal of information that is essential to county surveyors of that State in making and perpetuating surveys of lands and establishing boundary lines between tracts of land. Similar publications covering other States will be issued as rapidly as they can be compiled.

Another means of bringing to the attention of county surveyors and civil engineers the data that are essential in making precise surveys and which are available from this bureau is the continuance of the preparation and distribution of the Digests of Geodetic Publications—one for each State of the Union. By the use of these digests anyone interested in making land surveys can determine at a glance whether or not this bureau has established control and elevation

points within the area to be surveyed. For example, see illustration No. 1, which is from the Digest of Geodetic Publications for the State of Oregon, and which shows graphically the location of the basic control and elevation points, as well as the magnetic stations that have been established by this bureau within that State. To date a digest has been published for each of the following States: Alabama, Arkansas, Colorado, Florida, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Massachusetts, Minnesota, Missouri, Montana; Nebraska, Nevada, North Dakota, Ohio, Oregon, Rhode Island, South Dakota, Texas, Utah, West Virginia, and Wyoming. These digests have opened the way to hundreds of local surveyors to obtain control data for making local surveys, which data are absolutely necessary if the survey is to be standard and free from error. Every mail brings to this bureau a number of inquiries that have their origin in these digests.

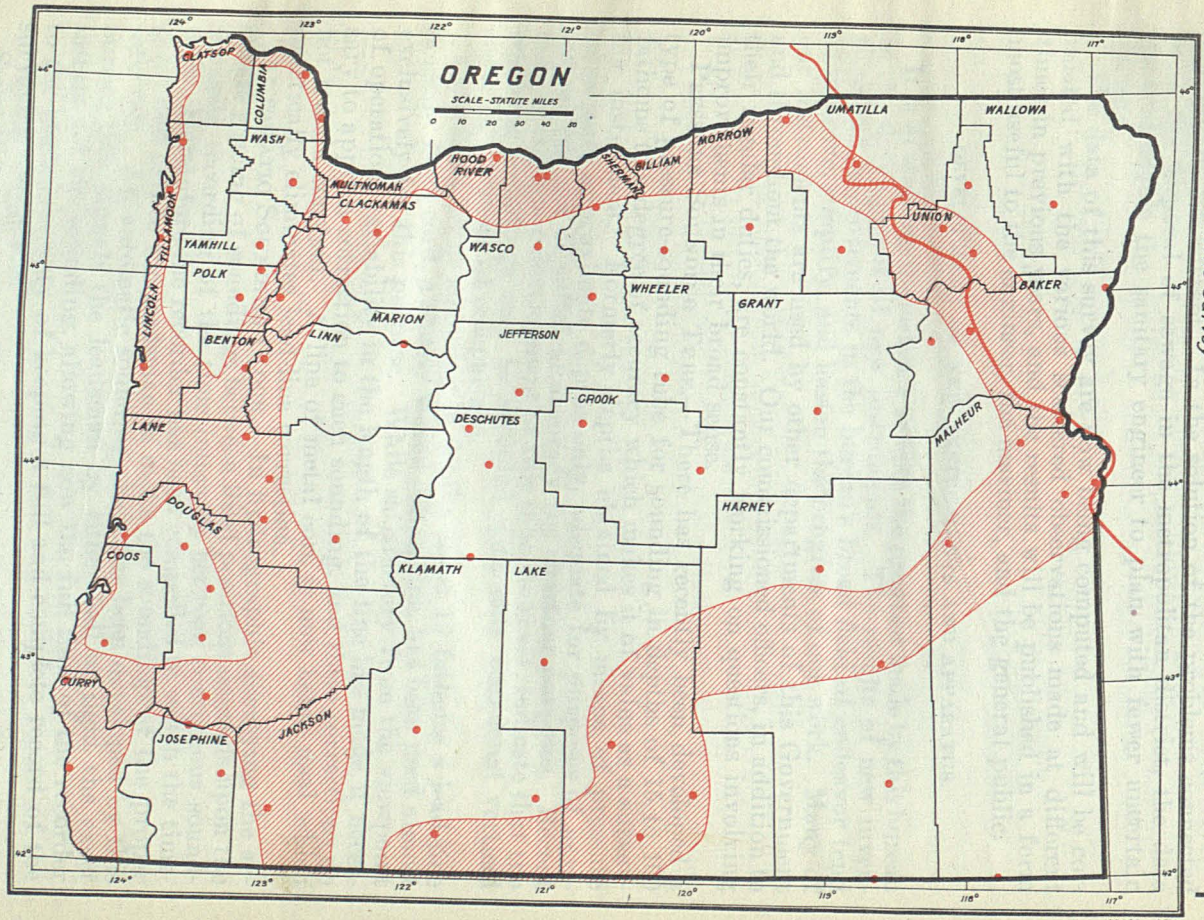
This cooperation with local engineers and surveyors has awakened a keen interest in city engineers in basing city surveys on standard control and elevation points. The city of Richmond, Va., is just completing an excellent survey of its area, based on points established by this bureau. The city of Greensboro, N. C., has also completed such a survey under the supervision of an officer of this bureau. The chief engineer of the department of public surveys of the city of Columbus, Ohio, is laying out a plan for a precise survey of that city. To assist these engineers and to enable this bureau to supply promptly information regarding city surveys, a pamphlet has been published under the title of "Use of Geodetic Controls for City Surveys." This publication contains complete information regarding the making of a city survey.

THE VALUE OF NEW YORK HARBOR CURRENT AND TIDAL SURVEY.

Most harbors consist of a tidal bay or river, but New York Harbor in this respect differs from other harbors, in that it consists not of a single waterway but of a number of communicating waterways which may be entered from the sea through two inlets many miles apart. This gives the leading port of our country a magnificent harbor; but at the same time the interaction of the tides and currents in the system of communicating waterways constituting the harbor gives rise to a series of complicated current and tidal phenomena.

Fifteen thousand square miles of territory have their drainage to the sea through three bays, four straits, one great tidal river, and the several smaller ones which comprise New York Harbor, and the fresh water from this large territory further complicates the movement of flood and ebb. To help in the solution of the problem which the mariner, the engineer, the scientist, and the public generally brought to this survey a precise and detailed knowledge of the tides and currents in these waterways was of first importance.

This knowledge of the tidal and current phenomena for New York Harbor is now available as a result of the comprehensive survey made the past fiscal year jointly by the United States Engineer Department and the Coast and Geodetic Survey. To the navigator bringing a giant trans-Atlantic liner into port, the current tables issued by this survey are an invaluable aid, since they inform him in advance of the time of slack water, which is of such importance in the berth-



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U.S. Coast and Geodetic Survey

• Magnetic Stations

Precise Leveling

Triangulation

ing of the large vessels. The engineer engaged in harbor improvement, both of a civil and of a military nature, or in wharf construction, can now undertake his work with a better knowledge of the phenomena accompanying the rise and fall of the tide and the flow and ebb of the current. In the solution of the problems connected with the disposal of sewage in the metropolitan district, the data secured enable the sanitary engineer to plan with fewer uncertain factors.

The data of this survey are now being computed and will be correlated with the various scattered observations made at different times in previous years, and the results will be published in a form most useful to the engineer, the mariner, and the general public.

DEVELOPMENT OF NEW INSTRUMENTS AND APPARATUS.

It is of striking importance to note the progress made by this bureau in the development of new instruments. The results of new inventions and improvements in the bureau's broad field of endeavor tend to improve, simplify, and hasten the progress of our work. Many of our instruments are used by other departments of this Government and throughout the world. Our commissioned officers, in addition to their regular duties, are constantly working on questions involving improvements in their broad sense.

PRESSURE SOUNDING TUBE.—There has recently been developed a type of pressure-sounding tube for sounding in depths of 15 to 100 fathoms to a degree of accuracy which makes it of value as a surveying instrument. Formerly depths obtained by means of pressure tubes were approximate depths only, adequate for purposes of navigation, but not of sufficient accuracy for charting purposes. Recent tests of the latest development of this tube, however, indicate that the resulting soundings may be accepted with only occasional vertical casts for purposes of comparison.

LEAD LINE.—For sounding in depths under 15 fathoms a lead line is used. Sash cord, a closely woven cotton line, has been used almost exclusively for this purpose. While satisfactory from the viewpoint of operation, variability in the length of the line has made it necessary to apply a correction to each sounding, and these corrections do not remain constant. A line of metal core is now being used which practically eliminates lead-line correction.

AUTOMATIC SOUNDING CLOCK.—In hydrographic surveying the accurate spacing of soundings between fixed positions depends upon the accurate recording of the time intervals between contiguous soundings. Heretofore the recorder has been compelled to watch the timepiece and call to the leadsman to make the soundings at the proper intervals. An automatic sounding clock has been developed by this bureau that signals the leadsman by either bell or light the exact instant for the sounding, allowing now the full time of the recorder to the important duty of keeping a full and complete record of the surveying operations.

SLIDE-RULE SOUNDING REDUCER.—The general principles of a circular slide rule have recently been adapted to the reduction of soundings from fathoms to feet and at the same time to the application of the correction for tide and the lead line, if any. This device, a working model of which has been completed, is now being manufactured

in quantity for the use of hydrographic parties in the field. It is estimated that a saving of about 50 per cent in office work on the reduction of soundings will be effected by this device.

WIRE DRAG AND SWEEP.—The development of the wire drag and sweep has continued. This is indicated by the fact that an area of 62 square miles has been covered with the sweep in a single working day. It is estimated that the completion of the dragging of the main steamer channels of southeastern Alaska during the present season is at least two years earlier than would have been possible with the methods in use in 1917.

DEVIASCOPE.—In many parts of the hydrographic work reliance is placed on dead reckoning, and a carefully compensated compass is necessary. An improved form of deviascope for use in instructing officers in compass compensation is under construction. A deviascope is a device which permits iron or steel to be brought near a compass under conditions similar to those on a vessel.

PORTABLE AUTOMATIC TIDE GAUGE.—During the past year a portable tide gauge has been developed for the use of hydrographic and tidal parties in the field. The main objects sought in the development of this instrument were minimum size commensurate with the required accuracy, portability and ease of installation, and the minimum amount of office work in the tabulation of the records. The gauge has for its float well a length of stock 3½-inch iron pipe, which also serves as a support or standard for the instrument, obviating the necessity of elaborate float well and platform. This last feature alone makes this instrument well adapted to field parties, particularly in Alaska and the Philippines where wharves are not available.

STANDARD TIDE STAFFS AND BACKING PIECES.—During the past year standard tide staffs and backing pieces have been developed for use at our principal tidal stations in order to obviate uncertainty in the zero of staff. This standard staff as originally developed was weighted with a strip of sheet lead to keep it from floating in a high tide. This arrangement has been superseded by an ingenious automatic clamp for holding the staff down in place while a reading is being made.

BIFILAR SUSPENSION CURRENT INDICATOR.—The Coast and Geodetic Survey has developed within the past year a device which solves in a simple manner a problem long of concern to engineers and navigators. The device is known as a bifilar suspension current indicator. This new instrument renders it possible not only for a current survey party to ascertain whether subsurface currents exist in different direction from the surface current, but also the exact depth at which the current changes direction and, too, the direction at the different levels. It also permits by its triple suspensions of simultaneous observations at three depths. This information is of considerable interest and value to hydrographic and hydraulic engineers. This problem has been solved by the Coast and Geodetic Survey along lines different from any heretofore attempted. The device solves in a very simple manner a rather troublesome question.

AUTOMATIC SIGNAL LAMP.—For the past two years efforts have been made to develop a type of signal lamp for use on precise triangulation which would do away to a great extent with the necessity for employing light keepers. Gratifying progress has been made, and it is believed that by next season the problem will be largely

solved. Instead of having a light keeper posted at each triangulation station to operate an electric signal lamp, an automatic lamp will be posted by a truck driver and will require no attention for a period of eight days. The mechanism consists of an electric signal lamp of the usual type, developing about 65,000 beam candlepower, run by dry batteries and actuated by an eight-day clock. The mechanism is so arranged that the clock will turn the light on at any desired time each day and will turn it off after any period of time, ranging from three to six hours. It is believed that in many regions where the topography adapts itself to the use of this type of lamp the device will result in a saving of several hundred dollars a month per party. A very small type of lamp is also being developed for use where back packing for long distances is necessary. With this smaller type two lamps with their packing boxes, the clock, and the six dry batteries necessary to run the two lamps for eight days, altogether will not weigh over 40 pounds.

Radio Longitude Recording Device.—The application of radio recording to the standard chronograph of this bureau by the sound laboratory of the Bureau of Standards was accomplished during 1922. Recent improvement have overcome many difficulties in field operations, and successful results are being obtained in southeastern Alaska from signals sent from Annapolis.

Field Magnetometers.—The field magnetometers of this bureau had through long service become unsatisfactory for field use. These have been remodeled, using available instruments and parts, and the scale has been placed in the telescope instead of the magnet. Accordingly, instruments are now available at a small cost which meet every requirement of the most modern type of magnetometer.

Variometer Temperature Control.—Application of temperature correction to magnetograph records is one of the most tedious parts of magnetic computations. Spare variometers have been equipped with control magnet, and the practicability of better temperature control is being studied in the small building erected for special studies of this character at Cheltenham, Md.

Sound Ranging.—Working in conjunction with the Bureau of Standards and with the cooperation of the Army we are engaged in the application of sound-ranging principles developed during and since the war to the location of vessels engaged in offshore hydrography.

PROGRESS IN ALASKA.

The charting of the Alaskan coast line and water routes is at the present time one of the most important projects engaging the attention of the bureau, both in point of magnitude and of the necessity for immediate and continuous progress. On that account it is desired to emphasize the accomplishments of the past fiscal year with respect to several important features completed and preparations effected for future rapid progress in the charting of those waters.

With suitable vessels provided, surveys were resumed in western Alaska for the first time since 1920. Owing to the discovery of oil fields there and the development of these fields now in progress, the need for surveys in that region is particularly urgent.

The lack of suitable vessels, which has prevented taking up of this work heretofore, is now overcome. Already a much-needed detailed survey of Portage Bay at the southern end of Shelikof Straits has been completed, and a detailed survey of Kachemak Bay, situated on the east side of Cook Inlet, and probably the finest large harbor in Alaska, has been practically completed.

Another important accomplishment of the fiscal year is the progress, to practically full completion of the project, of wire dragging the main ship channels of southeastern Alaska. This project includes the wire dragging of all the main ship channels from Dixon Entrance to Cape Spencer and will have been entirely completed before the end of August, 1923. In the beginning of the wire-drag operations in Alaska chartered launches were used. It later developed that more rapid progress could be attained by mothering the wire-drag boats with one of the Alaska ships, and that the ship could be used to decided advantage in towing one end and directing the drag. In 1921 a new type of drag was evolved, especially adapted to the deep Alaskan channels, which multiplied the progress and cut at least two years from the time required to complete the project.

In 1914 a wire-drag survey of the main inside steamship routes of southeastern Alaska was commenced. This exceedingly important work will be completed during this summer. At the end of the fiscal year the deep-water channels have been dragged as far west as Cape Spencer. This marks the completion of one of the most important surveying projects of Alaska, as practically all vessels entering and leaving the Territory pass through these waters. In the past the stranding of many vessels in these much-traveled waters, resulting in the loss of many lives and much property, emphasizes the importance of this work. It is reasonably certain that all pinnacle rocks along these routes have been found and accurately located.

The completion during the year of general surveys in Ernest Sound and Zimovia Strait marked yet another important step and furnished the necessary data for publishing a large scale chart of another inside steamer route between Ketchikan and Wrangell.

From the commencement of this bureau's operation in Alaska up to 1917 the surveys have been scattered here and there, since the equipment and personnel available were sufficient only to meet the most urgent of the demands for surveys. Since 1917 a systematic effort has been made toward progression by completed continuous surveys, and one large combined party has been able to carry on surveys of that character for four consecutive years, working northward from the Canadian boundary along the outside coast of Prince of Wales and Baranof Islands. Urgent requirements for scattered surveys continue heavy, however, and it has been impossible to confine the operations of the other parties to completed continuous surveys. The economy of that procedure is constantly in mind, however, and is being and will be as closely approximated as existing conditions permit.

During the early part of the fiscal year an arc of precise triangulation through Dry Strait was completed. This arc was a connecting link between the work of previous years and effected a continuous

chain of precise triangulation from the Canadian boundary at Dixon Entrance to the head of Lynn Canal, furnishing control of the highest accuracy for all completed and future surveys throughout southeastern Alaska. It is expected that Canadian Government engineers will in 1924 complete triangulation of a similar degree of accuracy across western Canada, with connection to United States and Alaska triangulation at Puget Sound and Dixon Entrance. This work will coordinate all Alaska surveys on the same datum with those of the United States proper and of Canada. The additional arcs of precise triangulation which are now being executed or are contemplated by this bureau will ultimately connect and establish control of the highest accuracy for the entire Alaskan territory.

The big outstanding feature of the bureau's Alaskan operations is the development of an adequate fleet to meet the conditions to be encountered there. Whereas in 1915 the Alaska surveying fleet consisted of four old, weak, obsolete, wooden vessels and three small steamers, the present fleet consists of four modern steel surveying vessels of approximately 1,100 tons displacement each, one wooden vessel of about 450 tons displacement, two small steam vessels of about 30 and 40 tons displacement, and four internal-combustion engine launches of 60 and 70 feet in length, besides a few minor launches. A 120-foot steel motor vessel, now in use elsewhere, will be added to this fleet next year if operating appropriations permit. This is by far the largest and best equipped outfit the bureau has ever had available, and while some of the smaller craft are old and must be replaced very shortly by similar-sized vessels, as indicated in another part of this report, greatly accelerated accomplishment is confidently anticipated from now on.

SOME OTHER IMPORTANT HYDROGRAPHIC SURVEYS ACCOMPLISHED.

Along the Atlantic coast hydrographic surveys were made at the entrances to Chesapeake Bay, the Cape Fear River, off the coast of Florida in the vicinity of St. Augustine, and on the Gulf coast in the vicinity of the Mississippi River Delta and the Chandeleur Islands, and Sabine Pass, Tex.

The completion of the much-needed drag work along the New England coast, the necessity for which was mentioned in my report of last year, was commenced during the latter part of the fiscal year.

On the Pacific coast surveys were made of San Diego Harbor and off the coast of southern California, including a detailed survey of Cortez Bank, which is approximately 40 miles offshore. Offshore surveys were also made in the vicinity of Coos Bay, and a detailed survey of Suisun Bay was also accomplished.

A survey of Lake Tahoe, on the eastern slope of the Sierra Nevada, was made during the summer of 1922. This lake is about 21 miles long and 12 miles wide, its elevation is over 6,200 feet above sea level, and the water is quite deep, about two-thirds of the water area being deeper than 1,200 feet. The greatest depth obtained was 1,640 feet.

In the possessions of the United States a wire-drag survey of Vieques Sound, P. R. (requested by the Secretary of the Navy), has just been completed. In the Philippine Islands surveys were made in

the Sulu Archipelago, off the west coast of Palawan Island, and in the vicinity of Sarangani Bay.

An important accomplishment was the deep-sea sounding done by the two new vessels, the *Discoverer* and the *Pioneer*, on their way from the east coast to the west coast. These soundings are of value to science and add greatly to the completeness of the navigational charts. They were accomplished at practically no additional cost over and above that of transferring the vessels to the Pacific coast. The *Lydonia* on the trip from the west coast to duty on the east coast also made similar deep-sea soundings. The work of these three vessels has added materially to the knowledge of the depths of waters on the usual track of vessels proceeding from coast to coast of the United States via the Panama Canal.

RECENT GEODETIC ACTIVITIES.

The precise triangulation completed, principally in New Mexico, Colorado, Idaho, Montana, California, Washington, and Alaska, had a total length through the schemes of 720 miles and covered an area of 23,840 square miles. An additional 300 miles of preliminary and secondary triangulation was completed, with an area of 1,740 square miles. Seven precise base lines were measured, with a total length of 74.5 miles, each having a probable error of less than one part in a million.

Lines of precise leveling, totaling over 1,400 miles, were run in 15 different States and in Alaska, and elevations were determined for over a thousand permanent bench marks.

Each of the parties engaged on precise triangulation determined the astronomic azimuth of a number of lines in its schemes, and in addition an astronomic party was in the field during the greater part of the year observing longitude and latitude and determining the intensity of gravity at a number of points in the United States and Alaska. A gravity party was engaged for four months on special investigations in Kansas, Oklahoma, and Texas to determine the extent to which gravity observations could be used to indicate the subsurface structure of the earth in the vicinity of salt domes and oil wells.

COOPERATION WITH OTHER GOVERNMENT BUREAUS.

It is a pleasure to call attention again to the cordial spirit of cooperation which is found among the Government departments. On the geodetic work of this bureau it is particularly noticeable. Valuable assistance has been received from the Bureau of Standards in standardizing and perfecting apparatus, such as the device for recording radio time signals for our longitude work. The Navy Department through the Naval Observatory and the Bureau of Naval Operations, has also been of signal assistance in the longitude work by sending special time signals for the use of the Alaska party and in lending special apparatus. Many other instances of help received from other bureaus could be cited.

It is the policy of this bureau to show the same spirit of helpfulness. The program of geodetic surveys for each year is made out to meet as far as possible the needs of other organizations, such as the General Land Office, the Geological Survey, and the Forest Service.

Cadastral engineers of the Land Office cooperate in the field with our engineers in connecting the system of land surveys with our precise triangulation. If an emergency call is made upon this bureau by another department for control data in a region where no geodetic surveys exist, every effort is made to meet the need in so far as funds and personnel permit. Only by such teamwork between bureaus and departments can the greatest service be rendered the public for the money spent.

COOPERATION WITH THE GEODETIC AND TIDAL SURVEYS OF CANADA.

Steady progress is being made toward the completion of the two great triangulation projects which are being executed in cooperation with the geodetic survey of Canada. The first project provides for an arc of precise triangulation extending along the international boundary from Lake Superior to the Pacific, of which the United States is to execute the western half and the Dominion of Canada the eastern. It is hoped that the calendar year 1924 will see the completion of our portion of this work.

The second cooperative project is the extension of an arc of precise triangulation from Puget Sound through British Columbia and southeastern Alaska to the upper waters of the Yukon, thence down the Yukon through western Alaska. This will enable the maps and charts of Alaska and western Canada to be placed upon the same datum as those of the United States. The southern Canadian section through British Columbia to Dixon Entrance will soon be finished, and the United States section from Dixon Entrance to the head of the Lynn Canal is completed, while a start has been made on the precise triangulation in western Alaska by parties working northward from Cook Inlet.

This cooperative arrangement gives each country all the benefits to be derived from both projects at about one-half the total cost. It is an illustration of the spirit of friendly cooperation which exists between many of the Federal bureaus and the corresponding organizations of the Canadian Government.

In connection with the coastwise commerce between our Pacific coast ports and Alaska and also with our northern neighbor the currents in the tidal waters connecting these ports are of very considerable importance. Because of the swift tidal currents in many places along the inside passages used by our vessels, particularly in Seymour Narrows in Canadian territory, where velocities have been observed at 12 knots, vessels attempting this passage at any time except near slack water place themselves in jeopardy. It is evident, therefore, that advance predictions for the mariner of the times of slack water in these narrow turbulent straits must be as accurate as can possibly be made.

In obtaining the necessary observations the cooperation of the tidal survey of Canada has been secured in furnishing the observations for Canadian waters. It is planned that all predictions may finally be made jointly, which plan will not only increase the accuracy of the predictions but will also permit a considerable saving in the labor involved. It is hoped to extend this cooperation to cover all stations, both tidal and current, for which predictions occur in both the Canadian and United States tables.

Part I.—OUTSTANDING CONDITIONS OF THE BUREAU.

CHAPTER I.

MORE ADEQUATE HOUSING QUARTERS NECESSARY.

This bureau in its present quarters is operating under a handicap that continually stifles production. I have dwelt at length on this subject in previous annual reports and would omit reference to it in this report were its relative importance not so great. Whether or not we are awake to the fact, we are yearly indulging ourselves in a costly extravagance. We are complacent in the apparent saving in appropriations in abstaining from providing funds for a modern building properly planned for the industrial operations carried on by the Coast and Geodetic Survey, and yet we are yearly paying an additional overhead in salaries of extra personnel and lack of production that is all out of proportion to the interest cost on money invested in a building adequate in every way for the Coast and Geodetic Survey.

I have before me an advertisement of a successful commercial firm. A prominent part of the advertisement is the reproduction of photographs of the housing facilities of the firm from the time of its inception in a small reconstructed barn to the present, when it is housed in large, commodious, sanitary buildings. While the advertisement has a sentimental appeal, it was not sentiment that prompted the razing, decade after decade, of the quarters in which this commercial firm was housed and their replacement by larger and better quarters; it was the stern necessity of competition with other firms in like fields which would have been enabled to produce at less cost than the firm issuing the advertisement had not that firm taken advantage of every opportunity to modernize production and reduce unit costs.

As I have stated in previous reports, this bureau is engaged in the buildings it occupies in Washington in two distinct commercial enterprises: (*a*) The compilation and printing of charts of all the navigable waters of the coasts of the United States and possessions; (*b*) the construction and repair of intricate surveying instruments and equipment for use in carrying on the surveys made by the bureau.

The output of this bureau has a world-wide distribution. The information that is on the charts that are compiled, printed, and distributed by the bureau is absolutely necessary to the pilot of every vessel that enters, traverses, and leaves the waters of the United States and its possessions. Such an enterprise in the hands of private firms competing against each other would unquestionably thrive at the expense of commerce, in that the price of these navigational charts would be increased greatly and would only be limited by the extent of the competition between the firms producing them, and

this very competition would force modern methods of producing the charts.

As it is, these charts are sold at the cost of paper and printing, but this cost is higher than is necessary, due to the fact that they are produced in a plant that is not modern and which can not be made modern in its present housing facilities. These housing facilities consist of one building constructed for a dwelling and the stables for this dwelling, another building constructed to be used as a hotel, and various smaller buildings. The bureau has been housed in these buildings 52 years. The extra cost of chart and instrument production under these conditions is absorbed in increased appropriations for extra personnel and in restricted production.

CHAPTER II.

NEED FOR AND ECONOMY IN ADDITIONAL FLOATING EQUIPMENT.

This year, for the first time, the Coast and Geodetic Survey has a fleet of modern ocean-surveying vessels adequate in number for the work which has been authorized by Congress. Unless it be desired that the survey of the coasts of the United States and its possessions be taken up in a larger way and increased funds be provided therefor, it will not be necessary to provide any more of this type of vessel for some time to come.

There is, however, an urgent need for additional small craft and for a small steam vessel of about 500 tons displacement for inshore work. Much of the Alaska waters along the outside coast should not be surveyed close inshore, and in some places should not be surveyed within several miles of the shore, by the valuable ocean-going vessels because of the great risk involved. These waters are particularly dangerous because of innumerable submerged rocks and are often too rough to be surveyed from small, open launches. For this work the surveying vessels should be aided by steam or power tenders of 30 or 40 tons displacement, which can maneuver more readily and safely among and over the rocks than can the larger vessels. Besides, should a tender be wrecked in this work, the loss would be small compared to the loss of a full-powered surveying craft. The bureau has two such tenders in operation in Alaska this year, but both are old (25 and 36 years, respectively) and can not last much longer. The purchase of one such tender to accompany each vessel operating on the exposed coast of Alaska would be the cheapest and most effective insurance that could be placed on these vessels and would also materially increase the amount of work accomplished by them.

On the Atlantic coast a new vessel of about 500 tons displacement is needed to replace a small vessel that has outlived her usefulness. This vessel, built cheaply 22 years ago, has reached the condition where her annual cost for upkeep and repairs is out of all proportion to the value of the work which can be accomplished with her. She can still be made use of for a few years, but she is an expensive vessel and is available only for work in comparatively smooth water. It would be a good investment to replace her now with a small steam vessel of about the same size.

There is also need for a small craft for work in the inside waters of the Atlantic coast, the bays, sounds, and inside passages which extend along this coast from Massachusetts to Florida. In recent years there has been a steadily increasing demand for larger scale and more complete charts of these waters. Most of them can be surveyed effectively from launches and power boats, but there are long stretches of the coast where fuel and supplies can not be had

within a practicable distance from the work and where camping facilities are poor. For work in such localities a shallow-draft, self-propelling craft of the general type of the cruising house boat is needed to provide quarters for the surveying personnel, and fuel and means for repairing launch machinery.

INCREASING DEMAND FOR HYDROGRAPHIC WORK.

The hydrographic projects that confront the bureau and demand immediate attention are stupendous in their total magnitude. They include every kind of hydrography and range the entire coast line of continental United States and of all her territorial possessions. The menace of the uncharted pinnacles and bowlders in undragged areas along the New England coast is constantly in mind. All important channels of southeastern Alaska must be swept. The charts of the approaches to important harbors and waterways in the changeable areas must be kept up to date. The old surveys, made with inadequate equipment and before vessels of the present-day draft were even anticipated, must be revised. The sketchily surveyed coasts of the Pacific States must be so charted that navigation by the lead is feasible when approaching them during the prevalent fogs. The commercial needs of western Alaska must be met. Uncharted reefs and other dangers are frequently reported adjacent to our coasts but outside the surveyed areas. These must be accurately located and charted by extending our surveys a reasonable distance from the coast. The first surveys of our outlying possessions must be completed.

The bureau is mindful of all these needs. Its plans are broad in scope and contemplate the most efficient utilization of the available equipment and personnel, and the wisest and most economical expenditure of the appropriations authorized, meeting the public requirements, in so far as is economically practicable, in the order of their urgency.

Wire-drag Surveys Along the New England Coast, Etc.—The imperative necessity for completion of wire-drag surveys of the coastwise steamer routes along the New England coast has been peatedly stressed in my previous reports. Large areas were dragged in the years immediately preceding the World War, and vast numbers of bowlders and pinnacles were discovered and located which had peviously menaced the immense wealth in shipping which necessarily traverses those routes. Since the war limited appropriations have prevented further progress. One party will resume operations the coming fiscal year, and it is most desirable that at least one party may continue in operation until the completion of all necessary areas. There remain to be wire dragged about 3,000 square miles along the cost of Maine and an extensive area along the route around Nantucket Shoals, besides areas in Long Island Sound, Boston Harbor, and between Key West, Fla., and the Dry Tortugas.

Hydrography, Atlantic Coast.—The important hydrography on the Atlantic coast includes revision surveys of changeable areas necessary to the protection of shipping, revision surveys of unchangeable areas the old surveys of which are inadequate to present needs, and completion of detailed surveys from the coast to the 100-fathom

curve. With reference to the offshore surveys to the 100-fathom curve, the most urgent areas are from completed work at Winyah Bay northward to Chesapeake Bay approaches and from completed work a little south of Mantanzas Inlet southward to Jupiter Inlet. One vessel, the *Lydonia*, is at present available to carry on this work and is thus engaged, extending completed work northward along the coast of the Carolinas during the summer months and southward along the Florida coast during the winter months. The *Lydonia's* present assignment is in the vicinity of Cape Fear, N. C. Because of frequent reports of changed depths over and adjacent to Frying Pan Shoals her present season's work will include a revision survey of those shoals. The launch *Mikawe* is working in conjunction with the *Lydonia* and will sound out the shoaler depths where it is hazardous for the larger unit to operate. Two launches, the *Elsie* and *Mikawe*, are available for revision work in protected waters and will be used to the full extent that appropriations permit.

GULF COAST.—The nature of the hydrography needed along the Gulf coast is comparable with that of the Atlantic coast and includes revision work of changeable areas and of old inadequate surveys and extension of hydrography to the 100-fathom curve. This work is being advanced by two parties on the steamers *Bache* and *Hydrographer*. At present they are engaged in surveys of Sabine Pass, and on the completion of work in that vicinity will take up surveys of the approaches to Galveston. Sabine Pass is the approach to Port Arthur, Tex. Both Port Arthur and Galveston have increased enormously in commercial importance since the original surveys of the sea approaches. The shore shelf, with critical depths thereon, extends many miles to seaward in this vicinity. Reports of changed depths affecting navigation of these waters have been frequent, hence the importance of immediate revision surveys of these approaches.

VIRGIN ISLANDS.—The hydrography of the Virgin Islands is now being started by the party on the steamer *Ranger*, assisted by the launches *Mitchell* and *Marindin*. The project contemplates detailed hydrography of all harbors and inshore areas and all passages surrounding these islands. All important navigable passages will be wire dragged.

PACIFIC COAST.—The Pacific coast of the United States is of a very different character from that of the Atlantic and Gulf coasts. The 1,000-fathom curve is comparatively close to the shore, and there are comparatively few harbors and inland waterways. Until recent years the existing surveys were very sketchy in character. Owing to the large amount of bad weather and fog common along this coast, the navigator is necessarily dependent upon his charts to a more than ordinary extent. Lack of adequate surveys has resulted in many serious wrecks. The hydrography required includes detailed surveys of the approaches to all important harbors and extension of the surveys to the 1,000-fathom curve the entire length of this coast. The bureau intends to meet the needs of this locality as rapidly as possible. The recently converted 1,100-ton naval mine sweeper, the *Guide*, will be sent to the Pacific station as soon as her equipment is complete and will take up and carry on the needed surveys. This vessel will be outfitted with the most modern hydrographic equipment known, and it is believed that nothing is being omitted to render her capable of the most rapid and efficient progress

attainable on hydrographic surveys of this character. During the winter months the *Guide* will extend northward surveys to the 1,000-fathom curve from completed work of the past year between the Mexican boundary and San Diego. During the summer months she will complete the partially surveyed area off dangerous Cape Blanco, working toward a junction with completed surveys off Cape Mendocino, and then proceeding northward along the almost entirely unsurveyed Oregon coast.

WIRE-DRAG SURVEYS IN ALASKA.—The wire dragging of the main ship channels from Dixon Entrance to Cape Spencer will be completed this season. There are, however, a number of side passages, arms, and bays to which vessels go regularly and which are of practically the same character and importance as the main ship channels. It is very desirable that the wire dragging of these proceed without interruption. The steamer *Explorer*, together with the launches *Helianthus* and *Scandinavia*, is equipped to carry on this work efficiently and rapidly, using the improved wire sweep wherever local conditions permit. Only lack of sufficient appropriations will be allowed to prevent this important work from proceeding.

CHARTING SOUTHEASTERN ALASKA.—The insistent demand for rapid progress in the charting of Alaskan waterways has been indicated elsewhere, as has also the expediency from an economical standpoint of proceeding by completed continuous surveys. This project will be continued by the party on the 1,100-ton steamer *Surveyor*, assisted by at least one large launch. This party is at present making final complete surveys of the west coast of southeastern Alaska and, working northward from the Canadian boundary, has reached the southwest coast of Baranof Island.

CHARTING WESTERN ALASKA.—Comparatively little of the south coast of Alaska has yet been charted. The entire extent of this coast from Cape Spencer to Dutch Harbor is now of such commercial importance that the most rapid progress possible is imperative. The bureau was able to resume surveys of this coast this season for the first time since 1920, using the steamers *Discoverer* and *Pioneer*, both recently converted naval mine sweepers of about 1,100 tons displacement. It is contemplated that these two vessels, assisted by at least two large launches, will continue surveys of this coast at least until the most urgent requirements have been met. The 120-foot motor vessel *Natoma* will also probably take up urgently needed additional work in Prince William Sound and in Cook Inlet.

CHARTING THE PHILIPPINE ISLANDS.—The first surveys of the Philippine Islands are approaching completion. There remains yet to be surveyed the greater part of the west coast of Palawan and of the Sulu Archipelago, portions of the south coast of Mindanao, the southern part of the Sulu Sea, and the north and northeastern coast of Luzon, including the chain of small islands extending northward from Luzon. Three vessels, the *Pathfinder*, *Fathomer*, and *Marinduque*, are continuously engaged in advancing this project. It is imperative that progress be uninterrupted, not only to insure the continuance of the present financial assistance received from the Philippine Government, but to complete the project during the useful life of present equipment.

Such are our present plans. The bureau will be awake, however, to new conditions that may make changes expedient. Better, more

efficient methods of hydrographic surveying, and better and time-saving instrumental appliances are constantly being developed and are utilized wherever they speed up production without loss of desirable accuracy. No false idea of governmental economy should be permitted to curtail its present production or prevent a natural expansion consistent with national growth. Our country is yet comparatively new. The end of the necessity for additional surveys is nowhere in sight. The forces that produce alteration in the changeable area never cease their activity. Areas unimportant and unconsidered in the present scheme of surveys will in time become of first importance. The vast field of oceanographic surveying will some day demand attention in the interest of our transoceanic commerce.

MAPPING OF THE INTERIOR OF THE UNITED STATES AND ITS POSSESSIONS SHOULD BE EXPEDITED.

The extension of the precise triangulation and precise leveling for the control of mapping and engineering projects is discouragingly slow because of insufficient funds. Engineering organizations throughout the country are asking for the rapid completion of the fundamental topographic map; yet the preliminary framework of geographic positions which is necessary to furnish starting and checking points for such a map is woefully inadequate. There are three areas in the United States proper, each exceeding 200,000 square miles, without a precise triangulation point in them, and there is one area of 265,000 square miles without a precise elevation established in it.

There is impending a widespread recognition of the economic necessity for speedily completing the topographic map of the country, and there will follow the determination to have it done. It is estimated that $4,000,000 will complete the control work required for continental United States, and that control work should be done as far in advance of the topography as possible. Where such large areas exist it would be at least a year before control positions could be furnished for territory near the center of the area. It is not economical to have the mapping follow immediately behind the triangulation, for it requires several months to compute and adjust the geographic positions for the control points ready for the topographer to plot them on his plane table sheets, to serve as starting points for his survey.

During this period, when construction materials are so expensive and competition for them so keen, it might well be asked if this is not the proper time to spend an increased amount of money in making surveys and so prepare the way for a more intelligent, because better informed, development of the resources of the Nation later. Judged by the demands which are being made upon the Coast and Geodetic Survey for data in unsurveyed regions, the appropriation made to this bureau for geodetic work is far short of that needed.

Any mention of requests for geodetic data brings up the vital question of cooperation between different departments and bureaus of the Government. Unless there is to be endless and costly duplication of work and effort, any bureau specially fitted to perform a certain function must be reasonably prepared to exercise such

special duty for the benefit of another bureau where requested to do so. Because the Coast and Geodetic Survey needs precise geodetic positions for its charts and precise elevations in connection with tidal observations, it has been charged by Congress with the duty of determining such geographic positions and elevations over the entire country. Such an arrangement undoubtedly makes for economy, yet, because of lack of funds, this bureau is compelled to deny, year after year, repeated requests from the General Land Office, the U. S. Geological Survey, the U. S. Forest Service, and others for control data which are urgently needed in connection with the special work of those bureaus. Such a condition should not longer endure; the Coast and Geodetic Survey should be supplied with sufficient funds reasonably to meet the urgent demands of other Government organizations. This work done by any other Government bureau would mean unnecessary duplication of personnel and special instrumental equipment.

What has been said regarding the need for basic geographic positions in the United States applies with even greater force to Alaska. Precise levels will be completed this season from Seward via Anchorage to Fairbanks and thence to Chitina and Valdez, and will be extended as rapidly as permanent wagon roads are completed in the Territory; but much more triangulation is needed at on e in western Alaska. The operations of the General Land Office and of the U. S. Geological Survey are greatly retarded by the lack of triangulation, and this decidedly hinders the development of that region. Funds spent for such a purpose during the next five years would give rich returns on the investment in the form of increased facilities afforded the operations of other Federal organizations upon which the development and prosperity of Alaska so largely depend.

BETTER CHARTS FOR THE MOTOR BOATMAN.

The numerous minor entrances, inlets, and anchorages of the coast region, as well as many of their tributary waters, have attained a degree of importance far exceeding that which attached to them in the comparatively recent past. This is due in a large measure to the phenomenal development of motor-boat traffic, which is now made up of large fleets operated by the various fishing interests, numberless local and coastwise light-draft commercial craft of all kinds, and the myriads of pleasure boats in universal use.

These craft sustain much the same relation to the community on navigable waters as the automobile does to the millions in the interior of the country who are dependent upon it for local land transportation. In fact, the services rendered the community are strikingly similar in all respects. Like the automobile, motor boats are used extensively for pleasure and private transportation of every sort. They operate on public passenger lines as does the motor bus, and in the transportation of freight and in other marine industries their wide application and demonstrated economy and efficiency parallel the results obtained by the use of motor trucks and tractors in their respective fields.

The construction, maintenance, and operation of these craft constitute a highly complex industry involving many important interests. Although made up of seemingly insignificant units, the aggre-

gate of lives and property exposed to its hazards and the total of investments involved are so enormous that this highly productive enterprise surely deserves our thoughtful and sympathetic attention. It merits and demands no less than the National Government's fostering care. Its military value alone as an effective naval auxiliary should guarantee such care, in the same measure, at least, that aid is extended to many other interests whose claim can not be urged so well.

These waters have, as a rule, fared rather badly in the matter of surveys and improvements, as provision made for such work usually has been so limited that its application is of necessity restricted to harbors and waterways of the first importance. As the waters available for motor-boat use are so extensive, it is evident that any general project for their early improvement and the maintenance of such improvements would require an expenditure far in excess of any available funds and out of proportion to the interests involved. It therefore appears that for the present no one practicable means can contribute more to the safety, efficiency, and normal development of the traffic than the publication of the best and most up-to-date charts and supplementary pilot notes and sailing directions covering all of our territorial waters adapted to the operation of motor boats.

The Coast and Geodetic Survey is charged by law with the production of such charts and other nautical information, including the execution of the surveys necessary to that end, yet the funds heretofore furnished for that purpose have been so limited that the charts at present issued for the guidance of these motor-boat men are based in many localities on surveys made many years ago. The evolution which this changeable area has undergone during that period has been so extensive that the navigator can no longer use the charts with reasonable assurance that they will guide him safely through the waters he must traverse.

There should be no further delay in undertaking the correction of this unfortunate situation. The need is at present urgent, and the constantly augmented traffic is rendering it increasingly so. The culpability of further delay is augmented by the fact that the operations necessary to furnish authentic and up-to-date charts would be on a very modest scale. Their cost would be so inconsiderable in view of the benefits to be derived that I feel no hesitancy in advocating the project even at this time when the Federal policy has quite properly come to be one of rigid economy in governmental expenditure.

COAST EROSION AND PROTECTION.

These surveys which we have just seen to be so necessary to the security of motor-boat traffic will serve another important purpose. In my last annual report I called attention to the effect of unceasing attack by winds, waves, and currents upon the easily eroded sand beaches of our Atlantic and Gulf coasts. That attack is slowly but inexorably driving the beaches landward. Particularly in time of storm the zone of shallow water adjacent to the shore is like some huge mill in which the materials subjected to wave action are torn from their resting places, seized upon by the whirling waters, and borne away to find an eventual resting place in the sheltered bays and lagoons, or in offshore depths so great that wave attack can have no appreciable effect upon the bottom.

Until comparatively recent years these beaches were, as a rule, desolate, uninhabited stretches of sand dunes and undergrowth, of no apparent economic importance. Recently, however, the development of better transportation facilities, as exemplified by the motor boat, the automobile, and the trolley, has made them accessible to the great centers of population adjacent to the coast, with the result that millions of people now visit them annually in search of relief from the more rigorous climatic conditions of the neighboring cities.

The rule has been that within a short time after these seaside resorts have come into existence they have been confronted with the necessity of finding some means of checking this encroachment of the sea upon their improved properties. To this struggle they have devoted themselves with an earnestness born of the realization that their continued existence depends upon a successful outcome of the fight.

Yet in these fights the sea, in a deplorable number of cases, has been the victor. Some communities have succeeded in at least temporarily protecting themselves. Others, however, have fought a losing fight. One can scarcely visit any long-improved section of this coast without hearing stories of beautiful properties undermined and swept away, along with the structures that have been erected in their defense; or of communities that have almost bankrupted themselves in the fight only to see the result of their efforts destroyed in some gale of unusual severity.

One of the outstanding reasons for the indifferent success of these efforts at protection has been our lack of knowledge of the precise nature and methods of the attacking forces or of the degree of resistance to attack offered by the various physiographic forms which characterize the shores. The decisive part of nature's battle between sea and land is fought beneath the surface of the water where it is invisible to the observer. Only the final result can be directly seen, and this result does not indicate the vicissitudes of the struggle of which it is the outcome.

Yet there is no reason to suppose that this evolution of the shores is not controlled by natural laws, which can be ascertained by the accumulation and study of adequate data. We know that nature acts according to rule, and that these rules can be determined and applied to promote the welfare of humanity. Already we know enough of the laws governing shore evolution to perceive clearly the character of the additional studies which must be made before we can utilize our knowledge with confidence in the result. In other words, this particular problem, while in process of solution, has not yet passed from the field of the physiographer, who determines the fundamental principles underlying shore evolution, to that of the engineer, who makes practical application of the principles established by his predecessor.

Certain portions of the surveys which I have just described as so vital to the motor boatman are precisely those which are most necessary to the determination of the laws governing shore-line changes. For example, more than any other part of the waters he traverses the motor boatman needs frequent surveys of the various inlets which connect the successive bays and sounds with the ocean, for it is at these inlets that the changes in channels and shoals are most rapid

and extensive, and consequently that he is most apt to get into difficulty.

Similarly, this very fact of most rapid and extensive changes means that at the inlets the natural forces are working in their greatest variety and effectiveness, and therefore that the inlets afford the ideal sites for the study of these forces.

The hydrographic surveys designed primarily to protect the motorboat traffic will incidentally and without additional cost furnish a record of successive stages in the hidden evolution of the shoal-water forms, and in consequence result in a contribution of first importance toward the solution of this important problem. This fact furnishes an additional and potent reason for undertaking such surveys at an early date.

MAGNETIC WORK IMPORTANT ON EARTH, AIR, AND SEA.

The results of the magnetic work of the bureau are used on earth, air, and sea. It is necessary to have on hand data which will make it possible to meet the needs of the land surveyor, the aviator, and the mariner. Formerly declination, sometimes called the variation of the compass, was the only magnetic element in constant practical use. Now the aviator requires similar knowledge of the dip of the needle or its inclination to the plane of the horizontal.

The accumulation of the needed information is made at five fixed observatories and by observations at numerous points or stations throughout the United States. Maintenance of these observatories is necessary, because the earth's magnetism is constantly changing in small amounts in a complicated manner. Records of these changes are made by continuous photographing of the position of the delicately suspended needles. These observations have to be made in isolated places, as there must be no electric railway, electric power, telegraph or telephone lines, nor iron or steel in any structure in this vicinity. Accordingly the observer must live in seclusion and suffer many inconveniences.

There is special need for improving the condition at the observatory at Cheltenham, Md., by the construction of a building to serve as an office building and a house for the observer, so that the observatory will not longer be without a guard at night within reasonable distance, as it has been heretofore.

There is also special need for the transfer of the Porto Rico observatory from Vieques Island, a small island east of Porto Rico, to the main island. Conditions, in so far as the observer is concerned, have been steadily growing worse, and it is becoming more and more difficult to replace observers as the term of duty at this observatory expires. Scientists consider that the continuance of an observatory in this region is of the greatest importance. A suitable site on the main island can be found which will meet all the requirements both of the observer and of the work.

It is most desirable that the atmospheric electricity work which was formerly carried on at Cheltenham magnetic observatory be taken up again as soon as practicable. This is an essential part of terrestrial magnetism, and more knowledge is necessary in regard to it before the problem of terrestrial magnetism can be solved.

This work has a most important bearing on the discovery of the causes of certain difficulties in radio transmission.

Observations at the field magnetic stations are needed for two purposes: First, to furnish the information for making magnetic maps which are so much in demand; especial maps are often called for between the customary five-year publication (the information for each station is also furnished in printed form); second, the stations established are utilized by surveyors who use magnetic instruments in testing the correctness of their instruments. The conditions resulting from the growth of towns and cities frequently eliminate or destroy the marks at these stations, so that the points of previous observations can not be found. In so far as it is found practicable these stations are being replaced with others so located as to be secure from future disturbance wherever possible. One party in addition to those that it has been possible to operate in the past is urgently needed.

There is great need for a magnetic survey of Alaska, especially in the interior and along the Aleutian Islands. Magnetic maps of Alaska are based on insufficient data, and the results at the Sitka Observatory, while invaluable, do not give the change for the entire region. The completion of the Government railroad, availability of power boats on the rivers, and other forms of transportation make the interior of Alaska more accessible. The Coast Guard patrol of the Aleutian Islands makes magnetic work practicable in hitherto inaccessible islands. The undertaking of this work should not be longer delayed. Magnetic data for Alaska are nowhere more than barely sufficient, and in many cases entirely insufficient for placing correct magnetic information on the mariner's charts.

There is immediate need for the reoccupation of magnetic stations in the Philippine Islands. It is only because the magnetic elements have been at a point of little change for some years in this region that it has been possible to delay this survey. Ten years have elapsed since the last survey, while the interval should not normally exceed five.

WHY SYSTEMATIC SEISMOLOGICAL WORK IS NEEDED.

Within the last two years earthquakes have been felt in Canada, near Maine and New York; in Illinois, Kentucky, Indiana, and Missouri; in Montana, Utah, Arizona, Washington, and California; beneath the sea off the coast of Oregon; and in the outlying territories. Some of these caused more or less local damage. Earthquake study is therefore important to the country as a whole.

An important seismological investigation has been started in California—which has suffered most from earthquakes. An earthquake map of California has just been issued as the result of cooperation in several Government departments and private institutions. This bureau is making measurements to determine earthquake displacements resulting from previous earthquakes.

The purpose of this California work is not only a scientific study of earthquakes but also a very practical one of useful information to architects and engineers in regard to places where they must use special precautions in order to avoid the danger of catastrophe. The

outstanding purpose is to make it possible to reduce loss of life and property in great earthquakes and eliminate it entirely in minor ones. The work in California, standing alone, is handicapped by the lack of investigation of a similar character for the country as a whole.

In spite of the seismological work by the Government and by institutions elsewhere than in California the amount of high-grade cooperative work is small. In such a vast region it is not possible to make a study of each locality affected by earthquakes nor to place instruments near each place where an earthquake may occur. Accordingly, a few stations should be completely equipped with instruments which can record both near and distant earthquakes. It is the consensus of opinion of scientific men that this work should be taken up by the Coast and Geodetic Survey, and that seismological stations should be established at the magnetic observatories of the bureau. The Coast and Geodetic Survey already has the personnel which is capable of making and interpreting records of the accuracy necessary for high-grade work.

Some of the results to be expected include better knowledge of the places where earthquakes have occurred and are likely to occur, a study of the western mountain region to determine whether earthquakes are likely to occur in the vicinity of the sites of great dams constructed in reclamation work, to learn in advance whether there is danger of recurrence of such great earthquakes as those at Charleston and New Madrid, to render a service to the country as a whole similar to that which is being given to California by the special investigations there, and to get more knowledge of the whole subject of earthquakes, so that more will be known about the internal structure of the earth and what is going on beneath the surface that may affect the conditions of life on the surface.

SAN FRANCISCO CURRENT AND TIDAL SURVEY.

What has been done in New York Harbor in the past year is now planned for San Francisco Harbor. Here, too, a knowledge of the behavior of the currents and tides is of great importance to shipping, to harbor improvement in its civil and military phases, to the solution of the question of the proper disposal of sewage, and to other activities that center in the modern harbor. Beginning in September, 1923, a comprehensive current and tidal survey is to be made in San Francisco Bay and tributaries and, as soon as possible, the results will be made available.

DEMAND FOR SURVEYS IN ALASKA.

This bureau is constantly in receipt of a large volume of insistent and urgent requests for detailed surveys of particular areas in all parts of Alaska. This is a natural result of the thousands of miles of coast line and the vast and varied amount of natural resources which are known to exist adjacent to water transportation in that Territory, resources which include such much-needed products as crude oil, coal, timber for paper pulp, copper and chrome deposits, marble, lumber, and enormous quantities of food fishes. In spite

of the bureau's activity in Alaska throughout past years, extending to the limit the appropriations of Congress available for such work, the greater part of Alaskan waters are still unsurveyed and uncharted. The development of industry there is directly dependent on the progress of the charting of these waters. The much-needed natural resources mentioned can not be reached until the adjacent waterways have been made safe for shipping.

The sources of these requests are, in general, threefold: (*a*) From other Government departments; (*b*) from steamship companies operating vessels in Alaskan waters; and (*c*) from private citizens or corporations interested in the development of various commercial projects in Alaska.

(*a*) The Navy Department, in furtherance of naval interests in Alaska, has requested extensive surveys which will require a large proportion of the whole Alaska surveying fleet several seasons to complete. The Department of the Interior is interested in establishing and assisting in the development of several industries in Alaska, particularly the paper-pulp industry. Their recent request that the entrance to Thomas Bay in Frederick Sound near Petersburg be wire dragged is to safeguard shipping in entering that bay and make it possible to interest capital in the project to establish a pulp mill at that place.

(*b*) The steamship companies operating in Alaskan waters are constantly under pressure to call at numerous new points adjacent to their regular runs, but outside the surveyed areas, in order to make deliveries and collections of cargo. This they dare not do until the surveys of those places have been made and charted. Consequently, they are continually urging the immediate survey of such places. As cases in point, the bureau has received the following requests within the last few months: From the Alaska Steamship Co. a request for a resurvey of Tuxedni Harbor in Cook Inlet, and from the Standard Oil Co. a request for a detailed survey of Port Alexander, Prince of Wales Island.

(*c*) The requests for surveys from private citizens and corporations are very numerous, cover all parts of Alaska, and come from people interested financially in the development of all the varied natural resources of that vast Territory. Recent insistent requests include detailed surveys of Portage Bay, Wide Bay, Chignik Bay, El Capitan Pass, Evans Bay, Unakwit Inlet, Icy Bay, Sea Otter Sound, Keku Strait, Dry Bay, Lost Harbor (Akun Bay), Kamishak Bay, False Pass, and Saint Catherine Cove, and wire-drag work in parts of Prince William Sound and Cook Inlet.

A number of these surveys have recently been made, others are now in progress, but the volume of work necessary to comply with reasonable requests already received will require years to complete, working to the full capacity of the appropriations, equipment, and personnel authorized. Meanwhile, the urgent requests for additional surveys will continue in great volume as additional resources are discovered and as old and new industries continue to develop.

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CHAPTER III.

DUTCH HARBOR, ALASKA, SHOULD BE FEDERAL BASE.

I have recommended for many years that the Federal Government purchase from the North American Commercial Co. property at Dutch Harbor, Aleutian Islands, Alaska, to be used as a fuel and supply base. Up to the present time nothing has been done toward acquiring this property.

With the development of Alaska and the increasing demands in the western territorial waters, the need for a Government-owned base is more emphasized than ever. At the present time the fuel and other supplies must be purchased through private concerns, and not only is this expensive, but the lack of ready supply often leads to unnecessary delays.

In the case of the Coast and Geodetic Survey more and more work is being done in the waters of western Alaska, and the necessity for steaming great distances to find a fuel base leads to delays and is very costly. This bureau is not alone concerned, as the Department of Commerce has many activities in Alaska and is much involved in matters looking to the interest of Government-owned vessels. The Bureau of Lighthouses has very important work the year round all through Alaskan waters, and outside of this department the Navy Department and the Coast Guard of the Treasury Department would benefit very much from such an investment.

It can not be disputed that the establishment of a modern fuel and supply base at this point would not only pay the interest on the investment but also, in a very short time, pay for the original cost.

CHAPTER IV.

DELEGATES SHOULD REPRESENT FEDERAL GOVERNMENT AT CONFERENCES.

For a number of years the United States Government has made appropriations to send delegates to conferences of several international scientific organizations, notably to the International Hydrographic Bureau, the International Geodetic Association, the International Navigation Congress, and the International Seismological Association. It is believed that this action on the part of our Government has been more than justified in the great saving in money and increase in accuracy in the several classes of scientific work represented by the international groups which have resulted from participation in these deliberations.

To-day millions of dollars are being spent each year in geophysical work and investigations by the National Government, private institutions, and individuals. The results of all of this work are given largely free of charge to the public and are looked on as an aid in the commercial and industrial development of our Nation.

There are now more than 20 countries adhering to the International Hydrographic Bureau and the International Geodetic and Geophysical Union, or which have expressed their desire to adhere within a short time. The expense of the delegates from countries other than the United States are paid by their Governments, and it is strongly recommended that a similar practice be adopted by the United States. If our Government furnishes the funds, and is thus able to designate qualified men as official delegates, the position of these representatives in the conferences will be much stronger than if they attend merely as private individuals.

What is here said in reference to international meetings also applies with equal force to such meetings as are held within the United States.

Part II.—THE WASHINGTON OFFICE.

CHAPTER I.

ACCOMPLISHMENTS OF THE WASHINGTON OFFICE DURING THE FISCAL YEAR.

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 care, custody, and upkeep of the buildings occupied by the bureau; the supervision of the expenditures from the appropriation for office expenses, including the purchase of supplies for the office, for chart printing work, 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 kept for the use of the bureau; the general supervision of all matters relating to the personnel work of the bureau, including reports of leaves of absence taken; the custody and accounting for the receipts from the sale of charts and publications, etc.; and the direction of the engineer, electrician, watch, messenger, and labor forces of the bureau, and other employees whose duty has to do with the care and protection of the buildings.

The more important accomplishments during the year have been a continuation of the plan to make a thorough renovation of the buildings occupied by the bureau. This work is still in progress.

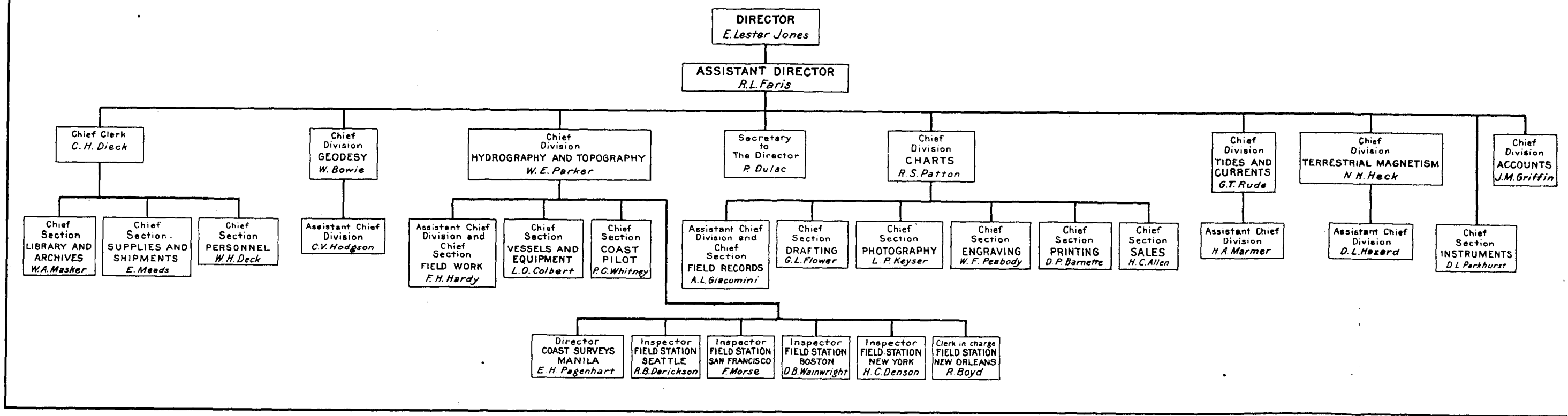
As mentioned in the 1922 annual report, negotiations were under way for the installation in the buildings occupied by the bureau of an ammonia water-cooling plant to supply cool drinking water throughout the buildings. By the end of the fiscal year this plant was in place, and the pipes for the circulating of the cool water throughout the buildings were partially installed.

The cost of care, maintenance, upkeep, and operation of the buildings occupied by the bureau has been reduced from somewhat less than 26 cents per square foot for the fiscal year 1922 to a little more than 22 cents per square foot for the fiscal year 1923.

In the office of the chief clerk the preparation of digests of geodetic publications of the bureau was continued. During the year digests were prepared for five different States.

In the library and archives 75 hydrographic and 117 topographic sheets, each representing new surveys made by the bureau, were received. Other additions to the library and archives were blue prints (mostly showing surveys made by Army engineers), 815; maps, 1,856; charts, 2,599; field, office, and observatory records, 4,073.

CHART SHOWING ORGANIZATION OF THE
U.S. COAST AND GEODETIC SURVEY
1923



C. & G. S. Print

During the year the expenditure from the appropriation for general expenses of the bureau was $100,500.74.

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, 229; field force, 176; total, 405. These figures do not include the persons engaged as rodmen, chainmen, heliotropers, and others in the field parties nor any enlisted men on vessels of the bureau.

The statistics in regard to leaves of absence during the calendar year are: Annual leave, 7,797 days; sick leave, 1,926 days; without-pay leave, 1,682 days; and accrued leave, 1,587 days. While the number of employees naturally varied on account of resignations and vacancies, calculated on the number actually in the service on June 30, 1923, as a basis of computation, the average annual leave taken during the year by each employee was approximately 19.3 days, and sick leave 4.8 days.

The receipts from the sale of charts, publications, etc., amounted to $51,600.84.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY.

The organization of the division remained the same as during the previous fiscal year, namely, three sections—field work, vessels and equipment, and coast pilot—each under a section chief; but in addition to these officers there were from time to time other officers detailed to the division for special work. As a result of such additional personnel it has been possible for the first time during many years to carry on a considerable amount of original research and investigation which will be of benefit to the bureau in improving its methods of surveying and to the public in expediting the surveys of the country and in making readily available the data obtained by field parties. These investigations include the subjects of improved methods for coastal and offshore hydrographic surveys, of oceanography, and of aero photography.

Due to the acquisition of three able sea-going vessels during the previous fiscal year, two of which were reconditioned and placed in service this year and the third nearly completed but not quite ready for service at the close of the year, it was necessary to revise the plans for survey work which had been drawn up and adopted last fiscal year. These plans, as stated in my last annual report, provided for a systematic and complete survey of the coasts of the United States, Alaska, Hawaii, and the West Indies, based upon the surveying equipment then available. The addition of three more vessels permitted modification of these plans so as to proceed immediately with parts of the work which had been planned for execution several years hence.

In cooperation with members of the Bureau of Standards of the Department of Commerce and of the subaqueous sound-ranging section of the Coast Artillery Corps of the War Department, the division studied the subject of subaqueous sound ranging as applied to fixing the position of a vessel at sea. Considerable progress had been made at the close of the fiscal year; available apparatus had been acquired and new apparatus designed for this work was under

construction and nearing completion. Tests will be made within a few weeks from one of the survey's new vessels. It is, of course, too early to state positively what can be expected of this apparatus, but should it operate nearly as satisfactorily afloat as it has on shore there is every reason to believe that the problem of fixing the position of a surveying vessel during fog and haze, and even when beyond visability of land objects, has been solved. This would easily double the output of a surveying vessel on, say, the Pacific coast of the United States, where much time is lost each year on account of thick weather.

During the fiscal years 1919 and 1920 three of the surveying vessels en route to the Pacific coast took soundings along their tracks and accomplished so much at such insignificant additional cost of their passages that it was decided to require such work hereafter of all suitable vessels while en route through unexplored waters. Accordingly, plans were made this fiscal year for similar work in connection with the passage of the three new vessels to the Pacific coast and the return to the Atlantic coast of one of the vessels which went around in the fiscal year 1920. In order that these several surveys might be properly coordinated, that each sounding might be so placed as to reveal the greatest possible amount of information, and that as large an area as possible of the oceans might be adequately surveyed, a careful study was made of all available information concerning the waters through which these vessels must pass, and in the light of this information minute instructions were prepared for the commanding officer of each vessel. During the year three of the vessels accomplished the passage between the Atlantic and the Pacific. The data furnished by these vessels, together with the data supplied by the earlier passages, was made the subject of study and a report which went to press just prior to the close of the fiscal year.

During the latter half of the fiscal year an officer was engaged continuously upon study, interpretation, and discussion of the photographs of the Mississippi River Delta, taken by naval aviators in the latter part of last fiscal year. This is perhaps the largest area ever surveyed by aerophototopography based upon adequate ground control (high-grade triangulation), and the results of this survey will go far toward clearing up any doubts that exist as to the practicability of this method of land surveying with present equipment. A full report upon the field and office methods pursued, the degree of accuracy secured, and cost of field and office operations will be published within a few weeks.

The section of vessels and equipment maintained supervision over the vessels and other floating equipment, passed upon repairs and purchase of equipment, preparing plans and specifications when required. In addition to its usual routine duties in connection with the above-named work, it supervised the completion of the two vessels which were undergoing alterations last fiscal year and got out plans and specifications for reconditioning a third similar vessel and supervised the work on that vessel. The last vessel was nearly ready for service at the close of the year. Preliminary plans were prepared for the construction of two steam tenders for duty in Alaskan waters.

Plans were prepared and arrangements made for the construction of two surveying power launches to be equipped with a new type of control which promises to eliminate the difficulties that have been experienced in getting deep soundings from a craft propelled by an internal-combustion engine. So much trouble has been encountered in getting soundings in depths too great for the hand lead from craft propelled by gas engines or other engines of the internal-combustion type that there is a strong sentiment in the service in favor of returning to steam launches for this kind of hydrography. Accordingly, considerable study has been given to the subject of controlling of launches propelled by internal-combustion engines in the hope of finding some means to avoid returning to the inefficient small steam engine for hydrographic launches.

The coast pilot section published the United States Coast Pilot of the Hawaiian Islands and the Coast Pilot, Section D, Cape Henry to Key West. Field revision was carried on for a new edition of Section C, Sandy Hook to Cape Henry, and Coast Pilot Alaska, Part I. Supplements of the following volumes were compiled and printed as the needs required: Coast Pilot, Section A; Coast Pilot, Section B; Coast Pilot, California, Oregon, and Washington; Alaska, Part 2; Philippine Islands, Part 1; Coast Pilot, Section E; and Inside Route Pilot, New York to Key West. Correction sheets were issued for the following volumes: Coast Pilot, Section C; Coast Pilot, Alaska, Part 1; and Coast Pilot, Philippine Islands, Part 2.

DIVISION OF GEODESY.

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

The computation and adjustment of the following pieces of triangulation:

1. Little Rock, Ark., westward to ninety-eighth meridian.
2. El Reno, Okla., to Needles, Calif.
3. Pecos, Tex., to Colorado Springs, Colo.
4. Memphis, Tenn., to Huntsville, Ala.
5. Pocatello, Idaho, northward to forty-ninth parallel.
6. Tacoma, Wash., to Canadian boundary.
7. California earthquake.
8. Lake Tahoe, Nev.
9. Cape Fear River, N. C.
10. Louisiana.
11. Mississippi River Delta, La.
12. Willapa Bay, Wash.

In connection with the triangulation listed above the computation of the following base lines:

1. Clayton, N. Mex.
2. Artesia, N. Mex.
3. Des Moines, Wash.
4. Icy Bay, Alaska.
5. Peters (Knik Arm), Alaska.
6. Dry Strait, Alaska.
7. Pasadena, Calif.
8. Quarantine, La.

The computation of the following lines of precise and primary traverse:

1. Savannah, Ga., to Norfolk, Va.
2. Cape Henry, Va., to Currituck Sound, N. C.
3. Memphis, Tenn., to Little Rock, Ark.
4. Green Bay, Wis., to Duluth, Minn.
5. Cape Fear River, N. C., to Beaufort, S. C.

The computation and adjustment of the following lines of precise levels:

1. Green Bay, Wis., to Duluth, Minn.
2. Anchorage to Fairbanks, Alaska.
3. Rouses Point, N. Y., to Portland, Me.
4. Centralia to Cairo, Ill.
5. Burlington to Anacortes, Wash.
6. Yonkers, N. Y., to Providence, R. I.
7. New Britain to Morris, Conn.
8. New Haven, Conn., to Springfield, Mass.
9. District of Columbia.

The computation of the following astronomic work:

1. Latitudes: Nine stations in the Mississippi Delta (completed), 1 station in Georgia, 1 station in South Carolina, and 4 stations in California which were observed in connection with the Pasadena base.
2. Azimuths: Five stations along the El Reno-Needles arc in Texas, New Mexico, and California (completed); 4 stations along the Pecos-Colorado Springs arc in New Mexico and Colorado; 7 stations in California which were observed in connection with the Pasadena base; 1 station in South Carolina; 1 station in Oregon; 1 station in Southwest Pass Lighthouse, Mississippi Delta, La.; and 1 station in Alaska.
3. Longitude: The computation of lag of radio signals; computation of longitude at 4 stations along the one hundred and fourth meridian in New Mexico and Colorado; the computation of the data for 738 latitude stations, 381 longitude stations, involving 487 differences of longitude, and 610 azimuth stations for the astronomic publication practically completed.

The preparing of the manuscript and proof reading of the following publications:

1. Special Publication No. 84: California-Oregon Arc of Precise Triangulation. (Proof reading only.)
2. Special Publication No. 86: Precise Traverse, Racine, Wis., to Vandalia, Ill. (Proof reading only.)
3. Special Publication No. 88: Precise Triangulation Along the Ninety-eighth Meridian, Kansas-Oklahoma Boundary to Alice, Tex. (Proof reading only.)
4. Special Publication No. 91: Use of Geodetic Control for City Surveys
5. Special Publication No. 92: Study of Time Errors in Precise Longitude Determinations by the U. S. Coast and Geodetic Survey.
6. Special Publication No. 93: Reconnaissance and Signal Building.
7. Special Publication No. 95: Precise Leveling in Georgia. (Not yet proof read.)

The manuscript for other publications is in course of preparation, two of which, an astronomic publication and a gravity publication, are nearly ready to send to the printer.

Computations were made for the topographic and isostatic compensation reductions of the 1921 and 1922 gravity observations; also computations of the standardizations of the pendulums to complete the 1922 season. Numerous miscellaneous gravity computations were made.

Investigations in regard to variations of latitude and as to the effect of a change of spheroid on triangulation, which were carried on last year, were continued during the present year.

At the request of the editor of the International Critical Tables, National Research Council, an examination was made of existing tabular compilation of geodetic and geophysical data in order to decide what matter would most appropriately appear in the geodetic and geophysical sections of the Critical Tables and what precaution should be observed in compiling matter of this sort in order to

secure precision of statement and mutual consistency of the various items. The conclusions reached were embodied in a report entitled "Notes on the Geodetic and Geophysical Sections of the Proposed International Critical Tables." These notes were submitted to the editor of Tables.

DIVISION OF CHARTS.

One of the best evidences of the bureau's service to the public is through the issue of its charts. Although the demand has fallen off somewhat since the war peak, it is still much above that of pre-war times.

An examination of the total issue of charts since the 1920 peak shows an appreciable decrease in sales until last year, then a very slight increase, and a moderate decrease in free issues and condemned.

The pronounced inactivity of our merchant marine is a matter of more than passing interest. The shipping news in the daily newspapers and articles appearing in financial and other magazines detail the various phases of this problem.

The division's policy of giving precedence to the correction of existing charts has been continued, and new prints and editions have been sent to the presses whenever important information warranted. The printing of limited editions minimizes hand-correction work and prevents a needless waste of paper. The few back orders resulting from this practice have been taken up promptly by immediate printing.

An added feature to the weekly Notice to Mariners, instituted in May, 1923, in cooperation with the Bureau of Lighthouses and the Hydrographic Office, consists in publishing in bold-face type the numbers of charts to which hand corrections will be made of the information contained in each notice.

STATUS OF 1923 CHART PROGRAM.—The chart program for 1923 contemplated the completion of 10 new charts, the reconstruction of 13 charts, and the construction of 3 new maps. At the close of the fiscal year there remained unfinished 3 new and 2 reconstructed charts. However, the program was expanded to include 2 new and 3 reconstructed charts and 1 new map, all of which were accomplished.

This program was materially modified and seriously interrupted by important miscellaneous work which necessitated its reconstruction to some extent. The precedence of special items naturally caused considerable delay, and properly so, because a program of this nature should be flexible. The actual accomplishment was highly satisfactory, and the total chart construction work finished, including that outlined on the program, special assignments, and additional construction, exceeded that originally contemplated.

The construction of new charts is not always the best measure of work accomplished, for two principal reasons: The amount of compilation and smooth drawing work vary greatly for different charts, and the correction of existing charts, which is a decidedly variable quantity, is always given precedence over all other classes of work.

The compilation of new charts on the 1923 program occupied 10¼ per cent of the total working time of the drafting section, while the allotted time for the program for 1924 contemplates 13½ per cent.

CHART CONSTRUCTION.—*Atlantic Coast.*—The reconstruction chart program for the Atlantic coast is partially accomplished and now awaits completion of additional surveys. The charts covering this coast from Maine to Cape Hatteras conform to the latest specifications; from Cape Hatteras to the Gulf, the old and new series intermingle, new where recent surveys warrant, elsewhere old, diagonal, double-unit, polyconic charts. Recharting of this section will progress as rapidly as new surveys are made.

On the Gulf coast the new series is completed from Pensacola to but not including the Delta of the Mississippi River and from Atchafalaya Bay to the Rio Grande, the more important areas being based on recent surveys. From the Brazos River to the Rio Grande the new charts are based on old surveys, which is justified by the minor importance of this area, which it is thought does not require new surveys at this time. This same policy of reconstructing charts without waiting for modern surveys will be extended during the coming fiscal year to the west coast of Florida, and it is hoped to complete the new series from Cape Sable to Tampa Bay.

The modification of existing charts of the West Indian Islands is dependent on the surveys now in progress, after the completion of which certain harbor charts of the Virgin Islands will be required.

Pacific coast.—On the Pacific coast the existing charts conform to the latest specifications, the work on the charts being limited to the correction of the present charts from new surveys by this and other organizations.

Alaska.—A series of new charts of the waters along the west coast of Prince of Wales Island is being expedited as rapidly as the surveys are received. General reconstruction of Alaska charts is still postponed pending completion and adjustment of the precise triangulation and of various subordinate loops radiating therefrom.

For western Alaska the problem consists in the application of new surveys to existing charts. A large scale chart may be necessary to meet the requirements of the surveys now being made by the Navy by airplane and sonic device methods.

Hawaiian Islands.—There is no new work in sight.

Philippine Islands.—The first charts printed in Manila after the establishment of the printing plant were made in February, 1922. During the fiscal year 1923 no less than 22,200 charts were printed from this plant in addition to the reproduction of one of the Philippine Islands topographic maps. Since the establishment of this plant new charts and new editions of charts are transferred to aluminum and reproduced long before the smooth drawings could reach Washington for the same process. Thus the charts are placed in the hands of the public at a much earlier date.

For the convenience of yachtsmen and owners of small craft a new series of charts is in project and will be finished during the year covering the inside water route from Norfolk to Key West.

This series will consist of 10 charts, 22 by 30 inches, printed on bond paper, each containing a number of strips from 6 to 8 inches wide. The strips are assembled largely from the published series of 1:80,000 charts.

The route as described in the Inside Route Pilots will be shown by a heavy red line and the soundings will be charted in feet. Certain outside areas on the coast where the route passes through open waters will also be included. This series will further meet the demands of the yachtsmen and small craft owners in that the charts may be cut into strips and carried in folders which will readily adapt themselves to limited spaces.

To meet demands from Government organizations and commercial interests permission was obtained through the department to issue a navigational chart of Lake Tahoe, Calif. and Nev. The shore line is a compilation from Government sources and the hydrography from a special survey by this bureau. At the close of the fiscal year this chart was on the presses.

Upon urgent requests of companies interested in the development of new oil fields a special survey and chart was completed of Icy Bay, southern Alaska.

On the recommendation of the board of surveys and maps, a new general map of the United States, scale 1:2,500,000, on Albers Conical Equal-Area projection with two standard parallels, is in preparation jointly by various member organizations of that board. The Coast and Geodetic Survey has been allotted the task of constructing and inking the projection and adding the shore lines and international boundaries, other bureaus undertaking thereafter to fill in the interior topography and complete the map. The dimensions of the completed map will be approximately 48 by 77 inches between neat lines. For convenience in handling, the drawing is to be made on a scale of 1:2,000,000 in nine sections, each 19.8 by 31.9 inches between neat lines.

The Albers Equal-Area projection, like the Lambert Conformal Conic projection, is especially suited for a map having a predominating east-and-west dimension, but while the maximum scale errors of the two are practically equal when the same standards are used (about 1¼ per cent) the Albers projection is equal area while the Lambert is not. Other projections now in use for maps of the United States have scale errors as great as 7 per cent.

The projection has been completed in the chart division and the mapping of the shore line is now in hand. A special drawing table and a beam compass arm 15 feet in length were necessary for constructing this projection.

The bureau also has in hand, for issue during the coming fiscal year, a new outline base map of Alaska on the Lambert Conformal Conic projection on a scale of 1:2,500,000, which is double the scale of the one published a year ago. The size of this outline map is 33½ by 44 inches. Delineation of the coast line is from the latest surveys, and only important place names are given, thus permitting ample space for the plotting of any special information that may be desired. The

map extends from the Arctic Ocean on the north to Dixon Entrance on the south and includes the Aleutian Islands and a part of eastern Siberia. It presents the coast line as a whole in one map in a more nearly true shape than heretofore. This map will be available for general distribution as a companion map to the one showing the same territory on a scale of 1:5,000,000.

On account of the predominating east-and-west extent of Alaska, the Lambert Conformal Conic projection adds to the general accuracy and offers advantages over other projections generally used in mapping this region.

A new series of three topographic maps of the Virgin Islands compiled from surveys by this bureau on a scale of 1:40,000 were printed and issued to meet urgent demands from official and commercial sources.

Special outline or base maps of Alaska on the Lambert Conformal Conic projection on a scale of 1:2,500,000 were prepared for the use of the presidential and other Government parties in connection with their visits to that Territory.

The progress of hydrographic surveys in Alaska and data showing various other Federal Government activities in the Territory, such as forest and fisheries reservations and locations of coal and other mineral mines, important canneries, pulp mills, and reported oil fields, were indicated by overprinting in colors, the condition of water surveys being shown on one map and the Government activities grouped on another. In addition the latter map showed the steamer tracks and distances between various points along the coast.

A special steamer-route chart, with distances, of British Columbia waters was also prepared for the same parties.

This series of maps and charts received the warm commendation of the numerous individuals to whom it was furnished.

A series of charts in strips showing the inside route from Fernandina to Key West, Fla., with additional special information, was prepared for use of the President and party on a trip through those waters. This series was received with appreciation and much favorable comment was made on the convenient method of showing this inside water route.

DIVISION OF TERRESTRIAL MAGNETISM.

The work of the division comprises: Computation of the observations made in the field and at the observatories and preparation of the results for publication; supplying compass data for nautical charts; preparation of replies to requests for information from engineers, surveyors, and others; systematic efforts to get in touch with local surveyors in order to let them know what magnetic information is available for their use and in return to find out the present condition of our magnetic stations and secure their assistance in preserving for future use those still intact; special investigations for the purpose of improving instruments and methods; discussion of results and study of the general problems of the earth's magnetism; analysis and tabulation of earthquake results and special investigations of the method of propagation of earthquake waves; training of observers; testing of instruments.

There has been a larger increase in the number of requests for information, due largely to the digests and circular letters sent out by the chief clerk's office, calling attention to the results of the work of the bureau available for the use of engineers and surveyors. Over 900 such requests were received during the year. In addition, over 600 letters were prepared concerning reports on the present condition of magnetic stations. As a result practically the entire time of one computer was occupied with this work, and it was only with the assistance of clerks in other divisions (chiefly charts) that this mass of correspondence could be handled in addition to the other clerical work of the division.

With a considerable portion of the time of another computer taken up with special investigations, training of observers, and testing of instruments, it was only with the assistance of two temporary computers loaned by the division of geodesy that it was possible to keep up with the routine reduction of field and observatory work. Additional computers and an additional clerk are urgently needed to permit the proper development of the work of the division.

Progress was made in the plans for the establishment of a compass school for junior officers in cooperation with the division of hydrography and topography, the most important item being the preparation of Instructions for the Compensation of the Magnetic Compass, a publication intended primarily for the use of officers of the bureau, but one which it is expected will be found very useful by the merchant marine. It was sent to the printer in June.

Special publication No. 90, Magnetic Declination in the United States for January 1, 1920, was completed and published and met with such a large demand that a reprint had to be ordered before the end of the year. This contains the information regarding the earth's magnetism most likely to be needed by the surveyor using a compass, together with directions for determining the true meridian.

Magnetic Declination in Arkansas was prepared and sent to the printer in June. This is the first of a series of publications giving for the States separately more detailed information regarding the magnetic declination and its change with the lapse of time. The recent field work in Florida has rendered the data for that State very nearly complete, and it will be the next publication to be issued.

An intensive campaign has been made to secure information regarding the present condition of our magnetic stations in California, Missouri, Arizona, New Mexico, and Texas, with a view to replacing missing stations where necessary and then getting out publications similar to the one for Arkansas.

The Sitka and Porto Rico Observatory results for 1919 and 1920 were completed, prepared for publication, and sent to the printer. The Tucson Observatory results for 1919 and 1920 were computed, and their preparation for printing was nearly completed.

Modifications in the method of publication were adopted which it is estimated will reduce the cost of publication about 55 per cent. The most important change is the photographic reproduction of the principal tables, thus eliminating the cost of typesetting and proof reading. In the reproduction of the principal magnetic storms the original magnetograms will be photographed directly, and the mak-

ing of vellum tracings will thus be avoided. In the case of the above results this change involved considerable additional labor, as all of the tables had to be copied on to new forms.

Progress was made in the computation of the observatory results for 1921 and 1922 to the extent that those for 1921 are about half completed and those for 1922 about one-fifth.

The computation of the field results was kept up to date, and the results were sent to the local surveyors interested as soon as they were ready. The results of the work done in 1922 were submitted for publication in May.

Proof was read of the Honolulu and Cheltenham Observatory results for 1919 and 1920, Magnetic Declination in the United States for 1920, and Horizontal Intensity Variometers, by George Hartnell, magnetic observer.

The earthquake recorded at the five magnetic observatories were tabulated monthly, and the results were transmitted to the Weather Bureau for publication in the Monthly Weather Review and to various persons engaged in the study of earthquake data. Special investigations were made of the theory of the propagation of earthquake waves and of the operation of seismographs. Additional lantern slides were prepared illustrative of the work in seismology.

The results of special observations made at the five magnetic observatories at the time of the solar eclipse of September, 1922, were tabulated and sent to the Journal of Terrestrial Magnetism for publication.

Special observations made in the vicinity of Birmingham, Ala., to investigate the possibility of locating nonmagnetic iron ore by means of magnetic instruments were discussed, and a copy of the results was sent to W. R. Crane, of the Bureau of Mines, at whose request the work had been undertaken.

A table giving the values of the magnetic declination and annual change for places in all parts of the United States was prepared for the 1924 edition of the World Almanac.

The division performed its alloted share of the marking of the examination papers of candidates for the position of deck officer and junior engineer.

The chief and the assistant chief of the division attended the meetings of the Geophysical Union in April and presented reports and papers before the sections of terrestrial magnetism, seismology, and oceanography. At the meeting of the section of terrestrial magnetism a resolution was adopted designating the Cheltenham magnetic observatory, in conjunction with the standardizing observatory of the department of terrestrial magnetism of the Carnegie Institution of Washington, as the observatory in the United States at which international comparisons of instruments are to be made.

A considerable portion of the time of the chief of the division was devoted to the study of problems relating to the application of new methods to secure the accurate determination of position in offshore hydrography. Compass data were supplied for 80 charts.

DIVISION OF TIDES AND CURRENTS.

The division of tides and currents has charge of the tidal and current work of all the coasts of the United States and Alaska and is

the only organization under the Federal Government having to do with the predictions of tides and currents. The work of the division is comprised under the following heads: Tidal observations and computations; current observations and computations; advance predictions of tides and currents, and preparation in advance of annual tables of tide and current predictions; tidal and current surveys of our principal harbors; physical oceanography; and the preparation of technical publications dealing with tides, currents, and related phenomena.

Tidal observations were made at six principal stations on the Atlantic coast, three on the Gulf coast, five on the Pacific coast, one in Alaska, and one at Honolulu, Hawaii.

Observations of currents were made at six light vessels on the Atlantic coast and one on the Pacific coast. Computations on the relation between wind and current were made for the light vessel observations on both coasts, in order to correlate wind and current for the preparation of current diagrams for the aid of the navigator in estimating the current, due both to tide and wind effects. The results of this work appeared as a separate current table for the calendar year 1923.

These current observations made along our Pacific and Atlantic coasts have brought out the important fact that, contrary to the belief of the mariner, a local wind creates a current not in its own direction but in a direction about 15° to the right of the wind and a velocity in knots per hour of about 2 per cent of the velocity of the wind in miles per hour on the Pacific coast and about 1½ per cent on the Atlantic. For example, a local south wind of 40 miles per hour on the Pacific coast creates a current setting about N. 15° E., and its velocity would be 40 by 0.02=0.8 knots per hour. These figures are not exact as taken from the observations but are sufficiently close for practical purposes and have therefore been furnished the mariner as forming a good working rule. The importance of the discovery that the set of the current is to the right of the wind direction lies in the fact that a wind blowing parallel with the coast may produce a current which tends to set a vessel on shore, a fact which until now has been unsuspected by the navigator.

For a number of years, by process of evolution as data became available, a considerable amount of information of interest and value to the mariner has been incorporated into Table 4 in the back of the Tide Tables published annually in advance by this bureau. Within the past few years the importance to the mariner of accurate current data along the coasts has been brought to the attention of Congress, and the interest of Congress in this important matter is reflected in the increase of appropriations for obtaining the necessary series of observations to permit the survey to obtain data on which to base conclusions and to make predictions of coastal currents. This increase in data and knowledge of our coastal currents has now warranted the separation of this material in Table 4 from the Tide Tables and the publication of separate volumes dealing with currents only. This was done for the calendar year 1923, when the current information appeared in two forms: Current Tables, Atlantic Coast, North America, and Current Tables, Pacific Coast, North America.

The Atlantic Coast Current Tables for 1924 are ready for issue; those for the Pacific coast are in the hands of the printer and will be issued early in the next fiscal year,

The predictions of tides and currents for the 1924 tide and current tables were made and the manuscript submitted for printing in five separate parts: Tide Tables, Atlantic Coast; Tide Tables, Pacific Coast; Tide Tables, United States and Foreign Ports; Current Tables, Atlantic Coast; and Current Tables, Pacific Coast. All except the Pacific Coast Current Tables are ready for issue.

During the past few years a policy has been adopted by the bureau of advancing each year by one month the time of submitting to the printer the different tide and current tables with the end in view of having all tables ready for issue six months before the beginning of the year for which predicted. This end has now been accomplished with all the tables except the Pacific Coast Current Tables, which will be issued this year five months ahead instead of six months.

The following table, showing the number of copies of the tide tables issued for each year since 1915, is indicative of the usefulness of these publications:

Tide tables for year—	Tide tables.	Atlantic coast tide tables.	Pacific coast tide tables.	Total.
1915	1,776	2,291	10,989	15,056
1916	1,195	2,682	10,565	14,442
1917	1,847	3,998	13,560	19,485
1918	3,331	3,997	13,959	21,287
1919	3,945	4,465	14,952	23,362
1920	3,474	5,252	15,738	24,464
1921	3,258	4,784	14,645	22,687
1922	3,056	5,704	14,902	23,662
1923	2,479	5,440	15,054	22,973

The above table, however, does not show the full value of the survey's tidal and current predictions to the public, for many thousands of privately printed tide tables, copied directly from the survey tables, are annually issued all over the country. These appear as separate tide tables for different localities and in almanacs and calendars. Some are sold and some given away in the form of advertisements, all reaching the public in useful form. In addition, the public receives the benefit of these predictions through the medium of the daily newspapers, a great many of which publish the tidal data in their columns, these data being furnished them by the Coast and Geodetic Survey directly or by means of the published annual tide tables.

DIVISION OF ACCOUNTS.

During the period from July 1, 1922, to June 30, 1923, the actual disbursements on account of appropriations for the Coast and Geodetic Survey amounted to $2,013,696.74. It must be understood, however, that this sum does not represent the actual expenses of the survey for the fiscal year 1923, but only the actual disbursements. In a separate report to Congress will be found an itemized statement showing disbursements from each appropriation and subitems thereof with all detailed information as to the character of the expenditure.

These expenditures include the accounts of all chiefs of parties in the field located throughout the United States, Alaska, Hawaii, Porto Rico, the Philippines, and the Virgin Islands. From 30 to 50 chiefs of parties were engaged on field duty at various times during the year, being financed through advances made to them by this division, and accounts arising under such advances were submitted to and through this division to the Treasury Department.

INSTRUMENT SECTION.

The instrument section is supervised by the assistant director. It is engaged in the construction, repair, and purchase of scientific instruments, which involves invention, designing, as well as improvement, with special adaptation for all the needs of the survey, in the fields of astronomy, geodesy, hydrography, navigation, the elements of the earth's magnetism, electricty, mechanical computations, mechanical engineering, and the like; also to keep account of all the tangible property of the bureau. During the year 1,202 instruments, special apparatus, and tools were made and 1,597 repaired.

PUBLICATIONS ISSUED DURING THE YEAR.

Serial No. 135. Special Publication No. 23 (revised edition). United States Coast and Geodetic Survey, Description of its Work, Methods, and Organization, 1920. 102 pp. octavo, 35 fig. This is a reprint of the publication descriptive of the work of the survey.

Serial No. 178. Special Publication No. 78. Precise Triangulation in Texas, Rio Grande Arc, by Clem L. Garner. 118 pp. octavo, 10 fig. The triangulation covered by this publication extends along the north and east side of the Rio Grande from a connection with the precise triangulation along the ninety-eighth meridian in the vicinity of Harlingen, Tex., to a connection with the Texas-California arc of precise triangulation near Alpine, Tex. The strip of territory covered by this control lies adjacent to the Rio Grande as far west as Marathon. Starting with a width of about 5 miles at the eastern end, it gradually widens to about 30 miles at the western end. The tabulation of data in this publication follows that adopted by the U. S. Coast and Geodetic Survey some years ago.

Serial No. 179. Special Publication No. 85. 97 pp. octavo, 49 fig. Plane Table Manual. This is a revised edition of the manual of topographical surveying of which several editions have been published by the survey, the last previous one in 1916. In this edition some changes have been made to conform with more recent practice, the matter has been condensed, and the publication appears in octavo instead of quarto form, as previously.

Serial No. 183. Special Publication No. 80. An Investigation of the Latitude of Ukiah, Calif., and of the Motion of the Pole, by Walter D. Lambert. 11 pp., 21 fig.

Serial No. 193. Special Publication No. 83. Tidal Bench Marks, State of New York, by L. A. Cole and I. A. Alpert. 175 pp. octavo, 2 fig.

Serial No. 194. Special Publication No. 84. California-Oregon Arc of Precise Triangulation. 53 pp. octavo, 10 fig. This publication contains the results for the arc of precise triangulation extending from the California-Washington arc in the vicinity of Mount Shasta in a northeasterly direction across the lower end of Oregon to a connection with the Utah-Washington arc just west of Boise, Idaho.

Serial No. 196. Special Publication No. 13 (second edition). California-Washington Arc of Precise Triangulation, by A. L. Baldwin. 53 pp. octavo, 7 fig. The data for this arc, together with a discussion of the least square adjustment and other purely scientific matter, were originally published as Special Publication No. 13. The original publication is entirely exhausted, and there is reprinted in the present edition only that part of the data which is of value to the engineer or surveyor for the control of surveys, namely, the geographic positions, elevations, and descriptions of stations.

Serial No. 200. Results of Observations Made at the United States Coast and Geodetic Survey Magnetic Observatory Near Honolulu, Hawaii, 1919 and 1920. 97 pp. quarto, 20 fig.

Serial No. 204. Special Publication No. 86. Precise Traverse, Racine, Wis., to Vandalia, Ill., by Charles A. Mourhess and Walter D. Sutcliffe. 81 pp. octavo, 20 fig. During the summer of 1920 a precise traverse was measured from a point about 215 miles west of Racine, Wis., to Vandalia, Ill. The resulting data are given here, in Part I, in convenient form for the use of engineers, surveyors, and others interested. In Part II is a brief discussion of the work.

Serial No. 205. Special Publication No. 87. Results of Magnetic Observations Made by the United States Coast and Geodetic Survey in 1921. 25 pp. octavo. This publication contains the results of magnetic observations made by the U. S. Coast and Geodetic Survey in the United States during the calendar year 1921, arranged alphabetically by States and Territories, with descriptions of the stations occupied, so that they may be conveniently referred to by surveyors or others wishing to use them.

Serial No. 206. Special Publication No. 88. Precise Triangulation Along the Ninety-eighth Meridian, Kansas-Oklahoma Boundary to Alice, Tex. 87 pp. octavo, 12 fig.

Serial No. 207. Digest of Geodetic Publications Issued by the U. S. Coast and Geodetic Survey Resulting from Surveys in the State of Indiana. 14 pp., 1 fig.

Serial No. 208. Current Tables, Atlantic Coast of North America, 1923. 80 pp. octavo, 2 fig., 7 diagrams. This is the first current table issued by the Coast and Geodetic Survey as a separate publication and contains in addition to daily predictions at 11 principal ports the time difference for about 350 additional ports, chapters on coastal tidal currents, the Gulf Stream, and currents produced by local winds. Especial attention is called to Table 5, giving the first published results from current observations made on light vessels for the study of wind-driven currents.

Serial No. 209. Digest of Geodetic Publications Issued by the U. S. Coast and Geodetic Survey Resulting from Surveys in the State of Massachusetts. 10 pp. octavo, 1 fig.

Serial No. 210. United States Coast Pilot, Atlantic Coast, Section D: Cape Henry to Key West. 217 pp., 1 litho.

Serial No. 211. Current Tables, Pacific Coast, North America, 1923. 48 pp. octavo, 1 fig. Gives data in regard to currents for the Pacific coast of North America, including predictions of time of slack water and turn of the current, with time differences for numerous localities and a chapter on coast tidal currents. Sold at the office of the U. S. Coast and Geodetic Survey, Washington, D. C.

Serial No. 212. Special Publication No. 89. Horizontal Intensity Variometers, by George Hartnell. 62 pp. octavo. This publication discusses the theory of the horizontal intensity variometers and the theory of the suspensions of the horizontal intensity variometers.

Serial No. 213. Digest of Geodetic Publications Issued by the U. S. Coast and Geodetic Survey Resulting from Surveys in the State of Texas. 26 pp. octavo, 1 fig.

Serial No. 214. Results of Magnetic Observations Made at the United States Coast an Geodetic Survey Magnetic Observatory at Cheltenham, Md., 1919 and 1920. 97 pp. quarto, 20 fig. These form part of the regular series of publications giving results of observations made at the magnetic observatories maintained by the survey.

Serial No. 215. Special Publication No. 90. Magnetic Declination in the United States for January 1, 1920. 30 pages octavo, maps. Gives results of field magnetic observations in the United States for date specified.

Serial No. 216. Special Publication No. 91. Use of Geodetic Control for City Surveys, by Hugh C. Mitchell. 80 pp. octavo, 25 fig. Explains the advantages of precise geodetic methods in city surveys.

Serial No. 217. Tide Tables, Atlantic Coast, North America, for the Year 1924. 151 pp. octavo. Gives predicted times and heights of tide for principal ports of the Atlantic coast of North America for the year 1924 and tables by means of which tidal data may be deduced for many other localities, besides much other useful information.

Serial No. 218. Tide Tables Pacific Coast of North America, Eastern Asia, and Island Groups for the Year 1924. 170 pp. octavo.

Serial No. 219. Supplement to United States Coast Pilot, Atlantic Coast: Section B, Cape Cod to Sandy Hook, September 30, 1922. 12 pp. octavo. Gives the more important corrections and additions affecting the text of this Coast Pilot volume since its publication.

Serial No. 220. Special Publication No. 92. Study of Time Errors in Precise Longitude Determinations by the U. S. Coast and Geodetic Survey, by William Bowie, chief of division of geodesy. This publication discusses the errors in time determinations in precise longitude work.

Serial No. 221. Digest of Geodetic Publications Issued by the U. S. Coast and Geodetic Survey Resulting from Surveys in the State of Rhode Island: Triangulation and Variation of the Compass. 7 pp. octavo, 1 fig. Gives brief references to publications containing results of triangulation, leveling, and magnetic observations in Rhode Island.

Serial No. 222. Digest of Geodetic Publications Issued by the United States Coast and Geodetic Survey Resulting from Surveys in the State of Maine. 10 pp. octavo, 1 fig.

Serial No. 223. Current Tables, Atlantic Coast, North America, for the Year 1924. 83 pp. octavo, 6 diagrams. This publication gives current data for a number of stations on the Atlantic coast and is illustrated graphically by diagrams.

Serial No. 224. Digest of Geodetic Publications Issued by the United States Coast and Geodetic Survey Resulting from Surveys in the State of Oregon. 15 pp. octavo, 1 fig. This gives brief references to publications containing results of geodetic work in the State named.

Serial No. 225. Special Publication No. 93. Reconnaissance and Signal Building, by Jasper S. Bilby. 77 pp. octavo, 76 fig. This publication is intended to supply information as to the methods used in reconnaissance and signal building in the U. S. Coast and Geodetic Survey.

Serial No. 226. Tide Tables, United States and Foreign Ports for the Calendar Year 1924. 449 pp. octavo. Gives times and heights of high and low water for the United States and foreign ports for the calendar year 1924, including tables by means of which tides may be deduced for a large number of localities besides those named in the tables; times of sunrise and sunset, moonrise and moonset, and other information useful to mariners.

Serial No. 227. United States Coast Pilot, Hawaiian Islands. 93 pp. octavo. This publication contains information relating to the Hawaiian Islands and includes the islands and reefs extending westward to Midway and Ocean Islands; aids to navigation are corrected to March 30, 1923. This volume has been compiled from surveys by the U. S. Coast and Geodetic Survey, the Geological Survey, the Hawaiian Government Survey; from U. S. Hydrographic Office Publication No. 115 (The Hawaiian Islands and the Islands, Rocks, and Shoals to the Westward), and from the results of a special investigation made in 1922.

Serial No. 228. Catalogue of U. S. Coast and Geodetic Survey Charts, Coast Pilots, Tide Tables, and Current Tables (Philippine Islands charts catalogued separately), February 1, 1923. 17 pp. quarto, 14 fig.

Serial No. 229. Supplement to U. S. Coast Pilot, Atlantic Coast: Section A, St. Croix River to Cape Cod. 13 leaves, octavo. Gives the most recent correction and changes to this volume of the Coast Pilot to bring it up to the present time.

Serial No. 230. Supplement to Inside Route Pilot, New York to Key West (fifth edition, January 1, 1923). Gives recent changes and corrections to the Inside Route Pilot.

Serial No. 231. Supplement to United States Coast Pilot, Atlantic Coast. Section E, Gulf of Mexico from Key West to the Rio Grande, March 30, 1923. Gives the more important corrections and additions affecting the text of the Coast Pilot volume since its publication.

Serial No. 232. Supplement to United States Coast Pilot, Pacific Coast, California, Oregon, and Washington (third edition, March 30, 1923). 20 pp. octavo. Gives the more important corrections to this volume of the Coast Pilot.

Serial No. 233. Supplement to U. S. Coast Pilot, Philippine Islands: Part I—Luzon, Mindoro, and Visayas (first edition, December 31, 1922). Gives the more important corrections and additions affecting this volume since its publication.

Annual Report of the Director, 1922. 148 pp. octavo, 38 fig.

Principal Facts of the Earth's Magnetism. 100 pp. quarto, 28 fig. (reprint).
Notice to Mariners. Issued weekly, jointly with the United States Bureau of Lighthouses.
Philippine Islands Notice to Mariners.
Coast and Geodetic Survey Bulletin, issued monthly.
U. S. Coast Pilot, Atlantic Coast, Section C (reprint). 284 pp. octavo.

NEW CHARTS.

1239. Charleston Harbor and approaches, S. C. June, 1922. Scale, 1:80,000; dimensions, 32 by 43 inches. This is one of the new series of 1:80,000 scale coast charts on the Mercator projection. It extends from Bull Island to St. Helena Sound and shows the results of new surveys along the coast made in 1921. It supersedes Chart No. 154. The soundings are in feet instead of feet and fathoms, as on charts of the old series.

1251. Florida Keys, Sombrero Key to Sand Key, Fla. June, 1922. Scale, 1:80,000; dimensions, 33 by 42 inches. This is one of the new series of 1:80,000 scale coast charts on the Mercator projection. It is oriented with the meridian, and the soundings are in feet. It shows the results of recent surveys at the western end of Hawk Channel and south of the Keys and replaces charts Nos. 168 and 169 of the old series.

1351. Florida Keys, American Shoal to Dry Tortugas, Fla. June, 1922. Scale, 1:80,000; dimensions, 25 by 38 inches. This is a companion chart to No. 1350, issued in May, 1922, and together with that chart meets a growing demand for sailing charts along the Florida Reefs on a larger scale than previously issued. It extends from American Shoal to Dry Tortugas and is on the Mercator projection. Scale, 1:80,000; in latitude 24° 50′. The soundings are expressed in fathoms.

1280. Aransas Pass to Baffin Bay, Tex. June, 1922. Scale, 1:80,000; dimensions, 32 by 39 inches. This is one of the new series of 1:80,000 scale coast charts on the Mercator projection. It supersedes Chart No. 210. The soundings are in feet instead of feet and fathoms, as on charts of the old series. It also contains a plan of Aransas Pass on a scale of 1:40,000, showing the results of a survey by United States Engineers in May, 1922.

4325. Nariz Point to Bugsuk Island, southeast coast of Palawan, Philippine Islands. June, 1922. Scale, 1:1,000,000; dimensions 31 by 43 inches. This chart shows the results of detailed surveys to 1921 by the U. S. Coast and Geodetic Survey over the entire area represented. Numerous dangers to navigation, especially in Island Bay and near vicinity, are published for the first time on this chart. Recommended courses for entering several of the anchorages are indicated.

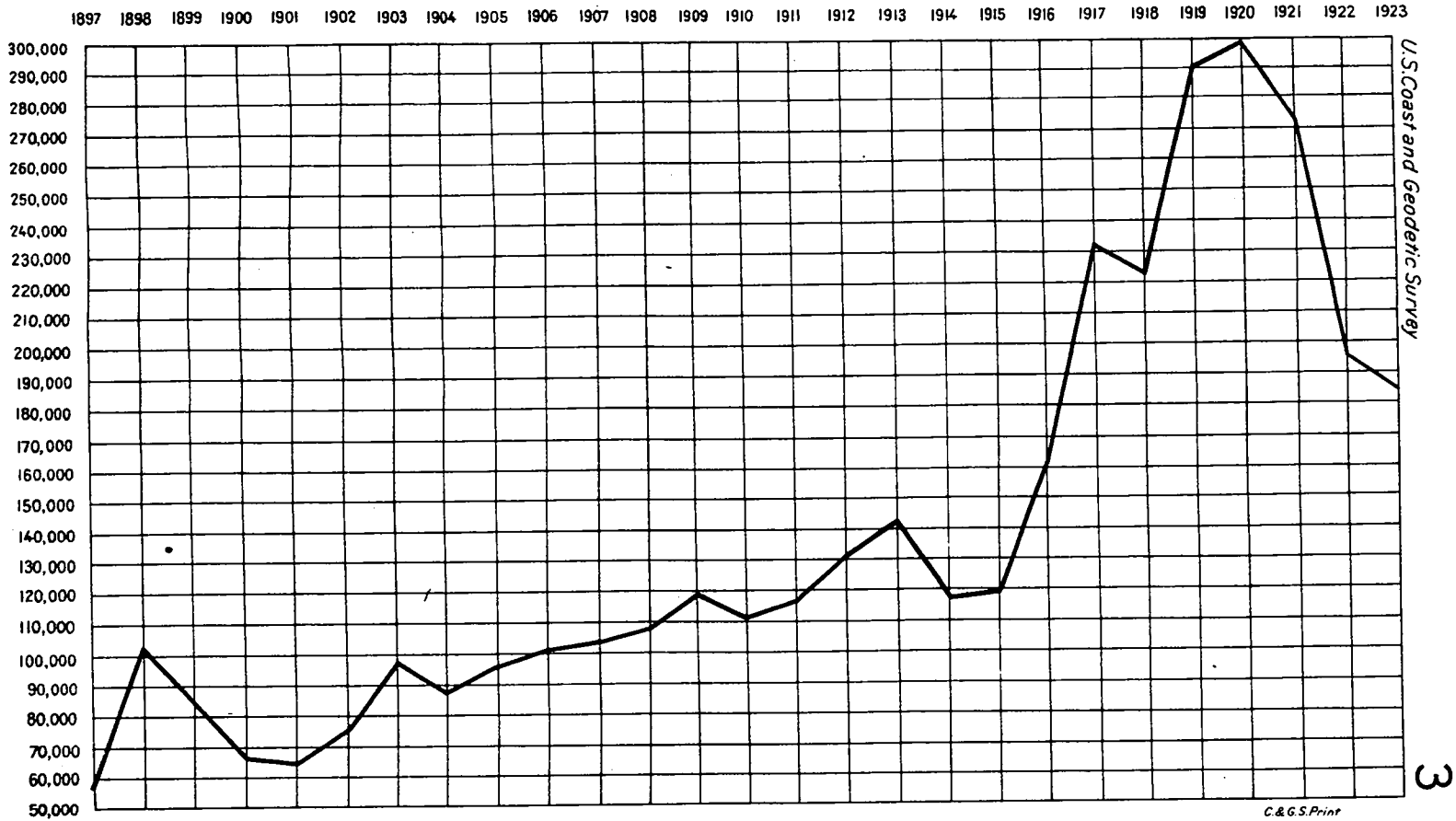
5603. Bodega and Tomales Bays, Calif. June, 1923. Scale, 1:30,000; dimensions, 33 by 42 inches. This chart is constructed on the Mercator projection, and soundings are charted in feet. It supersedes charts Nos. 5618 and 5627.

4325. Nariz Point to Bugsuk Island, southeast coast of Palawan, Philippine Islands. September, 1922. Scale, 1:100,000; dimensions, 32 by 44 inches. This chart shows the results of complete detailed surveys to 1921 by the U. S. Coast and Geodetic Survey over the entire area represented. Numerous new shoals are published for the first time on this chart.

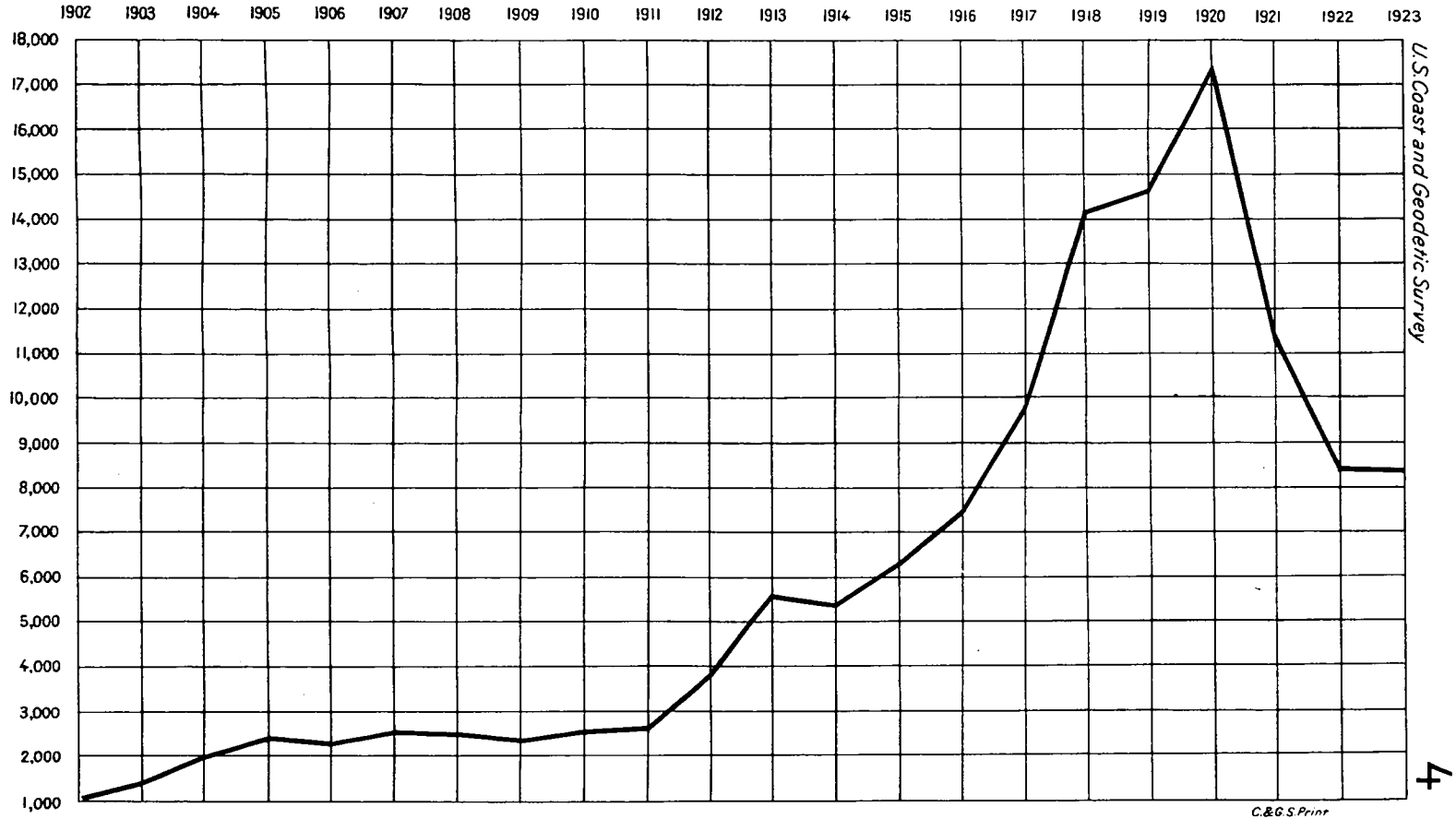
585. Dry Tortugas, Fla. December, 1922. Scale, 1:30,000; dimensions, 28 by 34 inches. This new chart is on a larger scale than chart No. 471a, which it supersedes, and the soundings are in feet instead of fathoms and feet, as on chart 471a. It is constructed on the Mercator projection and based on the North American datum. It contains as an insert a plan of Tortugas Harbor on a scale of 1:10,000.

1287. Northern part Laguna Madre, Tex. January, 1923. Scale, 1:80,000; dimensions, 32 by 41 inches. This is one of the new series of 1:80,000 scale coast charts on the Mercator projection, and it replaces chart No. 211. It embraces a stretch of the Texas coast from latitude 26° 32′ to latitude 27° 16′, and the soundings are charted in feet.

8145. South End of Prince of Wales Island, Kendrick Bay to Shipwreck Point, southeast Alaska. January, 1923. Dimensions, 31 by 42 inches. This chart is designed to chart on an adequate scale for navigational purposes the numerous bays indenting the south end of Prince of Wales Island, the difficult waters along shore, and Eureka Pass off the southwest coast of the island. The results of recent surveys along the southeast and eastern coasts falling



ISSUE OF CHARTS FROM 1897 TO 1923



ANNUAL DISTRIBUTION OF COAST PILOTS AND INSIDE ROUTE PILOTS

1288. Southern part of Laguna Madre, Tex. April, 1923. Scale, 1:80,000; dimensions, 32 by 41 inches. This chart is one of the new series of 1:80,000 scale coast charts on the Mercator projection. The soundings are in feet instead of feet and fathoms, as on the old series of charts.
8457. Icy Bay, South Coast, Alaska. May, 1923. Scale, 1:40,000; dimensions, 29 by 31 inches. This chart is published to fill a demand by the maritime interests. Icy Bay has recently become of commercial importance on account of the discovery of oil in its vicinity. The chart shows the results of surveys made in 1922. The soundings are charted in fathoms and give the depths at the mean of the lower low waters.
8171. Davidson Inlet and Sea Otter Sound, southeast Alaska. May, 1923. Scale, 1:40,000; dimensions, 31 by 38 inches. This chart is published to meet a demand for a chart of Davidson Inlet and Sea Otter Sound on a larger scale than previously published. It is constructed on the Mercator projection on a scale of 1:40,000 in the middle latitude of the chart. It forms one of the series of overlapping charts extending southward to Tlevak Strait.

NEW TOPOGRAPHIC MAPS.

3241. St. John, Virgin Islands, West Indies. October, 1922. Scale, 1:40,000; dimensions, 10 by 22 inches.
3240. St. Thomas, Virgin Islands, West Indies. November, 1922. Scale, 1:40,000; dimensions, 17 by 29 inches.
3242. St. Croix, Virgin Islands, West Indies. May, 1923. Scale, 1:40,000; dimensions, 16 by 37 inches.

NEW EDITIONS OF CHARTS.

1217. Little Egg Inlet to Hereford Inlet, N. J.
436. St. Helena Sound, S. C.
5143. Los Angeles Harbor and vicinity, Calif.
8074. Harbors in Dixon Entrance and Clarence Strait, Alaska.
908. San Juan Harbor, P. R.
1222. Chesapeake Bay Entrance, Va.
8802. Alaska Peninsula and Aleutian Islands to Seguam Pass.
78. Chesapeake Bay, southern part.
544. Kill van Kull, N. Y. and N. J.
5531. San Francisco Bay, Calif., southern part.
4226. Lamon Bay and Polillo Island, east coast of Luzon, P. I.
4269. Harbors of Catanduanes, P. I.: Cabaugano Bay, south coast; Bagamanoc and Anajao, east coast; Cobo Bay, west coast; Port Manamrag, west coast; Pandan Bay, north coast; Gigmoto Bay, east coast; Kalapadan Bay, east coast.
4649. Malalag Bay, south coast of Mindanao, P. I.
327. Richmond Island Harbor, Me.
369. New York Harbor, N. Y. and N. J. (Two editions.)
157. Sapelo Island, Ga. to Amelia Island, Fla., Ga. and Fla.
5107. San Diego Bay, Calif.
950. Colon Harbor, Canal Zone.
470. Charleston Harbor, S. C.
4235. Pasig River, West Coast of Luzon, P. I.
1252. Sand Key to Rebecca Shoal, Fla.
5602. Point Arena to Trinidad Head, Calif.
560. Potomac River, Mattawoman Creek to Georgetown, Md., Va., and D. C.
520. Galveston Entrance, Tex.
6122. Nehalem River, Oreg.
6112. Tillamook Bay, Oreg.
6152. Columbia River, Harrington Point to Grims Island, Oreg. and Wash.
6154. Columbia River, St. Helens to Willamette River, including Vancouver and Portland, Oreg. and Wash.
153. North Island to Isle of Palms, including Cape Romain, S. C.
6023. Siuslaw River, Oreg.
5984. Coos Bay, Oreg.
5971. Coquille River Entrance, Oreg.
4466. Harbors in Negros and vicinity, P. I.
5832. Humboldt Bay, Calif.

549. Approaches to Baltimore Harbor, Md.
8002. Dixon Entrance to Cape St. Elias.
8200. Frederick Sound and Summer Straits, Alaska.
425. Cape Fear River, Reeves Point to Wilmington, N. C.
5525. Mare Island Strait, Calif.
150. Old Topsail Inlet to Shallotte Inlet, including Cape Fear, N. C.
6058. Yaquina River and approaches, Oreg.
250. Eastern entrance to Nantucket Sound, Mass.
6378. Bellingham Bay, Wash.
4257. Anchorages, vicinity of Verde Island Passage, southwest coast of Luzon, P. I.
1112. Cape Canaveral to Key West.
5386. San Luis Obispo Bay and approaches, Calif.
8102. Hecate Strait to Etolin Island, including Behm and Portland Canals, Alaska.
4200. Philippine Islands.
1282. Galveston Bay and approaches, Tex.
424. Cape Fear River Entrance to Reeves Point, N. C.
6451. Commencement Bay and city of Tacoma, Wash.
4707. Philippine Islands, southwestern part.
584. Key West Harbor and approaches, Fla. (Two editions.)
8152. Dixon Entrance to Chatham Strait, Alaska. (Two editions.)
920. Porto Rico and Virgin Islands, West Indies.
4218. Ragay Gulf to Tayabas Bay, Luzon, P. I.
453. Fernandina Entrance, Fla.
6195. Grays Harbor, Chehalis River to Montesano, Wash.
8076. Harbors in Clarence Strait, Alaska; north arm of Moira Sound.
341. Provincetown Harbor, Mass.
345. Robinsons Hole and Quicks Hole, Mass.
369. Hudson and East Rivers, from West Sixty-seventh Street to Blackwells Island, N. Y. and N. J.
4651. Harbors on the South and West Coasts of Mindanao, P. I.
541. New York Harbor, Upper Bay and Narrows (anchorage chart), N. Y. and N. J.
525. Brazos River Entrance, Tex.
4706. Philippine Islands, central part.
4716. Palawan, P. I.
284. Hudson River, Coxsackie to Troy, N. Y., etc.
542. Jamaica Bay and Rockaway Inlet, N. Y.

CHAPTER II.

PROGRAM FOR THE CURRENT FISCAL YEAR IN THE WASHINGTON OFFICE.

CHIEF CLERK.

The program for this division will be, in addition to routine duties of the division, the continuation of the renovation of the buildings occupied by the bureau and the preparation and distribution of digests of geodetic work of the bureau for as many States of the Union as time permits.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY.

The program for office work in this division for 1923 includes—

(*a*) Further study of field work projects to meet current demands for charts, particularly on the Atlantic coast of the United States and in Alaska.

(*b*) Study of conditions in the Philippine Islands with the view of adopting a general program for the completion of the survey of Philippine waters and, in particular, to determine the order in which the unsurveyed areas should be taken up.

(*c*) Continued study of cost analysis of field work to determine wherein further economies can be effected.

(*d*) Investigation and development of surveying apparatus, particularly the various sonic methods of measuring depth and fixing the position of the surveying vessel.

(*e*) Completion of the report on the aerophoto topographic survey of the Mississippi River Delta.

(*f*) Preparation of a manual of hydrographic surveying.

(*g*) Preparation and publication of United States Coast Pilots: Section C, Sandy Hook to Cape Henry, and Part I, Alaska. Preparation and publication of supplements or revision sheets of Coast Pilots: Section D, Cape Henry to Key West, Porto Rico and Virgin Islands, and Alaska, Part II. Preparation and, if possible, publication of United States Coast Pilot: Section E, Gulf of Mexico from Key West to the Rio Grande, and Inside Route Pilot, Gulf Coast.

DIVISION OF GEODESY.

The program of office computations for the division of geodesy for 1924, by project, is as follows:

(*a*) TRIANGULATION AND TRAVERSE.—Green Bay, Wis., to Duluth, Minn.; Mansfield to Naples, La.; traverse along Canadian boundary in Minnesota; El Reno, Okla., to Needles, Calif.; Pecos, Tex., to Colorado Springs, Colo.; Tacoma-Canadian boundary; Pasadena base; triangulation in connection with Texas-Oklahoma boundary; in Maryland and Louisiana; any special piece of work that may be requested.

(*b*) LEVELS.—In Alaska; in New England States; in Yellowstone National Park; revision work in Oregon.

(*c*) ASTRONOMIC.—Azimuths, latitudes, and longitudes along the arcs of triangulation and lines of traverse given under (*a*).

(*d*) GRAVITY.—Computation and reduction of the gravity observations for the stations to be determined by two parties working this year—one in Alaska, the other in Texas.

(*e*) PUBLICATIONS.—Longitude, Latitude, and Azimuth Determinations in the United States by the U. S. Coast and Geodetic Survey and other organizations; Studies of Gravity and Isostasy in Local Areas; Triangulation Manual; Triangulation, Traverse, and Precise Levels in the Interior of North Carolina; Precise Length Determinations in California; Precise Leveling in Alabama; Geodetic Operations in the United States, 1922–1924; Precise Leveling Manual.

DIVISION OF CHARTS.

The program for 1924 calls for the production of 17 new charts and the reconstruction of 17 existing charts. A series of 10 special inside-route charts, in strips, will also be prepared.

DIVISION OF TERRESTRIAL MAGNETISM.

The program for the fiscal year 1924 is as follows: Complete the computation of the results for all of the observatories for the years 1921 and 1922; compute the observations at field stations and for the standardization of instruments at the observatories as received; tabulate the earthquakes recorded at the five magnetic observatories as received; supply information to surveyors and engineers as requests are received; prepare for publication the results for 1921 and 1922 for the Honolulu, Cheltenham, and Sitka Magnetic Observatories; prepare for publication the field results for 1923; prepare publications giving complete data regarding the magnetic declination for the States of Florida, North Carolina, California, and Missouri; prepare a new edition of Principal Facts of the Earth's Magnetism; establish, in cooperation with the division of hydrography and topography, a compass school for the instruction of the young officers of the bureau.

DIVISION OF TIDES AND CURRENTS.

The program for the division of tides and currents for the year ending June 30, 1924, is as follows:

The tide tables for 1925 will be completed, scanned for the detection and removal of errors, and submitted to the printer.

The current tables for 1925 will be completed and sent to the printer.

The sounding records received from the hydrographic parties will be checked as received, so that no delay will be occasioned to the chart division in the publication of charts.

The bench-mark records received will be computed for those demanding immediate attention and the remainder kept up to date as the force of mathematicians will allow.

The manuscript of a publication on the Tidal and Current Phenomena of New York Harbor will be completed and sent to the printer about the first of the calendar year 1924.

The manuscript of a publication on the Harmonic Analysis and Publication of Tides will be completed in August, 1923, and sent to the printer.

The manuscript of a publication on Tidal Bench Marks in the States of Delaware, Maryland, Pennsylvania, and New Jersey will be begun during the fiscal year, but will not be completed until the following fiscal year.

A study of mean sea level will be taken up during the fiscal year as time permits, but no manuscript of a publication will be prepared during the year.

A study of the efficiency of the present method of tabulating and reducing tidal records will be taken up during the year, looking toward the saving of a considerable amount of the time of the mathematicians engaged on this work.

An investigation will be made during the year and tests carried on in connection with devising a large tide gauge for our principal tidal stations, looking toward a more efficient gauge than the present one, both from the standpoint of more accurate records and economy in tabulating the records at this office.

The observations obtained on the current and tidal survey of San Francisco Harbor will be analyzed immediately upon their receipt from the field, the results discussed and interpreted, and the manuscript of a publication on this important piece of work prepared for early distribution to engineers and to the interested public. In addition, the improvement to our present current predictions made possible by this survey will be incorporated in the present current tables for the use of the mariner.

In general the work of the division will be so arranged as to take up immediately the work upon which the publication of charts and the prosecution of the general field work of the bureau depend; after that the energies of the division will be directed toward keeping its tabulations and computations up to date and to issue in the form of publications the large mass of material that has accumulated in the division and which is of considerable value to the navigator, the engineer, the scientist, and the public generally.

DIVISION OF ACCOUNTS.

The program for this division will be a continuance of the duties incident to disbursing the funds appropriated for the operation of this bureau, including the financing of all chiefs of parties at work in the field, together with the verification of all accounts arising under such advances.

In compliance with directions from the comptroller general, new records have been installed, including a daily record in detail of all vouchers paid and a classification of all expenditures by symbol number. This latter record is an elaboration of the old allotment book and is in addition thereto.

INSTRUMENT SECTION.

The program for the ensuing fiscal year will be to continue to keep up the instrumental equipment, to improve the same in harmony with modern progress, to maintain the system of accounting for property belonging to the bureau, and to continue to improve the method of accounting in adjustment with necessity and convenience.

Part III.—IN THE FIELD.

CHAPTER I.

ACCOMPLISHMENTS IN THE FIELD DURING PAST FISCAL YEAR.

HYDROGRAPHIC WORK.

The following is a statement of vessels at the disposal of the U. S. Coast and Geodetic Survey at the beginning of the fiscal year: *Bache*, *Cosmos*, *Discoverer*, *Explorer*, *Fathomer*, *Hydrographer*, *Lydonia*, *Marinduque*, *Natoma*, *Pathfinder*, *Pioneer*, *Ranger*, *Surveyor*, *Wenonah*, and *Yukon;* total, 15. The steamer *Guide* was transferred to this service from the Navy Department on January 23, 1923, and during the remainder of the fiscal year was undergoing alterations to convert it for surveying purposes, having been built for mine-sweeping duty by the Navy. The *Wenonah* was returned to the Navy on February 6, 1923.

The following is a brief statement of the assignment of vessels at the disposal of the U. S. Coast and Geodetic Survey within the fiscal year:

Bache.—At the beginning of the fiscal year this vessel was undergoing repairs at Norfolk, and on July 21 hydrographic work was commenced in the vicinity of the entrance to Chesapeake Bay. This work extended from the beach to the 100-fathom curve, and was continued until November 3, when the vessel proceeded to Norfolk to undergo repairs. These repairs were completed, and the vessel left Norfolk on February 7 and arrived at Port Arthur on February 28, having stopped at Charleston, Jacksonville, and Key West en route. During the remainder of the fiscal year the vessel was engaged in offshore hydrography in the Gulf of Mexico, in the vicinity of Sabine Pass, Tex., which work was in progress at the end of the fiscal year.

Cosmos.—Was operated by the party on the steamer *Surveyor*, and the work accomplished by this vessel is covered in the statement of the *Surveyor*.

Discoverer.—Alterations were completed, and the vessel left Philadelphia, Pa., on August 9, for Norfolk, Va., where minor repairs were made and supplies taken on for the trip to the west coast. On September 25 the vessel left Norfolk en route to the Pacific coast, arriving at Cristobal, Canal Zone, on October 8, having stopped one day at Kingston, Jamaica. On October 12 the vessel left Balboa, Canal Zone, and arrived at San Diego on October 27. During the trip from the east coast to the west coast deep-sea soundings were taken and valuable data for navigational charts obtained. From October 28 to November 10 minor repairs were accomplished by the ship's force, and preparations were made for undertaking offshore soundings in the vicinity of San Diego. On the latter date this work

was commenced and continued until February 10. The work included offshore soundings from the boundary line north to approximately the entrance to San Diego Harbor and from the beach to the 1,000-fathom curve; also a close development of Cortez Bank, the latter piece of work being done in conjunction with the party on the steamer *Pioneer*. On February 13 the vessel left San Diego and arrived at San Francisco on the same date. From this date until March 27 repairs were being made and supplies taken on board for the coming season's work in Alaska; also, the officers were engaged in completing the records of the past season's work along the California coast. On March 27 the vessel sailed from San Francisco and arrived at Seattle on March 30. The work on the past season's records of the California surveys was completed and the records forwarded to the office. On April 20 the vessel sailed for the working grounds in Alaska. A short stop was made at Ketchikan on April 25, and on May 2 the vessel arrived at Uyak, having placed a detached party at Kachemak Bay en route. During the remainder of the fiscal year the party was engaged in surveys in Shelikof Straits in the vicinity of Portage Bay and a survey of Kachemak Bay.

Explorer.—From the first of the fiscal year until September 30 the vessel continued drag work and combined operations in Lynn Canal and Icy Straits. The launch equipment was hauled out at Ketchikan, and the vessel arrived at Seattle on October 20. During the winter the records of the past season's work were completed and forwarded to the Washington office, necessary repairs were made, and supplies taken on board. The vessel left Seattle on March 15 to resume field operations in Alaska, arriving at Ketchikan on March 20. The launches assigned to this party were put into the water, and the vessel proceeded to Juneau with this equipment, arriving on March 31. On April 3 field work was commenced, which is a continuation of the work in progress during the previous season. At the end of the fiscal year the drag work was extended to Lemesurier Island, and most of the deep water of Cross Sound had been covered with a wire sweep.

Fathomer.—This vessel has been employed in surveys in the Philippine Islands. From the first of the fiscal year to September 7 this vessel was engaged in surveys in the Sulu Archipelago, and was undergoing repairs at Manila from September 9 to November 10, and resumed operations in the Sulu Archipelago on November 16 and continued on this work until the close of the fiscal year.

Guide.—This vessel was transferred from the Navy on January 23, 1923, at Portsmouth, N. H. On February 5 the vessel arrived at New York, where alterations were made, and at the end of the fiscal year was at the Brooklyn Navy Yard undergoing repairs and having a sonic depth finder installed.

Hydrographer.—From the first of the fiscal year until October 14 this vessel was engaged upon surveys in the Gulf of Mexico in the vicinity of the Chandeleur and Breton Islands. This work completed the hydrography which was started east of Pensacola in 1919 and extends west to the Southwest Pass of the Mississippi River. On October 14 the vessel left Gulfport and arrived at Mobile on the same day, and from that date until November 17 was undergoing repairs. The vessel arrived at Port Arthur, Tex., on November 22

and was engaged during the remainder of the fiscal year in offshore hydrography in the Gulf of Mexico in the vicinity of Sabine Pass, Tex.

Lydonia.—From the first of the fiscal year until September 18 the *Lydonia* was engaged in offshore work in the vicinity of Cape Blanco. On September 21 the vessel arrived at San Francisco, and from this date until October 11 repairs were made and necessary arrangements for the trip to the east coast completed. During this period office work on the records of the survey work off Cape Blanco were completed and forwarded to the office. On November 11 the vessel left San Francisco and arrived at Jacksonville, Fla., on November 30, having stopped en route at San Diego, Calif.; Salina Cruz, Mexico; Panama Canal; and Kingston, Jamaica. Oceanographic work was continued during the trip, and deep-sea soundings were taken. After the necessary repairs incident to the long trip were accomplished, offshore hydrography was taken up in the vicinity of St. Augustine, Fla. This work was continued until April 25, when the vessel proceeded to Jacksonville to undergo repairs and make the necessary preparations for field work. On June 6 offshore hydrography was started in the vicinity of the Cape Fear River, which work was in progress at the end of the fiscal year.

Marinduque.—Was employed the entire year in surveys in the Philippine Islands. From the first of the fiscal year to November 5, engaged in surveys in the Sulu Archipelago; from November 9 to February 27, undergoing repairs at Manila; from March 2 to April 26 and May 13 to the end of the fiscal year, engaged in surveys in the Sulu Archipelago, the period from April 28 to May 11 being spent in Manila undergoing minor repairs.

Natoma.—From the 1st to the 17th of July the vessel was undergoing repairs at San Francisco. On the latter date work was taken up in Carquinez Strait and Suisun Bay, Calif. This work was continued until March 2, when work was discontinued and the vessel proceeded to San Francisco, where arrangements were made for laying the vessel up. The vessel was laid up on March 21 at San Francisco for the remainder of the fiscal year.

Pathfinder.—This vessel has been engaged during the entire year in surveys in the Philippine Islands. From the first of the fiscal year until July 9 the vessel was undergoing repairs at Manila. From July 10 to November 25 the vessel was engaged in combined operations off the west coast of Palawan Island. From November 28 to February 10, undergoing repairs and completion of field records of the past season's work at Manila. The sailing from Manila was delayed, owing to the death of the chief engineer, until February 28, when the vessel sailed for Sarangani Bay, where work was in progress from early in March until the end of the fiscal year.

Pioneer.—Alterations to the *Pioneer* were completed on August 9, and the vessel left Philadelphia, Pa., on that date and arrived at Norfolk on August 10. Repairs and preparations for the trip to the west coast were in progress until September 23, when the vessel sailed for San Diego, Calif. The vessel arrived at San Diego, Calif., on October 29, having arrived at the Canal Zone on October 5 and sailed from there on October 12. Deep-sea soundings were made en route and information of value to the navigator was accumulated

on the trip. Early in November a cable survey was made from San Pedro to Catalina Island. After the completion of this work a survey of San Diego Harbor and offshore hydrography from San Diego to Delmar, Calif., was made. This work was completed on February 20. In addition to the offshore hydrography a detailed survey of Cortez Bank was also accomplished during this period, this work being executed in conjunction with the party on the steamer *Discoverer*. The vessel arrived at San Francisco on February 22 and was engaged from that date until April 5 in making the necessary repairs, the completion of field records, and necessary preparations for Alaska field work. On April 5, the vessel left San Francisco and arrived at Seattle on April 8, sailing from Seattle on April 20. During the stay in Seattle the survey records of the work executed off the California coast were completed and forwarded to the office. On April 25 the vessel arrived at Ketchikan, Alaska, sailing May 4. The launch *Wildcat* was placed in commission at Ketchikan and convoyed to the working grounds in western Alaska in the vicinity of Cold and Morzhovoi Bays, at which place the party arrived on May 18. Survey work was in progress in that vicinity at the end of the fiscal year.

Ranger.—From the first of the fiscal year until the end of the year the *Ranger* was engaged in wire-drag operations in Vieques Sound, P. R. In addition to the regular boat equipment of the vessel the launches *Mitchell* and *Marindin* were assigned to this party for wire-drag work.

Surveyor.—From the first of the fiscal year until November 27 this vessel was engaged in general surveys in southeastern Alaska on the outer coast from Noyes Island to Coronation Island and inside near El Capitan Pass. After completing the field work the launch *Cosmos*, assigned to the party, was hauled out at Ketchikan, and the vessel arrived in Seattle on December 12. From December 13 to March 26 the vessel was at Seattle undergoing repairs and making arrangements for work in Alaska and the completion of the field records of the past season's work. On March 27 the vessel sailed from Seattle. The vessel arrived on the working ground on March 31, at which time a continuation of last season's work was commenced and was in progress at the end of the fiscal year. After placing parties in the field the vessel proceeded to Ketchikan and placed the launch *Cosmos* in commission.

Wenonah.—From the first of the fiscal year until October 27 the vessel was engaged in general survey operations in Clarence Strait, Ernest Sound, and Zimovia Strait, and in addition to the topographic and hydrographic work an arc of precise triangulation was measured in Clarence Strait and Dry Strait. After hauling out the larger launches assigned to the party at Ketchikan the vessel arrived at Seattle November 7. From the latter date the party was engaged in the completion of field records and in the preparation of the necessary inventories and perfecting the necessary arrangements to transfer the vessel to the Navy, which was accomplished on February 6, 1923.

Yukon.—This vessel was not operated during the calendar year of 1922, but was placed in commission by the party on the steamer *Dis-*

coverer in May, 1923, and was operated in connection with that party during the remainder of the fiscal year.

The following launches were operated during the fiscal year.

Mikawe.—Was placed in commission early in May and was engaged in surveys in the vicinity of Southport, N. C., from that date until the end of the fiscal year.

Wildcat.—Left Seattle April 25 and arrived at Icy Bay, southwest Alaska, on May 27. From that date until September 27 a survey of Icy Bay was made. On the latter date the launch left Icy Bay and proceeded to El Capitan Pass, where she arrived October 7, and from that date until November 25 was engaged upon a survey of El Capitan Pass, this work being done in conjunction with the party on the steamer *Surveyor.* After completing the work in El Capitan Pass the launch was hauled out and secured for the winter at Ketchikan and the party proceeded to Seattle on the steamer *Surveyor.* The latter part of April the *Wildcat* was placed in commission and convoyed to the western Alaska grounds by the steamer *Pioneer* and was operated with that vessel until the end of the fiscal year.

DETACHED PARTIES.—A survey of Lake Tahoe, Calif., was made, using the launch *Mount Rose*, belonging to the U. S. Reclamation Service. This work was commenced on July 6 and was completed on October 16, when the party was disbanded and the officers returned to Washington and completed the field records of the season's work. Wire-drag party working in the vicinity of Portland, Me., was organized on June 4 and arrived on the working ground on June 11, from which date until the end of the fiscal year the necessary preliminary signal building and control work was executed, and the party was ready to commence the actual wire-drag work on June 30. A detailed topographic survey made at the request of the Bureau of Standards of their grounds at Washington, D. C., was accomplished during the month of December.

AERIAL SURVEYS.—The necessary control for the aerial survey of the Mississippi River Delta completed during previous fiscal year was executed between September 26 and November 12, and the office work in connection with this survey has been in progress during the entire fiscal year. This bureau has been ready to cooperate in every way possible in aerial surveying, but the Air Services of the Army and the Navy have been hampered by either lack of funds, equipment, or personnel, necessitating a curtailed program. It is hoped that this new branch of applied science will receive its proper support in the near future and that its importance as an accurate, rapid, and economical method of surveying and its value as a training school for the personnel of the air service will be recognized.

SHIP AND LAUNCH HYDROGRAPHY PERFORMED DURING THE FISCAL YEAR.

Ship hydrography:	Area, square miles.
Chesapeake Bay approaches	1,547
Chandeleur and Breton Sound	973
Sabine Pass and approaches, Tex	1,656
Florida, east coast	927
North Carolina, off Cape Fear River	148
California—	
Suisun Bay and Carquinez Straits	40
San Diego Bay and southern California coast	4,215
Oregon, vicinity Coos Bay	291

	Area, square miles.
Ship hydrography—Continued.	
Alaska—	
Ernest Sound and Stephens Passage	114
West coast of Prince of Wales Island	2,886
Vicinity Shelikof Straits	79
Vicinity Cape Pankof	101
Philippine Islands	2,527
Total	15,504
Launch hydrography:	
Icy Bay, Alaska	43
Lake Tahoe, Calif.-Nev.	188
Total	231
Wire-drag surveys:	
Porto Rico	215
Southeastern Alaska	596
Total	811
Oceanography	640,000

This makes a total of 1,000,000 square miles of deep area sounded by vessels of the bureau while making routine changes of station between the Atlantic and Pacific coasts since 1918.

Topography.	Shore line.	Area.
	Miles.	*Sq. miles.*
Florida	20	14
Louisiana	33	5
North Carolina	10	3
Texas, vicinity Sabine Pass	28	7
California:		
Vicinity of San Diego	18	12
Suisun Bay and Carquinez Straits	89	50
Oregon, vicinity Coos Bay	18	6
Southeastern Alaska:		
El Capitan Pass	44	41
Ernest Sound and Stephens Passage	253	241
West coast of Prince of Wales	153	55
Lynn Canal and Icy Strait	142	144
Alaska:		
Icy Bay	36	63
Vicinity Shelikof Straits	126	122
Vicinity Cape Pankof	17	8
Philippine Islands	326	132
Total	1,313	903

GEODETIC WORK.

	Length of scheme.	Area covered.
	Miles.	*Sq. miles.*
Triangulation, precise:		
New Mexico and Colorado (Pecos-Colorado Springs arc)	225	4,000
Idaho and Montana (Pocatello-Canada arc)	125	6,000
Texas and Oklahoma, Texas-Oklahoma boundary	70	1,000
California, earthquake investigations	200	12,000
California, Pasadena base	20	200
Washington, vicinity of Tacoma	10	30
Alaska, Dry Strait	30	160
Alaska (Cook Inlet-Fairbanks arc)	40	450
Total	720	23,840

GEODETIC WORK—continued.

	Length of scheme.	Area covered.
	Miles.	*Sq. miles.*
Triangulation, primary:		
Texas and Oklahoma, Texas-Oklahoma boundary	25	125
California and Nevada, Lake Tahoe	20	200
North Carolina, Cape Fear River	5	15
Total	50	340
Triangulation, secondary:		
Maine, vicinity of Portland	5	15
North Carolina, vicinity of Cape Fear River	5	15
Florida, vicinity of St. Augustine	5	5
Louisiana, Mississippi River Delta	15	75
Texas, vicinity of Sabine Pass	20	155
California, vicinity of San Diego	5	15
California, Carquinez Strait and Suisun Bay	30	160
Oregon, Coos Bay to Coquille River	10	50
Porto Rico, Vieques Sound	10	50
Alaska, Shakan Strait and El Capitan Pass	35	215
Alaska, Coronation and Warren Islands	25	110
Alaska, Icy Strait	30	280
Alaska, Icy Strait, Cross Sound and Port Frederick	35	145
Alaska, Kachemak and Portage Bays	20	110
Total	250	1,400
Traverse, primary:		
Virginia and North Carolina, Cape Henry-Currituck Sound	34	.....
North and South Carolina, Cape Fear River-Myrtle Beach	54	.....
Total	88	.....
Base lines, precise:		
New Mexico, Clayton base	7.5	.....
New Mexico, Artesia base	12.5	.....
California, Pasadena base	22.0	.....
Washington, Des Moines base	1.5	.....
Alaska, Dry Strait base	4.0	.....
Montana, Bozeman base	18.0	.....
Montana, Havre base	12.0	.....
Total	77.5	.....
Base lines, secondary: Alaska, Point Gustavus base	3	.....
Reconnaissance: Texas and Oklahoma, Texas-Oklahoma boundary	160	1,860
Recovering and re-marking stations and revising descriptions: Kansas and Colorado, thirty-ninth parallel and ninety-eighth meridian	700	15,000
Precise leveling lines:		
Anchorage to Fairbanks, Alaska	253	.....
Duluth, Minn., to Green Bay, Wis	271	.....
Rouses Point, N. Y., to Portland, Me	277	.....
Yonkers, N. Y., to Providence, R. I	142	.....
Centralia to Cairo, Ill	116	.....
Burlington to Anacortes, Wash	25	.....
Vicinity of Pasadena Base, Calif	60	.....
New Haven, Conn., to Springfield, Mass	76	.....
New Britain to Morris, Conn	27	.....
Hartford, Conn., to Auburn, R. I	73	.....
Livingston to Gardiner, Mont	26	.....
District of Columbia	6	.....
Fox Farm Road House to Valdez, Alaska	129	.....
Total	1,481	.....
SUMMARY.		
Precise triangulation	720	23,840
Primary triangulation	50	340
Secondary triangulation	250	1,400
Primary traverse	88	.....
Precise base lines	74.5	.....
Secondary base lines	3	.....
Reconnaissance	160	1,860
Recovering and re-marking stations and revising	700	15,000
Precise leveling lines	1,481	.....

As usual, the field work consisted of the extension of the control systems for geographic positions and elevations, the determination of latitude, longitude, and azimuth by astronomic observations, the measurement of base lines and the determination of the intensity of gravity. The several projects, either completed or on which progress was made during the year, are as follows:

1. The triangulation which is to run from the vicinity of Pocatello, Idaho, northward to the Canadian boundary, was about half completed during the fiscal year by a party working during the season of 1922 and in the spring of 1923. In the spring of 1923 a base line was measured in the vicinity of Bozeman, Mont.

2. In June, 1923, a base line was measured in the vicinity of Havre, Mont., near the intersection of the forty-ninth parallel and the one hundred and ninth meridian, and after this measurement the party began precise triangulation working westward from the base line. This work is a part of a cooperative plan between the Coast and Geodetic Survey and the Geodetic Survey of Canada, by which precise triangulation will be executed from the Pacific coast, along the international boundary, to Lake Superior. The Coast and Geodetic Survey will complete the work to the westward of the one hundred and ninth meridian and between the Lake of the Woods and a point on the boundary a short distance to the westward of Lake Superior. The Geodetic Survey of Canada will undertake the work from the Lake of the Woods westward to the one hundred and ninth meridian. This great arc of precise triangulation will adequately meet the needs of the two countries for surveys and maps along their common border. If this cooperative arrangement had not been entered into, each country would have been required to execute an arc in its own territory close to the boundary to meet its surveying and mapping needs.

3. A primary traverse was run from the vicinity of Cape Henry, Va., southward along the coast to Currituck Sound, N. C. This work was done to furnish horizontal control stations for hydrographic and topographic surveys of the Coast and Geodetic Survey.

4. A traverse was extended to the southwest from the mouth of the Cape Fear River. Its southern end is in the vicinity of Myrtle Beach, S. C. It is expected that this traverse will be completed to Charleston, S. C., during the fiscal year 1924.

5. The traverse party which executed projects 3 and 4, mentioned above, also executed a small amount of triangulation in the Cape Fear River, N. C., in order to coordinate previous surveys and to leave stations on which to base new surveys.

6. A precise base line was measured in Puget Sound just to the north of Tacoma, Wash. Some observations were also made to strengthen the triangulation done a number of years ago in the vicinity of Tacoma, Wash.

7. Upon request of the commissioners of the Supreme Court for the boundary between Texas and Oklahoma two parties were organized by the Coast and Geodetic Survey, which made a reconnaissance, erected signals, and made observations for the precise triangulation which will extend along the boundary westward from the triangulation of the ninety-eighth to the one hundredth meridian. From there the triangulation will turn northward, and a connection

will be made with the existing arc of triangulation running westward from the vicinity of El Reno, Okla. By the end of the fiscal year the reconnaissance and signal building had been completed. The observing for the triangulation will be completed early in the fiscal year 1923. By the agreement made between the commissioners and the Coast and Geodetic Survey all of the field expenses except the pay and allowances of the commissioned officers detailed for the work were paid from funds available to the boundary commissioners.

8. The reconnaissance and triangulation which had been started late in the fiscal year 1922 to the northward of Cook Inlet were continued during the summer of 1922 and in the spring of 1923. The triangulation follows very closely the railroad which runs from Anchorage northward to Fairbanks.

9. Shortly after the beginning of the fiscal year a party was organized in California which reoccupied a number of old precise triangulation stations in order to detect, if possible, what movements of the ground had taken place since the first establishment of the stations from 25 to 40 years ago. This party started its work from the stations Round Top and Mount Lola, near the eastern boundary of California, and extended its work westward to the coast and thence to the south a short distance beyond Mount Hamilton. It will be necessary to establish astronomic longitude stations at some of the triangulation stations occupied before final results of this testing of the stability of the ground will be available. This work was resumed by a triangulation party in the spring of 1923, and this party was in operation at the close of the fiscal year.

10. At the request of Prof. A. A. Michelson, of the University of Chicago, observations were made in the vicinity of Mount Wilson and San Antonio Peak, Calif., from which to determine with extreme accuracy the distance between two points established on those peaks which will be used by him in the determination of the velocity of light. In order that the work might be done with sufficient accuracy for the purpose a base line was measured over the plain to the southward of the range on which Mount Wilson and San Antonio Peak are situated. Many difficulties had to be overcome in the measurement of this base, which was nearly 22 miles long, because of the ruggedness of the country and the presence of many orange groves. In spite of the handicaps the party successfully measured the base. In order to refer the length of the base line to the line between the two peaks in question, observations for horizontal and vertical angles were made at a number of points and the astronomic latitude and azimuth were determined at a number of the triangulation stations involved in the determination of the distance between the two peaks.

11. The important arc of precise triangulation extending from the vicinity of Pecos, Tex., northward through eastern New Mexico and then into Colorado to the thirty-ninth parallel was completed during the summer of 1922. Work on this arc had been started during the very early spring of that year. A number of monuments along the boundaries between New Mexico and Texas and New Mexico and Colorado were connected to the precise triangulation, thus enabling map makers to place these boundaries, or at least a part of them, in their true geographical positions. Many of the boundaries between States of the Union were established astronomically, and, owing to the deflections of the vertical at the astro-

nomic stations occupied in connection with the boundary surveys, the boundaries in question are found not to be along a geographic parallel or meridian when connections are made between the boundaries and the precise triangulation systems of the country.

12. Prior to about 1909 triangulation stations were marked in a rather inconspicuous way, and as a result the surface marks at a number of the old triangulation stations were destroyed either thoughtlessly or maliciously. There was nothing on the marks, which usually consisted of blocks of concrete or stone, to show what they represented. Since 1909 properly inscribed metal tablets have been set into concrete or stone to mark triangulation and other surveying stations of this bureau. All of the triangulation along the thirty-ninth parallel was completed prior to the adoption of the metal tablets, and many of the surface marks of the stations have been removed. A party of the Coast and Geodetic Survey was assigned the duty of recovering and re-marking and also redescribing triangulation stations along that portion of the thirty-ninth parallel which runs through Missouri, Kansas, and into eastern Colorado. This work was completed during the season of 1922, and the party doing that work also recovered, re-marked, and redescribed some of the stations along the ninety-eighth meridian triangulation in Kansas.

13. The line of levels extending from Rouses Point, at the Canadian boundary, in northeastern New York, to Portland, Me., was completed during the season of 1922. Work on this line had begun during the last month of the previous fiscal year. This line is a part of the general plan for the joining of the precise level systems of the United States and Canada in order to avoid discrepancies in elevation in surveying, mapping, and other engineering work along the boundary between the two countries.

14. During the season of 1922 a line of precise leveling was extended from Yonkers, N. Y., along the railroad, paralleling the coast of Connecticut, to the Rhode Island line. This leveling was connected with bench marks established at a number of places along the coast as reference points for tidal observations made in the past, and also with the bench marks of a number of cities through which the line ran. This line was run at the request of the Director of the U. S. Geological Survey, and that organization cooperated to the extent of furnishing an automobile truck for the transportation of the party.

15. During the spring and early summer of 1923 precise leveling was executed in Connecticut from New Haven northward through Hartford, Conn., to Springfield, Mass., eastward from Hartford to the Rhode Island line, and westward from the vicinity of Hartford to East Morris, Conn. This leveling in Connecticut during the spring of 1923 was done at the request of the U. S. Geological Survey, and a transfer of funds from the appropriation made for the work of that bureau was made to the Coast and Geodetic Survey to pay about half the expenses of the field work.

16. The precise leveling which was done in Wisconsin during the latter part of the fiscal year 1922 was continued during the early part of the fiscal year 1923. The leveling in question extends over the line of traverse which had been established during the previous calendar year. The line starts at Duluth, Minn., and runs through

Ladysmith and Laona Junction to Green Bay, Wis. When the work was complete in Wisconsin the party was transferred to southern Illinois, where a short line of levels was run in response to a request of the Director of the U. S. Geological Survey.

17. Precise leveling was started in Montana, just to the northward of Yellowstone Park, late in the fiscal year 1923. This work will be continued during the fiscal year 1924 and will provide elevations along a number of roads through the National Park. There will also be leveling done to the southwest and the southeast of the park for furnishing elevations for topographic surveys by the U. S. Geological Survey. This work was done at the request of the Director of the U. S. Geological Survey, and most of the expenses of the work are being paid by money transferred from that bureau to the Coast and Geodetic Survey.

18. A short line of precise leveling was run in the State of Washington between Burlington and Anacortes for the purpose of connecting a tidal station at the latter place with the line of precise levels which runs northward from Seattle into Canada.

19. A small amount of precise leveling was done in the District of Columbia in order to determine the elevations of a number of tidal bench marks.

20. Precise leveling was done during the summer of 1922 and the spring of 1923 in Alaska along the railroad which runs from Anchorage northward to Fairbanks and along the highway from the latter place southeastward to Valdez. This leveling has been requested by the U. S. Geological Survey for a number of years, and the lack of elevations along the routes has retarded or greatly handicapped the topographic surveying by that bureau.

21. The district engineer of the Corps of Engineers of the United States Army stationed at Duluth, Minn., has been cooperating with the Coast and Geodetic Survey by testing the stability of a number of bench marks established in the vicinity of that place. It is well known that the action of frost will lift blocks of stone and concrete unless special precautions are taken in the design of the blocks. The bench marks in question were of various sizes and shapes, and it is hoped that, from the results obtained in the testing, it will be learned which is the best type of mark to use in high latitudes where there is much frost action.

22. About 50 miles of precise leveling were run in southern California in the vicinity of the base line which was measured in connection with the determination of the distance between Mount Wilson and San Antonio Peak, mentioned above.

23. During the summer of 1923 the astronomic latitude and longitude and the intensity of gravity were determined at a number of traverse stations in Wisconsin and at a number of triangulation stations in New Mexico and Colorado. The longitude work depended on the receipt of time signals from the Annapolis radio station which were recorded automatically on a chronograph. It was found that the differences in longitude determined in this way were at least equal in accuracy to the determinations which had been made for a number of years by means of signals sent over telegraph wires.

24. A party determined the value of gravity at a number of places in Kansas, Oklahoma, and Texas to determine whether there is a relation between the value of gravity and the densities of material

below the earth's surface. At the point selected for the observations the densities of material were well known from borings for oil. This work was done at the request of the U. S. Geological Survey, and if it is found that there is a decided change in the value of gravity with a change in subsurface density, it is possible that the pendulum may be used for the discovery of extra light or extra heavy material which will be of value in oil investigations. A discussion of the data collected will be made by the staff of the U. S. Geological Survey. The chronometers used in connection with the gravity observations were rated by time signals sent from the Naval Observatory at Washington through the Annapolis station and recorded automatically at the several gravity stations. By the use of the wireless it was possible to have stations at any place without regard to the location of land telegraph lines.

25. After certain investigations were carried on in Washington with apparatus used in determining differences of longitude by means of radio signals, a party was organized at Seattle late in the fiscal year and proceeded to southeastern Alaska to determine the astronomic longitude and latitude at various triangulation stations. The party also determined the astronomic azimuths of certain lines of the triangulation and the value of gravity. The latitude, longitude, and azimuth observations were for the purpose of controlling the directions in the precise triangulation of southeastern Alaska, which will be a part of the great arc extending from the State of Washington into northwestern Canada and into Alaska. The operations of this party were greatly assisted by the cooperation of officials of the Bureau of Standards, the Naval Observatory, and the Bureau of Operations of the Navy Department. Time signals especially for the Alaska party were sent from the Naval Observatory through the Annapolis radio station for five minutes each morning just before 4 o'clock.

MAGNETIC WORK.

The field work in terrestrial magnetism for the year may be grouped under four heads:

1. The occupation of repeat stations for securing knowledge of the secular change.

2. Completion of the establishment of meridian lines and determination of the magnetic elements in Florida at the request of the Florida Engineering Society.

3. Establishment of magnetic stations at county seats where no observations had heretofore been made and at places where the old stations are no longer available.

4. Investigation of the possibility of locating deposits of magnetic iron ore by means of magnetic instruments.

TIDAL AND CURRENT WORK.

TIDAL OBSERVATIONS, PRINCIPAL STATIONS.—Automatic tide gauges were in operation throughout the year at the following stations:

1. Portland, Me.
2. Boston, Mass.
3. Philadelphia, Pa.
4. Baltimore, Md.
5. Charleston, S. C.
6. Fernandina, Fla.
7. Key West, Fla.
8. Cedar Keys, Fla.

9. Galveston, Tex.
10. San Diego, Calif.
11. San Francisco, Calif.
12. Seattle, Wash.
13. Anacortes, Wash.
14. Olympia, Wash.
15. Honolulu, Hawaii.
16. Ketchikan, Alaska.

TIDAL OBSERVATIONS, SECONDARY STATIONS.—Tidal observations were received from the following stations to cover a part of the year:

1. Bowdoin Harbor, Baffin Land.
2. Barge office, New York.
3. Belmont Island, N. Y.
4. College Point, N. Y.
5. East Eighty-six Street, New York.
6. Fort Hamilton, N. Y.
7. Fort Schuyler, N. Y.
8. Hell Gate arch, New York.
9. North Third Street, Brooklyn, N. Y.
10. Port Morris, N. Y.
11. Romer Shoal Light, N. Y.
12. Spuyten Duyvil, New York.
13. Tarrytown, N. Y.
14. Willis Avenue, bridge, New York.
15. Atlantic City, N. J.
16. Sandy Hook, N. J.
17. Breakwater Harbor, Del.
18. Aberdeen Proving Grounds, Md.
19. Washington, D. C.
20. Alexandria, Va.
21. Fishermans Island, Va.
22. Fajardo, P. R.
23. Balboa, Panama, Canal Zone.
24. Cristobal, Panama, Canal Zone.
25. Gandy Bridge, Tampa Bay, Fla.
26. Pensacola, Fla.
27. Burrwood, La.
28. Chandeleur Light, La.
29. Humboldt Bay, Calif.
30. McNears Landing, Calif.
31. Oakland, Calif.
32. Pittsburg, Calif.
33. Refugio Landing, Calif.
34. Suisun Point, Calif.
35. Tubbs Island, Calif.
36. Tahoe City, Lake Tahoe, Calif.
37. Bandon, Oreg.
38. Empire, Oreg.
39. Toke Point, Wash.
40. Anchorage, Alaska.
41. Anguilla Islands, Alaska.
42. Funter Bay, Alaska.
43. Icy Bay, Alaska.
44. Menefee Inlet, Alaska.
45. North Point, Walter, Alaska.
46. Olive Cove, Alaska.
47. Portage Cove, Alaska.
48. Santa Anna, Alaska.
49. Shakan, Alaska.
50. Steamboat Bay, Alaska.
51. Union Bay, Alaska.
52. Kailua, Hawaii.
53. Kaunakakai, Hawaii.
54. Manila, P. I.
55. Panabatan, P. I.
56. Port Santa Maria, P. I.
57. Sibako, P. I.

Automatic tide gauges were kept in operation throughout the year at 6 stations on the Atlantic coast, 3 stations on the Gulf coast, 5 stations on the Pacific coast, 1 station in Alaska, and 1 station in the Hawaiian Islands, a total of 16 years of records. In addition, tidal observations in connection with hydrographic surveys were made at 19 stations in the United States, with a combined length of 6 years 5.3 months; 1 station in Porto Rico, with a length of 9.8 months; 12 stations in Alaska, with a combined length of 2 years 10.7 months; 2 stations in the Hawaiian Islands, with a combined length of 5.7 months; 4 stations in the Philippine Islands, with a combined length of 4.1 months; 2 stations in the Canal Zone, 2 years in combined length; 17 stations received from outside sources, with a combined length of 12 years 5.2 months of record; and 17 small series stations, with an aggregate length of 6.6 months; making a grand total of 41 years 11.4 months of tidal records received.

TAPE GAUGE.—An automatic tide gauge was installed at Atlantic City, on the steel pier, and as the roughness of the water in this locality made the use of a plain tide staff impracticable the tape gauge was designed as a substitute. This gauge was installed November 30, 1922, and consists essentially of a float attached to a tape and operating in a vertical pipe in which the effects of the waves caused by the winds have been damped. A fixed line on a reading board in the tide

house serves as a reference from which the surface of the water may be measured.

PENSACOLA TIDE STATION.—On May 2 a new automatic tide-gauge station was established at Pensacola, Fla. This station, located at the foot of South Baylen Street and fitted with the usual equipment, is in charge of E. W. Holcomb, meteorologist of the U. S. Weather Bureau. Temperature and density observations, in addition to tidal observations, will be made.

The new field automatic tide gauge, which was devised during the year 1922 and constructed at this office, has been thoroughly tested on the Potomac River at Washington for minor improvements and has proven to be a very satisfactory surveying instrument. This new gauge, which is portable, will aid in securing better observations for use in connection with hydrographic surveys and obviate the necessity of maintaining one or more paid tide observers with each hydrographic party, thus securing increased accuracy at considerably decreased cost.

TEMPERATURE AND DENSITY OBSERVATIONS.—Temperature and density observations, frequently requested from this office by prospective builders, by fishing concerns, vacationists, and especially by men engaged in scientific investigations, are being taken and recorded at Diamond Shoals Light Vessel and at the following principal tidal stations:

1. Portland.
2. Boston.
3. Atlantic City.
4. Breakwater Harbor.
5. Philadelphia.
6. Baltimore.
7. Charleston.
8. Cedar Keys.
9. Galveston.
10. San Diego.
11. San Francisco.
12. Seattle.
13. Anacortes.
14. Ketchikan.
15. Pensacola.

It is planned to gradually increase the scope of this work, so as to include all of the principal tidal stations and as many of the light vessels as possible.

Current observations for the year were made on six light vessels on the Atlantic coast and on one light vessel on the Pacific coast. In addition, short series of observations were made at four stations. The combined current observations total four and one-half years of record.

During the year current observations were made on the following vessels:

Light vessel.	State.	Station.	Time employed.	
			Years.	Months.
Nantucket Shoals	Massachusetts	1	1	
Scotland	New York	1		4
Ambrose Channel	do	1		4
Fire Island	do	1		4
Cornfield Point	Connecticut	1		4
Diamond Shoals	North Carolina	1	1	
Blunts Reef	California	1	1	
Total		7	4	4

Short series of observations were made at the following localities:

Locality.	Stations.	Time employed, months.
Approaches to Chesapeake Bay, Va.	1	2.0
Diamond Shoals Light Vessel, N. C.	1	0.1
El Capitan Pass, Alaska	1	0.1
Icy Bay, Alaska	1	0.1
Total	4	2.3

During the past year an important current survey of New York Harbor was made. This work, covering two months, was carried on from 96 stations situated in the following waters: East River, Harlem River, Hudson River, Upper Bay, Lower Bay, Newark Bay, Arthur Kill, and Kill van Kull.

CHAPTER II.

PRESENT CONDITION OF HYDROGRAPHIC, GEODETIC, MAGNETIC, AND TIDAL AND CURRENT SURVEYS.

HYDROGRAPHIC WORK.

It has been found convenient to arrange this work in the form of separate projects. These projects may be divided into two classes, as follows: (1) Unchangeable areas, (2) changeable areas which will require continuing operations for an indefinite period.

In the first class there are offshore hydrography of the Atlantic and Pacific coasts; wire-drag work on the Atlantic, Gulf, and Pacific coasts, including Porto Rico and southeast Alaska; the first complete survey of certain sections of southern and western Alaska, which are of immediate commercial importance. No estimate is made of the Aleutian Islands west of Unalaska, most of the area in Bering Sea or Arctic Alaska, since their commercial development seems to belong to the distant future. For the offshore work we have planned to go seaward to a depth of 100 fathoms in the Atlantic Ocean and Gulf of Mexico and to a depth of 1,000 fathoms in the Pacific Ocean. When these ocean surveys have been accomplished in accordance with present standards, there will be no necessity for additional work inside of the 100-fathom depths on the Atlantic Ocean and Gulf of Mexico and the 1,000-fathom depths on the Pacific Ocean, except in those places of comparatively shallow depths, such as Georges Bank, Nantucket Shoals, Diamond Shoals, and the shallow coastal waters which are subject to constant changes. Likewise, after the surveys of the designated sections of Alaska, the Hawaiian, and Philippine waters have been completed, the only additional work that will be required in these areas will be such as may result from changes in localities of shallow depth, or where greatly increased commercial importance necessitates more detailed surveys of small bodies of water, or where changes have resulted from public works undertaken subsequent to the original survey, and work in the Bering Sea and Arctic Ocean.

The second class of work—chart revision and the resurvey of the bays and inside waters of the Atlantic and Pacific coasts of the United States and, to a lesser extent, of Alaska and the insular possessions—must be carried on indefinitely, just as we are to-day resurveying waters that have been adequately surveyed several times in the past. This is due to the fact that the forces of nature are continuously cutting out and building up along the entire shore where the formation is not solid rock, and also to the fact that the industrial development of the country is continuously changing both the waterways and shore line by dredging channels, filling in, constructing piers, and other works. In order that the charts may be kept up to date and be of real service to the mariner, it is necessary that they be corrected from time to time to show these changes.

The oceanographic work which the bureau should carry on can not be treated as a project on which any time limit for completion can be given. At the present time there is an urgent need for the detail of one able vessel on this work on the Atlantic coast, for the exploration of the Gulf Stream is one of the problems that was laid down in the organic act creating the Coast Survey. We have done very little work of this kind in the hundred and more years of the existence of the survey, and no work of any consequence has been done within the last 30 years.

These projects do not include all of the work that should be performed by the bureau in the line of hydrography and topography, but it is believed that they do include all the projects that should be undertaken at this time or in the near future, the other work to be deferred until the completion of some of these projects. After the completion of any of these projects the personnel and equipment that had been employed on the project will be available for other work.

This other work includes hydrographic investigations beyond the limits of the present projects and other special investigations. It is clearly the duty of this country to perform its share of ocean investigation, and there is a large field for such investigation in the Atlantic Ocean and Gulf of Mexico contiguous to our coast but outside of the 100-fathom contour. There is a like need for such work in the Pacific Ocean outside of the 1,000-fathom contour, which is comparatively close to our coast. There are fishing banks seaward of the 1,000-fathom contour in the Pacific Ocean that should be investigated for the benefit of our fisheries. There is a stretch of unexplored water extending hundreds of miles west of the Hawaiian group through which our ships are required to pass. These waters are known to contain many shoals, reefs, and rocks that are a menace to navigation. The survey of these waters, together with resurveys of the shallow, changeable offshore waters, would fully employ any equipment and personnel that would be released on the completion of any of the projects which require similar equipment.

Wire Drag, Atlantic and Gulf Coasts.—Area to be dragged, 5,000 square miles (3,000 square miles of this area are on the coast of Maine and includes much deep water). Owing to lack of appropriations, it has been impossible to do any work on this project during the last fiscal year, but a party was in the field at the close of the fiscal year and work was to commence early in July.

Atlantic and Gulf Coasts.—Area of offshore work required, 162,000 square miles.

Porto Rico and Virgin Islands.—Area wire-drag work required, approximately 200 square miles, mostly in Vieques Sound. All harbors should be surveyed and coastal water should be dragged.

Pacific Coast, Calif., Wash.—Area wire-drag work required, 1,360 square miles. No work has been done on this project, owing to lack of equipment and money.

California, Washington, Oregon.—Area offshore surveys, 63,300 square miles. This project is divided into the following three sections, owing to the different conditions existing in each: San Diego to Point Conception: Area, 17,000 square miles. Two vessels worked on this project from November to February, and work in this locality will be resumed during the next fiscal year. Point Conception to Cape Blanco: The area required to be covered is 18,300 square miles.

Cape Blanco to Puget Sound: The area required to be covered is 28,300 square miles. Work was accomplished during the last fiscal year and will be resumed during the latter part of the next fiscal year.

SOUTHEAST ALASKA.—There are approximately 6,500 square miles to be covered by wire drag.

DIXON ENTRANCE TO CAPE SPENCER.—On the outer coast the inshore and protected work to be covered has an area of 4,120 square miles and the offshore work has an area of 9,230 square miles.

PACIFIC COAST OF ALASKA.—Cape Spencer to Attu Island. Incomplete hydrography area, 26,250 square miles. The surveys of a large part of this are sufficient for present navigational needs. For administrative purposes it should be considered in the same class as the changeable areas on the continental coasts of the United States. Additional surveys will be made in response to the demand, and the ideal arrangement would be to assign one or more parties each year to this class of work. Two vessels commenced work on this project during the latter part of the fiscal year, which work will be continued during the next fiscal year.

Exploratory or unsurveyed area, 120,465 square miles. Of this area there are 40,000 square miles of immediate importance to navigation. This includes the stretch of coast from Prince William Sound to Unalaska Island. The party should be prepared to undertake all classes of surveys. The type of organization would be that of the *Surveyor* in 1920.

ALASKA, BERING SEA, AND ARCTIC OCEAN.—Area unsurveyed, 427,345 square miles. Most of this area is of such a distance from land that its survey is of no present navigational importance. The stretch of coast on the north side of the Alaskan Peninsula and extending from Unalaska Island to the mouth of the Kuskokwim River promises to be of increasing commercial importance due to the large fishing industries and the possibility of the discovery of gold-bearing sands, the characteristics of the shores of the Kuskokwim being similar to those found at Nome. No work was accomplished on this project during the present fiscal year nor is any contemplated during the next year.

HAWAIIAN ISLANDS.—The unsurveyed area is 10,280 square miles. Most of this area is deep water, which could be done by a steamer of the *Discoverer* and *Pioneer* type. The hydrography of the bays and close alongshore, as well as the topography, would be done by a detached party from the steamer living ashore and assigned a launch. This work is much needed, but owing to lack of appropriations it has been impossible to do any work on this project during the fiscal year, nor is any contemplated during the next.

In the present and previous annual reports there are printed diagrams of the condition of field operations. These diagrams are intended to show in a graphic manner where our surveys are at present adequate, or where surveys are needed, and the type of survey required to make our charts up to date and thoroughly reliable for safe navigation.

To facilitate reference to the text and to the locality, diagrams are inserted showing the important steamer courses, the courses being numbered to correspond to the paragraphs of descriptive matter. Using these sketches as base maps, I have endeavored to show the progress that has been made in the hydrographic and

topographic work, using the same sequence in numbering the courses and descriptive matter pertaining thereto.

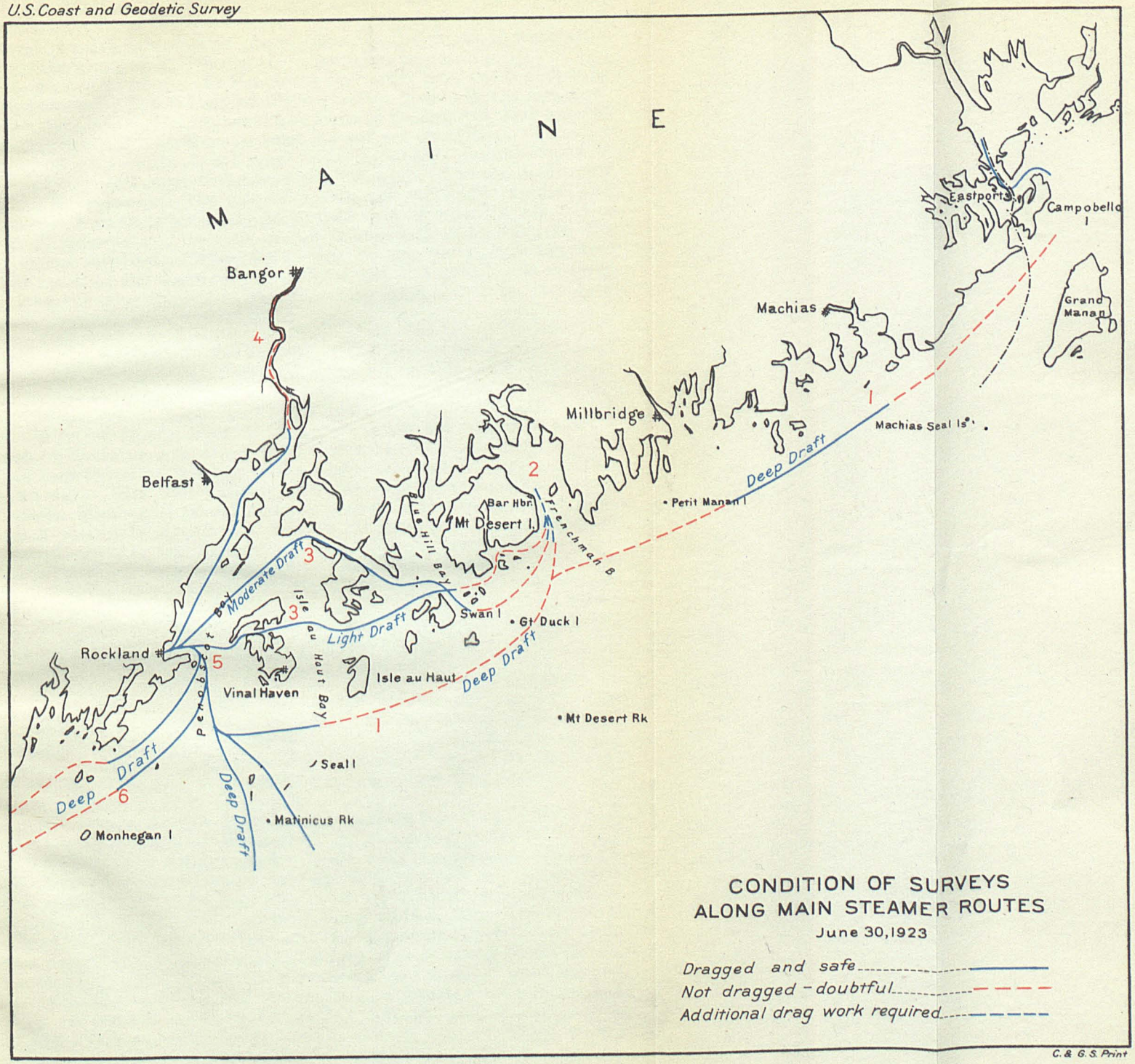
A detailed analysis of the conditions and the progress of the work can not be given in this limited space, but there are shown on the base maps the areas covered during the past year.

1. DEEP-DRAFT ALONGSHORE COURSE FROM THE CANADIAN BOUNDARY TO THE OUTER LIMIT OF ISLE AU HAUT BAY.—The entire area that this course covers is a region of ledges and bowlders. The ledges rise abruptly from the deep water, and the bowlders ordinarily lie singly or in clusters on an otherwise flat bottom, so that the navigator can not depend on the lead to avoid them. The thoroughfares affording an exit to the Bay of Fundy from Passamaquoddy Bay and St. Croix River have been wire dragged; also an area 15 miles in length between Machias Seal Islands and Petit Manan Island. There is still remaining a large area as yet untouched by the wire drag. There are a number of towns along this course that depend on water-borne traffic for shipping out their produce and receiving their supplies. The commerce consists of lumber, fish, fuel, and miscellaneous merchandise, constituting the supply of the smaller and larger fashionable resorts, of which the largest is Bar Harbor, Me. The exceptionally rocky coast makes it certain that a wire-drag survey will result in the discovery of many rocks that now endanger the safety of commerce over this course. (See fig. 5, opposite.)

2. FRENCHMANS BAY.—This body of water lies westward of Schoodic Peninsula and eastward of Mount Desert Island. It is the approach to the town and important summer resort of Bar Harbor, Winter Harbor, Southwest Harbor, Northeast Harbor, and many small villages and naval coaling stations on the north side of Eastern Bay. The bay is frequented by many passenger steamers, yachts, small craft, fishing vessels, and a few cargo vessels. This area has been dragged to a line extending westward from Schoodic Island whistle buoy, though not to depths now considered necessary. The value of the work is further impaired by the necessity of passing over not less than 14 miles of undragged, doubtful area in order to reach the bay from the open sea. (See fig. 5, opposite.)

3. INLAND THOROUGHFARES FROM MOUNT DESERT ISLAND TO ROCKLAND.—There is a series of valuable inside passages along the Maine coast that are very narrow in places and wind between rocky ledges. Owing to the nature of the bottom they are in particular most likely to be obstructed by pinnacle rocks of the extension of narrow ridges out into the channel. The only part of these channels which has been dragged lies between Bluehill Bay and the western entrance of Penobscot Bay. The results obtained have been so startling that they clearly indicate dangers in the use of channels that have not been dragged. (See fig. 5, opposite.)

4. PENOBSCOT RIVER.—This river, emptying into the head of Penobscot Bay, forms the approach to the towns of Bucksport, Winterport, Hampden, and Brewer, and the city of Bangor, the latter two at the head of navigation, about 24 miles above Fort Point Lighthouse, at the entrance. It has considerable trade in regular steamers drawing about 10 feet, and many vessels trading to Bangor draw as much as 18 feet. Practically the entire river above Bangor is used in lumbering. From the mouth of the river to Bangor there will



CONDITION OF SURVEYS ALONG MAIN STEAMER ROUTES

June 30, 1923

Dragged and safe

Not dragged - doubtful

Additional drag work required

C. & G.S. Print

be no positive certainty of the absence of all dangers to navigation until the area has been dragged. (See fig. 5, opposite p. 70.)

5. PENOBSCOT BAY.—In Penobscot Bay every port has benefited by the practical completeness of the wire-drag work. There are, however, some of the less important sections to be dragged, and some of the approaches from the eastward are not yet completed. The wire drag, as used by the Coast and Geodetic Survey, was developed in this region, and some of the area was not dragged to the depth now believed necessary. The size of vessels has increased rapidly, and additional work is necessary to protect this increased draft. (See fig. 5, opposite p. 70.) As it has required time to solve all the problems involved in dragging to this greater depth, it is probable that much of the deeper part of Penobscot Bay which was covered during the development of the wire-drag apparatus will later have to be dragged to a greater depth.

6. PENOBSCOT BAY TO CASCO BAY (DEEP DRAFT).—The coast of New England throughout its length presents practically one uniform problem to the hydrographic engineer. Surveys of varying degrees of completeness have been made of the entire area, and it is possible for navigators to select channels which are apparently safe. They would be of ample depth if it were not for the ice-worn granite rock or the large bowlders deposited during the glacial period. The lead line is not adapted to find without assistance dangers of this character. This thoroughfare presents uneven and rocky bottom between Monhegan Island and the eastern entrance to Casco Bay, which should be dragged to remove all doubt of the existence of pinnacle rocks or small ledges. (See fig. 5, opposite p. 70.)

7. PENOBSCOT BAY TO CASCO BAY (MODERATE DRAFT).—From the western entrance of Penobscot Bay to Casco Bay there has been no wire-drag work done. The inside route is constantly used by coasting steamers, but it is certain that it has within its limits many uncharted rocks, some known locally and some unknown. (See fig. 6, opposite p. 72.)

8. BOOTHBAY HARBOR.—This forms the approach to the town of Boothbay Harbor and numerous smaller summer resorts. It is frequented by many vessels and by a large number of fishing boats and pleasure craft in summer. It is one of the best anchorages on the coast of Maine, and is much used as a harbor of refuge by all classes of vessels. This area is in urgent need of a wire-drag survey. (See fig. 6, opposite p. 72.)

9. KENNEBEC RIVER.—It is the approach to the cities of Bath and Augusta, the towns of Woolworth, Richmond, and Gardiner, and numerous smaller villages and summer resorts. The river has considerable water-borne commerce, the deepest draft being about 21 feet to Bath and 14 to Augusta. There is urgent need for a wire-drag survey of the river. (See fig. 6, opposite p. 72.)

10. CASCO BAY.—Casco Bay and the approaches to Portland have been dragged, with the result of finding numerous uncharted shoals, thereby furnishing important evidence of the need of carrying the survey to the eastward and westward to a junction with completed work. A resurvey of inner Casco Bay is badly needed, the glaciers having left a series of long, narrow, and dangerous ledges, which require closer examination. (See fig. 6, opposite p. 72.)

11. PORTLAND HARBOR AND APPROACHES.—These have been dragged, and all dangers to navigation are shown on the charts. (See fig. 6, opposite.)

12. PORTLAND TO PORTSMOUTH (MODERATE DRAFT).—Westward of Portland the succession of sand beaches, of which Old Orchard is the best known, might appear to indicate an absence of rocks in this region. The depth of sand above the underlying rock is not great, however, and pinnacle rocks occur outside these beaches. There is a gap in the wire-drag surveys between Cape Porpoise and Cape Elizabeth which must be completed to make this portion safe. A party was in the field at the end of the fiscal year, and work on this project was started early in June. (See fig. 6, opposite.)

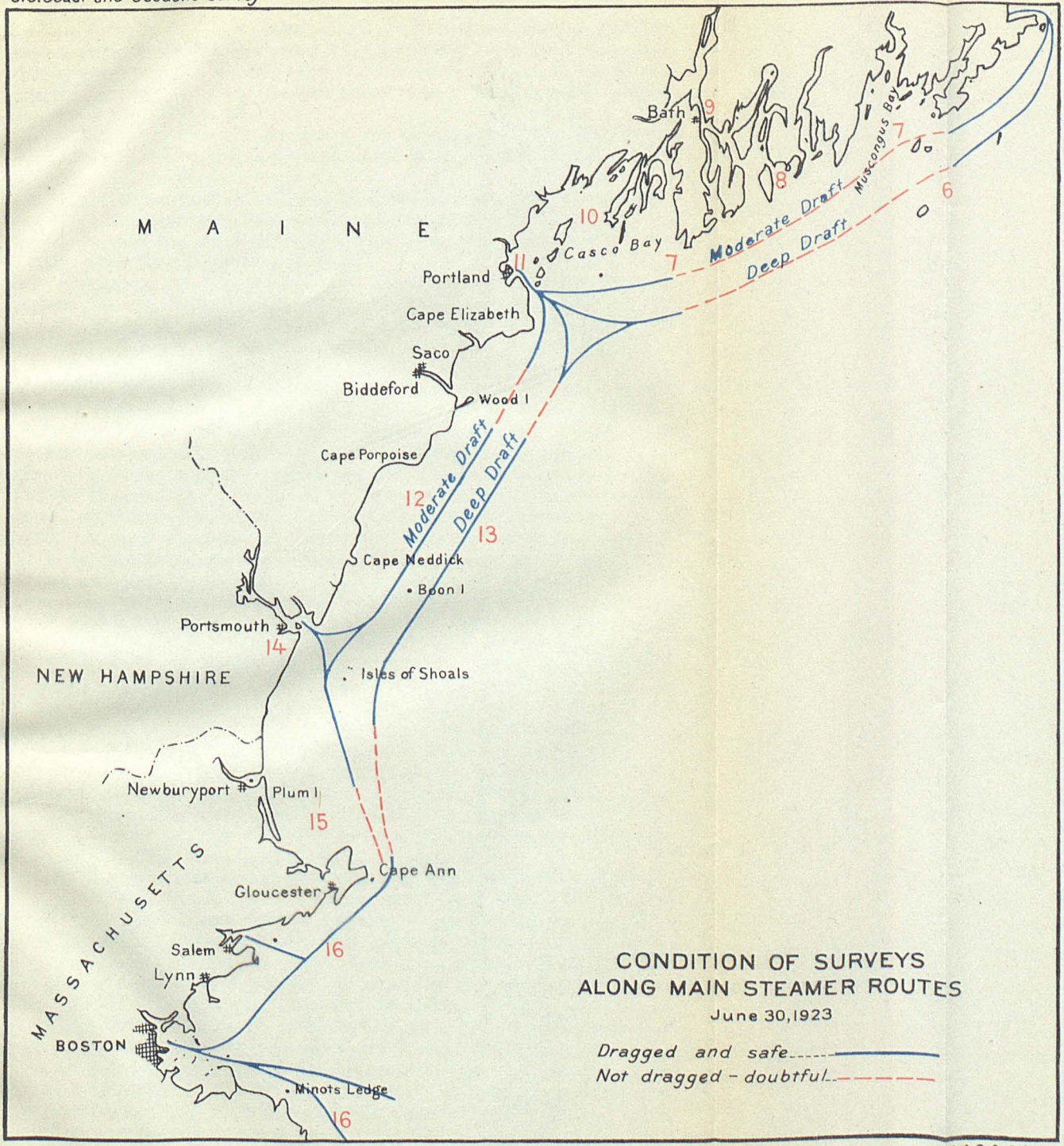
13. PORTLAND TO CAPE ANN (DEEP DRAFT).—The region from Boon Island to Isle of Shoals is very rocky, and its importance as the approach to Portsmouth is well recognized. The area has been covered by the wire drag, which now forms a continuously dragged area from Cape Porpoise to within 10 miles of Cape Ann. (See fig. 6, opposite.)

14. PORTSMOUTH HARBOR.—This area has been dragged, and all dangers to navigation are known. (See fig. 6, opposite.)

15. MASSACHUSETTS COAST NORTH OF CAPE ANN.—From the New Hampshire border to Cape Ann the shores are entirely different from those to the north or south. There are high sand bluffs in places and low sandy shores in others. As a result the depths along the shore are changeable and though they have been recently surveyed they will need further attention. (See fig. 6, opposite.)

16. CAPE ANN TO CAPE COD CANAL.—A completely dragged area extends from Cape Ann to Cape Cod Canal and from the head of Buzzards Bay to Sakonnet Point, R. I. With the exception of the areas near the shores of Buzzards Bay this important survey is complete. This work was made especially necessary by the opening of the Cape Cod Canal in 1915, the original surveys having been made while the commerce of the region was relatively unimportant. A number of shoals were found of less than the proposed canal depth. It was important not only to find those shoals of less than the proposed canal depth but also those which might become a menace at some future date in case it should be necessary to deepen this canal to take care of the largest vessels. With this view the drag was carried at a sufficient depth to meet such requirements. Even should a depth of 40 feet be adopted for the canal the present surveys of the approaches will be found adequate, and where less depths have been found the information will be invaluable to the engineers making the improvement. (See fig. 6, opposite.)

17. FROM BOSTON SOUTH OUTSIDE CAPE COD.—Much of the traffic between eastern New England and points west and south passes outside of Cape Cod; most of it through Nantucket and Vineyard Sounds. Off Cape Cod the surveys are not complete. In Nantucket Sound the entire route is through channels bounded by shifting sand and requires frequent revision work. In one part of the channel most used—through Pollock Rip Slue—a shoal was formed in the last few years that has been steadily narrowing and decreasing the depth of the channel. A resurvey of part of this route is needed every few years to insure safety to navigation. No rocks occur eastward


MAINE
Bath
9
Muscongus Bay
7
8
10
Casco Bay
Moderate Draft
Deep Draft
6
11
7
Portland
Cape Elizabeth
Saco
Biddeford
Wood I
Cape Porpoise
12
Moderate Draft
Deep Draft
13
Cape Neddick
Boon I
Portsmouth
14
NEW HAMPSHIRE
Isles of Shoals
Newburyport
Plum I
15
Cape Ann
Gloucester
MASSACHUSETTS
Salem
16
Lynn
BOSTON
Minots Ledge
16
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30,1923
Dragged and safe
Not dragged - doubtful

C. & G. S. Print

of Cape Cod, but in the north half of Nantucket Sound and the western part of Vineyard Sound large bowlders occur and wire-drag work is needed. At present vessels must pass over 10 miles of undragged area in following the best channel through Vineyard Sound. (See fig. 7, opposite p. 74.)

18. FROM CAPE COD CANAL THROUGH BUZZARDS BAY.—This route has been dragged to the eastern limit of Long Island Sound. (See fig. 7, opposite p. 74.)

19. NARRAGANSETT BAY.—This area has been dragged, with the exception of the thoroughfare leading through Mount Hope Bay to Fall River and the small stretch to the north and east of Prudence Island. (See fig. 7, opposite p. 74.)

20. ENTRANCE TO NARRAGANSETT BAY, BLOCK ISLAND SOUND, FISHERS ISLAND SOUND, AND THE EASTERN PART OF LONG ISLAND SOUND.—These areas are practically completed, with the exception of the central and western parts of Long Island Sound, which remain to be dragged. (See fig. 7, opposite p. 74.)

21. GULF OF MAINE.—The portion of the Gulf of Maine of which the bureau makes surveys may be considered as lying to the westward of meridian 67° 0′ and extending to Nantucket Shoals. This entire area has been inadequately surveyed, as it was accomplished at an early date when both the appliances and the methods were far inferior to those of the present day. Not only are the soundings obtained insufficient, but many of them are not located correctly on the charts. A good example of this is the discovery several years ago that only one shoal rock exists on Cashe Ledge, where two were charted, and that Sigsbee and Ammen Rocks, formerly shown 4 miles apart, are really the same rock. These defects in the charts are serious for two reasons: The trans-Atlantic steamers approaching the ports of northern New England, especially Portland and Boston, are unable to depend on the charts of the gulf sufficiently to locate themselves accurately by sounding. This is particularly serious during the fogs of summer, which often extend far out to sea and last for days, and the winter snowstorms. In addition to this the fisheries of the Gulf of Maine are an important national asset. Not only are many important fishing banks uncharted, but the limit and depths of known banks are not correctly given. Besides, there is not at present enough information available as to the character of the bottom. The knowledge of rocky bottom may lead to the discovery of good fishing grounds. (See fig. 8, opposite p. 74.)

22. NANTUCKET SHOALS TO GEORGES BANKS.—Extending eastward from Nantucket Sound there is an immense shoal area, consisting of sandy ridges which are shifted by the waves and currents. Nantucket Shoals extend about 50 miles offshore; then there is a deep channel followed by ridges. It is readily seen that it is important to keep the channel surveyed and to examine the adjacent shoals to detect changes; but it might readily be asked, What is the use of surveying such areas as Nantucket Shoals, which vessels are most careful to avoid? First, it is necessary to be certain that the outer limits of these shoals are clearly defined in order that they may be avoided; second, the shoals are important fishing grounds; third, more careful surveys may develop safe channels for coastwise navigation, channels which are already indicated on the charts but are

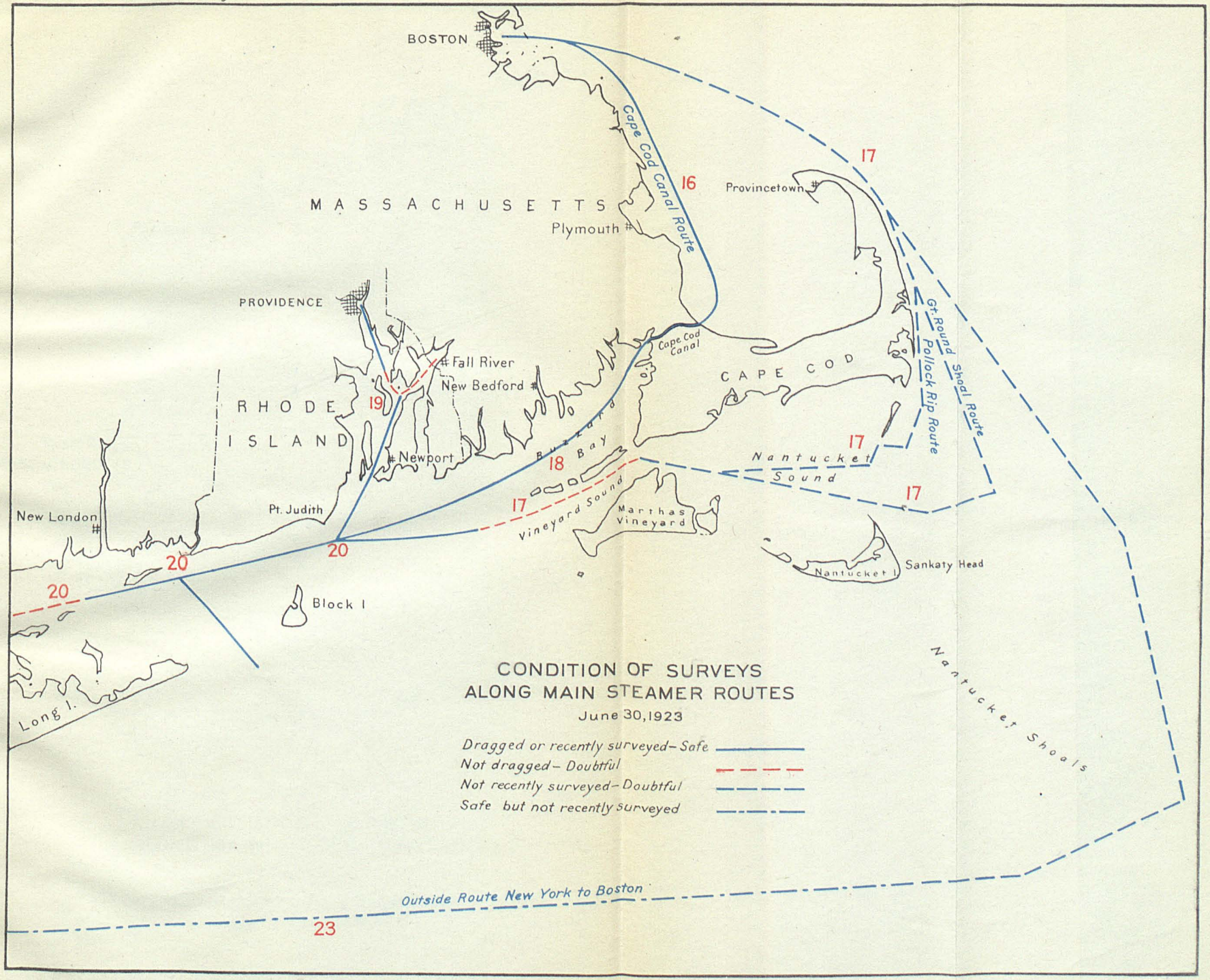
unsafe to use because of inadequate surveys. Due to the constant changes the existing surveys are nowhere adequate. The shoals are so numerous and the channels so intricate that a difficult problem is presented in their examination by accurate methods. The ground fishing, which has in recent years assumed large proportions, is steadily moving seaward. During the winter Nantucket Island is the headquarters of this industry. Not only do the present charts lack the needed information in the search for new ground, but the absence from the charts of existing shoals is a source of danger to the boats running to and from the harbor. Breakers often occur where there is ample depth for boats when the water is smooth. This is an excellent example of how a region usually avoided by commerce may be of importance to an industry which furnishes part of the food supply of the Nation. (See fig. 8, opposite.)

23. TRANS-ATLANTIC APPROACH TO NEW YORK.—There is scarcely any part of our coast where correct soundings are of more importance than in the approach to New York from the eastward, as all trans-Atlantic steamers bound to that port pass over this area. Many of them have to depend on soundings for safety. A fairly good survey of this area is available, but additional work should be done by modern methods in the portion out of sight of land, so that the needs of the enormous traffic will be met. (See fig. 9, opposite.)

24. FROM POINT JUDITH TO NEW YORK.—It is almost unnecessary to go into particulars, except to make it clear that the central and western parts of Long Island Sound remain to be dragged. This work will be undertaken at the earliest opportunity. At present New York Harbor has but one exit to the sea for deep-draft vessels—by way of the Lower Bay and through Ambrose Channel over Sandy Hook Bar. The other exit—through Long Island Sound and Block Island Sound—is obstructed by ledges at Hell Gate, in the East River. The project to remove these and secure a depth of 40 feet is now in progress. Before it is completed channels of this depth in the Sound should be examined with the drag to make certain they are safe. This would also apply to Fort Pond and approaches, if the proposed trans-Atlantic terminal is located at that place. The project to deepen East River to 40 feet makes it necessary to be certain where the channels with such depths are located in Long Island Sound. The work done in Block Island Sound has defined the limit of such depths in the eastern approach to Long Island Sound, and it is urgent that the entire area should be completed without delay. The approaches to all the harbors on Long Island Sound should be dragged. The shoaler bays are used extensively by motor boats, and the number in operation for a given area is probably greater than anywhere else in the United States. (See fig. 9, opposite.)

25. HUDSON RIVER.—The Hudson River is a valuable waterway between New York and Albany and is a part of the canal system of the State. A few years ago a dangerous rock was found directly on the path of steamers between New York and Albany. With such a possibility all the doubtful parts of the Hudson should be dragged. (See fig. 9, opposite.)

26. NEW YORK HARBOR.—New York Harbor has had a recent survey, but as it is an area subject to change it will require a survey, at least in part, every few years. (See fig. 9, opposite.)


BOSTON
Cape Cod Canal Route
16
17
Provincetown
MASSACHUSETTS
Plymouth
PROVIDENCE
Fall River
New Bedford
Cape Cod Canal
CAPE COD
Gt Round Shoal Route
Pollock Rip Route
RHODE ISLAND
19
Buzzard Bay
18
Newport
17
Nantucket Sound
17
17
Pt. Judith
New London
Vineyard Sound
Marthas Vineyard
20
20
20
Nantucket I
Sankaty Head
Block I
Long I.
Nantucket Shoals
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30,1923
Dragged or recently surveyed–Safe
Not dragged–Doubtful
Not recently surveyed–Doubtful
Safe but not recently surveyed
Outside Route New York to Boston
23

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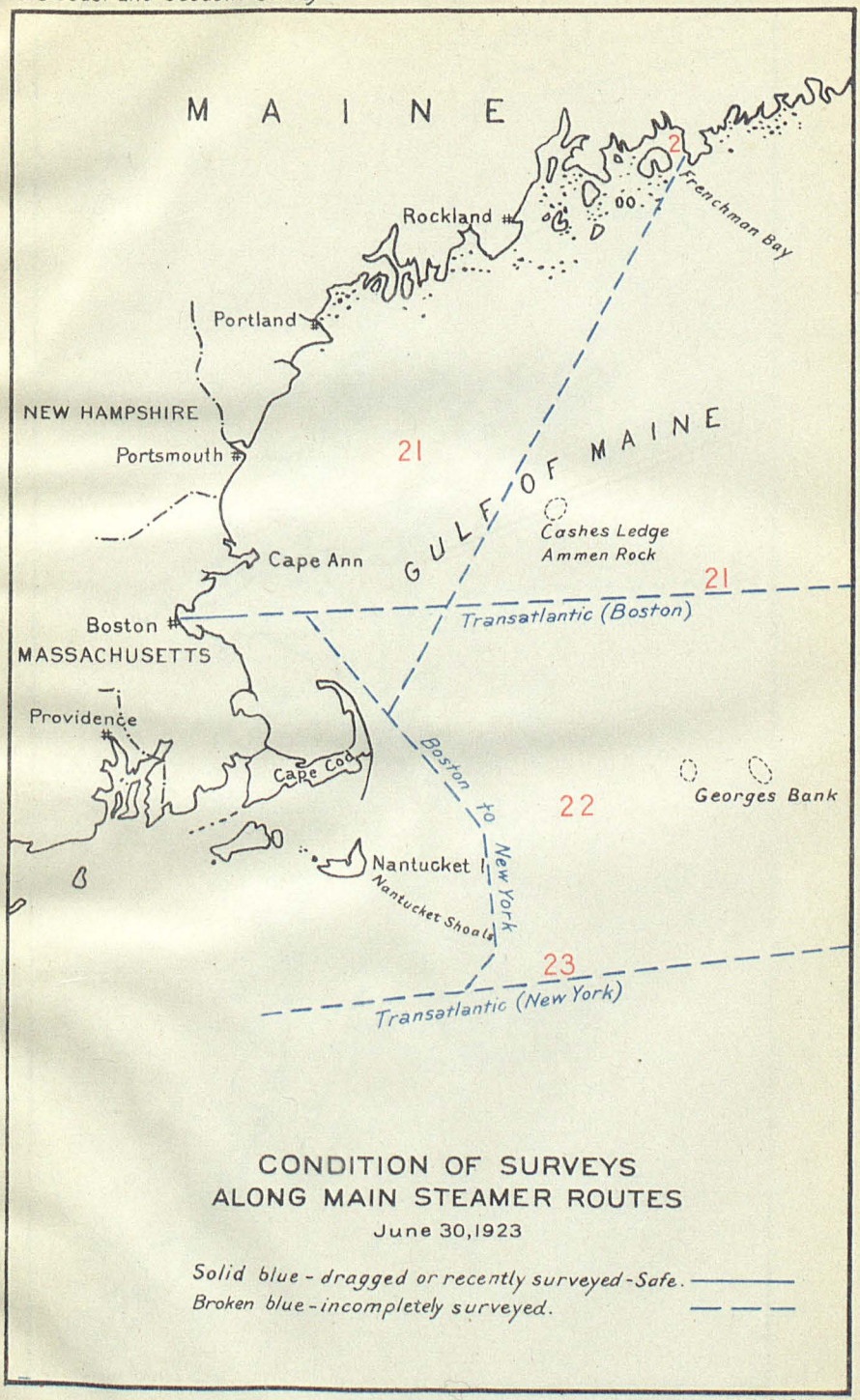

CONDITION OF SURVEYS ALONG MAIN STEAMER ROUTES

June 30,1923

Solid blue - dragged or recently surveyed - Safe. ———

Broken blue - incompletely surveyed. — — —

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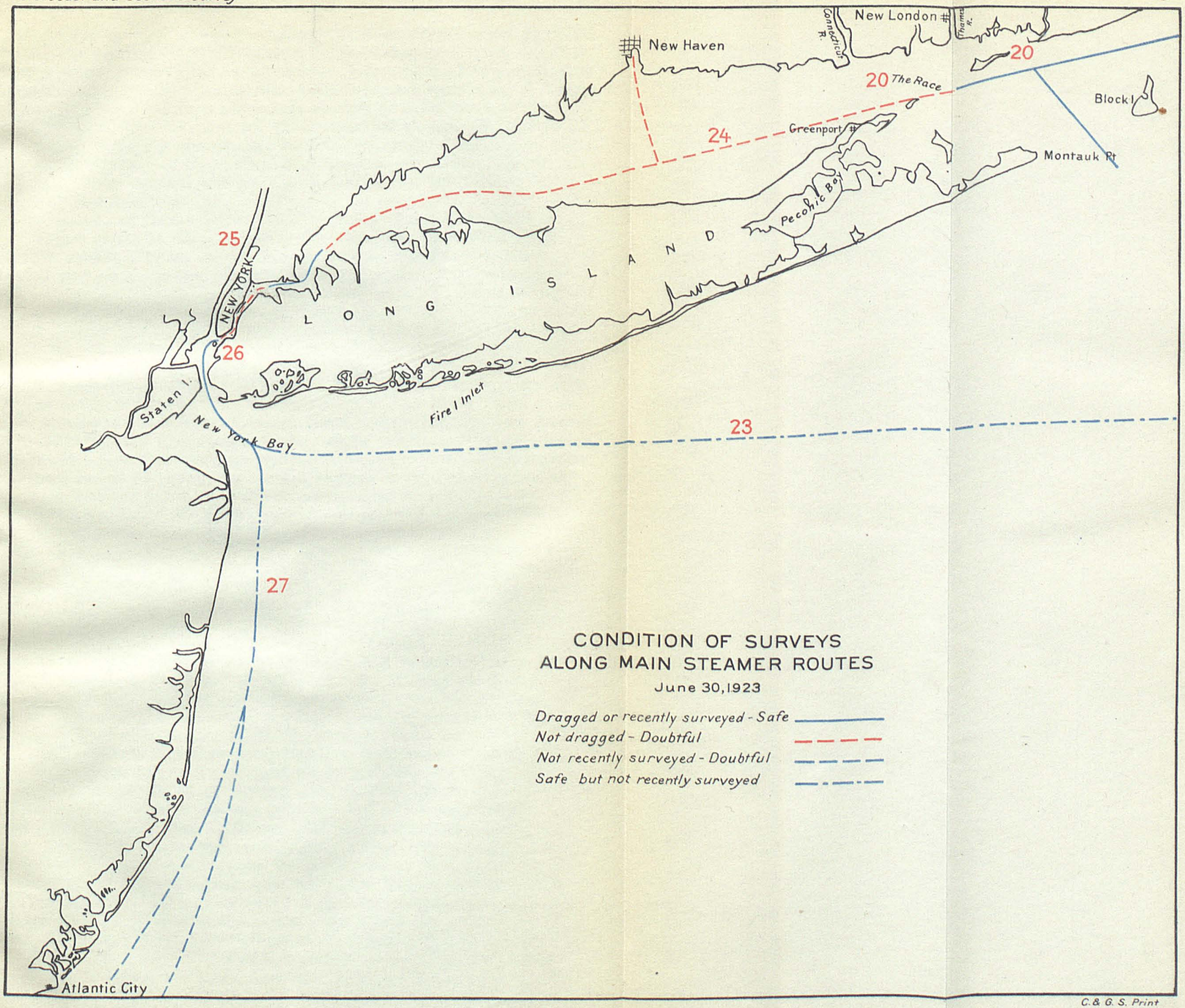

New Haven
New London
Connecticut R.
Thames R.
20
20 The Race
Block I.
24
Greenport
Montauk Pt
Pecohic Bay
25
NEW YORK
L O N G I S L A N D
26
Staten I.
Fire I Inlet
New York Bay
23
27
Atlantic City
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1923
Dragged or recently surveyed - Safe
Not dragged - Doubtful
Not recently surveyed - Doubtful
Safe but not recently surveyed

C. & G. S. Print

27. COAST OF NEW JERSEY.—Along the most of the coast of New Jersey the character of the bottom is such that the exact existing depths should be ascertained beyond all doubt, particularly as shoals dangerous to coastwise traffic have been reported from time to time. The only reliable surveys along this stretch of coast have been made in connection with searches for these reported shoals. Eastward of Cape May there are shoals that need a resurvey. A survey of this area in the vicinity of Cape Henlopen was made in 1920. The sounding lines were carried out to sea as far as the 100-fathom curve. (See fig. 9, opposite p. 74.)

28. DELAWARE BAY.—Delaware Bay has as its most marked characteristic a series of narrow, fairly deep channels separated by long, narrow shoals. These shoals are subject to change. A survey is needed now, and one should be made about every 10 years in the entrance and at longer intervals in the upper bay. While dredged channels are maintained for most of the distance from the entrance of the bay to Philadelphia, vessels of moderate draft use the other channels. In view of the importance of the cities at the head of the bay and on the river, it is highly important that the needed survey of Delaware Bay be made so that a chart of the proper standard may be issued. (See fig. 10, opposite p. 76.)

29. DELAWARE BAY ENTRANCE TO CHESAPEAKE BAY.—From Delaware Bay entrance to Chesapeake Bay there is a succession of shoals and banks. Many of these are buoyed so that moderate-draft vessels may pass inside of them. In certain regions it is of the highest importance that the survey should be correct and kept up to date. At only one place has a comprehensive survey been made, and this was the investigation of a reported shoal.

30. CHESAPEAKE BAY AND TRIBUTARIES.—These have been extensively surveyed in recent years, and a large number of tributaries will not require resurveys for many years. This is also true of the Potomac River. The parts which need resurveying are parts of the bay from Cape Charles to a point opposite Annapolis, parts of the James River, and the Rappahannock and Susquehanna Rivers. The entrance has been recently surveyed, but another survey will probably be needed in 10 years. Owing to the shifting sandy bottom the bay is greatly in need of examination at critical localities where depths are near the draft of vessels, frequent reports indicating the presence of new shoals. (See fig. 10, opposite p. 76.)

31. CHESAPEAKE BAY ENTRANCE TO CAPE HATTERAS.—The diagram shows the tracks for both the light-draft and deep-draft vessels. A party worked just south of the entrance to Chesapeake Bay, where shoals had been reported, during the first part of the fiscal year.

32. ALBEMARLE SOUND.—Albemarle Sound and its tributaries, with a few exceptions, have been resurveyed within the last few years and will not require resurveying for a long time. The uncompleted portions, including the North and Alligator Rivers, should be finished in the near future, as they form part of the project for a through 12-foot channel of the inside waterway route. The Chowan River, which is the western extension of this sound, should also be finished, and then the surveys of this region would be in a most satisfactory up-to-date condition. (See fig. 10, opposite p. 76.)

33. CROATAN SOUND.—Croatan Sound, connecting link between Albemarle and Pamlico Sounds, has recently been resurveyed, but the depth is so near to the draft of the vessels using it that the surveys will have to be revised from time to time. Changes in the main channel have occurred within the last two years. (See fig. 10, opposite.)

34. PAMLICO SOUND.—Pamlico Sound has additional importance owing to its relation to the inland waterway route. The eastern half of the sound is well surveyed, but the entire western half and the Neuse River, in addition to its local use as part of the through 12-foot channel, has not been completed. The survey was in progress up to October, 1920, when it had to be discontinued owing to the steamer proving unsuitable and too expensive to operate. (See fig. 10, opposite.)

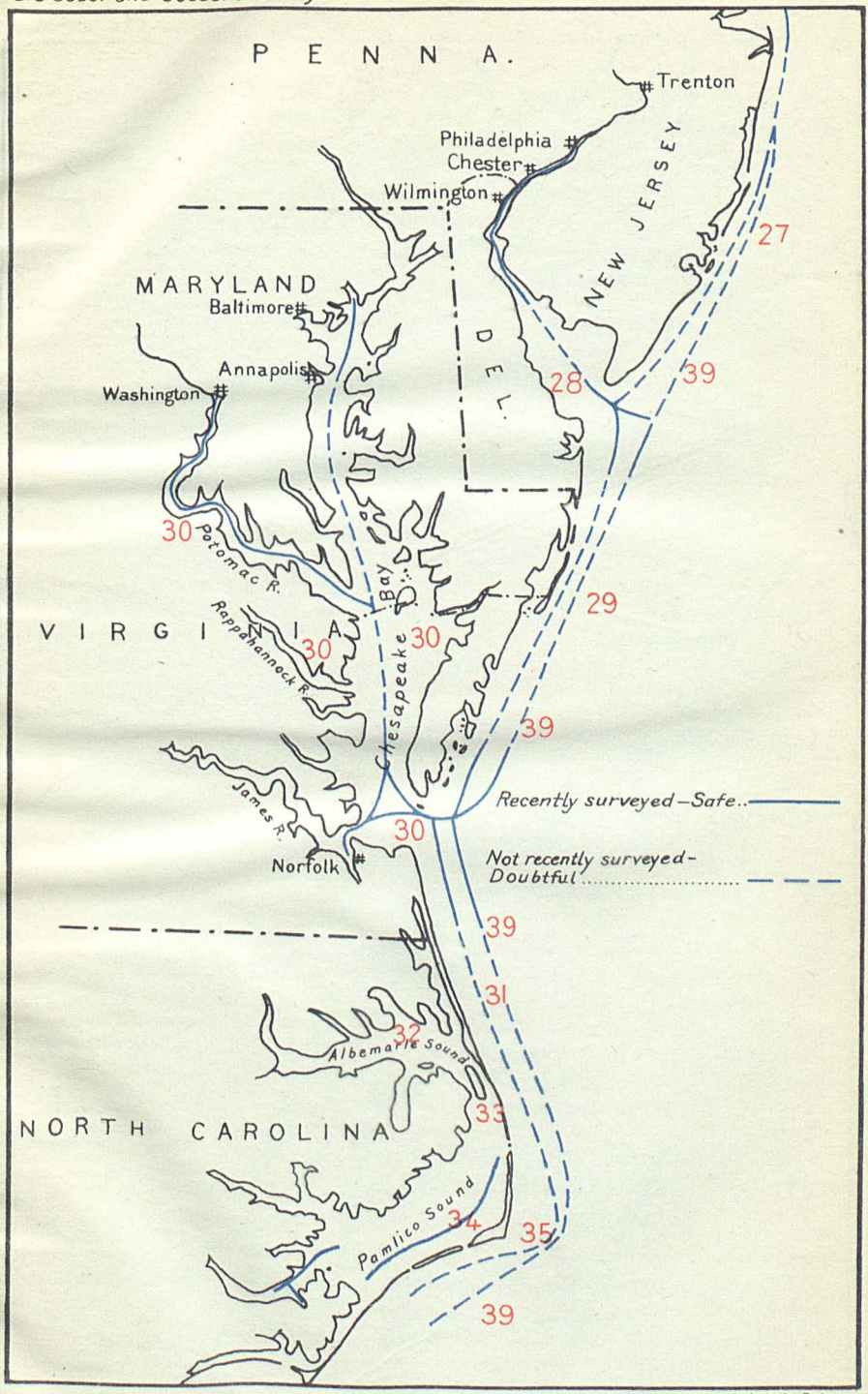
35. DIAMOND SHOALS.—Diamond Shoals, off Hatteras, should be resurveyed chiefly to to determine changes in their extent and particularly to obtain a knowledge of the correct depths on the seaward side. (See fig. 10, opposite.)

36. CAPE HATTERAS TO WINYAH BAY, S. C.—Nearly the whole of this area is in need of a new survey, as those areas now charted are not in sufficient detail for modern navigation. Next to Diamond Shoals in importance to coastwise navigation are the shoals extending seaward from Cape Lookout and Cape Fear. They are subject to change and should be examined at short intervals. (See fig. 11, opposite.)

37. WINYAH BAY TO FERNANDINA, FLA.—This region has been recently surveyed, the work extending out to the 100-fathom curve. The topography of the immediate coast line has also been revised, the work extending from Bull Bay south to Savannah. The results show many changes of importance to small craft.

38. FERNANDINA TO THE FLORIDA REEFS.—From Fernandina to the Florida Reefs the area of moderate depths continually narrows, until at Palm Beach the distance to the 100-fathom curve is very small. The completed survey referred to in paragraph 37 extends southward to a little below St. Augustine. South of St. Augustine the bottom is probably not subject to change except as noted below, and the surveys, while by no means complete, are fair. Off Cape Canaveral and outside the southern half of the Indian River there are extensive banks and ridges in urgent need of resurvey. Known depths of 11 to 16 feet a long way offshore show the need of further surveys to make certain that all the shoals are correctly charted. From Jupiter Inlet to Fowey Rocks, where the Florida Reefs begin, the deep water approaches so close to the shore that it will be a slight task to complete inshore work in connection with the offshore surveys. (See fig. 11, opposite.)

39. GENERAL, ATLANTIC, AND GULF COASTS.—An explanation of the method used in verifying the location of a vessel by sounding when objects on shore are obscured by distance or thick weather will show why accurate charts are particularly needed from New York to Palm Beach and from Key West to the Mexican border. At fixed intervals the vessel takes soundings, which are plotted to the scale of the chart on tracing paper, and this is moved over the chart, keeping the line joining the soundings parallel to the course of the vessel until the soundings agree with those shown on the chart. If


PENNA.
Trenton
Philadelphia
Chester
Wilmington
NEW JERSEY
27
MARYLAND
Baltimore
DEL.
Annapolis
Washington
28
39
30
Potomac R.
Bay
29
VIRGINIA
Rappahannock R.
30
30
Chesapeake
39
James R.
Recently surveyed—Safe..
30
Norfolk
Not recently surveyed-
Doubtful.....
39
31
32
Albemarle Sound
NORTH CAROLINA
33
Pamlico Sound
34
35
39

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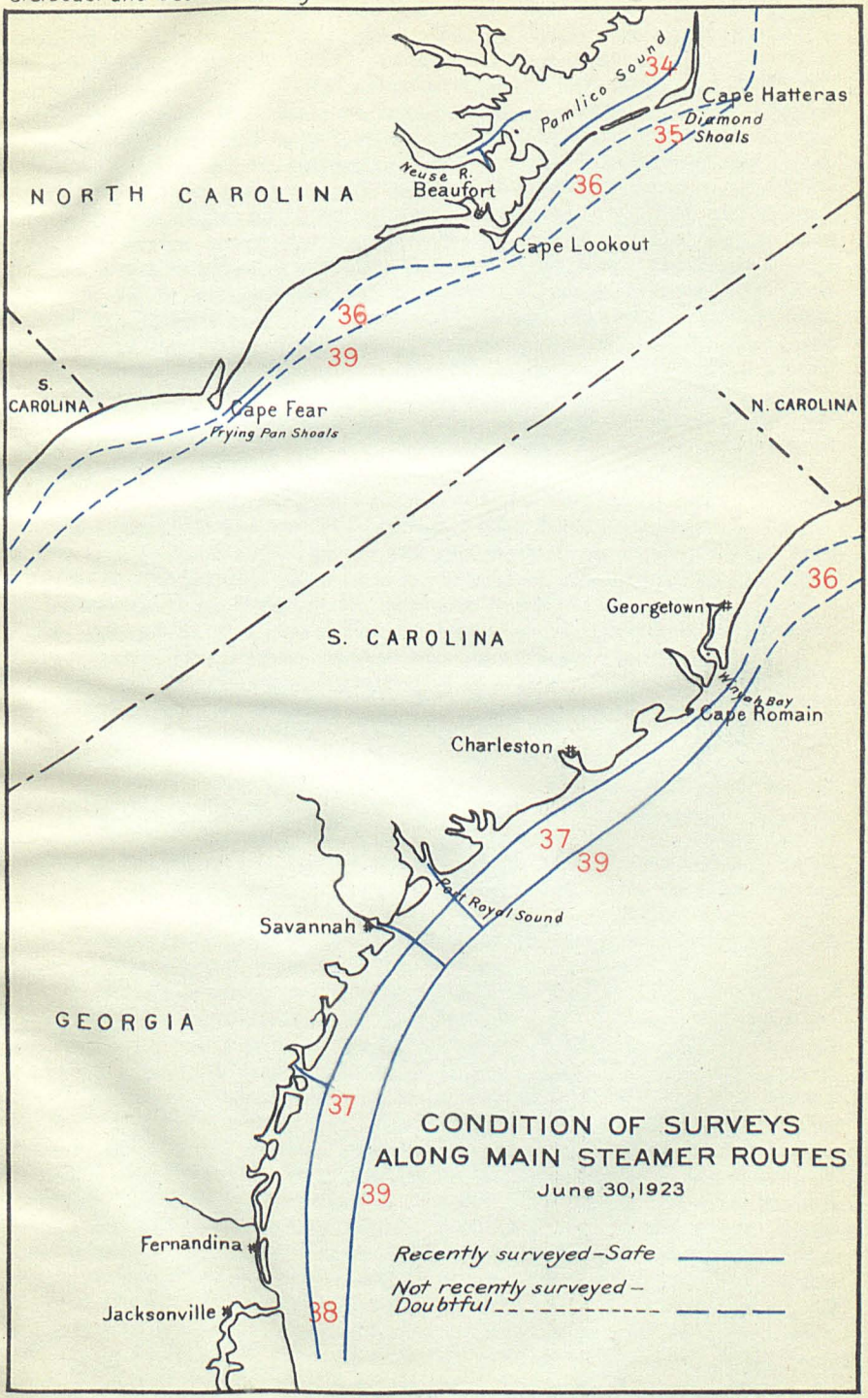

Pamlico Sound
34
Cape Hatteras
Diamond Shoals
35
Neuse R.
Beaufort
36
NORTH CAROLINA
Cape Lookout
36
39
S. CAROLINA
Cape Fear
Frying Pan Shoals
N. CAROLINA
36
Georgetown
S. CAROLINA
Winyah Bay
Cape Romain
Charleston
37
39
Port Royal Sound
Savannah
GEORGIA
37
39
Fernandina
Jacksonville
38
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1923
Recently surveyed–Safe
Not recently surveyed–
Doubtful

the charts are correct and based on a sufficiently modern survey, the method is one of the best known for verifying the ship's position. If, on the other hand, the soundings are few and far apart, so that the ship's soundings fall between them, and if those on the chart are wrongly placed, this method becomes much more difficult, and an accidental agreement may lead the vessel into danger.

From New York to Cape Hatteras the charts, while fairly good, are by no means good enough to meet the full needs of navigation, but the work required to bring them up to date has been postponed, as the need for resurveys has been more urgent farther south. Up to a few years ago the offshore surveys from Cape Hatteras to the Florida Reefs were almost unbelievably deficient. This condition is being remedied as rapidly as possible, and between Winyah Bay, S. C., and St. Augustine, Fla., the offshore work out to the Gulf Stream is complete. It is important that this work be extended both north and south from its present limit as rapidly as possible. With adequate funds full advantage can be taken of the season, and by working north in the summer and south in the winter the cost of the work will be greatly reduced. (See fig. 11, opposite.)

40. INDIAN RIVER.—There have been no recent surveys of these waters. Revisionary work is needed. (See fig. 12, opposite p. 78.)

41. BISCAYNE BAY.—Recent surveys have been made of this area out to the 100-fathom curve in the vicinity of Miami and as far south as Fowey Rocks. (See fig. 12, opposite p. 78.)

42. VICINITY OF FOWEY ROCKS LIGHT.—No recent surveys have been made. The present surveys are not sufficient in detail.

43. COAST OF FLORIDA FROM PALM BEACH AROUND TO CEDAR KEYS.—For a distance along the shore of 567 miles from Palm Beach southward around to Cedar Keys on the west coast of Florida coral reefs are found, in some places more abundant than in others. Coral reefs, whether the result of disintegration or of a building up by animal growth, are found in a great variety of forms and in vast numbers of sharp projections from the general bottom, where conditions are favorable for the growth of coral. While we are informed that an enormous number of uncharted rocks exist in this region, due to the fact that they are so numerous and that the region is so large, an effort has been made to first drag areas of the coast used by commercial and naval vessels because of both the time and cost involved. Wire-drag work is accordingly undertaken in localities where there are commerce and naval operations. To accomplish even this will require years of work. Westward-bound vessels through the Florida Straits have to force their way against the strong current of the Gulf Stream, which in places attains a velocity of 5 miles an hour. Along the northerly edge of the stream and close to the reefs the current is very weak. There is a strong temptation to keep dangerously close to the reefs and save fuel, and this is the cause of frequent accidents. Besides the danger of running into the known reefs, which are in many places bare and are of no great depth throughout their length, another danger, the extent of which is not yet known, has been discovered in a secondary reef parallel to the main reef and about one-half mile outside of it. This secondary reef is found to approach the surface in places as a narrow ridge with depths as little as 25 feet. Twenty-five miles of this reef have been examined, but 200 miles remain to be examined. It is important to

nearly all the great traffic entering the Gulf of Mexico that this examination be completed at the earliest possible moment. During 1920 a vessel was employed on surveys of the Florida reefs between the Marquesas Keys and Fowey Rocks. This includes supplementary surveys of the channels through the reefs from deep water into the inside route lying between the reefs and the mainland; also the close development of the shoal area westward of Key West and southward of the Marquesas Keys. In connection with this the work has been carried out to the 100-fathom curve for a distance of 50 miles along the reefs. (See fig. 12, opposite.)

44. Vessel Courses North from Key West.—Vessels bound for eastern Gulf ports naturally wish to take the shortest route. If of light draft, they can cross the Florida Reefs at Key West. The next channel is between Rebecca Shoal and Dry Tortugas, and if this is not used vessels must pass well to the westward of Dry Tortugas to avoid a shoal bank west of it. The Rebecca Shoal channel has been dragged and has ample depth of water. The bank west of Tortugas should be dragged, especially as vessels making land from the westward have to cross part of it. Northward of the keys from Key West to Tortugas a doubtful area should be dragged. The necessity of this is emphasized by the fact that the U. S. S. *Ellis*, while steaming northward of the Marquesas Keys, struck a coral head which proved to have only 7 feet over it. This coral head was directly out of a depth of 35 feet, with no indication of its existence until struck by the naval vessel, which was severely damaged. The channel between the keys and the reef, known as the Hawk Channel, is important for moderate-draft vessels. It will be necessary to drag the axis of the channel to insure against dangers to the vessels making use of it.

45. Cape Romano.—This area is in need of surveys. An inspection of the existing maps and charts of the State of Florida shows practically a blank area for that part of the peninsula south of Lake Okechobee. There are but few areas of the United States of like size about which so little definite information can be obtained. Northward of this unknown region drainage canals are opening up the country for development. It is not unlikely the same means will be extended southward. At the present time the bureau should prepare to meet a demand in the near future for the delineation of a broader belt of country back of the shore from Cape Sable to Punta Rosa than is now shown on our charts. Tourists and land prospectors are now exploring this intricate system of islands and waterways. (See fig. 12, opposite.)

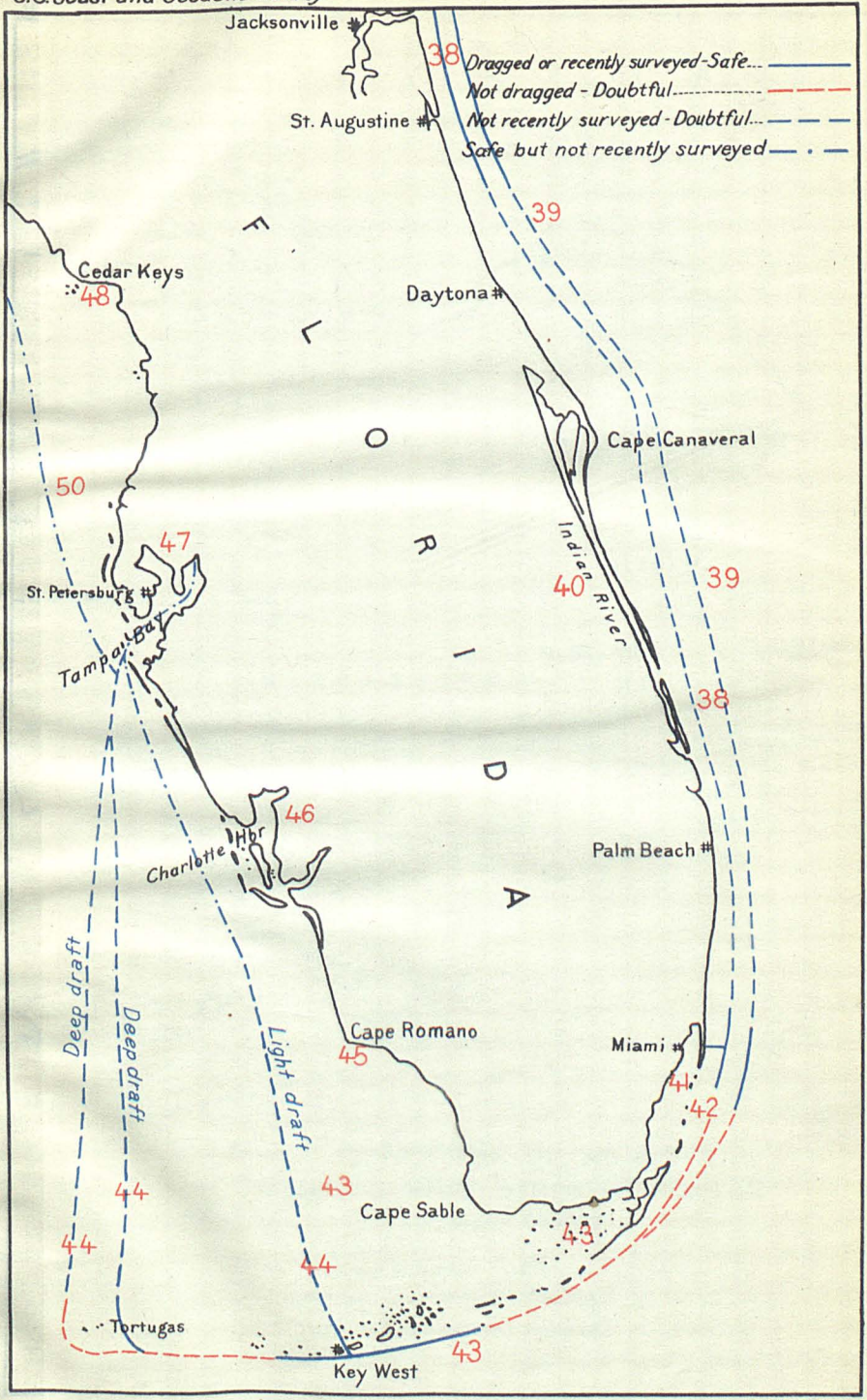
46. Charlotte Harbor.—No recent surveys have been made of this area, and it should be resurveyed. (See fig. 12, opposite.)

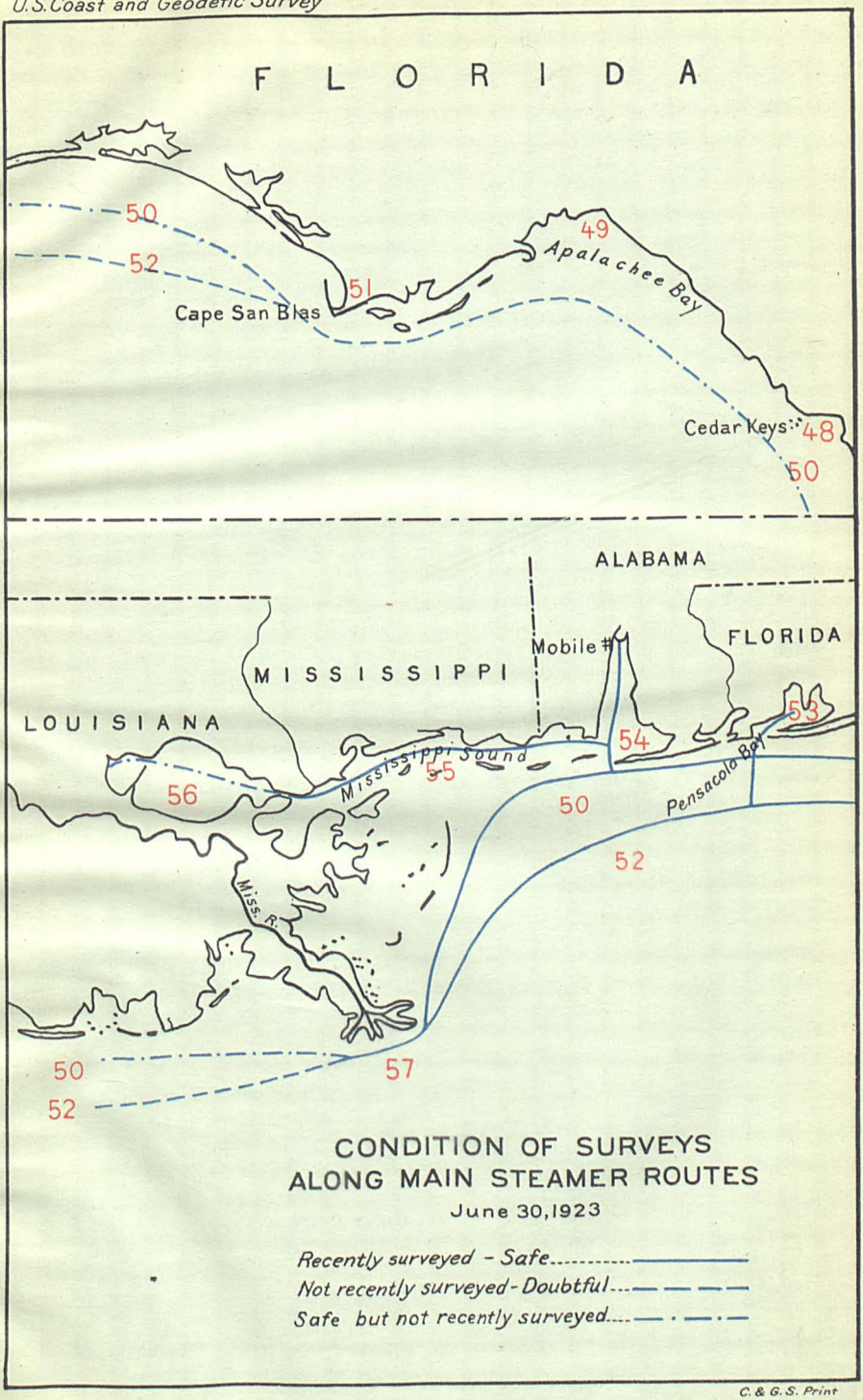
47. Tampa Bay and Approach.—The existing surveys at present meet the needs of navigation of these waters. (See fig. 12, opposite.)

48. Cedar Keys.—No recent surveys have been made of this region. Wire-drag surveys are badly needed. (See fig. 12, opposite.)

49. Apalachee Bay.—No recent surveys have been made of this region and revision work is needed. (See fig. 12, opposite.)

50. Inshore Waters, Gulf Coast.—The chief characteristics of the west coast of Florida are the distances to which shoal water extends offshore between Cape Sable and Cape Romano and from


Jacksonville
St. Augustine
Dragged or recently surveyed-Safe
Not dragged - Doubtful
Not recently surveyed - Doubtful
Safe but not recently surveyed
38
39
Cedar Keys
48
Daytona
FLORIDA
Cape Canaveral
50
47
St. Petersburg
Tampa Bay
Indian River
40
39
38
46
Charlotte Hbr
Palm Beach
Deep draft
Deep draft
Light draft
Cape Romano
45
Miami
41
42
44
43
Cape Sable
44
44
43
Tortugas
Key West
C. & G. S. Print



CONDITION OF SURVEYS ALONG MAIN STEAMER ROUTES

June 30, 1923

Recently surveyed - Safe

Not recently surveyed - Doubtful

Safe but not recently surveyed

C. & G. S. Print

Tampa Bay to Appalachicola and the existence of a large number of bays connected with the sea by deep channels, either natural or dredged. From Apalachee Bay to Cape San Blas the coast begins to assume a character more like the South Atlantic coast, and coral bottom is no longer found. This stretch of coast is sandy, and sand shoals extend off some distance, especially in the vicinity of Cape San Blas. This region needs a resurvey and, like other sandy portions of the coast, will need resurveying from time to time. The Florida and Alabama coasts differ somewhat, as deep water approaches close to the shore in the latter. The coast of Mississippi and Louisiana has a very large proportion of changeable area and resurveys are needed now and will be needed from time to time in the area from Mobile Bay to the end of the offshore shoals of Vermilion Bay. The immense load of sediment carried by the Mississippi River, especially in time of flood, causes constant changes in the delta. The deposit of sediment and the action of the waves on the deposits result in rapid growth in some places and of erosion in others. Sixty miles west of the Mississippi Delta there begins an extensive shoal region which is in need of survey. The inshore region along the rest of the Louisiana coast and the Texas coast, with an important exception, has deep water fairly close to the shore. The exception is along the eastern part of the Texas coast from Sabine Pass to Galveston. Sabine Bank and Heald Bank have shoal depths at a considerable distance from the shore, and they should have a thorough resurvey. Galveston Bay also needs resurveying. (See fig. 12, opposite p. 78.)

51. St. Josephs Bay.—No recent surveys have been made of this area, and a reexamination is needed. (See fig. 13, opposite p. 78.)

52. Offshore Waters, Florida Reefs to the Mexican Border.—Along the northern edge of the Florida Straits the soundings are insufficient, and they will have to be carried out somewhat beyond the 100-fathom curve. Along the west coast of Florida the distance out to the 100-fathom curve is about 100 miles. Over much of this area the depths are moderate, and the charts are based on reconnaissance surveys only. The bottom is coral rock in many places, and projections from coral banks may come sufficiently near the surface to be a menace to navigation. Fishermen have reported several uncharted ridges, and while the somewhat incomplete surveys of the reported localities have not confirmed all the details of their reports, important differences from the charted depths have been found. The 100-fathom curve approaches fairly close to the Mississippi Delta, then swings offshore again, so that it is about 60 miles south of Sabine Pass. It then swings to the southward in a curve, which brings it within about 80 miles offshore at the Mexican border. This whole offshore area is badly in need of a thorough resurvey. There is no other part of the work in offshore waters so likely to be productive in furnishing important changes in existing charted depths. (See fig. 13, opposite p. 78.)

53. Pensacola Bay.—Surveys have recently been completed in the entrance to the bay. The entire bay requires reexamination. (See fig. 13, opposite p. 78.)

54. Mobile Bay.—A resurvey of this bay has been completed. (See fig. 13, opposite p. 78.)

55. Mississippi Sound.—A resurvey of this sound has been completed. (See fig. 13, opposite p. 78.)

56. LAKE PONTCHARTRAIN.—In connection with the surveys in Mobile Bay and Mississippi Sound a recent survey has been made at the eastern end of the lake. The greater part of the lake has not been examined for 20 years. (See fig. 13, opposite p. 78.)

57. APPROACHES TO MISSISSIPPI PASSES.—The hydrography of this area from close inshore to the 100-fathom curve has been completed. The offshore work which has been in progress from Pensacola entrance westward has been extended to Mississippi River Passes.

58. VERMILION BAY AND COTE BLANCHE.—No recent surveys have been made of these areas. Surveys are needed. (See fig. 14, opposite.)

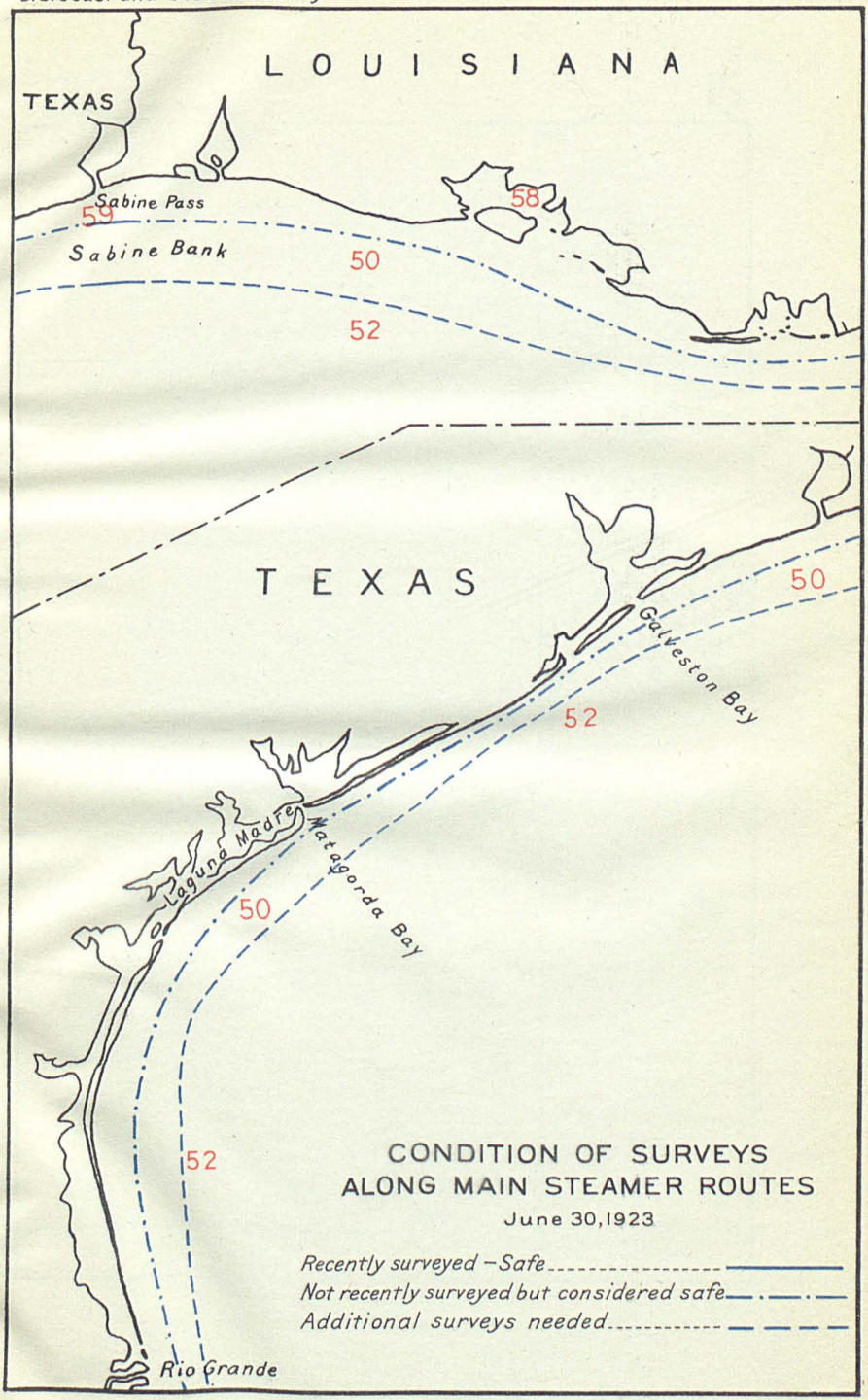
59. APPROACH TO SABINE PASS.—A resurvey of this area was completed during the fiscal year. (See fig. 15, opposite.)

60. PORTO RICO.—The surveys of Porto Rico were begun when the island came under the jurisdiction of the United States as a result of the Spanish-American War. By 1910 the surveys of the bays, channels, and inshore were completed, and a number of deep-sea soundings were taken around the island. There are, however, extending to the eastward and westward of the island and along the south coast extensive areas where the bottom is of coral formation. There are also reefs along the north coast, but as they are close to shore and must be avoided by vessels it is only important to know their location and limits. The areas on the east, south, and west are different, in that there is traffic between the reef and over areas where the depth is little greater than the draft of the vessel, and the probable existence of uncharted projections is a source of danger. A vessel was engaged during the entire year in completing the dragging of the waters of Vieques Sound and its approaches. This work has resulted in finding many coral rocks, the existence of which was not discovered by the hydrographic survey of previous years. (See fig. 15, opposite.)

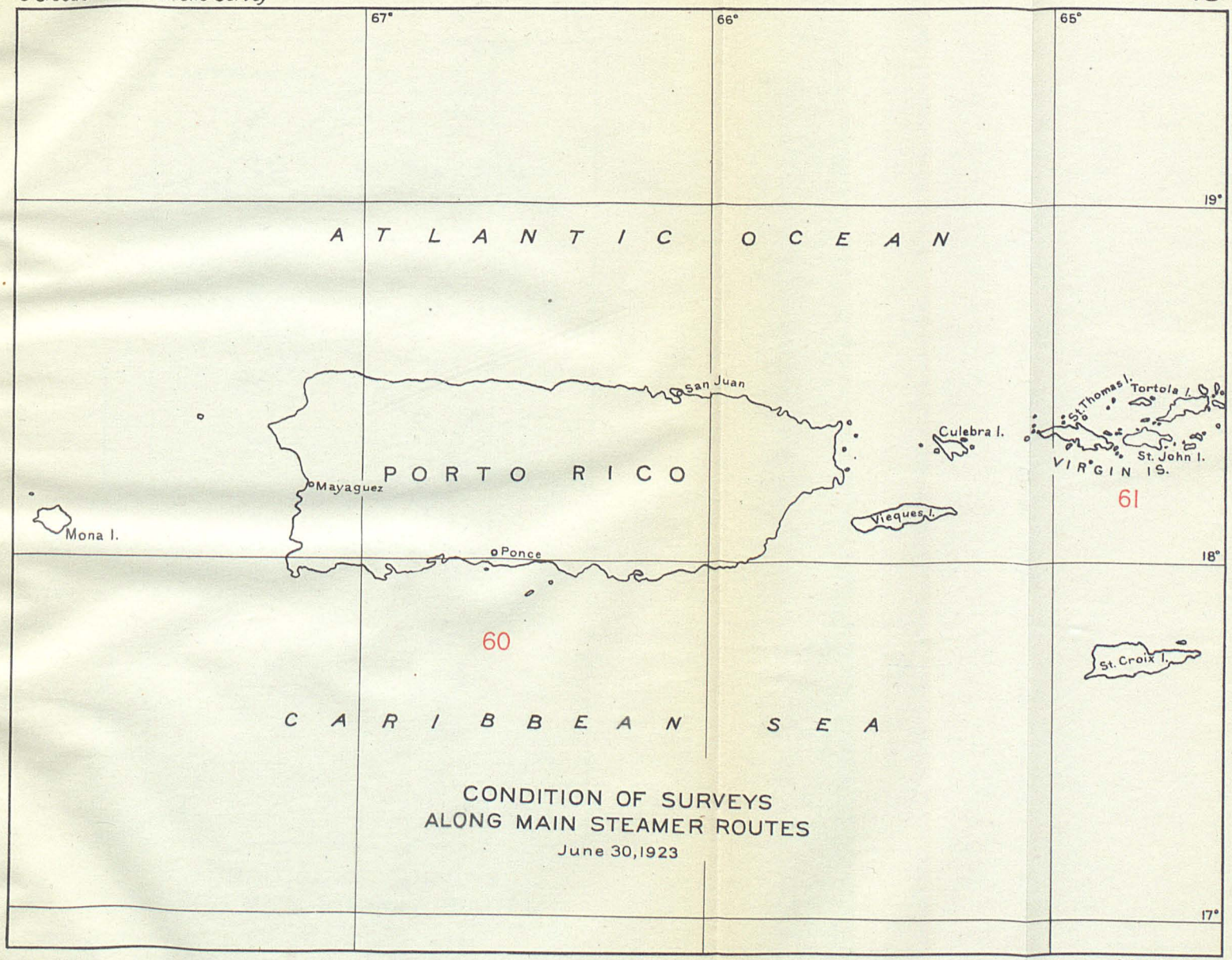
61. VIRGIN ISLANDS.—The Virgin Islands were purchased from Denmark, and the United States took possession in 1917. The surveys that have been made are by the British and Danish Governments. It is certain that the coral formation in the waters touching these islands requires extensive wire-drag surveys before accurate charts can be issued. Topographic surveys of these islands were requested by the Navy Department. The triangulation was extended eastward from Porto Rico for the control of the topography. St. Thomas, St. John, and St. Croix have been completed. Hydrographic work will be taken up there during the next fiscal year. All harbors will be thoroughly sounded out, and the shallow coastal waters will be dragged.

62. PANAMA CANAL.—The Atlantic approach to the Panama Canal has been surveyed since work started on the canal construction. Limon Bay is, however, a region where pinnacle rocks occur. All the anchorages should be dragged, and the work should be carried a short distance outside. The Pacific approach to the canal has had a recent survey and has been dragged. (See fig. 16, opposite.)

63. PACIFIC COAST OF THE UNITED STATES.—The western coast of the United States is very different from the eastern. Generally mountainous, with comparatively few harbors or inside waterways and with comparatively deep water close to the shore, it presents little resemblance to the low shores and wide continental shelf of the


LOUISIANA
TEXAS
Sabine Pass
Sabine Bank
58
59
50
52
TEXAS
50
Galveston Bay
52
Laguna Madre
Matagorda Bay
50
52
Rio Grande
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1923
Recently surveyed – Safe
Not recently surveyed but considered safe
Additional surveys needed

C&G.S. Print



CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1923

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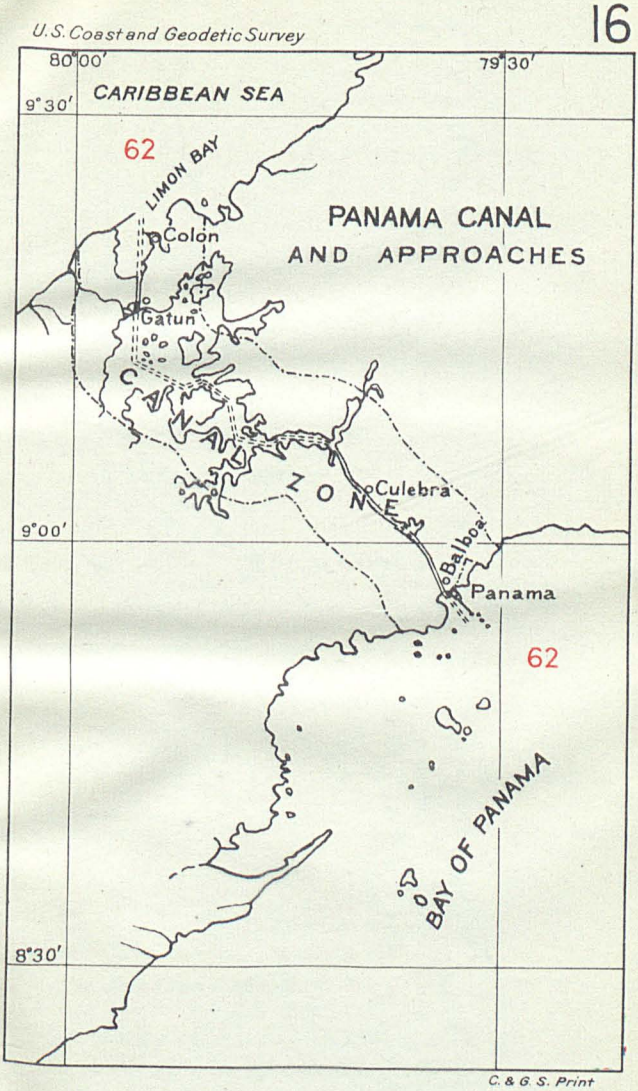
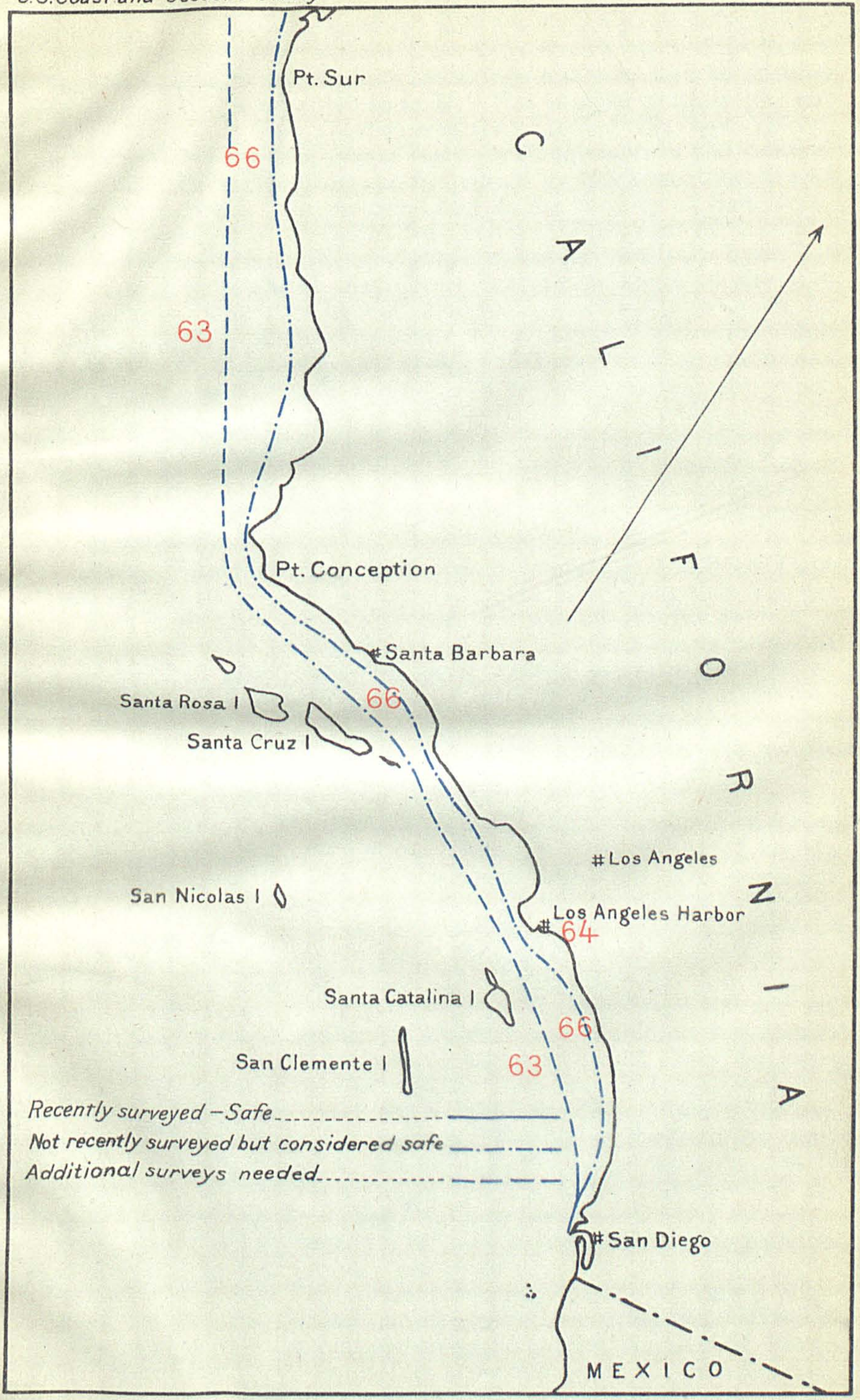


CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1923

U.S. Coast and Geodetic Survey



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Atlantic. The purpose of the survey is, then, to meet the needs of vessels approaching from seaward and coasting vessels, which keep to a few comparatively narrow tracks, to insure up-to-date charts of the various harbors, to make soundings offshore, and to develop fishing banks that are known to exist. The weather is an important factor in increasing the importance of the charts of this coast. From Los Angeles Harbor northward fog is very common in the summer time, and in the winter gales, accompanied by thick weather, are of frequent occurrence. On the coast and in the vicinity of San Francisco thick weather is prevalent for perhaps 25 per cent of the time. Under such conditions the navigator must rely entirely upon his chart, and it is essential that detail surveys be made to the 100-fathom curve, which is beyond the limit of soundings taken by merchant vessels. Along the shore of southern California much work was done up to 1895, and some of the surveys then made may be accepted as final. In the vicinity of the outer islands surveys extended only a little way from the shore, and the deep waters between and outside of them are unsurveyed. The few soundings taken show irregular bottom, and breakers have been reported in places where the chart shows 600 fathoms. These waters, therefore, should be surveyed out to the 1,000-fathom depth. The Oregon coast is practically unsurveyed.

A limited amount of work was done years ago south of Cape Blanco and in the vicinity of the Columbia River, but this was not more than a reconnaissance and does not extend out far enough to be of practical value to navigators. Elsewhere no surveys have ever been undertaken until recently. Even in such an important locality as Cape Blanco, which must be rounded by all vessels plying between the Columbia River and San Francisco, there are no soundings to serve as a guide in thick weather, and vessels have been lost wholly on account of this lack of surveys. On the coast of Oregon there are eight important harbors on which the Government and private interests have expended approximately $40,250,000 in improvements designed to facilitate navigation. One of these is the Columbia River, the gateway to one of the most important transportation centers of the Pacific coast. Yet, in spite of the immense expenditures for improvements, there is not a single one of these harbors the approaches to which have been adequately surveyed. The approaches to the Columbia River have been sounded for a short distance offshore, but even in this area the soundings are too far apart to more than indicate in a general way the depth which may be expected. This partial survey extends southward along the coast to include the approaches to two other harbors. The approaches to the remaining five, on which $3,826,000 have been expended in improvements, are entirely unsurveyed. The entire Washington coast stands in urgent need of a first survey, except in the approach to the Straits of Juan de Fuca and in the straits themselves, where the present work is adequate. (See fig. 17, opposite p. 80.)

64. Los Angeles Harbor.—A revision survey of Los Angeles Harbor and approach was recently completed.

65. San Francisco Bay.—San Francisco Bay is of varied character of bottom and needed surveys vary to correspond. The immediate approaches are complete except in the vicinity of Farallones. Here additional sounding is needed, and an investigation

there should be made with the wire drag to verify the existence of other rocks than those charted. Wire-drag work has been carried through the Golden Gate and inside, both northward and southward of San Francisco to the limit of the rocky area. The resurvey of the bar outside the Golden Gate has been completed. A resurvey of San Pablo Bay has been made.

66. ALONGSHORE WATERS OF THE PACIFIC COAST STATES.—From the western end of the Santa Barbara Channel to Monterey Bay the surveys, as a rule, extend only to the 50-fathom curve, which lies but a short distance offshore. The surveys should be extended seaward to include the usual track of coastwise vessels, which lies an average distance of about 10 miles from shore. From San Francisco Bay to Point Arena a widely spaced system of sounding lines has been carried out to the 100-fathom curve. Here an additional amount of work, about equal to that already accomplished, is necessary before the survey can be considered complete. Between Point Arena and Cape Mendocino the surveys extend a uniform distance of 6 miles from shore, reaching depths varying from 50 to 600 fathoms.

Additional detailed surveys should be made in the vicinity of Point Arena and from there to the completed work south of Cape Mendocino. Detailed surveys are badly needed in the vicinity of Cape Blanco, and this work should be extended to Cape Flattery, joining the northern limits of the work completed in the vicinity of Cape Mendocino.

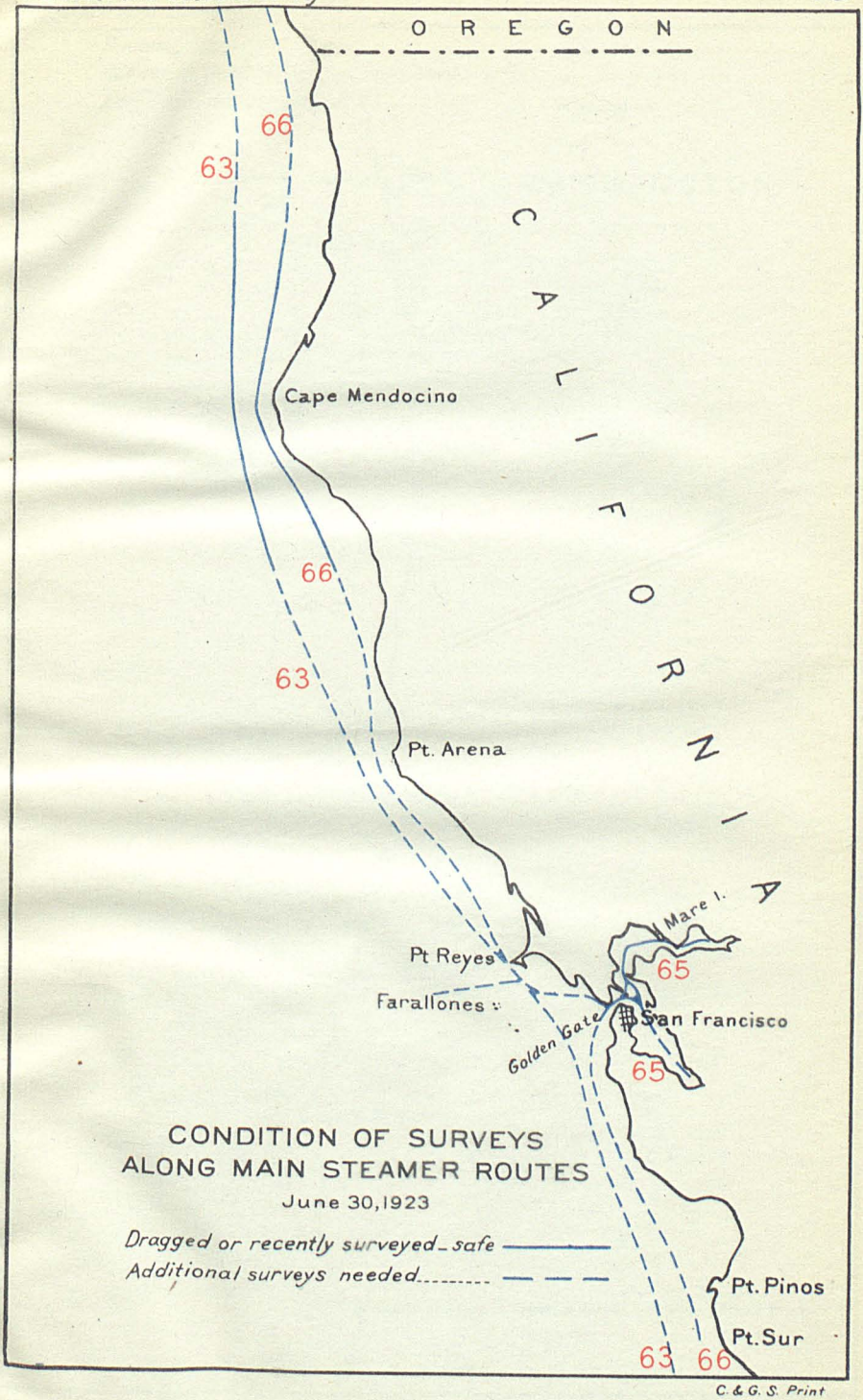
The offshore surveys which have been in progress during recent years in the vicinity of Cape Mendocino have been completed. This work extends from close inshore to the 1,000-fathom curve.

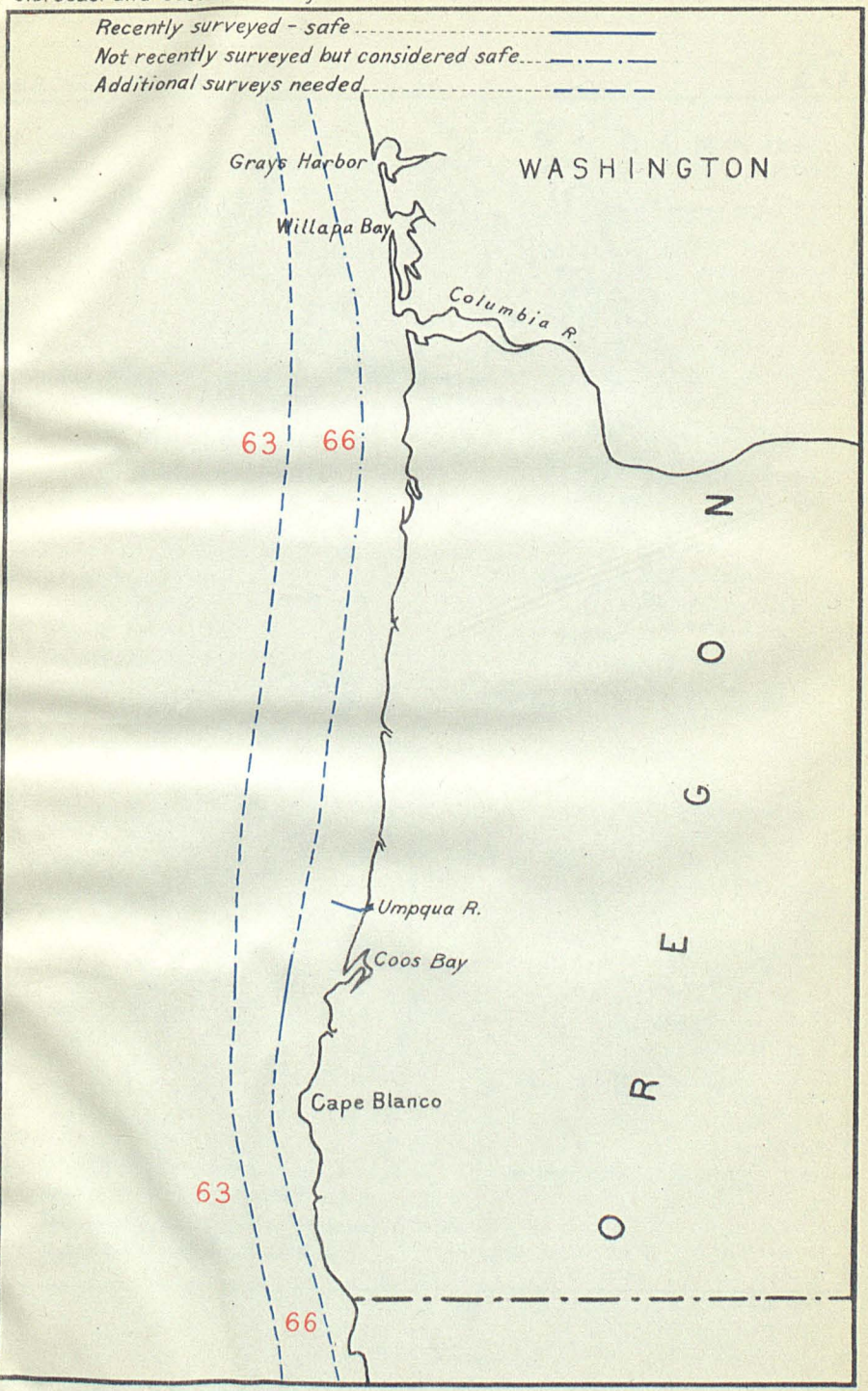
The necessity for such surveys is shown by the location of the hitherto uncharted submarine valley north of Cape Mendocino, which was a factor in causing the wreck of the steamer *Bear*.

A vessel was engaged during the fiscal year in making a survey of the water area in the vicinity of Cape Blanco, Oreg. This work is to extend both north and south of Cape Blanco from close inshore to the 1,000-fathom curve. There are no adequate surveys of the inshore area along the State of Oregon. Of the water off the northern part of the Pacific coast little is known, except that the Bureau of Fisheries, acting on the information obtained from fishermen, has located certain banks. These banks should be surveyed to determine their depth and extent, and it is believed that a general survey carried out to the 1,000-fathom curve will result in the discovery of other banks of great value. (See fig. 17, opposite p. 80.)

67. INTERIOR WATERS OF THE STATE OF WASHINGTON.—The interior waters of the State of Washington represent the point of change from a practically strait coast line to the broken formation of the coast of British Columbia and southeastern Alaska. There are many channels of importance leading to Seattle, Tacoma, Everett, Bellingham, and Olympia and connecting with the inside passage to southeastern Alaska. All these should be dragged wherever there is the slightest doubt as to the presence of dangers to navigation. (See fig. 20, opposite.)

68. STEAMER ROUTES, SOUTHEASTERN ALASKA.—In southeastern Alaska the first and most obvious need is to complete the wire-drag work. Most of these waters have been sounded, so that only dragging is necessary to complete the survey. This drag work should be


OREGON
66
63
CALIFORNIA
Cape Mendocino
66
63
Pt. Arena
Mare I.
Pt Reyes
65
Farallones
San Francisco
Golden Gate
65
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30,1923
Dragged or recently surveyed_safe
Additional surveys needed
Pt. Pinos
Pt. Sur
63
66
C. & G. S. Print


Recently surveyed - safe
Not recently surveyed but considered safe
Additional surveys needed
Grays Harbor
WASHINGTON
Willapa Bay
Columbia R.
63
66
O R E G O N
Umpqua R.
Coos Bay
Cape Blanco
63
66

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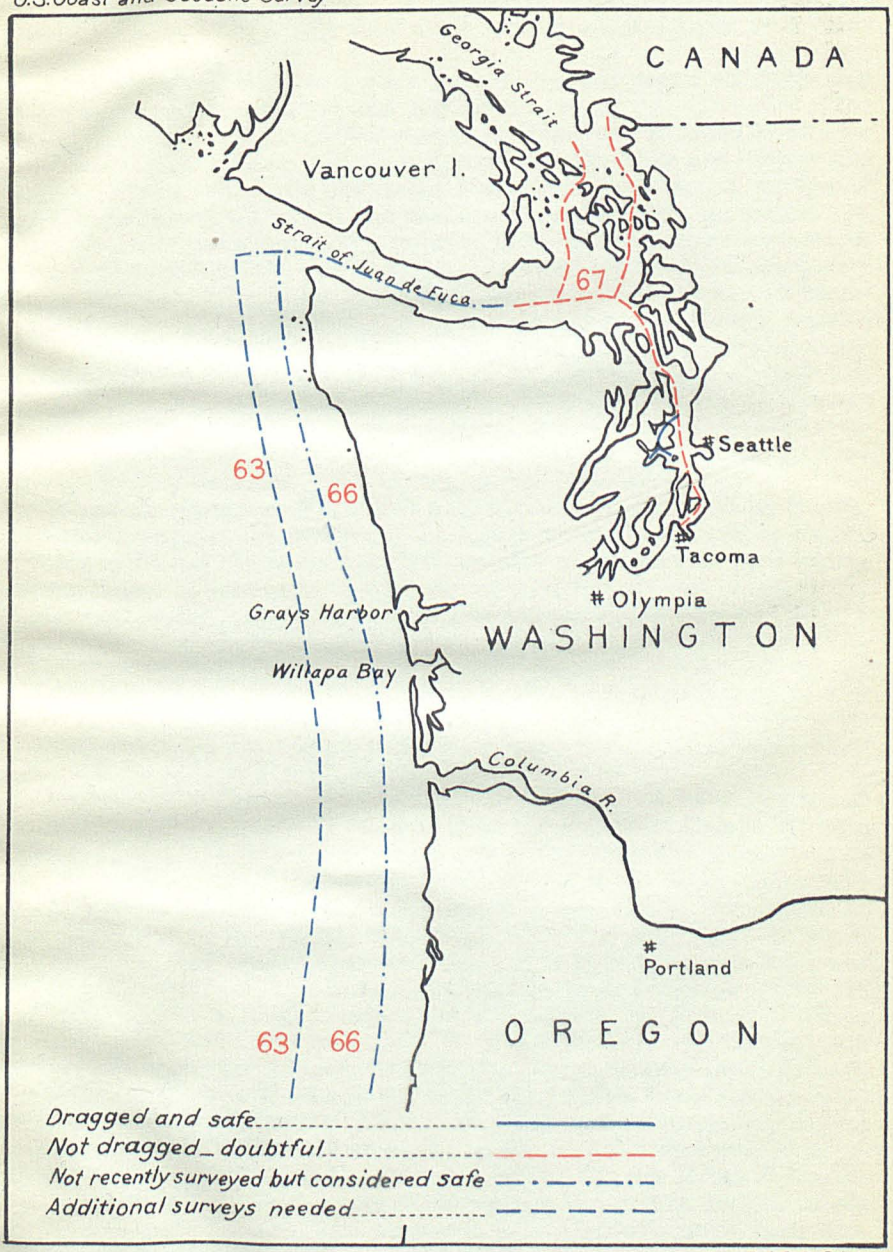

CANADA
Georgia Strait
Vancouver I.
Strait of Juan de Fuca
67
63
66
Seattle
Tacoma
Olympia
Gray's Harbor
WASHINGTON
Willapa Bay
Columbia R.
Portland
63
66
OREGON
Dragged and safe
Not dragged_doubtful
Not recently surveyed but considered safe
Additional surveys needed

C. & G. S. Print

taken up in the order of its importance, beginning with the main steamer route through the region and then taking up the various tributary waters leading to areas of commercial importance. For some years past parties have been actively engaged in dragging the main steamer routes, and this work is now about 95 per cent complete.

At the end of the fiscal year a party was engaged in wire-drag operations in Cross Sound and Icy Straits.

69. The Outside Coast Waters of the Islands Bordering on the Open Pacific.—These and their connecting channels are largely unsurveyed and should be navigated with great caution. A navigator seeing the chart on which the shore line is sketched—no soundings, several rocks and shoal banks, notes as to rocks and breakers reported, and a statement on the chart to the effect that the area is unsurveyed—is, to say the least, unable to proceed with confidence, and this situation is by no means unusual. The same pressing need of such regions is a complete hydrographic survey followed later in places by wire-drag work. The rapidly increasing commercial importance of this region and the exceptionally dangerous character of the waters through which traffic must pass render surveys in the near future imperative. Work on the outer coast is now in progress northward from Dixon Entrance. (See fig. 21, opposite p. 84.)

70. Cross Sound to Prince William Sound.—From Cross Sound, the northernmost channel from the inside waters to the sea, to Prince William Sound the coast has few features of present or prospective importance. There is, however, urgent need for surveys to insure the safety of vessels approaching and passing the coast. In this region the charts are very defective in the manner of showing soundings and prominent coastal mountain peaks and headlands that would enable the navigator to obtain his position on approaching from seaward.

Additional surveys are needed in Yakutat Bay. A survey of Icy Bay was completed during this fiscal year.

71. Prince William Sound to Unimak Pass.—A very important section of the Alaska coast extends from the waters of Prince William Sound westward to Unimak Pass. Not only are the industries of present importance, but there are extensive mineral resources largely undeveloped through lack of cheaper transportation. The point to be emphasized is that this is not an old, settled country, with its needs in the matter of transportation fixed, but it is still capable of great future development, and in considering the needed surveys its future must be taken into account. The approaches to Prince William Sound have been surveyed, and no resurveys for the present are needed except in the vicinity of Cape St. Elias and Middleton Island. Wire-drag work will be needed in both of these localities, as reefs and pinnacle rocks exist. Prince William Sound needs additional soundings over most of its area, and many of its branches need original surveys. Cordova is the terminus of the Copper River & Northwestern Railway, which gives access to the important copper mines on the Copper River. The approaches to Cordova have been surveyed, except for wire-drag surveys needed to insure complete safety. Seward, on Resurrection Bay, is the terminus of the Alaska Railroad. The surveys of its approach are completed except for wire-drag work.

It is probable that much of the trade originating along the line of the Government railway will be transshipped at Anchorage, at the head of Cook Inlet. Not only will this make it necessary for many vessels to navigate these waters, but there are now very large salmon canneries all along its shores, as well as considerable mining. The present surveys are inadequate, and wire-drag work is needed over much of its area. Kodiak Island, with a number of canneries and with some cattle grazing, is largely unsurveyed. From Kodiak Island westward to Unimak Pass surveys are now in progress; only a comparatively small part has been surveyed at present. While the amount of present traffic is small, it is sufficient to need protection. At present the Coast Guard vessels and the freight and passenger vessels run grave risks in using the protected natural channel leading along the coast inside the island. This is a particularly bad stretch of coast, with many reefs and islands. Only in the vicinity of the Shumagin Islands and from Unimak Pass to Unalaska Island have surveys been made, and they are inadequate. It is not now practicable to drag the entire area, but it is important that the immediate needs of navigation, even though of limited amount, be met by dragging a selected channel to insure the safety of vessels from Shelikof Strait to Unimak Pass. Unimak Pass is the almost universally used channel into Bering Sea. It has been surveyed, but it is probable that part of it should be dragged or at least further soundings be taken. (See fig. 22, opposite.)

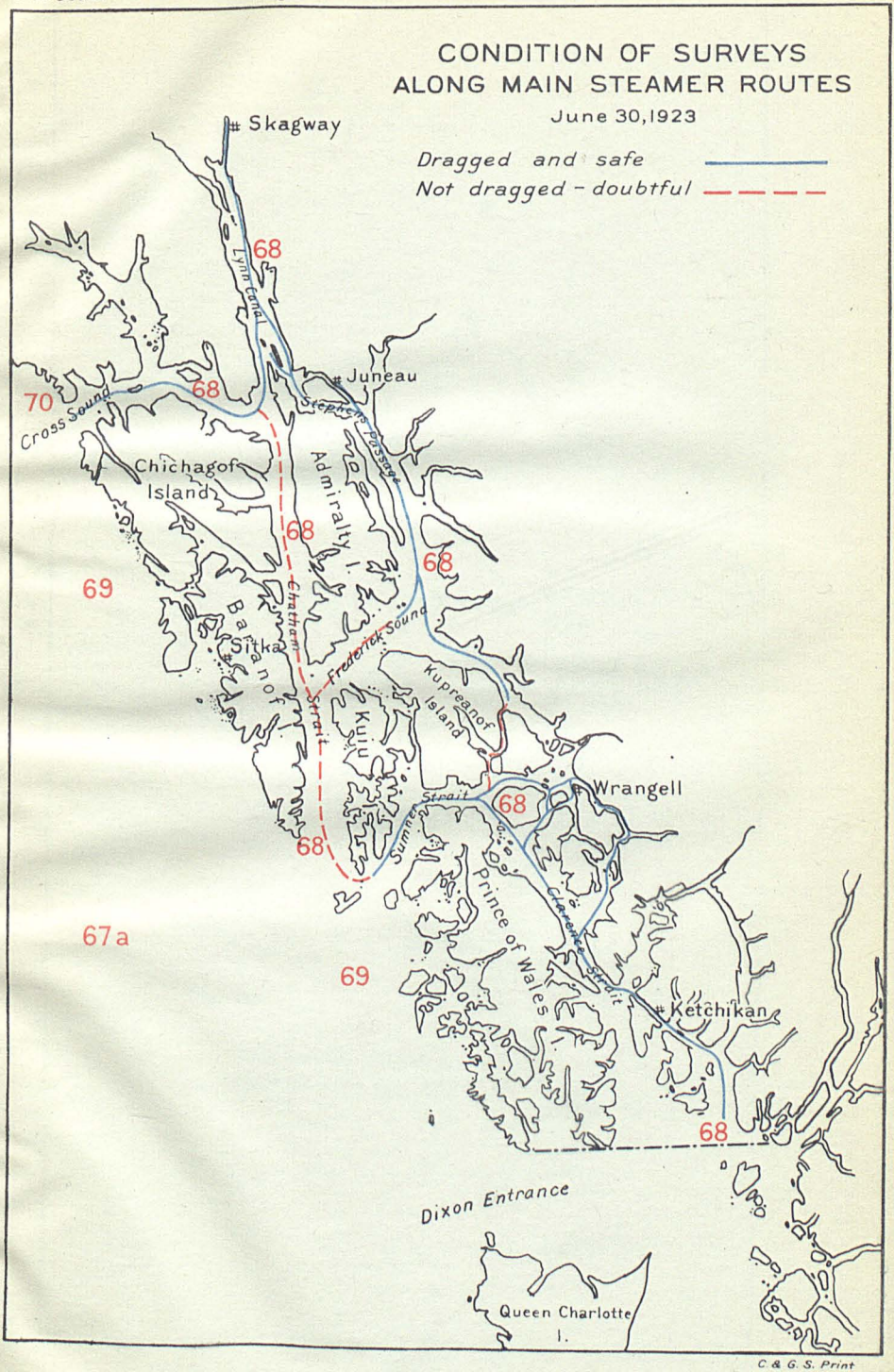
72. ALEUTIAN ISLANDS.—The Aleutian Islands have comparatively little traffic and are without survey. It is necessary that this region be patrolled by Coast Guard vessels. The loss of one of the vessels of this service a few years ago was wholly due to the lack of adequate surveys. (See fig. 22, opposite.)

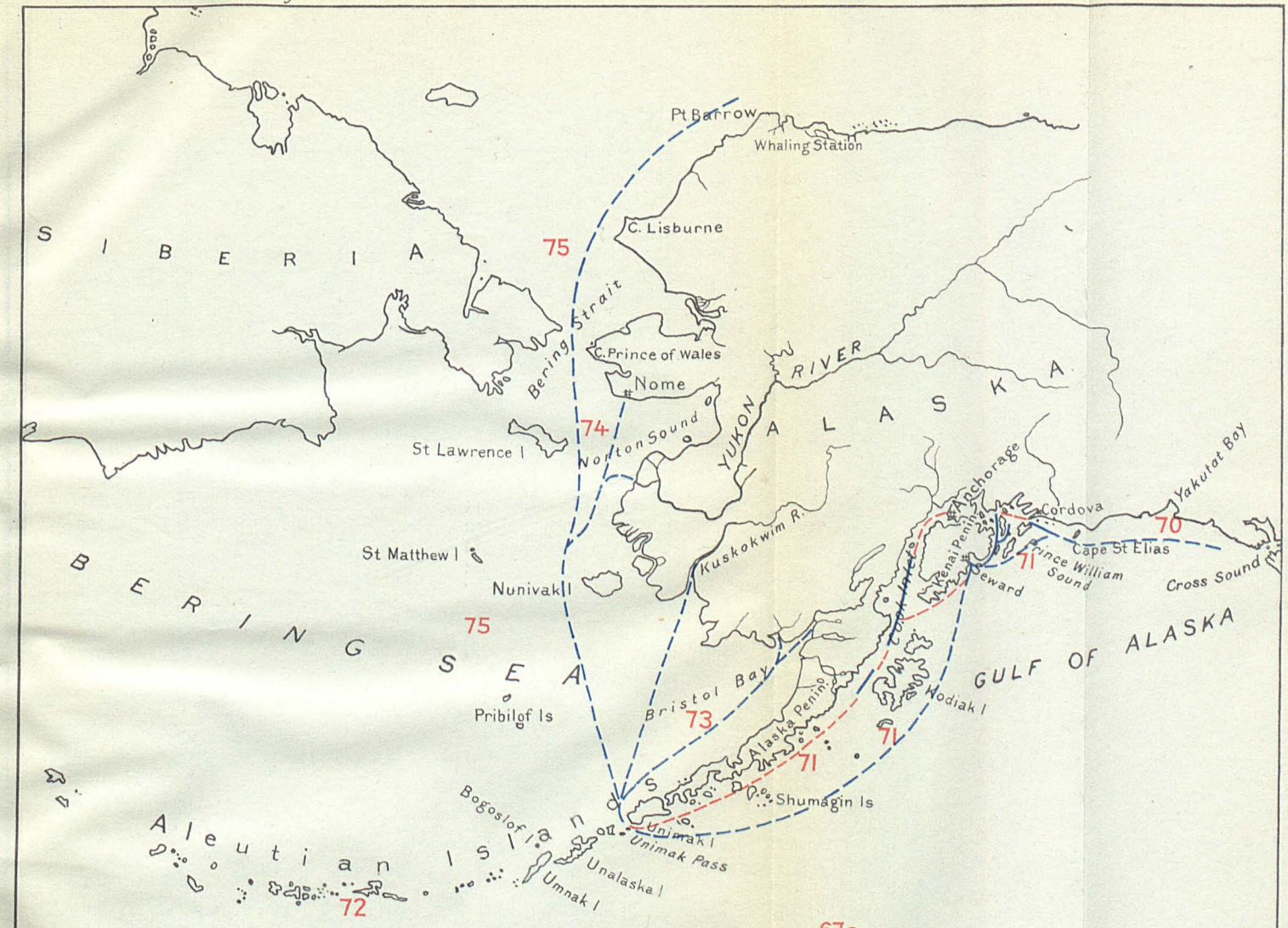
73. BRISTOL BAY.—A large part of the salmon shipped from Alaska comes from Bristol Bay. This is without surveys except in Nushagak Bay and Kuskokwim Bay and River. Both of these have had recent surveys, but, as the bottom is subject to change on account of the large river, future additional surveys will be needed. As an example of what surveys mean in a new region, the discovery of an entrance to the Kuskokwim River suitable for moderate-draft vessels opened up an immense area for grazing and also in places for general agriculture. (See fig. 22, opposite.)

74. NORTON SOUND.—The importance of Norton Sound is due to the gold mining on its northern shores and as being the outlet of the Yukon Delta on the southern shore. In all of Norton Sound additional surveys are needed. It is curious that in this sound, which according to all available information is of quite level, sandy, or muddy bottom, Besboro Island rises very abruptly to a height of 1,012 feet. With such an occurrence it is not absolutely certain that no pinnacle rocks exist. (See fig. 22, opposite.)

75. BERING SEA AND ARCTIC OCEAN.—Except in the vicinity of Pribilof Islands there are no other existing surveys in Bering Sea or to the north which can be considered of value. (See fig. 22, opposite.)

76. GUAM.—The present chart of the island of Guam is compiled from Spanish and British charts and some harbor surveys by the United States Navy. No attempt at a comprehensive survey has been


CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1923
Dragged and safe
Not dragged - doubtful
Skagway
Juneau
Lynn Canal
Stephens Passage
Admiralty I.
Cross Sound
Chichagof Island
Baranof I.
Sitka
Chatham Strait
Frederick Sound
Kupreanof Island
Kuiu I.
Sumner Strait
Wrangell
Clarence Strait
Prince of Wales I.
Ketchikan
Dixon Entrance
Queen Charlotte I.
68
70
69
67a
C. & G. S. Print



This locality visited by Coast Guard Cutters and Whalers.

CONDITION OF SURVEYS ALONG MAIN STEAMER ROUTES

June 30, 1923

Dragged or recently surveyed - Safe ——————

Not dragged - Doubtful – – – – –

Not recently surveyed - Doubtful – – – – –

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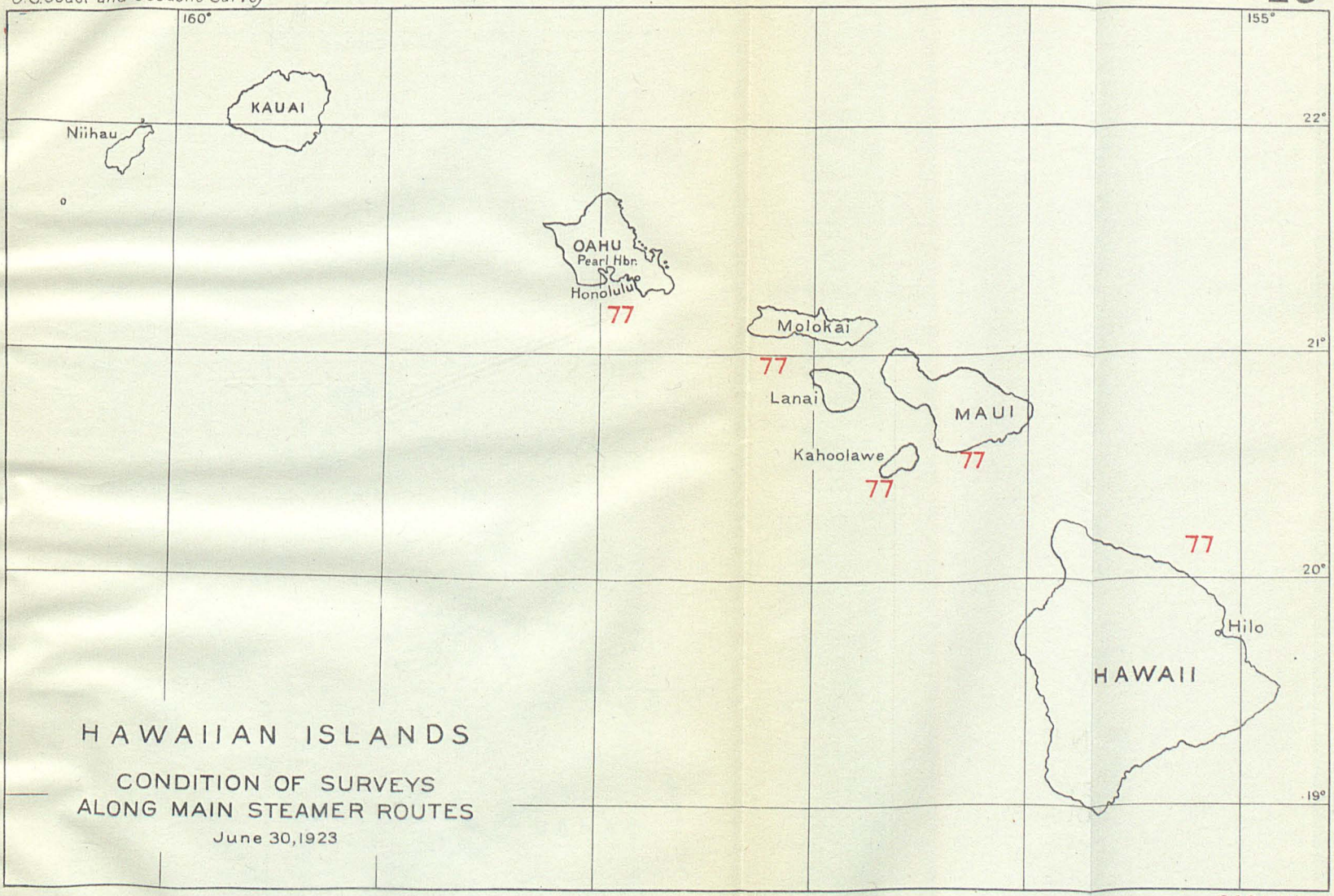

HAWAIIAN ISLANDS

CONDITION OF SURVEYS ALONG MAIN STEAMER ROUTES

June 30, 1923

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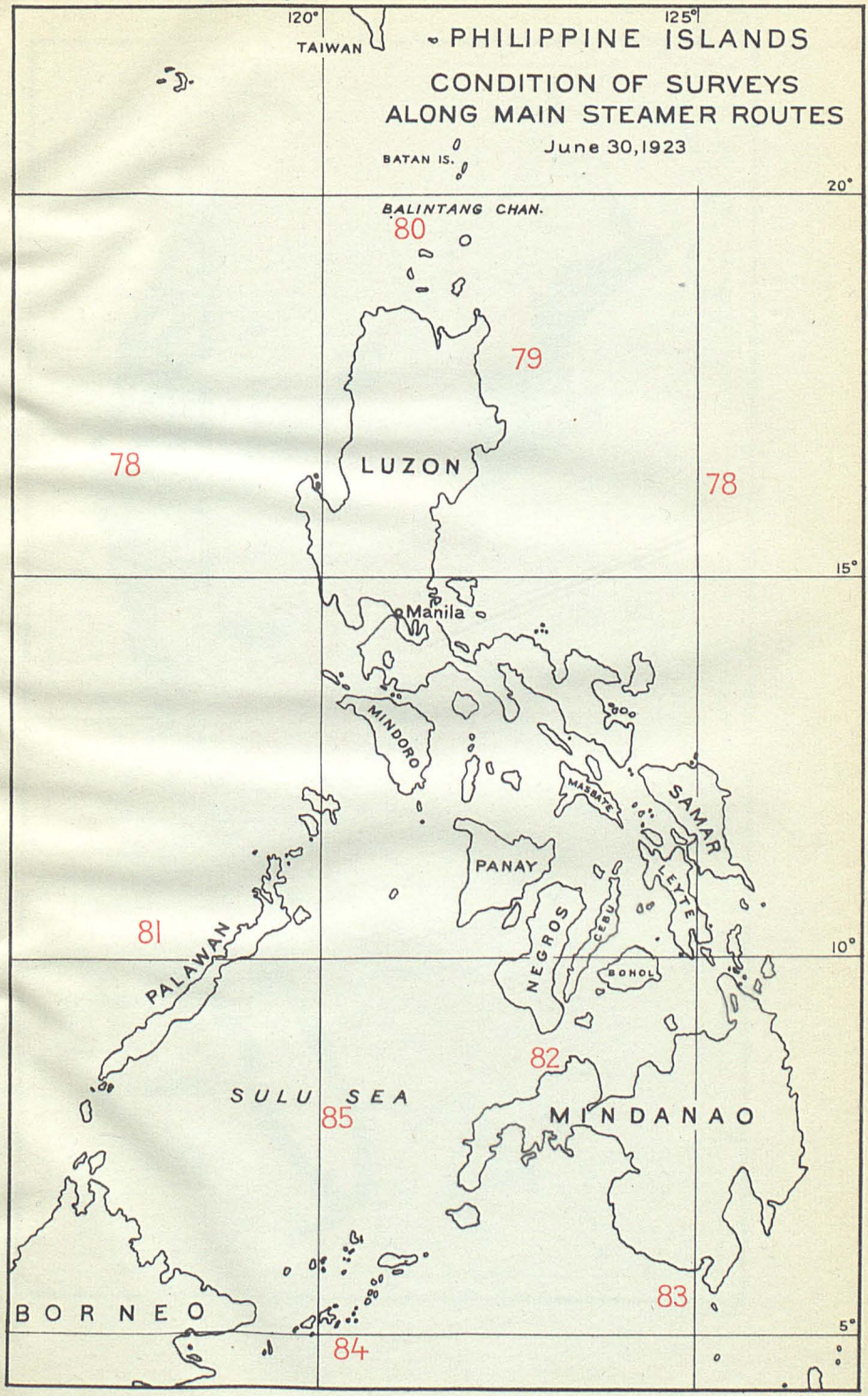
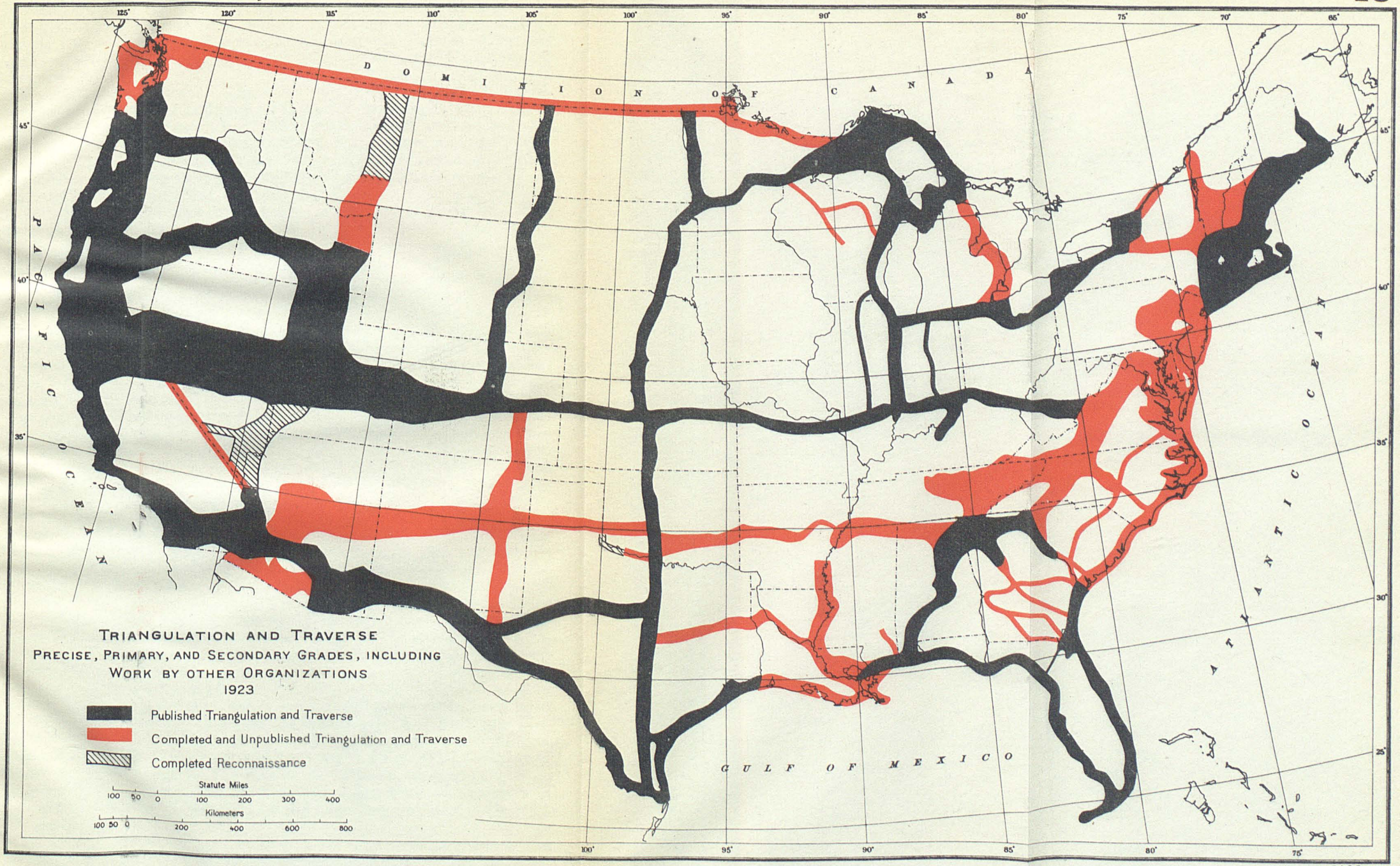

PHILIPPINE ISLANDS
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30,1923
120°
125°
20°
15°
10°
5°
TAIWAN
BATAN IS.
BALINTANG CHAN.
80
79
78
78
LUZON
Manila
MINDORO
MARBATE
SAMAR
LEYTE
PANAY
NEGROS
CEBU
BOHOL
81
PALAWAN
82
SULU SEA
85
MINDANAO
BORNEO
83
84
C&G.S.Print


DOMINION OF CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
125°
120°
115°
110°
105°
100°
95°
90°
85°
80°
75°
70°
65°
45°
40°
35°
30°
25°
TRIANGULATION AND TRAVERSE
PRECISE, PRIMARY, AND SECONDARY GRADES, INCLUDING
WORK BY OTHER ORGANIZATIONS
1923
Published Triangulation and Traverse
Completed and Unpublished Triangulation and Traverse
Completed Reconnaissance
Statute Miles
100 50 0 100 200 300 400
Kilometers
100 50 0 200 400 600 800

C.&G.S. Print

made. A complete survey should be made, not only including the harbors, but the surrounding waters, carrying the work out to a depth that will be certain to include all dangers. In these waters shoals rise abruptly from great depths, and the absence of soundings on the charts does not imply safety, but simply absence of surveys.

77. HAWAIIAN ISLANDS.—There are only two good harbors on all the Hawaiian Islands, and both of these are on Oahu Island. All of the islands except Hawaii have coral reefs around at least part of them. In the vicinity of Oahu, Maui, Kahoolawe, and the south coast of Molokai the surveys are fairly complete. In the vicinity of Hawaii the surveys are very inadequate except in the only harbor, Hilo Bay. The west coast of Lanai and the vicinity of the westernmost islands, Jauai and Niihau, are practically unsurveyed. The various channels between the islands from Taui to Oahu are fairly well surveyed. The others are practically without surveys. (See fig. 23, opposite p. 84.)

78. PHILIPPINE ISLANDS.—The Philippine Islands are composed of not less than 3,000 islands and islets covering an area of approximately 150,000 square miles and about the same as that of the five New England States and the State of New York combined. The total length of the general coast line, measured on small-scale charts using 3-mile spaces of dividers and omitting islands and bays less than 3 miles long, is approximately 10,850 miles, or about the same as that for the entire Atlantic coast of the United States, including the islands. The unsurveyed hydrography covers a large area on account of the necessity of extending this work, in some localities for many miles offshore, and on account of the very extensive area of the Sulu Sea. The unsurveyed regions are as follows: The northeast coast of Luzon from Polillo Island northward to Aparri; the region off the north coast of Luzon, including the Babyan Islands, Balintang Channel, the Natan Islands, and Bashi Channel; the west coast of the island of Palawan; the south coast of Mindanao, from Pola Point to Malita, in Davao Gulf; the Sulu Archipelago and the Sulu Sea from the Tubbataha Reefs south to the limit of our possessions off the coast of Borneo. (See fig. 24, opposite p. 84.)

79. NORTHEAST COAST OF LUZON.—This entire unsurveyed region, from Polillo Island on the south to Aparri on the north, is of little commercial importance, and being quite free from dangers to navigation the execution of the work is being delayed until more important localities are completed. Little reliable information relating to this region is available, but a number of good anchorages have been reported. Among these are the inner harbors of Port San Vincente, Dilasac Bay, Casiguran Sound, and Dingalan Bay. The first and third mentioned are excellent typhoon harbors. The work must, however, be done during the season of frequent typhoons, it being impossible to approach the coast at any other time of the year on account of the heavy sea caused by the northeast monsoon. (See fig. 24, opposite p. 84.)

80. OFF NORTH COAST OF LUZON.—A survey should be made of the islands and the waters to the northward of Luzon as far as Bashi

Channel, as, in accordance with the numerous reports, there is considerable uncertainty in regard to the true location of the islands and the rocks that are dangerous to navigation in the locality. As it is in the region visited by frequent typhoons, the work should be undertaken during the period when the typhoons are less frequent. (See fig. 24, opposite p. 84.)

81. West and East Coast of Palawan.—The coast line of the island of Palawan is very irregular, indented with deep bays, forming some of the finest harbors in the archipelago. The whole region about the island and extending southward to Balabac Island, to Cagayan Sulu, and off the north coast of Borneo consists of coral reefs, many small islets, and innumerable hidden dangers to navigation. To the westward of Palawan reefs dangers extend to over 100 miles off shore. The hydrographic survey of this region involves an immense amount of labor. A preliminary survey for the location of channels through the reefs and entrances to harbors will first be necessary. This work was in progress during the fiscal year. These localities must be swept with the wire drag. (See fig. 24, opposite p. 84.)

82. West Coast of Mindanao.—This island is of little commercial importance due to the absence of harbors and having a rugged mountainous country adjacent to the coast which is not adapted to the growth of any of the staple products. The usual steamer tracks do not approach the shore within 4 or 5 miles, a sufficient distance to avoid all dangers. For these reasons the surveys now in progress have been postponed for more important localities.

83. South Coast of Mindanao.—This stretch of about 150 miles, from Pola Point to Malita in Davao Gulf, is similar in many respects to the west coast. In general it is bold and steep, with numerous outlying reefs, which, however, do not extend a great distance from shore. The triangulation for furnishing the controlling positions for the hydrography and topography presents a difficult problem, the shore line being invisible from the peaks and ridges but a short distance back.

84. Sulu Archipelago.—This region, about 75 miles wide, extending in a southwesterly direction from Zamboanga on the southern coast of Mindanao to the coast of Borneo, a distance of about 180 miles, has scattered over it about 300 islands and islets and numerous hidden dangers to navigation. Surveys in this area are now in progress. It required a survey of the most careful and intricate character, and much of the locality must be swept with the wire drag after the present hydrographic survey is made. The formation is coral and dangerous to navigation, as rocks are frequently found in localities where they are least expected to exist. The currents in the region are very strong. The physical conditions are such that excellent control to coordinate the work with that along the coast of Mindanao can be obtained. (See fig. 24, opposite p. 84.)

85. Sulu Sea.—The northern end as far south as the Tubbataha Reefs, except certain small areas, has been surveyed with a fair degree of accuracy, but owing to the coral formations, where hidden dangers frequently exist, wire-drag sweeping will be necessary in selected passages. A large part of the region to the south of the

Tubbataha Reefs remains unsurveyed, except for a reconnaissance with approximate locations by navigational methods. A survey of this area is now in progress. Numerous rocks and reefs dangerous to navigation are scattered throughout the sea, but certain well-defined passages have been examined with sufficient accuracy to make navigation through them reasonably safe. (See fig. 24, opposite p. 84.)

GEODETIC WORK.

The control surveys carried on in the interior of the United States and in Alaska by the U. S. Coast and Geodetic Survey are very important functions of the Government, for they are essential to the efficient development of our industries, transportation, and commerce.

There is scarcely a human activity of any magnitude that is not dependent on exact knowledge of the configuration of the ground within the area in which the activity is carried on, and also on a knowledge of geographic positions and elevations of topographic features. All of this information is furnished by topographic surveys such as are made by the topographic branch of the U. S. Geological Survey.

For many years the Coast and Geodetic Survey has been endeavoring to meet the needs of the surveyor and map maker by extending long arcs of triangulation and lines of leveling through the country, but the great expansion of our industries, commerce, and especially the development of our highway systems and the construction of power plants have made the progress of the control surveys totally inadequate to the demands made for control data.

The Coast and Geodetic Survey is the only national organization charged with the extension of the fundamental control surveys through the country and in Alaska, and the people of this country look to the Coast and Geodetic Survey to meet their requirements for geographic positions and elevations on which to base their surveys, maps, and other engineering operations.

There are seven areas in the United States to-day, each greater than 100,000 square miles, in which there are no fundamental geographic positions, and there are seven areas, each larger than 90,000 square miles, in which there are no precise elevations. This seems to be a most anomalous condition for a country like the United States, which is so highly developed and which is spending so many millions of dollars annually in engineering works which require an accurate knowledge of position and elevation. Many millions of dollars are spent annually on highways alone, and yet it has been stated that if the country were completely surveyed topographically and these surveys were based on precise fundamental control systems the saving in a few years in the construction and maintenance of the highway system alone would pay for completing the topographic map. It is strongly urged that funds be made available for the rapid construction and completion of the fundamental control work of the United States. It is also urged that larger appropriations be made available for the extension of control systems of Alaska which is now beginning a great industrial development.

It is almost as unreasonable to expect surveys and maps to be made of a large area without a proper framework in the form of precise

triangulation and leveling as it would be to erect the walls, floors, and other parts of a large building without first having erected the steel framework.

The appropriation made to the Coast and Geodetic Survey for carrying on gravity observations in the United States proper are adequate for that purpose, but it is believed to be very important, and this view is indorsed by many geologists, that the gravimetric survey of the United States should be extended to offlying islands and contiguous coasts with a view to studying the condition of the earth's crust in regions beyond our own area. It is also important that gravimetric surveys should be made in Alaska, Porto Rico, the Hawaiian Islands, the Philippines, and in other island possessions of the United States in order to extend the earth crust studies of the bureau. For this purpose additional appropriation and authority should be granted by Congress.

The Coast and Geodetic Survey has cooperated with the U. S. Geological Survey in the extension of precise level lines in the States of Connecticut, Montana, and Wyoming. That part of the work to be done in Wyoming is largely in the Yellowstone Park. The chiefs of party and the instrumental equipment are furnished by the Coast and Geodetic Survey while the other equipment and party expenses are provided by the U. S. Geological Survey. These two pieces of work are special in their nature and do not come within the plans for general control surveys of the Coast and Geodetic Survey which are to be made in the near future.

The Coast and Geodetic Survey has cooperated to a limited exent during the past fiscal year with officials of Greensboro and Durham, N. C.; Richmond, Va.; and Columbus, Ohio. The cooperation consisted largely in giving advice and making suggestions as to the accuracy with which control surveys should be made over the areas of the cities in question.

Excellent progress was made during the fiscal year on the earthquake investigation in California. The work consisted of precise triangulation, designed to detect any horizontal movements which have occurred within the area covered by the triangulation since the stations were established from 25 to 40 years ago. Preliminary results of the work done during the season of 1922 have been furnished a number of seismologists, but final results will not be available until longitude determinations have been made at a number of the triangulation stations at which were also observed the astronomic azimuths. By means of the astronomic data both the old and the new triangulation can be made more accurate, and differences in the geographic positions by the two systems will then most nearly represent earth movements.

Several members of the Coast and Geodetic Survey have taken part during the past fiscal year in the activities of the Board of Surveys and Maps, created by Executive order to encourage cooperation of the various map making and map using bureaus of the Government. The board has done excellent work in standardizing surveying and mapping practices and has been the means of enabling officials of the various bureaus to get in personal contact, with the results that each bureau having representation on the board is doing its utmost to be of service to any other bureau needing its help.

The board has also been the means of disseminating information to the public in regard to the surveying and mapping data which exist in the various Government organizations.

The cooperative plan arranged during the previous fiscal year by officials of the Coast and Geodetic Survey and of the General Land Office, whereby an engineer of the latter organization was to be assigned to each of the triangulation parties of the Coast and Geodetic Survey, was continued in effect during the fiscal year 1923. It was found that by this plan it was possible to identify positively General Land Office marks and tie them into the triangulation system of the country. This resulted in furnishing horizontal coordinates for the land system in the regions covered by the triangulation which will make it possible for the land lines to be placed in their proper geographic positions on maps made by organizations of the Government and by private map makers.

PRESENT CONDITION OF THE MAGNETIC SURVEY.

The magnetic survey of the United States as planned in 1899 included the establishment of a magnetic station at every county seat in the United States. This plan is so near completion that there remain only 136 county seats to be occupied out of a total of 3,064. Of this number 34 are new counties established since the survey in their region, and 102 are, in most cases, in counties that were not readily reached at the time of the survey.

The magnetic survey as being carried on at the present time includes observations at the hitherto unoccupied county seats, observations at new stations not at county seats, additional observations in places of local magnetic disturbances, the occupation of repeat stations, and the recovery and replacement of old stations, including the station and reference mark. The two last-named parts of the work are chief in magnitude and importance.

A program has been adopted which includes the occupation of about 40 stations a year for the purpose of supplementing the observatory observations in recording the changes in the earth's magnetism. These stations are scattered throughout the United States, and the work is so planned that, in so far as possible, each one will be occcupied at five-year intervals.

During the fiscal year a very successful effort was made to learn the condition of magnetic stations from county and other local surveyors in order that the stations might be kept in such condition as to be available for local use in standardizing surveying instruments. As the result of information from these surveyors and the field operations of the bureau, the condition of 767 out of 3,719 stations, or 20.6 per cent of the total number, is now known; 325 of these need replacement in part or entirely, in addition to 24 which have been inspected and replaced during the year. The replacement program is now of greater importance than the occupation of new stations.

As the result of correspondence with more than 1,000 local surveyors the conditions are better known than formerly in regard to the use of magnetic survey methods throughout the United States. The States will be discussed in detail.

MAINE.—There is considerable interest in the early values of the declination, and old lines are constantly being retraced. Useful information in regard to early values has been received. Some inspection and replacement of stations is needed.

NEW HAMPSHIRE.—Magnetic methods are considerably used in retracing old surveys. There is therefore much interest in the early values of the declination. Some areas of local disturbances should be further investigated.

VERMONT.—Most of the town lines were run between 1780 and 1820 and changes of the declination from that period to the present time are needed for retracing old lines.

MASSACHUSETTS AND RHODE ISLAND.—Magnetic methods have been generally superseded except for occasionally retracing old lines. The adoption of more exact methods has reduced the interest in magnetic methods.

CONNECTICUT.—There is considerable interest in the early values needed for the retracing of old surveys.

NEW YORK.—Land surveys by magnetic methods are made in some parts of the State and old lines are rerun. A number of county surveyors regularly standardize their instruments at the magnetic stations. The northern and western parts of the State show considerable local disturbance, and these areas should be more fully examined.

PENNSYLVANIA.—Magnetic methods are being used to some extent for farm and woodland surveys, and in the past approximately all such surveys were so made. Beds of magnetic iron ore have been traced with the use of the magnetic needle. The magnetic stations are used to a considerable extent for standardizing instruments.

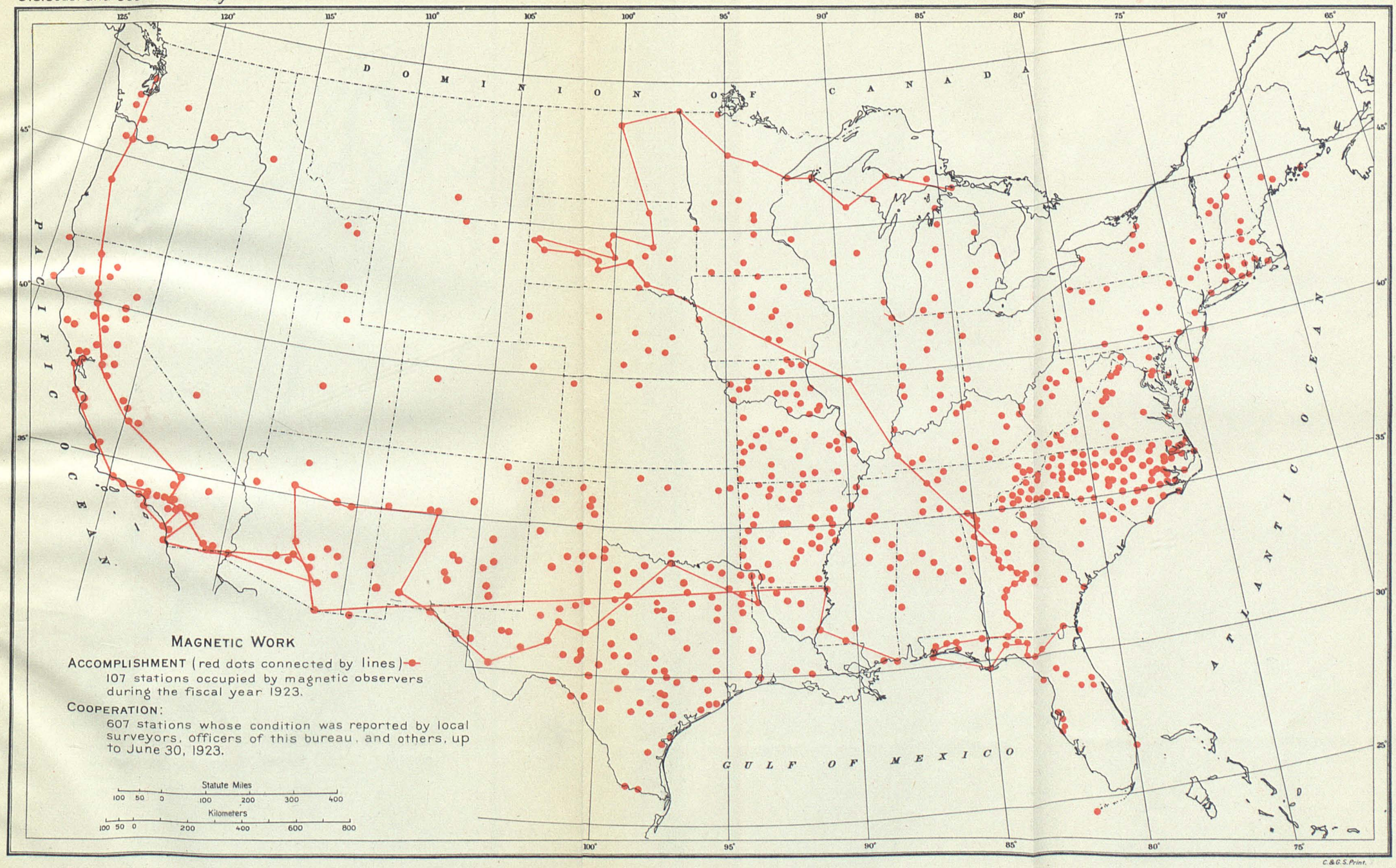
NEW JERSEY.—Magnetic methods are used somewhat for retracing old surveys and for the search for magnetic iron ore, but not to any great extent.

MARYLAND.—A very complete magnetic survey of Maryland was made about 25 years ago, but many of the old stations were not well marked or the marks have disappeared with time, and there is therefore considerable need for inspection and replacement of stations. A number of counties are still using magnetic methods, and practically all bearings in deeds are referred to the magnetic meridian; there is therefore considerable interest in early values.

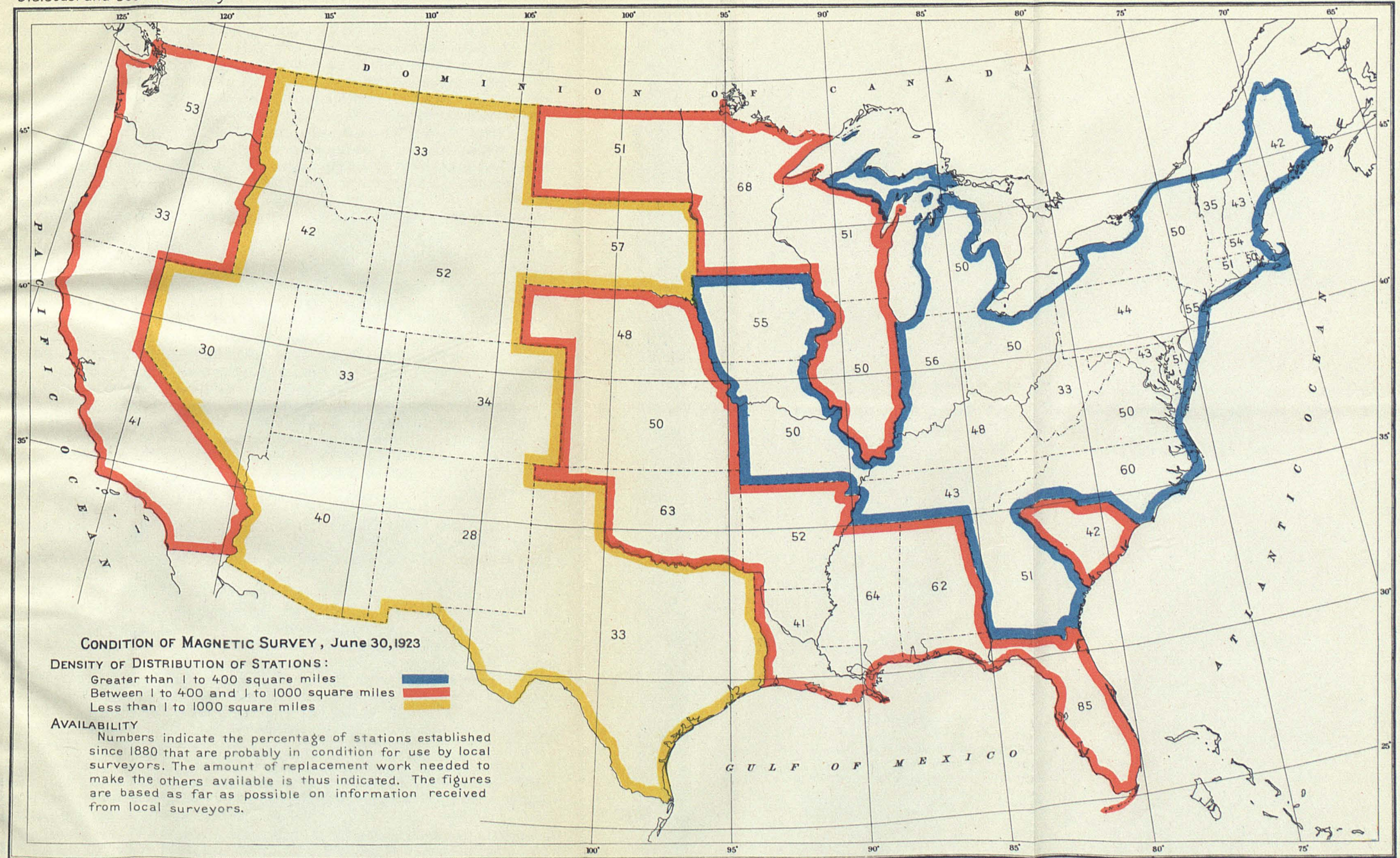
DELAWARE.—Magnetic methods are apparently very little used.

VIRGINIA.—Magnetic methods are very generally used. There is considerable trouble in retracing old surveys. In many cases it has been difficult for surveyors to carry out the requirement of the law for standardizing of magnetic needles because of the poor condition of the magnetic stations. Inspection and replacement of stations is urgently needed. Many surveyors express willingness to cooperate in the magnetic work of the bureau.

WEST VIRGINIA.—Magnetic methods for making land surveys are and have been generally used. In some of the mountain districts the early surveys were made with poor instruments and great difficulty is experienced in retracements. Inspection and replacing of stations is needed.


DOMINION OF CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
125°
120°
115°
110°
105°
100°
95°
90°
85°
80°
75°
70°
65°
45°
40°
35°
30°
25°
MAGNETIC WORK
ACCOMPLISHMENT (red dots connected by lines)
107 stations occupied by magnetic observers during the fiscal year 1923.
COOPERATION:
607 stations whose condition was reported by local surveyors, officers of this bureau, and others, up to June 30, 1923.
Statute Miles
100 50 0 100 200 300 400
Kilometers
100 50 0 200 400 600 800

C.&G.S. Print.


DOMINION OF CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
125° 120° 115° 110° 105° 100° 95° 90° 85° 80° 75° 70° 65°
45° 40° 35° 30° 25°
53 33 51 68 42
33 42 57 51 50 35 43 50
52 54 51 50
55 44 55
48 50 56 50 43 51
30 33 50 33
34 50 48 50
41 60
43
63 42
40 28 52 51
64 62
41
33
85
CONDITION OF MAGNETIC SURVEY, June 30, 1923
DENSITY OF DISTRIBUTION OF STATIONS:
Greater than 1 to 400 square miles
Between 1 to 400 and 1 to 1000 square miles
Less than 1 to 1000 square miles
AVAILABILITY
Numbers indicate the percentage of stations established since 1880 that are probably in condition for use by local surveyors. The amount of replacement work needed to make the others available is thus indicated. The figures are based as far as possible on information received from local surveyors.
C.&G.S. Print.

NORTH CAROLINA.—A complete magnetic survey of the State was made by cooperation of the State Geological Survey with the Coast and Geodetic Survey. Through the cooperation of the State geologist and various local surveyors the present condition of 82 of the stations is known; 40 need replacement in various degrees, and this work will be started during the next fiscal year. Improvement in magnetic methods used in making land surveys is an urgent need of this State according to the various reports. The magnetic conditions generally favor the use of the compass, and much early work was done with inferior instruments and methods at a time when land was cheap; consequently difficulty has arisen in retracing old lines. The information furnished by this bureau is in constant demand and is considerably used.

SOUTH CAROLINA.—The magnetic compass is much used, but the failure of early surveyors to understand secular change in the declination has caused much trouble. Much needed replacement of stations is planned for the near future. Many surveyors find the information furnished by this bureau to be very useful.

GEORGIA.—Frequent land surveys are made by magnetic methods. Errors made in the early surveys are the source of much trouble, and the lack of knowledge of the secular change has introduced many errors. The State is subdivided into comparatively small counties, and it is therefore a greater task to keep the stations at county seats in available condition. The work, however, has been systematically undertaken and should be completed within a few years.

FLORIDA.—Surveys by magnetic methods are considered very satisfactory. With the recent completion of an extensive program there are now stations at all county seats, all of which have been occupied since 1914, the great majority of them within the last two years. Little additional work in Florida is contemplated at the present time.

ALABAMA.—Land surveys by magnetic methods are frequently made. Some discrepancies in the old surveys have been reported. The possibility of finding iron ore by magnetic methods is being investigated.

MISSISSIPPI.—The early surveys in Mississippi were made from 1826 to 1834, and in many cases there is considerable difficulty in rerunning these old lines. There is considerable interest in the use of magnetic methods.

TENNESSEE.—The early surveys cover the period from 1796 to 1837. Discrepancies in regard to these old lines are frequent. The information furnished by this bureau is stated to be extremely valuable and is frequently requested for use in court. Considerable replacement work is needed in addition to that which was in progress at the end of the fiscal year.

KENTUCKY.—There is considerable demand for magnetic information, and the replacement of defective stations is important. The isogonic lines are very irregular in this State, and more observations are needed.

OHIO.—Surveys are made from time to time by magnetic methods, but, as a rule, more accurate methods are in general use.

INDIANA.—The early lines were all run with the magnetic compass, but the compass is not used in rerunning such lines. More accurate methods are used in the vicinity of cities.

ILLINOIS.—There is a moderate amount of interest in magnetic stations, especially in points where the true meridian has been established. In most of the early surveys the General Land Office used the magnetic compass, and information in regard to changes in the declination is of considerable importance. In some parts of the State land surveys are now being made by compass, in others it is considerably used for retracing old lines. Correspondence with surveyors indicates interest, and the discussion is exceptionally intelligent. There is but little local disturbance in the southern part of the State but considerable in the northern.

WISCONSIN.—Much of the early surveying was done with the magnetic compass, and it is still used in retracing old lines. In some parts of the State the loss of monuments is becoming a serious matter. There is considerable interest in magnetic stations and in current values of the declination, apparently for comparison with values in use for retracing old lines.

MINNESOTA.—There is moderate use for the magnetic needle to retrace surveys made 60 years ago. There is considerable local disturbance in this State.

IOWA.—Areas of local disturbance are widespread and handicap the local surveyor who desires to use magnetic methods.

MISSOURI.—The early surveys were made from about 1815 to 1820 by use of the magnetic needle. There is considerable interest in present and past values of the magnetic declination. The magnetic needle is much used for farm and woodland surveying. The condition of 50 per cent of stations is known, and about half of these require replacement. In some parts of the State there is considerable local attraction.

ARKANSAS.—The early surveys were made from 1825 to 1830, and many of the old corners have disappeared. Early and present values of the declination are in constant demand. The condition of about 50 per cent of the stations is known, and of these about half need revision.

LOUISIANA.—Some of the surveys known as Spanish grants were made prior to the purchase of the territory in 1803 and are hard to trace. Many of the surveys were made between 1812 and 1835, but there is considerable difficulty in retracing these, even with the best available magnetic information. There is considerable need for inspection and replacement of magnetic stations which have become defective.

TEXAS.—Various methods were used in the early surveys of Texas; many of them defective because made in the presence of hostile Indians. In some parts of Texas the vara is used and the determination of bearings by rough magnetic methods. A strong appreciation is expressed of the usefulness of the magnetic data of the station. The loss of stations has been exceptionally high for various reasons, and from known information a year's work of one observer would be required for replacements. Twenty-one county seats have not yet been occupied. Conditions are favorable to the use of the magnetic needle in making surveys.

OKLAHOMA.—The chief use for the magnetic needle is in rerunning old lines. There is considerable difficulty in findng old corners. Many stations need to be inspected and replaced.

KANSAS.—There is considerable interest in magnetic stations and in values of the declination at different times in connection with the rerunning of old lines in the public-land survey.

NEBRASKA.—The magnetic needle is used to some extent in rerunning old lines.

SOUTH DAKOTA.—Additional magnetic observations are needed in some parts of the State. The needle is used some in retracing old lines.

NORTH DAKOTA.—There is a limited use for the needle in retracing old lines.

MONTANA.—Additional stations are needed at 13 county seats and replacement and inspection of other stations badly needed. Conditions are not unfavorable for magnetic survey methods.

WYOMING.—There is need for the revision of existing stations; there is some demand for magnetic information for use in rerunning old lines.

IDAHO.—In some parts of the State local disturbances interfere with the running of the old lines.

COLORADO.—The chief use for the magnetic compass is in rerunning old lines which were run about 40 years ago.

UTAH.—The chief need is for additional stations and for replacement of poorly marked ones. Magnetic methods are used in several counties.

NEVADA.—The condition of the magnetic survey in this State is most unsatisfactory, even when the lack of density of population is considered. More stations are needed, especially those at six county seats, but the great need is the replacement of most of the old stations.

NEW MEXICO.—Interest in magnetic methods is moderate. Many of the magnetic stations need replacement.

ARIZONA.—There is considerable use for the magnetic needle and demand for magnetic stations. The surveys made in about 1870 were executed under difficult conditions, and many corners have been lost.

CALIFORNIA.—The declination is recorded on all land surveys, but in most parts of the State lines are run by more precise methods. The magnetic compass is used to some extent for forest work. A moderate amount of replacement work will meet the needs of this State.

OREGON.—There is need of revision of old stations and for establishing new ones to get sufficient information for tracing the isogonic lines. There is a great deal of local disturbance in small amounts which greatly distort the isogonic lines.

WASHINGTON.—The needs are revision and replacement of stations. There is some local disturbance in the southern part of the State, but apparently the amount is small.

State.	Condition of known stations.		Original marking, unknown stations.		Total marked stations.	Counties.	County seats not occupied.	Repeat stations.
	Good.	Revision needed.	Good.	Poor.				
Alabama	9	2	57	8	76	65	0	4
Arizona	10	10	9	12	41	14	2	3
Arkansas	20	17	47	6	90	75	3	3
California	26	25	23	34	108	58	5	10
Colorado	0	3	51	22	76	63	2	6
Connecticut	5	3	14	1	23	8	0	1
Delaware	0	0	8	3	11	3	1	0
Florida	45	3	23	11	82	61	1	6
Georgia	27	5	122	9	163	160	6	7
Idaho	5	2	27	13	47	47	7	6
Illinois	4	1	102	4	111	102	2	4
Indiana	9	5	82	0	96	92	0	4
Iowa	8	5	102	5	120	99	0	6
Kansas	3	2	95	8	108	104	1	6
Kentucky	5	8	89	11	113	120	[1] 5	3
Louisiana	4	4	47	13	68	64	2	3
Maine	1	3	33	9	46	16	0	3
Maryland	2	2	22	5	31	24	0	2
Massachusetts	4	1	27	3	35	14	1	2
Michigan	8	6	73	11	98	83	4	4
Minnesota	12	3	79	18	112	86	6	4
Mississippi	10	4	73	4	91	82	4	4
Missouri	32	18	50	11	111	115	0	5
Montana	5	1	33	27	66	53	13	7
Nebraska	6	4	89	6	105	93	2	5
Nevada	0	1	5	7	13	17	6	4
New Hampshire	1	2	24	1	28	10	0	1
New Jersey	1	2	55	0	58	21	1	1
New Mexico	5	14	24	20	63	29	1	3
New York	5	3	88	7	103	62	2	5
North Carolina	49	39	19	0	107	100	3	5
North Dakota	4	0	53	6	63	53	9	4
Ohio	4	1	92	2	99	88	2	4
Oklahoma	7	3	75	7	92	77	2	6
Oregon	3	0	30	29	62	36	3	3
Pennsylvania	7	6	68	7	88	67	1	4
Rhode Island	1	0	4	1	6	5	0	1
South Carolina	3	7	30	9	49	46	1	4
South Dakota	15	2	46	6	69	68	0	4
Tennessee	8	9	75	10	102	95	1	5
Texas	40	74	134	15	263	254	19	13
Utah	0	2	15	4	21	29	9	2
Vermont	3	1	21	11	36	13	0	3
Virginia	12	8	81	15	116	100	4	4
Washington	5	3	31	16	55	39	2	3
West Virginia	3	8	48	9	68	55	2	2
Wisconsin	4	2	90	0	96	71	1	6
Wyoming	4	1	27	2	34	21	0	4
Total	444	325	2,512	438	3,719	3,064	136	199

[1] Several stations at county seats not marked.

The information in regard to the condition of stations is fairly complete for North Carolina, Florida, Arkansas, Missouri, Texas, New Mexio, Arizona, and California. The amount of revision work required in the other States is not always indicated, as the facts are not accurately known. In general, the correspondence indicates that magnetic methods were and are used where land is cheap, and the expense of a more accurate survey has not appeared to be warranted. Further, in practically all of the States land surveys have been made by magnetic methods some time in the past, and magnetic information is needed for retracing old lines. There are many parts of the country where the use of instruments properly standardized at the Coast and Geodetic Survey stations would greatly improve the records and prevent future disputes. The matter of actual use of magnetic methods, though not strictly a part of the statement of

the present condition of the magnetic survey, is so closely related that it can not be ignored.

PORTO RICO.—It is expected that all necessary work will be done during the next fiscal year.

ALASKA.—A considerable amount of magnetic work has been done along the main lines of travel, but little of it is recent. Observations of the declination made recently in southeastern Alaska are especially valuable in defining areas of local disturbances. Little magnetic information is available for the interior of Alaska. Observations are needed along the lines of the Government railroad. There is especial need for observations on the Aleutian Islands, owing to the fact that the Great Circle course from the Pacific coast of the United States to the Orient passes close to these islands. Observations should be made on some of the islands in Bering Sea. The small value of the horizontal force and lack of knowledge of the values of the declination and possible fluctuations make navigation precarious. It will take several years of continuous work in Alaska to obtain needed information.

HAWAII.—Occupation of repeat stations and revision of stations is needed.

GUAM.—Magnetic surveys have been made by this bureau, but advantage should be taken of a stop by transport at Guam to occupy one or more repeat stations.

PHILIPPINE ISLANDS.—The occupation of repeat stations and revision of stations is urgently needed, and this work should be taken up without delay. It is only because we know from observations at Manila that the secular change is slight at the present time that this lack of a magnetic resurvey has not resulted in placing erroneous values of the declination on the charts of the Philippine Islands. It is probable that the rate of secular change will increase in the near future.

OBSERVATORIES.—Each of the observatories is now furnishing a complete and continuous record of the values of the magnetic elements. As these instruments record only the variations, determinations of the absolute values are frequently made. The result of this work is that at five widely scattered places within the jurisdiction of the United States—namely, Vieques, P. R.; Cheltenham, Md.; Tucson, Ariz.; Sitka, Alaska; and near Honolulu, Hawaii—continuous values of the magnetic elements are available. As a result it is possible to reduce the values obtained in the field surveys to the standard values. Need for this is indicated by the statement that without such correction the change in declination from year to year could not be furnished. The observatory records show magnetic storms for periods when the actual values differ more or less from the normal values. The observatories near the seacoast have an important function in that they indicate the rates of change from year to year over adjoining sea areas. This makes it unnecessary to remeasure the declination at frequent intervals.

Even with the old-type seismograph in use at all stations except one a great amount of useful information in regard to earthquakes has been obtained. The observatories are in a position to do a much higher grade of seismological work if made of primary importance as a function of the work. The five observatories named do not pro-

vide all of the needed information. There is urgent need for an additional observatory in the Canal Zone.

SEA OBSERVATIONS.—This bureau has not made magnetic observations at sea for a number of years, as it has been felt that the observations of the *Carnegie*, combined with shore observations along the coast, give all necessary results. There is urgent need, however, for observations in the shallow waters along the Atlantic coast, and these could be made by means of a nonmagnetic launch or scow which could be held in a given direction. It should be understood that in most cases present values for most of the bays and inlets are deduced from shore observations, and accordingly the charts do not show areas of local disturbances.

TIDE AND CURRENT WORK.

The current observations carried on for a number of years on the light vessels along both coasts of the United States in connection with a study of coastal wind-driven currents have furnished sufficient data to warrant giving the mariner considerable information relative to the general law of coastal currents. Since the current data obtained from the observations on the light vessels limit our knowledge of the coastal currents to the vicinities of these vessels only, it is necessary finally to make short series of observations from a survey vessel anchored at critical points between and simultaneous with observations at the light vessels. A correlation of the two series can then be made looking toward obtaining average conditions at these midway critical points. Such a survey is designed to bring out the effects of both the tidal currents and the wind-driven currents along the entire coast.

This work was begun in the early part of the calendar year 1922 on the Pacific coast. The *Surveyor* between Alaska seasons occupied four stations along the coasts of Washington and Oregon between light vessels. It has been found impossible, however, to continue this important work because of lack of sufficient experienced mathematicians in the office to work up the results and at the same time prepare the tide and current tables for the mariner and carry on the other normal activities of the tide and current division of the bureau. This emphasizes again the need of about six additional computers of a subprofessional grade to permit the division to carry on the work necessary to the proper and economical functioning of this important division.

The officers charged with the work of this division are making every effort to reduce to a minimum the amount of work of a routine nature. This result is gradually being accomplished by the devising of new instruments, methods, and forms for lessening this class of work. During the past year a portable tide gauge for the field work of the survey was devised by this division, the record from which will require no tabulations by the office force but constitutes a complete record in itself. It is proposed to devise a larger instrument having a somewhat similar record to replace the instruments now maintained at the principal tidal stations of the survey. It is also proposed during the next year to devise a form for tabulating for mean sea level directly from the record to an adding machine carrying this form.

The current and tidal conditions in our principal harbors are not well known, but with the recent survey in New York Harbor, followed during the next fiscal year by such a survey in San Francisco Harbor, the following year in Delaware Bay, etc., will bring this phase of the work fairly well in hand. All this field work is done in cooperation with the Army engineers charged with the development of the harbors, who have stood half the expense of the field operations, the Coast and Geodetic Survey making all office computation and discussing and interpreting the resulting data.

Another matter of considerable importance in the tidal and current survey of our principal harbors is the encircling of the harbor with a line of precise levels, with branch lines where necessary, to connect all bench marks over the area into a common datum plane. This was not necessary at the time the survey was made in New York Harbor, owing to the fact that such a precise level net was already in existence over that territory. The appropriation for tidal and current work should be increased for the next fiscal year by $1,500 to do this essential work.

The cooperation of the Canadian Tidal and Current Survey has been obtained in securing observations in Seymour Narrows, Alaska, with a view to improving the predictions of slack waters for this strait, which is of considerable importance to United States vessels plying between our ports and southeastern Alaska. The observations made by Canadian officials during the present summer will be furnished this bureau for analysis and predictions on the Coast Survey predicting machine.

The currents in Seymour Narrows are of the hydraulic type, found in straits connecting two independently tided bodies of water, and are due to a temporary difference in head between the two bodies of water brought about by tidal action. While it is a comparatively simple matter to predict from tidal observations at each end of the strait the times the heads will be equalized and that slack water should occur, account must be taken of the momentum of this mass of water and of the continuance of the flow due to this inertia after equalization of heads.

No satisfactory series of tidal observations are at present available for each end of Seymour Narrows, and the Canadian Tidal and Current Survey has expressed a willingness to obtain these observations during the summer of 1923. These tidal observations, together with slacks observed several years ago, will make possible the accurate predicting of future slack waters for this important waterway in which at times the current velocity reaches 8 to 10 knots.

This is but one example of the cooperation of Canada and England in this important work. For many years the United States and England each made tidal predictions for a considerable number of the same ports published in their respective tide tables. A cooperative arrangement was made whereby the Coast Survey furnished England predictions for five ports in exchange for five. This has since been increased to nine ports, and recently the British Admiralty has requested that the number be increased to 15.

Under physical oceanography, comprising miscellaneous oceanographic observations and computations for the purpose of furnish-

ing information relative to densities, temperatures, ocean currents, and related matters to navigators, engineers, and scientists, very little has been done and much is required to bring our state of knowledge and amount of information to that of other even less important maritime nations. We have the Gulf Stream paralleling our entire Atlantic seaboard. A study of this oceanic river is one of the most important items in oceanography, which should be continued systematically by the survey. Considerable work of a reconnaissance nature was done a number of years ago by the Coast and Geodetic Survey in this important field, but lack of funds has not permitted further work.

At present the survey is making use of every available means for obtaining densities and temperatures. These are now being secured at 14 of the principal tidal stations maintained by the survey, and during the past year an attempt has been made to have densities and temperatures of the sea water made by observers on the light vessels in connection with the current observations being made on those vessels through the cooperation of the Lighthouse Service.

CHAPTER III.

PROGRAM FOR CURRENT FISCAL YEAR IN THE FIELD.

HYDROGRAPHIC AND TOPOGRAPHIC WORK.

ATLANTIC COAST.—*Offshore hydrography.*—The steamer *Lydonia* will continue the offshore hydrography in the vicinity of the Cape Fear River, which work is now in progress, until the latter part of November, when work will be taken up in the continuation of the offshore hydrography in the vicinity of St. Augustine, Fla. This latter work will continue until near the end of the fiscal year, when work will again be resumed by this vessel in the vicinity of the Cape Fear River. The steamers *Bache* and *Hydrographer* will continue the work in the Gulf of Mexico in the vicinity of Sabine Pass, extending the work westward toward Galveston.

Wire-drag work.—The work is now in progress off the coast of Maine, will be continued until the latter part of September, and if appropriations are sufficient will be taken up again next spring.

Inshore hydrography and topography.—If funds are available the latter part of the fiscal year, inshore hydrography and topography from Bull Bay to Winyah Bay will be completed, and this class of work will be continued from Savannah south. In addition to the inshore hydrography a topographic revision of the shore line will be accomplished by the parties working on the *Mikawe* and *Elsie.* If funds and equipment are available, a survey of Lake Okeechobee will be made during the fiscal year.

Virgin Islands.—The steamer *Ranger* with wire-drag launches will make a hydrographic survey of the Virgin Islands, supplementing the hydrography by wire-drag work. This survey will include a survey of all harbors and passages in these islands.

PACIFIC COAST.—*Offshore hydrography.*—Upon arrival of the steamer *Guide* on the west coast she will continue the offshore hydrography in the vicinity of southern California executed by the steamers *Discoverer* and *Pioneer* during the last fiscal year. This work will extend from the completed work close in shore to the 1,000-fathom curve and will be continued until March. From April until the end of the fiscal year the *Guide* will continue the offshore hydrography in the vicinity of Cape Blanco commenced by the party on the steamer *Lydonia* during the fiscal year 1922.

Revision work.—During the winter the parties which worked in Alaska during the summer will make revision surveys of different harbors of Puget Sound.

SOUTHEASTERN ALASKA.—*Offshore hydrography.*—The steamer *Surveyor* will continue the offshore hydrography and the combined operations, triangulations, topography, and hydrography upon which she was engaged during this fiscal year. It is contemplated that this

work will be continued without interruption to Cross Sound, as much work as possible being done each year.

Wire-drag surveys.—The steamer *Explorer* will continue wire-drag operations during the summer of 1923, which will complete the wire-drag work along the main inside ship channels from Dixon Entrance to Cape Spencer. Dependent upon the appropriations, it is uncertain whether or not that vessel will be engaged during the next fiscal season in the dragging of the more important side passages and of those arms and bays to which vessels go regularly.

Inshore hydrography.—As stated in the above paragraph, it is uncertain whether or not the party on the steamer *Explorer* will be engaged in wire-drag work during the next fiscal year. If the party is not so employed, a much-desired survey of Keku Strait and Tuxekan Passage by the party on the steamer *Explorer* will be executed.

WESTERN ALASKA.—*Triangulation, hydrography, and topography.*—The party on the steamer *Discoverer* will continue work in the vicinity of Shelikof Straits upon which she is now engaged during the fiscal year. The *Yukon* will be used by this party. The *Pioneer* will continue the survey of Morzhovoi and Cold Bays and the offshore work in the vicinity of Cape Pankof, upon which she is now engaged during the fiscal year. The launch *Wildcat* will be used in connection with this party. If funds are available, the *Natoma* will be used in making a survey of the northern part of Prince William Sound and of bays and inlets in this vicinity used regularly by commercial steamers.

HAWAIIAN ISLANDS.—*Inshore hydrography.*—The work will be executed by a detached party in the Hawaiian Islands during the fiscal year 1924 in the vicinity of Lahaina Roads.

PHILIPPINE ISLANDS.—*Triangulation and hydrography.*—Three vessels, the *Pathfinder*, *Fathomer*, and *Marinduque*, will operate during the fiscal year in continuation of the projects on which they are now engaged. This will include general survey operations on the west coast of Palawan Island and work in the southern part of the Archipelago.

OCEANOGRAPHY.

The steamer *Guide* on the trip from the east to the west coast of the United States will make deep-sea soundings and accumulate specimens of the bottom and water samples taken at the bottom. A sonic sounding apparatus has been installed and will be used in connection with the deep-sea sounding machine in the determination of depths. This work will be so planned as to supplement the work of this nature done during the last few years, so upon its completion there will be an excellent deep-sea survey on the route followed by vessels from the east coast to the west coast of the United States via the Panama Canal.

GEODETIC WORK.

TRIANGULATION.—The major project contemplated for the year 1924 is a continuation of the triangulation in Montana, Idaho, and Washington, which was begun in the fiscal year 1922 by observations started northward from Pocatello, Idaho. This project entails the completion of the arc from Pocatello northward to the forty-ninth

parallel triangulation, thence along the forty-ninth parallel from its intersection with the one hundred and ninth meridian westward to the Pacific Ocean, with a short arc extending from the vicinity of Umatilla, Oreg., northward to the forty-ninth parallel. Two parties will be engaged on the reconnaissance along the forty-ninth parallel during the first half of the fiscal year, and two observing parties will continue their operations throughout the fiscal year, except during the winter months. This constitutes part of the cooperative work with the Dominion of Canada, which has for its object the completion of an arc of precise triangulation along the boundary from the Pacific Ocean to Lake Superior.

Another party will be engaged during most of the fiscal year on another part of this cooperative work along the northern boundary of the United States. This party will extend triangulation and traverse from the Lake of the Woods eastward to the vicinity of the eastern end of Lake Namakan. Part of the traverse will be over a railroad, and this will be complete during the early months of the fiscal year 1924. Another section will be traversed over the ice, which will be executed shortly after the first of the calendar year when the ice becomes strong enough to support teams.

Precise triangulation in Alaska in extension of the work begun early in the spring of 1924 will be continued throughout the fiscal year whenever weather conditions permit.

PRECISE TRAVERSE.—Owing to the limitations set by our small appropriation for geodetic work, no precise traverse will be executed during the year except that mentioned above to be run over the ice in the vicinity of Rainy Lake.

LEVELING.—Only four precise level projects are contemplated for the ensuing fiscal year. The leveling party in New England and the Middle Atlantic States will be continued, except during the winter months. Revision levels will be run in Washington and Oregon, and a line of levels in South Dakota will be begun toward the latter part of the fiscal year. The precise level line from Fairbanks to Valdez, Alaska, will be completed during the first half of the fiscal year.

ASTRONOMY AND GRAVITY.—A party will be operating in southeastern Alaska during the early part of the year determining the astronomic longitude and latitude at a number of stations. The party will also observe azimuth and measure gravity at each of the longitude stations. It is expected that a similar party will also operate during the spring of 1924 in California.

A gravity party will begin work in the vicinity of Houston, Tex., in August, 1923. The stations will be selected with a view to further investigating the value of gravity observations in determining the subsurface structure of the earth.

MAGNETIC WORK.

Two magnetic observers will be kept at work for the greater part of the year in inspecting and replacing old magnetic stations reported gone or in bad condition, in occupying repeat stations for the determination of the secular change, and in establishing stations at places where observations have not previously been made. The work

of replacement will be mainly in California, Texas, and North Carolina; the occupation of repeat stations will be in the tier of States extending from Indiana to Maine and in the northwestern part of the country. Special observations will be made at the time of the solar eclipse on September 10.

The five magnetic observatories will continue the magnetic and seismological work as usual; buildings and equipment will be maintained and improvements made as found necessary.

It is planned to make special investigations at the Cheltenham magnetic observatory of a new type of vertical intensity variometer and of a method of temperature compensation for horizontal intensity variometers.

The instrumental outfits for field and observatory use will receive attention, and replacement and improvements will be made so far as available funds will permit.

TIDAL AND CURRENT WORK.

Early in the fiscal year, in cooperation with the Army engineers, it is proposed to carry out an extensive and final current and tidal survey of San Francisco Harbor, for which an appropriation was made by the last Congress.

Principal tidal stations representative of tidal conditions along the different stretches of coast will be continued at the following places:

Portland, Me.
Boston, Mass.
Atlantic City, N. J.
Philadelphia, Pa.
Baltimore, Md.
Charleston, S. C.
Fernandina, Fla.
Key West, Fla.
Cedar Keys, Fla.
Pensacola, Fla.
Galveston, Tex.
San Diego, Calif.
San Francisco, Calif.
Seattle, Wash.
Anacortes, Wash.

The tidal station at Anacortes, Wash., established for the purpose of defining a mean sea-level datum for connecting the Canadian and American precise leveling, will be continued during the fiscal year; also the tidal station established at Anchorage, Alaska, for the purpose of defining a mean sea-level datum for controlling the precise leveling in that section of Alaska.

In cooperation with the Scripps Institute, a principal tidal station will be installed on the long ocean pier at La Jolla, Calif. The importance of this station lies in its being the only station maintained by this survey on the open ocean on the Pacific coast. It will correspond to the ocean station maintained at Atlantic City for the Atlantic coast.

The tide gauge loaned to the Gandy Bridge Co. and installed at St. Petersburg, Fla., will be continued during the year for the purpose of defining tidal datum planes for use in connection with the construction of the bridge across Old Tampa Bay. The record from this gauge becomes the property of the Coast and Geodetic Survey at no cost except for the loan of a self-registering gauge.

One of the new portable automatc tide gauges devised during the past year by this bureau will be installed at Los Angeles, at the

request of that city. This gauge will be maintained by the city and the record become the property of the survey.

It is proposed to maintain a tidal station at Washington, D. C., for the purpose of testing, under the immediate supervision of this office, new instruments and appliances for the observation of tides.

It is a part of the program of the tidal and current work for the fiscal year to continue the installation of standard staffs and backing pieces to replace the old type staffs at all the principal stations maintained by the survey. In order to maintain a fixed zero of staff, a most essential matter in obtaining a long series of tidal observations, tide staffs of standard design with special backing piece, cap, and stop were designed in the division in 1920, and installation of these are being made as the different stations are visited until all the principal stations are so equipped.

A precise-level party will visit the locations of discontinued tidal stations in Maryland, Delaware, Pennsylvania, and New Jersey for the purpose of leveling to old nonregulation bench marks as they may be recovered and installing sufficient standard disk bench marks to comply with the present policy of the survey of maintaining five standard bench marks at all stations having a year of observations and one additional for each additional year of observations to a maximum of 10 disk bench marks. This work is absolutely necessary in order to perpetuate long series of observations which are now protected by a few nonregulation bench marks, many of which have been destroyed and others in danger of being lost.

Datum planes for the use of the engineer and mariner, based on tidal definition, are the only ones which lend themselves to coordination of surveys widely distributed and subsequently brought together. The survey has for many years by means of its principal and subsidiary tidal stations established bench marks, and is furnishing to engineers in all parts of the country descriptions and elevations of such bench marks based on mean sea level. Since an accurate determination of mean sea level can be obtained only from a comparatively long series of observations, the value of such bench marks and the importance of their preservation is apparent.

In order to carry on this essential work, it has been found necessary to curtail somewhat the current observations on the light vessels on both coasts. On the Atlantic coast observations will be continued only on Nantucket Shoals and Diamond Shoals Light Vessels. On the Pacific coast current observations will be continued for the full year at Blunts Reef Light Vessel, and for the period of the current and tidal survey of San Francisco Harbor observations will be made on San Francisco Light Vessel.

Part IV.—DETAILED STATEMENT OF FIELD WORK.

HYDROGRAPHIC AND TOPOGRAPHIC WORK, ATLANTIC COAST.

MAINE.

[Lieut. O. W. SWAINSON, Chief of Wire-Drag Party No. 1.]

SUMMARY OF RESULTS.—Triangulation: Length of scheme, 4 statute miles; 16 square statute miles of area covered; 3 signal poles erected; 4 signals built; 3 stations in main scheme occupied for horizontal measures; 3 stations occupied for vertical measures; 16 geographic positions determined. Leveling: 5 statute miles of tidal levels run.

The following deck officers were attached to this party from the dates specified: John McCormick, from June 11; V. A. Bishop, from June 12; J. C. Sammons, from June 18; W. T. Brown, from June 25; and I. Rittenburg, from June 25.

On June 4 the chief of party took over the wire-drag launches *Ogden* and *Rodgers*, then in storage at Fairhaven, Mass. As these launches and the equipment of wire-drag party No. 1 had not been in service for some time, a great deal of preparatory work was necessary. The party proceeded on June 7 to the working grounds in the vicinity of Portland, Me., arriving June 11. The remainder of the month was occupied in completing the overhaul of equipment, the establishing of the necessary control, and the preliminary training of new officers. The party was practically ready to start dragging at the end of the fiscal year.

MASSACHUSETTS (BOSTON FIELD STATION).

[Lieut. Commander D. B. WAINWRIGHT (retired), Inspector in Charge.]

This field station is charged with the maintenance of a chart sales agency, the gathering and submitting to the Washington office of data regarding changes in that vicinity affecting coast and geodetic charts and publications, and with furnishing to the local public such information as is requested. This field station was maintained throughout the fiscal year with quarters at Appraisers Stores, 408 Atlantic Avenue, Boston.

NEW YORK (NEW YORK FIELD STATION).

[Lieut. Commander ISAAC WINSTON (retired), Inspector in Charge, July to January; Commander H. C. DENSON, Inspector in Charge, February to June.]

This field station is charged with the maintenance of a chart sales agency, the gathering and submitting to the Washington office of data regarding changes in that vicinity affecting coast and geodetic charts and publications, and with furnishing to the local public such information as is requested. Frequently assistance is also rendered to survey parties operating in the vicinity of New York. The quarters of this station were moved during the month of February from the customhouse to Rooms 311–312 in the Maritime Exchange Building.

VIRGINIA.

[Lieut. EOLINE R. HAND, Commanding Steamer *Bache*.]

SUMMARY OF RESULTS.—Magnetic work: One sea station occupied for magnetic observations. Topography: 24 miles of plane table traverse to locate hydrographic signals, scale of topographic sheet, 1: 20,000. Hydrography: 1,547 square miles of area covered; 1,707 miles run while sounding; 3,948 positions determined, double angles; 18,440 soundings made; 3 tide stations established; 61 current stations occupied; 2 hydrographic sheets finished, scale of hydrographic sheets, 1: 40,000 and 1: 120,000.

On July 1, 1922, the *Bache* was undergoing repairs at Norfolk; meanwhile a detached party was engaged in erecting tall hydrographic signal NECK on the shore below Virginia Beach, and another party was sent to erect a tide gauge at Fishermans Island and establish an automatic gauge there. Repairs to the vessel were completed on July 19, and the next day the *Bache* sailed for the

working grounds outside the Virginia capes, stopping on the way to visit the tide gauge at Fishermans Island. On July 21 the hydrographic work began and was continued throughout the season. By November 3 all of the hydrographic work planned for the party, excepting one dead-reckoning line, had been completed and sounding operations were concluded. The vessel then returned to Norfolk, picking up the tide gauge from Fishermans Island on the way in. The following week the vessel went out again to obtain log factors and afterwards returned to port, thus closing the season's operations in this locality. Further repairs to the vessel were then undertaken and were in progress until December 12. After further inspection of the boiler some additional repairs were found necessary, and these were not completed until December 28. No further field work was done during the first half of the fiscal year.

During the season a number of tall hydrographic signals were erected along the coast south of Virginia Beach, the last being at Coast Guard Station No. 166 (new station), or 4 miles north of Currituck Light. It was impracticable to locate them by triangulation, and so the preliminary location of these signals was by topographic methods. An accurate taped traverse was made later by a separate party. The southern limit of fixed position hydrography is the 36° 30′ parallel of latitude, and the southernmost dead-reckoning line is in approximately latitude 36° 32′. Work was begun at the lower end and carried to the northward, and the whole area north to the junction of the old work was completed. The work extended to the 100-fathom curve, except where extension to the 1,000-fathom curve was required by supplemental instructions of June 6. Fixed position work was carried out about 16 miles, and beyond that all lines were located by dead reckoning. Sounding was done by the launch in the inshore area from the 2-fathom to the 5-fathom curve. The survey buoys were of the same type as those previously used. The spacing of lines conforms to the requirements of the instructions.

Comparison was made of existing soundings and no new shoal spots were found within the area controlled by fixed positions. The area off False Cape was very closely developed both by ship and launch.

Considerable experimental work was done to test the accuracy with which compass bearings from adjacent radio compass stations would locate the vessel while on dead-reckoning lines, and while the results appeared satisfactory for navigational purposes they proved to be without value as a means of more accurately locating dead-reckoning positions. The following radio compass stations cooperated with the *Bache* in these tests: Hog Island, Virginia Beach, Poyners Hill, and Hatteras.

A plain tide staff was maintained at Coast Guard Station No. 165 and observed during the times when hydrography was in progress in that vicinity. The required bench marks were established.

NORTH CAROLINA.

[Lieut. LEROY P. RAYNOR, in Charge of Launch *Mikawe*.]

SUMMARY OF RESULTS.—Triangulation, secondary: 10 signal poles erected; 7 stations in main scheme occupied for horizontal measures; 6 geographic positions determined. Leveling: 8 permanent bench marks established. Topography: 9.8 statute miles of detailed shore line surveyed; 2.5 statute miles of roads surveyed; scale of topographic sheet 1:20,000. Hydrography: 1 tidal station established.

Early in May, 1923, Lieutenant Raynor put the launch *Mikawe* in commission at Baltimore, Md., and proceeded to Southport, N. C., to take up field work in the vicinity of Cape Fear, in conjunction with the party of the steamer *Lydonia* and under the direction of the commanding officer of that vessel. During the remainder of the fiscal year this party was engaged in preliminary work, consisting of the building and locating of hydrographic signals, triangulation, the establishing of a tide station, and shore-line topography. On June 30 the party was practically ready to start hydrography.

[Lieut. A. M. SOBIERALSKI, Commanding Steamer *Lydonia*.]

SUMMARY OF RESULTS.—Triangulation, secondary: 11 square statute miles of area covered; 3 signal poles erected; 3 stations occupied for horizontal measures; 2 geographic positions determined. Magnetic work: 2 ship swings at sea. Hydrography: 148 square statute miles of area sounded; 302 statute miles run while sounding. 4,012 soundings obtained; 7 current stations occupied; 6 buoy signals placed and located; 2 tide stations established.

The following officers were attached to the party: Lieut. R. P. Eyman, executive officer; Lieut. (Junior Grade) C. D. Meaney, Lieut. (Junior Grade) R. F. A.

Studds, Lieut. (Junior Grade) C. J. Itter; John Wyer, chief engineer; and E. M. Denbo, deck officer.

This abstract covers coast hydrography in the vicinity of Cape Fear, N. C. Field work was started June 6 and was in progress at the end of the fiscal year.

An automatic tide gauge was established at Fort Caswell. One tall hydrographic signal was located by triangulation methods. Hydrography was started at the northern limits of the work assigned, and a strip over 2 miles wide and extending over 30 miles offshore was completed, besides a reconnaissance sounding line around the end of Frying Pan Shoals and some sounding in the vicinity of the entrance to the Cape Fear River.

FLORIDA.

[Lieut. Commander R. F. LUCE, Commanding Steamer *Lydonia*.]

SUMMARY OF RESULTS.—Triangulation: 3.5 square statute miles of area covered; 2 signals erected, 3 stations occupied for horizontal measures; 2.5 statute miles of traverse run; 3 geographic positions determined. Topography: 6.2 statute miles of shoreline run to locate 9 signals. Hydrography: 5 tall type signals erected, 218 square statute miles of area sounded; 408 statute miles run while sounding; 1,235 positions determined; 4,398 soundings obtained. Tides and currents: 1 tidal station established; 7 current stations occupied. Magnetic: 1 complete ship swing at sea.

This abstract covers work executed from December 6, 1922, to February 24, 1923. The following officers were attached to the party during this period: Lieut. R. P. Eyman, executive officer; Lieut. (Junior Grade) L. M. Mower, Lieut. (Junior Grade) C. D. Meaney, Lieut. (Junior Grade) E. F. Lewis, Lieut. (Junior Grade) R. F. A. Studds, Lieut. (Junior Grade) C. J. Itter, and John Wyer, chief engineer.

The necessary position control was first obtained by building and locating five tall-type hydrographic signals and planting and locating an offshore line of buoy signals. The hydrography accomplished consists of hand lead and trolley soundings from the shore line out to the 16-fathom curve and extending from the junction with previous work immediately south of St. Augustine southward to abreast Matanzas Inlet. After February 24 this work proceeded under the direction of Lieut. A. M. Sobieralski.

[Lieut. A. M. SOBIERALSKI, Commanding Steamer *Lydonia*.]

SUMMARY OF RESULTS.—Traverse: 3.5 statute miles of traverse run; 1 principal station occupied for horizontal measures. Topography: 13.5 statute miles of shore-line run; 1 topographic sheet finished, scale 1:20,000. Hydrography: 709 square statute miles of area sounded; 840 statute miles run while sounding; 7,108 positions determined, double angles; 21,246 soundings obtained; 2 tidal stations established; 35 current stations occupied; 3 hydrographic sheets finished, scales 1:20,000, 1:40,000, and 1:80,000.

This abstract covers the period from February 24, 1923, to April 23, 1923, the close of the season's work in this locality. With the exception of the chief of party, the officer personnel remained unchanged. The work was a continuation of that in progress in the immediately preceding months under the direction of Lieut. Commander R. F. Luce. The usual methods for executing this class of work were employed.

An automatic tide gauge was established at St. Augustine on March 18, and readings continued till April 30. The gauge was placed in the same position occupied in 1916, and the staff referred to the same bench marks.

Hydrography.—In the area covered by Captain Luce a number of splits and cross lines were run, and the work was extended out to the 100-fathom curve. The inshore launch hydrography was extended from a junction with the work done by the *Isis* down to latitude 29° 35′. The inshore and offshore soundings were extended from a junction with the work done by Captain Luce down to latitude 29° 35′, so that the work is complete down to this latitude.

Topography.—The topography was carried down to latitude 29° 35′. While the primary object of this work was to locate signals for launch hydrography, considerable detail was shown around Matanzas Inlet.

In accordance with instructions dated January 10, 1923, a special examination was made of the spring off the coast of Florida below St. Augustine. In general, the examination consisted of a hydrographic development, collection of water specimens at various depths, and a record of temperatures at various depths. This remarkable phenomenon has excited considerable interest, and a long account of it appeared in Harper's Weekly about 25 years ago.

The survey of the coast of Florida has been followed with interest by mariners using these waters; the accurate location of the 10-fathom curve interests them particularly. The current and temperature observations on the dead-reckoning lines give valuable information which can be compared with previous investigations of the Gulf Stream, and an accurate determination of the inshore limits of the Gulf stream, a subject which is of great interest to mariners.

LOUISIANA.

[Lieut. FRANK S. BORDEN, Commanding Steamer *Hydrographer.*]

SUMMARY OF RESULTS.—Topography: 5.3 square miles of area surveyed; 33 miles of detailed shore line surveyed; 1 topographic sheet finished, scale 1:20,000. Hydrography: 973 square miles of area covered; 2,038.8 miles run while sounding; 4,575 positions determined (double angles); 36,133 soundings made; 1 tide station established; 2 hydrographic sheets finished, scale of hydrographic sheets 1:80,000.

The following officers were attached to the party: Lieut. W. D. Patterson, executive officer, entire season; Ensign A. R. Jessup, entire season; Ensign A. H. Wagener, to July 31; E. F. Delaney, deck officer, entire season; and H. O. Olson, deck officer, from August 5.

This abstract covers the operations of the steamer *Hydrographer* from the date of taking up combined work in the vicinity of Chandeleur and Breton Sound to the date of its completion. The party began this project on June 12, 1922, most of the time to the beginning of the fiscal year being occupied with the necesssary preparatory work. As no part of this project had previously been reported, the summary of results includes a very small amount of hydrography accomplished prior to July 1. During this period the area east of Chandeleur and Breton Island extending from latitude 29° 41′ southward to Pass a Loutre entrance and between the 2 and 15 fathom curves was surveyed. In addition to this, an area of approximately 170 square miles was surveyed in Chandeleur Sound in the vicinity of North, Freemason, and Harbor Islands and the topography of these islands completed.

The season's work completed the hydrographic work which was started east of Pensacola in 1919, and extended westward to Southwest Pass, Mississippi Delta. The portion completed during the present season by the party on the steamer *Hydrographer* joins the fixed position work of the steamer *Bache* to the northward, the dead-reckoning work of the steamer *Bache* to the eastward, and a previous survey of the steamer *Hydrographer* to the southward.

Control for all of the work done during the season was obtained from recovered triangulation stations established by the party on the *Hydrographer* during a previous season. Many of the signals were still standing. It was necessary, however, to build several tall hydrographic signals and supplement these with additional smaller ones. A 100-foot signal was built on Breton Island and an 80-foot signal on Errol Island. Special attention was paid to the signal built on Errol Island, as two signals built here by previous parties had been destroyed by the shifting of the sand within the course of a few months. To protect this signal from the action of the seas which wash around its base, a wooden bulkhead was constructed entirely around its base and the space inside the bulkhead filled with sand.

Shore signals furnished control for approximately one-half the distance to the 15-fathom curve, which in this locality is 17 miles offshore. For the outer part of the work control was furnished by a line of buoys about 3 miles apart and as far out as it was possible to locate them with cuts from shore fixes. With the exception of a small area at the north end of the work where it was necessary to plant three additional markers, this single line of buoys made it possible to carry fixed positions to the 15-fathom curve. A new type of buoy was designed for this work and excellent results obtained with it.

The only topography done during the season was that of the islands known as North, Freemason, and Old Harbor, which form a chain extending for 15 miles in a southwesterly direction from Chandeleur Island. These islands have undergone extensive changes since the last survey. In general, the islands have shifted to the southeastward, while large portions of them have been washed away entirely. These changes have been brought about by northwest storms, which occur frequently during the winter months.

All sounding work done during the season was fixed-position hydrography. Practically all of the soundings were in less than 16 fathoms of water and were taken with the hand lead. Over a small area off Pass a Loutre, in depths up to 50 fathoms, the stream-sounding machine was used, all soundings being vertical casts.

In connection with the navigation of the vessels through Chandeleur Sound it was found that many changes had taken place in the water areas adjacent to North, Freemason, and Old Harbor Islands. Instructions were given to correct the chart where discrepancies existed. A new survey was made of this locality and the work extended until a satisfactory junction had been made with the old surveys. Detailed descriptions of all the important changes found during the season were included in the descriptive reports accompanying the sheets.

As the topographic work which was to be done was small in comparison and far removed from the hydrographic work covered by this sheet, and as the best months of the year for hydrographic work in the Gulf are July, August, and September, the entire strength of the party was devoted to completing the hydrographic work during these months. The party was divided into two watches, the first watch having charge of the sounding from daylight until 8 a. m. and from noon until 4 p. m. and the second watch was in charge from 8 a. m. until noon and from 4 p. m. until dark. In general the vessel ran a continuous sounding line from the time signals were visible in the morning until they were shut out in the evening by darkness except when the line had to be broken on account of rain squalls. Usually the vessel anchored at night on the last position for the day and picked up the line at the same point the following morning. Buoys were constructed over the week end and while running to and from the working grounds (average distance 60 miles). The buoys were dropped on Monday, generally with very little loss of time from sounding work, and were located while running lines in their vicinity.

As the vessel can not carry coal for two weeks when engaged on intensive hydrographic work of this class, the vessel was coaled each week. The general procedure was to return to Gulfport Friday evening, the vessel tying up at the coal wharf. Coal, water, and supplies were taken aboard on Saturday, and the necessary anchors for buoys to be used the following week were cast. The vessel left port early Monday morning, completed the superstructures of the buoys while under way, and dropped them on arrival on the working grounds.

Different types of hand lead-line material were used, but by far the best results were obtained with the waterproofed, solid braided tiller rope No. 8 with phosphorus bronze wire center. This line was used for perhaps 90 per cent of the work. The only fault of this material is that it deteriorates rapidly, due to the bending and breaking of the wire center after it has been in use for some time. For the reduction of soundings over this entire area tidal observations were made at Chandeleur Island Lighthouse.

The tides apparently are largely influenced by winds in this locality. In general a reference plane established from mean low waters obtained in winter time. This is due to the fact that the northerly winds in the winter time lower the level, while the prevailing southerly winds in the summer time raise the level of the water.

The currents in the locality covered by this report are small and are largely due to winds except off the Passes of the Mississippi, where they set offshore. The Gulf Stream countercurrent, which is supposed to set to the southward off the Chandeleur Islands, was not noticed during the progress of the work.

LOUISIANA (NEW ORLEANS FIELD STATION).

[ROBERT BOYD, Clerk, Temporarily in Charge, July to September and February to June; Commander H. C. DENSON, Inspector in Charge, October to January.]

This field station is charged with the maintenance of a chart sales agency, the gathering and submitting to the Washington office of data regarding changes in that vicinity affecting Coast and Geodetic Survey charts and publications, and with furnishing to the local public such information as is requested. This field station was maintained throughout the fiscal year with quarters at 314 Customhouse, New Orleans.

TEXAS.

[Lieut. EOLINE R. HAND, Commanding Steamer *Bache.*]

SUMMARY OF RESULTS.—Magnetic work: 1 ship swing at sea. Hydrography: 1,246 square statute miles of area sounded; 1,846 statute miles run while sounding; 154 positions determined (double angles); 14,433 soundings obtained; 159 current stations occupied, scale of sheets 1 : 80,000.

The following officers were attached to this party: Lieut. G. C. Jones, executive officer; Ensign L. B. Clore; C. N. Conover, chief engineer; Wilhelm Weidlich, mate; T. B. Reed, Frank Larner, and William G. Craib, deck officers.

The steamer *Bache* arrived on the working grounds off Sabine Pass, Gulf of Mexico, on February 26 and at once began precise dead-reckoning hydrography in that vicinity, working outside the inshore areas being sounded by the steamer *Hydrographer.* In spite of unfavorable weather conditions for this class of work considerable progress had been made at the close of the fiscal year.

[Lieut. F. S. BORDEN, Commanding Steamer *Hydrographer.*]

SUMMARY OF RESULTS.—Triangulation: 153 square statute miles of area covered; 3 observing tripods built, 3 observing scaffolds built, 5 stations in main scheme occupied for horizontal measures; 1 station in supplemental schemes occupied for horizontal measures; 10 geographic positions determined. Leveling: 7 permanent bench marks established; 2 statute miles of tidal levels run. Topography: 7 square statute miles of area surveyed; 27.5 statute miles of detailed shore line surveyed; 0.5 statute mile of shore line of creeks surveyed; 1 topographic sheet finished, scale 1 : 20,000. Hydrography: 410 square statute miles of area sounded; 2,390.4 statute miles run while sounding; 6,911 positions determined (double angles); 46,248 soundings obtained; 2 tidal stations established; scale of hydrographic sheets, 1 : 40,000.

The following officers were attached to the party: Lieut. W. D. Patterson, executive officer, entire season; Ensign A. R. Jessup, to May 6; Ensign C. M. Thomas, from March 10; R. P. Marshall, chief engineer, from June 3; H. O. Olsen, deck officer, to March 8; and J. A. Kibler, deck officer, from June 9.

This abstract covers continued operations in the vicinity of Sabine Pass in progress from November 28 to the end of the fiscal year and being the inshore portion of the total project assigned to this party in conjunction with the party on the steamer *Bache.*

To control the survey the triangulation stations Pat Glennon Bayou 1874 and Sabine Pass Lighthouse 1874 were recovered. As a check on the recovery of these stations the station Johnson Bayou 1909 was recovered. Inverse computations were made for the bases between the latter station and each of the other two. Using the three sides of this fixed triangle as bases, a five-pointed central point figure was expanded over the entrance to Sabine Pass and the sides of this figure used as bases to locate all the hydrographic signals thus far used in the survey.

The tall hydrographic signals are each 100 feet high and are spaced ¼ nautical miles apart. This gives control for a distance of approximately 12 miles offshore. As it is necessary to carry the fixed position hydrography from 19 to 23 miles offshore, the tall signals have been supplemented with two rows of buoys, the outer row being close to the outer limit of the fixed-position work and the inner row approximately 6 miles inshore from the outer row. The buoys are planted and located in conjunction with the party on the steamer *Bache*, which vessel uses the outer row for determining the inner ends of her dead-reckoning lines.

The topography has consisted simply in a revision of the shore line. In general the shore line has changed very little. From work accomplished thus far it appears that the coast is building out somewhat to the eastward of Sabine Pass and is eroding somewhat west of the pass. On account of the high marsh grass which fringes the shore for several miles east and west of Sabine Pass it was impracticable to use the plane table for all of this work, and the greater part of the coast line was located with the sextant. The topography was carried up Sabine Pass until a connection was made with the present chart.

In the division of the work betweeen the two vessels engaged on the present project this party has undertaken all of the fixed position launch and ship hydrography in addition to signal building, triangulation, topography, and tidal work. However, practically all good sounding days are devoted to hydrog-

raphy, and other operations, with the exception of signal building, being carried on when hydrographic work can not be done.

As the area being charted by the party is of comparatively shallow depth and is used by deep-draft vessels, extreme care is taken to obtain accurate soundings as well as to obtain correct tidal reducers. In certain areas very strong currents and in others a very soft bottom make it difficult to obtain accurate soundings, and it has been necessary to rerun a few lines under better conditions in order to obtain satisfactory crossings.

All soundings have been taken with lead line made of waterproofed, bronze-centered, tiller rope No. 8. These lines have been marked to the nearest foot up to 8 fathoms, which is the maximum depth of water within the entire area.

When engaged on hydrographic work the officers and crew are divided into two watches. The first watch is on duty from the time signals are visible in the morning until 8 a. m. and from 12 noon until 4 p. m. The second watch is on duty from 8 a. m. until noon and from 4 p. m. until signals are shut out by darkness.

When work was first started in this locality a tidal station was established at Sabine Pass Lighthouse and an observer employed. However, it was found that this observer was not very reliable, and as no other observer could be obtained a second tidal station was established on the opposite side of the pass, at the U. S. Coast Guard station. The staff at the second station was set at the same level as the first, and by simultaneous observations on the two staffs it was found, as supposed, that the ranges were the same. The reference plane for the reduction of soundings was obtained by making simultaneous observations for four consecutive days with the automatic gauge at Galveston, Tex.

In order to obtain the difference in range between the tide at the Coast Guard station and the Gulf, observations were made at East Jetty Lighthouse and the range at this station found to be 50 per cent larger than the range in the pass. Since the range in the pass is 40 per cent greater than the range at Galveston, the range in the Gulf is 2.1 times the range at Galveston.

The currents are very strong in this locality, particularly in the area west of Sabine Pass between Sabine Bank and the coast. The prevailing set, which is southwestward, is increased greatly by winds from the northeast, east, and southeast. Winds from the south and southwest tend to counterbalance the prevailing set, and if blowing hard enough cause the current to set in an easterly direction. While running north and south sounding lines west of Sabine Pass with light easterly breezes, it has been found necessary to allow as much as 25° for the current setting to the westward. This would correspond to a current of 2.2 knots setting to the westward, and it is probable that with the southerly component the actual current would approach 3 knots. With easterly gales this current is undoubtedly increased to 4 or 5 knots.

Thus far the only change of importance from previous surveys found is the building out of the shoal west of Sabine Pass. It was found that the shoal is encroaching on the much used lane between Galveston and Sabine Pass. This undoubtedly is due to the effect the jetties have on the deposit of sediment which is brought down the pass or dropped by the dredges. The prevailing westerly set carries the sediment to the westward, where it is deposited when coming in contact with the eddy caused by the jetties protruding into the Gulf.

The report that the passage throughout Sabine Bank, locally known as the "Hole in the Wall," has shoaled to 30 feet is incorrect. It is possible that the master of the vessel making this report obtained a 30-foot sounding in the passage, but as this occurred on a minus tide during a "Norther" the water level was perhaps at that time as much as 3 feet below the reference plane. The present survey shows 33 feet as the least depth in the locality of the reported shoaling.

All tall signals used on the present survey are of the standard Coast Survey type and are 100 feet in height. These are spaced approximately 4 nautical miles apart and are visible from the bridge of the *Hydrographer* for 15 miles. The buoys used are of the single steel drum type.

TIDAL AND CURRENT WORK, ATLANTIC COAST.

NEW YORK.

[Commander H. C. DENSON.]

SUMMARY OF RESULTS.—107 stations occupied for current observations.

On July 15 a tidal and current survey of New York Harbor was begun in cooperation with the United States Army Engineers. Preliminary arrangements for this work had been discussed by representatives of the United States Army engineers and the chief of division of tides and currents of the Coast and Geodetic Survey, and an agreement had been arrived at as to the extent of the cooperation, such as the equipment to be supplied and the number of units each bureau was to furnish, and also the assignment of the stations to be occupied by the different units. The Coast and Geodetic Survey launches *Ogden*, *Rogers*, and *Elsie III* were used in this work and later on the *Mikawe*.

The launch *Gannett* belonging to the United States Engineers was also equipped for the work of observations, but proved unsuitable and a barge was substituted. The plan finally adopted was that originally decided upon that the Coast and Geodetic Survey units should occupy the principal or controlling station, while the engineer units were assigned to stations that required to be occupied for only 13 or 26 hours. Several additional barges were afterwards furnished by the United States Engineers to take the place of the Coast and Geodetic Survey launches.

The cooperative assistance of the engineers was discontinued August 17, after the completion of the observations in the Hudson River and Lower Bay. The original program provided that each bureau should operate three units, but after the completion of the work on the Hudson River the Coast and Geodetic Survey operated not less than four units, and after August 17 not less than five and sometimes six units. While the work was in progress on the East River the engineers often operated four units.

All observations in connection with this work, with the exception of three stations, were made either from launches or barges. One unit made observations during 48 consecutive hours from a drill boat anchored in Hell Gate; another made observations during six hours from the railroad bridge spanning Hell Gate. Thirteen hours' observations were made from the bridge spanning Newton Creek. While the work was in progress most favorable weather conditions were experienced.

The observations were continuous from the beginning of the season on July 15 until the close of the work on September 7, except when minor repairs were being made to the current meters and on five occasions when the observing barges were struck by passing tows.

Rough weather was encountered while the work was in progress off Sandy Hook, and the observations in that locality were not as satisfactory as could be desired. These unsatisfactory results are partly due to the floating equipment which was found not adaptable to offshore work.

After completing the original program nine additional stations were occupied in the Hudson River for the purpose of making a study of the directions of the subsurface currents.

Seventy-eight stations were occupied for obtaining data in connection with circulation and 30 stations for obtaining data for local conditions. The locations of the current stations were plotted on appropriate charts which were sent to the office with the records of the work.

All tidal data to be used in connection with the reduction and tabulation of observations, with one exception, were furnished by the records of automatic tide gauges located throughout the harbor and maintained by the engineers. While the work was in progress the Coast and Geodetic Survey maintained an automatic tide gauge at Port Newark in Newark Bay. At only one station near the barge office were daylight observations made on tide staffs. The United States Army Engineers, besides effectively cooperating in the work, incidentally rendered valuable assistance in many ways.

NEW YORK AND NEW JERSEY.

[HARRY A. MARMER.]

In July an inspection was made of the parties engaged in making a tidal current survey of New York Harbor. The force engaged in this work consisted of six units—three operated by parties of the Coast and Geodetic and three by parties of the United States Engineer office. Each of these six parties was visited, and their records and methods of work were inspected.

A conference was held with Prof. W. D. Johnson relative to change in tidal régime resulting from changes in shore line and the relation between mean sea level of points situated on the open coast and those nearly inclosed.

At Atlantic City, N. J., a site was secured for the location of a tide gauge on the Steel Pier about 1,500 feet from the Board Walk, where there is a depth of 17.2 feet.

In March, 1923, an examination was made of the tidal and current records on file at the office of the district engineer, first district, at New York, with a view of obtaining copies of these records, and afterwards an inspection was made of the tidal station at Philadelphia.

NEW JERSEY.

[PAUL SCHUREMAN, Computer.]

In compliance with instructions of October 19, 1922, and upon receiving information that the U. S. Construction Co. was ready to begin immediately upon the work of installing the float pipes for a proposed tide gauge at Atlantic City, the observer proceeded to that place on November 14. Upon his arrival the work of installing the float pipes proceeded without delay and was sufficiently advanced to permit the automatic gauge to be installed on November 30. On the following day the station was placed in charge of a permanent tide observer whose appointment was recommended to the office. On December 5 the tide station was again visited, and both the automatic and the tape gauge were found to be operating satisfactorily. The observer returned to Washington on the evening of December 5 and reported for duty at the office on the following morning.

NORTH CAROLINA.

[E. A. LE LACHEUR.]

On April 20 and 21 special current-meter observations were made on Diamond Shoal Light Vessel. Observations were made continuously from 9 a. m. to 11 p. m. on April 20 and from 5.30 a. m. to 1.30 p. m. on April 21. Densities and temperatures of the sea water near the surface were obtained. Transportation for the observer was furnished by the lighthouse tender *Orchid*.

HYDROGRAPHIC AND TOPOGRAPHIC WORK, PACIFIC COAST.

CALIFORNIA.

[Lieut. Commander H. A. SEBAN, Steamer *Discoverer*.]

SUMMARY OF RESULTS.—Triangulation: 1 signal pole erected; 3 stations in supplemental scheme occupied for horizontal measures; 8 geographic positions determined. Leveling: 10 permanent bench marks established; 2 miles of levels run. Magnetic work: Ship swung at 3 sea stations; 100 observations on course made. Hydrography: 2,270 square miles of area covered; 1,970 miles run while sounding; 2,920 positions determined (double angles); 7,960 soundings made; 4 hydrographic sheets finished, scales 1:120,000, 1:20,000, and 1:40,000.

The following officers were attached to the party during this season's work: Lieut. J. H. Peters, executive officer, Lieut. (Junior Grade) H. W. Hemple, Lieut. J. M. Smook, J. C. Herman, chief engineer, J. F. Downey, jr., and P. H. White, deck officers.

On November 1, 1922, the steamer *Discoverer* was at San Diego, Calif., being overhauled after the cruise from Norfolk, Va., and being prepared for field work on the coast of California, as called for in the director's instructions of October 18. These instructions provided for hydrographic work northward from the Mexican boundary to be executed by the parties of the *Discoverer* and *Pioneer*,

under the direction of the commanding officer of the *Discoverer*. Overhauling the vessel and preparation for work, including a reconnaissance trip over the working grounds, occupied the time until November 10, and on November 13 hydrography was begun in the vicinity of the boundary. From that date until February 10, 1928, field work was in progress. During this time the hydrography was executed by the two parties from the Mexican boundary north to Del Mar. The party of the *Pioneer* did the work northward of the water tank (hydrographic signal tank) on Point Loma. In addition to this hydrography, a detailed hydrographic survey of Cortez Bank, including a trigometric location of the whistle buoy and the bank itself, was made by the parties of both ships working in conjunction.

In the section covered by the *Discoverer* very little triangulation was necessary, as there were a number of natural objects previously located which could be used for hydrographic signals. The three wireless masts at the new Navy radio station in East San Diego, the highest points of the hills on Los Coronados, and the water tank on Point Loma were determined by occupying Point Loma Old Tower Lighthouse, Coronado hotel tower, and triangulation station Dune. These points were used in the hydrographic work.

The hydrography was extended from the 1,000-fathom curve inshore connecting with the inshore hydrographic work of previous years. Although this previous hydrography was done a matter of 30 or 40 years ago, it checked remarkably close inside the 20-fathom curve. In deeper water it did not check so well. In fact, the present survey has changed the 50 and 100 fathom curves off San Diego to a large extent.

There were two large kelp patches within the limits of the work—one near the southern limit of the work and the other a long narrow patch parallel with the shore line west of Point Loma. A couple of sounding lines were run through the southern patch, and a line along the outside edge of this patch was run. No lines were run through the Point Loma patch, although the western edge was defined. The kelp in both these patches is quite thick.

The hydrographic work inside the 20-fathom curve was done with hand lead, using the bronze wire center lead line. Between the 20 and 100 fathom curves sounding tubes with the improved valve were used.

A search was directed to be made for the two banks shown on Chart 5002. While no indication was found in the immediate vicinity of the one reported in latitude 31° 50′ N., longitude 119° W., on account of the unevenness of the bottom in this entire locality and in view of having obtained one sounding of 68 fathoms about 50 miles farther inshore, the commanding officer was loath to recommend that this reported bank be removed from the chart. The bank reported in latitude 32° 05′ N., longitude 119° 45′ W. was north of the work accomplished during the season.

One sounding of 68 fathoms was obtained in latitude 32° 07′ N., longitude 118° 16′ W. This depth is certain, as the lead was picked off the bottom and dropped a second time. Although the outline of the 500-fathom curve in this vicinity was closely defined, no other such shoal sounding was encountered.

The detailed instructions provided for a wire-drag survey of Cortes Bank within the 50-fathom curve, and, if this were impracticable this year, to drag within the 20-fathom curve, obtain the least water on Bishop Rock, the shoal extending south and east from it, and on the shoal about 4½ miles north and west of Bishop Rock.

The assembling of wire-drag outfit in San Diego at the same time that field work was in progress was a matter of considerable difficulty on account of getting the various necessary parts. Work was started in assembling this outfit as soon as the approved estimates were received, and it took until January 15 to get the wire drag in shape and the buoys constructed. From January 15 until February 10 both the *Discoverer* and *Pioneer* were standing by at Cortes Bank for suitable weather to do drag work. During this time there were only two days that the drag could be put over. During this period, however, a detailed hydrographic survey of the bank was executed. This survey was carried out to the 100-fathom curve, except on the eastern and northwestern ends of the bank. This survey was all controlled by fixed positions on buoys.

An important feature of the Cortes Bank work was the trigonometric location of the bank itself and the location of the buoys. After the first six buoys had been planted the *Discoverer* was anchored close to buoy A. Triangulation stations Rest and Peak on San Clemente Island were recovered and observers from the party of the *Pioneer* stationed at each. Station Slope was

recovered and used as an azimuth mark for station Rest, and station Ledge was recovered and used as an azimuth mark for station Peak. (The two occupied stations were not intervisible.) Lights were posted at each of the azimuth marks, and each observer measured the angle between the ship's searchlight and his azimuth mark. An inverse computation gave the distance and azimuth between the occupied stations, and thus the base of the triangle Peak, Rest, *Discoverer*. From this triangle the geographic position of the ship was determined. The distance between the ship and buoy A was determined by observing the angle between the water line at buoy A and the horizon from the bridge of the ship, which was 32 feet above the water. The direction of the buoy was taken from the standard compass. This trigonometric position of Cortes Bank buoy and Cortes Bank differs from the position shown on the chart by about 2¼ miles.

The first six buoys were planted on two ranges. Buoys A, B, and C on one range and buoys D, E, and F on another. The distance between buoy C and buoy F along the line of the buoys was determined by log runs. Using this distance as base, the buoys were located with reference to each other by sextant triangulation with the ship and launch. The launch occupied each buoy in turn, and the ship took position about 1 mile outside the line of the buoys. The entire system was then oriented by observing celestial azimuths. The *Discoverer* anchored near buoy A and the *Pioneer* near buoy E. The *Discoverer* measured the angle between the *Pioneer* and the moon at low altitude, and for a check the *Pioneer* measured the angle between the *Discoverer* and a star of low altitude. Knowing the exact position of the *Discoverer*, and to all intents the exact position of the *Pioneer*, the azimuths of the moon and star were computed and from this the azimuth between the *Discoverer* and *Pioneer* or from A buoy to E buoy. The later buoys beyond F buoy were located in a similar manner.

From January 2 to January 10 the ship was laid up for the purpose of cleaning boilers. During this time the dredged channel from Ballast Point south to the bell buoy was sounded. The work is an extension of the harbor work of the party of the *Pioneer* and connects with the ship work of the *Discoverer* at the bell buoy. The motor sailing launch of the *Pioneer* was borrowed for this work, as the launch of the *Discoverer* was being equipped for wire-drag work at that time.

The tidal bench marks in the vicinity of San Diego were inspected. Ten new bench marks were established in the vicinity of the tidal station at the quarantine station.

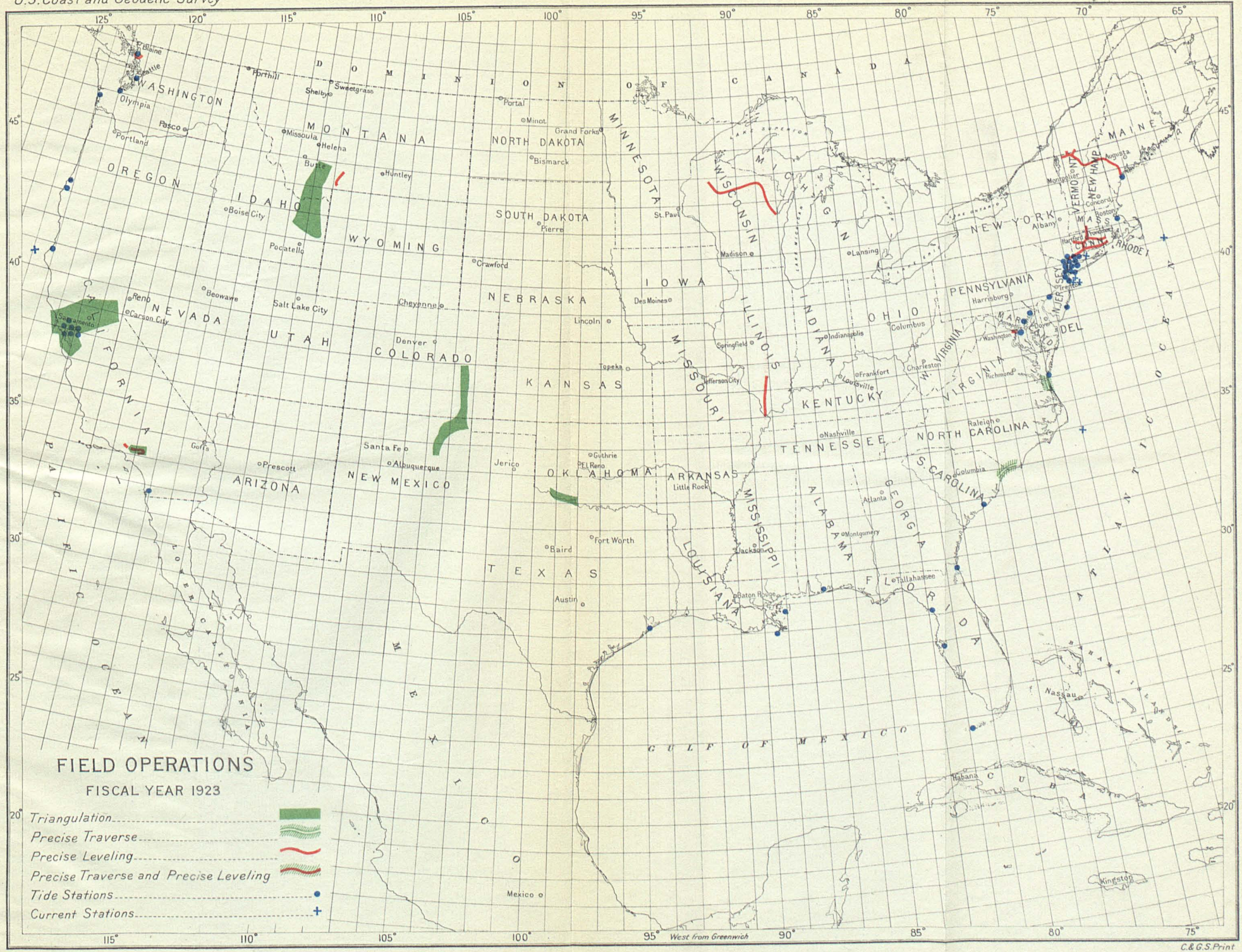
[Lieut. O. W. SWAINSON, Commanding Motor Vessel *Natoma*.]

SUMMARY OF RESULTS.—Triangulation: 160 square miles of area covered; 24 signal poles erected; 2 observing tripods and scaffolds built, height 5 feet; 27 stations in main scheme occupied for horizontal measures; 1 station in supplemental scheme occupied for horizontal measures; 22 stations occupied for vertical measures; 70 geographic positions determined. Leveling: 12 permanent bench marks established; 2 miles of levels run. Topography: 50.1 square miles of area surveyed; 89 miles of general coast line surveyed; 2 miles of shore line of creeks surveyed; 62.7 miles of roads surveyed; 5 topographic sheets finished, scale 1:10,000. Hydrography: 40 1 square miles of area covered; 579.1 miles run while sounding; 4,500 positions determined (double angles); 21,048 soundings made; 4 tide stations established; 5 hydrographic sheets finished, scale 1:10,000.

The following officers were attached to this party: Lieut. M. O. Witherbee, executive officer, hydrography and topography; Lieut. (Junior Grade) J. A. Bond, hydrography; Ensign R. W. Byrns, topography, hydrography; and Antone Silva, chief engineer (motor).

At the beginning of the fiscal year the *Natoma* was at San Francisco undergoing repairs and outfitting for work during the coming season. The officers were engaged in work upon the records of the past season. On July 17, repairs being finished and supplies taken on board, the vessel ran to Martinez at the entrance to Suisun Bay. The work was then continued in Carquinez Straits and Suisun Bay in compliance with instructions.

The triangulation was continued eastward from where it had been dropped before going to San Francisco. It was tied to two recovered stations on the west side of Suisun Bay, namely, Goodyear and Army Point 2. The discrepancy of the connection was seven-tenths meter, or 1 in 4,500 in distance and 30 seconds in azimuth. The office value of the line Army Point to Goodyear was used to carry the scheme east and north across Suisun Bay. This scheme was tied onto two old stations on the eastern end of the bay. As many natural objects as possible were cut in by the triangulation.


FIELD OPERATIONS
FISCAL YEAR 1923
Triangulation
Precise Traverse
Precise Leveling
Precise Traverse and Precise Leveling
Tide Stations
Current Stations
DOMINION OF CANADA
WASHINGTON
OREGON
CALIFORNIA
IDAHO
MONTANA
NEVADA
UTAH
ARIZONA
WYOMING
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
W. VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VERMONT
NEW HAMPSHIRE
MASS.
CONN.
RHODE
N. JERSEY
DEL.
MARYLAND
Lake Superior
Lake Michigan
Lake Ontario
Lake Erie
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
Caribbean Sea
Bahama Is.
Cuba
Blaine
Seattle
Olympia
Portland
Pasco
Northill
Sweetgrass
Shelby
Missoula
Helena
Butte
Huntley
Boise City
Pocatello
Portal
Minot
Grand Forks
Bismarck
Pierre
Crawford
Beowawe
Reno
Carson City
Salt Lake City
Cheyenne
Denver
Santa Fe
Albuquerque
Prescott
Goffs
Jerico
Guthrie
Ft Rerio
Baird
Fort Worth
Austin
Mexico
Topeka
Lincoln
Des Moines
St. Paul
Madison
Springfield
Jefferson City
Little Rock
Jackson
Baton Rouge
Indianapolis
Columbus
Frankfort
Louisville
Nashville
Atlanta
Montgomery
Tallahassee
Columbia
Raleigh
Charleston
Richmond
Washington
Harrisburg
Albany
Lansing
Montpelier
Augusta
Concord
Boston
Hartford
Trenton
Dover
Nassau
Kingston
Habana
West from Greenwich
C.&G.S. Print

A new method of referencing subsurface marks was used where surface marks could not be established with assurance of their not being disturbed. Two 8-foot sections of 2 or 2½ foot galvanized pipes were filled with cement and buried at the same depth as the subsurface mark, one on each side, to form a straight line. The general direction of this pipe was given in the description. Hence, in recovering the station a trench of the required depth can be dug at right angles to the line of pipe and extended until the pipe, or core of cement, if the pipe has corroded away, is encountered. Then, by following along the pipe the station mark can be found.

The bromide copy of the original plane-table sheet was used to revise the topographic features of Carquinez Straits, but this method proved unsatisfactory, and consequently a projection was made for each of the remaining sheets and used in the field. All of the work was done on the scale of 1:10,000. Maps of industrial plants were obtained for use in correcting the charts.

A complete hydrograhpic survey was made. The lines were spaced from 100 to 200 meters and crossed by lines one-fourth to one-half mile apart. The launch did the inshore work and the vessel the deeper portions. All work was on a scale of 1:10,000. All soundings were taken with a hand lead.

An automatic tide gauge was kept in operation from August 1 to December 31 at Suisun Point. Several days' record was missed, however, due to the unexpected stopping of the gauge clock.

A plain staff was erected at the Bay Point shipyard and connected with Suisun Point by 52 hours of continuous simultaneous readings. Readings were made on the plain staff at Bay Point when sounding east of Point Edith and west of Middle Point. Permanent bench marks were established at each station. An automatic gauge was put in operation at Pittsburg on the 1st of December. The surveys of the main channels as called for in the instructions were completed on March 2.

[Lieut. R. R. LUKENS, Commanding Steamer *Pioneer*.]

SUMMARY OF RESULTS.—Triangulation: 8 signal poles erected; 8 observing tripods built, total height 72 feet; 8 stations in supplemental schemes occupied for horizontal measures; 3 geographic positions determined. Leveling: 1 permanent bench mark established; 1.6 statute miles of tidal levels run. Topography: 12 square statute miles of area surveyed; 18 statute miles of detailed shore line surveyed; 2 topographic sheets finished, scales 1:10,000 and 1:20,000. Hydrography: 1,945 square statute miles of area sounded; 1,225 statute miles run while sounding; 4,306 positions determined (double angles); 11,560 soundings obtained; 1 tidal station established; 6 hydrographic sheets finished, 4 of which were worked on in conjunction with the steamer *Discoverer*. Physical hydrography: 126 surface water temperatures recorded; 126 surface water specimens preserved; 126 plankton specimens preserved.

The following officers were attached to this party: Lieut. K. T. Adams, executive officer, Lieut. O. S. Reading, Lieut. (Junior Grade) J. A. Bond, Ensign A. H. Wagener, D. E. Morris, chief engineer, D. W. Taylor and C. P. Meyer, deck officers.

This abstract covers field work accomplished along the coast of California during the period November 1, 1922, to February 20, 1923. Two days at the beginning of this period were utilized in running two lines of reconnaissance hydrography between the port of San Pedro, Calif., and Catalina Island to obtain the desired information requested by the Pacific Telegraph & Telephone Co. to enable them to lay a submarine cable. Upon the completion of this work the *Pioneer* returned to San Diego and made the necessary preparations to take up hydrographic surveys along the southern California coast from the Mexican boundary northward in conjunction with the party on the steamer *Discoverer*.

The commanding officer of the *Discoverer*, Lieut. Commander H. A. Seran, had general charge of the field operations of both vessels. In dividing the work between the two ships the *Pioneer* was assigned the greater part of the inshore areas, including portions of San Diego Bay. The survey of Cortez Bank, 100 miles offshore, was executed jointly by the two vessels. Only a very small amount of new control was needed, as there were in the vicinity of the work numerous artificial and natural objects which had already been located by triangulation. During the months of November and December favorable weather was encountered and excellent progress made. Decidedly unfavorable conditions, however, were experienced while making the survey of Cortez Bank, which permitted very little wire-drag work. A thorough hydrographic survey of the bank by means of the lead was accomplished.

The vessel cooperated with the Scripps Institute at La Jolla by obtaining for them a number of sea temperatures, surface water samples, and plankton hauls while engaged in offshore work for use in research studies in marine biology and oceanography.

CALIFORNIA—NEVADA.

[Lieut. F. L. PEACOCK, in Charge; Ensign A. W. SKILLING.]

SUMMARY OF RESULTS.—Reconnaissance: 4 old stations recovered; 11 points selected for scheme; length of scheme, 21.5 miles; 200 square miles of area covered. Triangulation: 200 square miles of area covered; 12 signal poles erected; 11 stations in main scheme occupied for horizontal measures; 1 station in supplemental scheme occupied for horizontal measures; 101 geographic positions determined. Leveling: 7 permanent bench marks established; 3.6 miles of levels run. Topography: 1.5 miles of general coast line surveyed, scale of topographic sheets 1:30,000. Hydrography: 188 square miles of area covered. 681.8 miles run while sounding; 3,770 positions determined (double angles); 7,397 soundings made; 1 tidal station established, scale of hydrographic sheet 1:30,000.

Lake Tahoe is a large, deep lake covering an area of about 200 square miles and situated at an elevation of about 6,225 feet above mean sea level on the eastern slope of the Sierra Nevada Mountains at about the thirty-ninth parallel of latitude. The locality is famed as a summer resort.

A launch belonging to the U. S. Reclamation Service, the *Mount Rose*, was obtained for the use of the party. Actual field work was begun July 6, the first field work being the triangulation necessary for efficient control.

Four supplementary triangulation stations of the "triangulation along the thirty-ninth parallel" were recovered, namely, Deadman 1893, Folsom Peak 1893, Rubicon Point 1893, and Observatory Point 1893. The first three were held as a fixed base triangle from which a secondary scheme of 11 stations was extended north and south embracing the whole area of the lake. From these 11 stations about 90 intersection stations were cut in with the theodolite by single cuts from 3 or more stations for use as hydrographic signals. All secondary stations were well marked and described by this party, as were also 7 of the intersection stations. Upwards of 30 of the remaining intersection stations are permanent artificial objects, such as flagpoles, gables, cupolas, and towers of buildings, aids to navigation, etc., and were also described.

Particular care was exercised in making the targets of the secondary stations small and distinct and in centering and plumbing them carefully. The results showed plainly that this effort was well expended.

The average closing error of 14 triangles in main scheme was 2.3 seconds and the maximum 6.2 seconds; 101 geodetic positions located; 1 State line monument located; area, 200 square statute miles. Triangulation was completed on July 29.

The party at once proceeded to take up the hydrography. Owing to the considerable depth of the lake, nearly all of the soundings were necessarily with wire. A Ballauf hand sounding machine with a maximum capacity of about 400 fathoms was installed on the stern of the launch and driven by power from the launch engine.

A systematic hydrographic survey was made of the entire area of the lake, which is 21.5 miles long and 12 miles in width. The greater part of this area is within the State of California. Several days of sounding with the hand lead were done during the season while sounding the shoal shelf off Tahoe City, the narrow shelf extending along the southern shoal of the lake, and in developing the reefs dangers, etc., which were encountered. A system of east and west parallel lines was used, although this was varied in the close inshore development. Outside of depths of 175 fathoms lines were spaced about three to each statute mile, with soundings spaced about 600 meters apart along the line. From 175 fathoms to 50 fathoms the spacing is three lines per statute mile, with a corresponding shortening of the sounding interval. The inshore development is intended to be sufficiently close to enable depth curves to be drawn smoothly and readily and to leave no dangers or shoalings undetermined.

The shore line as determined by the U. S. Reclamation Service, and adjusted by the division of charts, U. S. Coast and Geodetic Survey, was tested and found to be of a satisfactory degree of accuracy for chart purposes. No contours were run, as examination of the maps of the Geological Survey showed that the features as represented were sufficiently accurate.

A number of permanent artificial features suitable for use by the Lighthouse Service in locating aids to navigation were located and described.

The U. S. Reclamation Service tide staff at Tahoe City was read daily during the period hydrography was in progress in order to determine all fluctuations of lake level and enable the soundings to be accurately reduced to the selected datum plane. In addition, a tide staff was established at the south end of the lake near the mouth of the Upper Truckee River. This staff was read at such times as shoal sounding in the vicinity was in progress, and its relation to the Tahoe City staff was determined by simultaneous observations on the staffs under conditions favorable for such determination.

Two permanent bench marks in the vicinity of the Tahoe City staff (one established by the U. S. Geological Survey and the other by the U. S. Reclamation Service) were recovered, and four additional Coast and Geodetic Survey standard bench marks were established, making a total of six at this station. Three Coast and Geodetic Survey standard disk bench marks were also established in the vicinity of the staff at the south end of the lake near the mouth of the Upper Truckee River. All bench marks were connected to the adjacent staffs by spirit levels.

As this lake had never before been systematically sounded, various erroneous conceptions of the depths to be encountered were locally prevalent. In general, the lake was believed to be considerably deeper than is actually the fact. The greatest depth in the lake was found to be 1,640 feet. Field work was completed on October 17, 1922.

CALIFORNIA.

[Lieut. Commander FREMONT MORSE, Inspector, San Francisco Field Station.]

The work of the San Francisco field station was continued during the year and included the usual details.

An agency for the sale and distribution of charts and nautical publications is maintained. Information affecting the charts, coast pilots, tide tables, and current tables is collected and transmitted to the Washington office and information on matters relating to the survey is furnished to Government officers, State and municipal authorities, and others upon application. Assistance was given the commanding officer of the steamer *Lydonia* in planning a coal supply for that vessel on her voyage to the eastern coast. Bids for repairs of that vessel were opened at the field station.

The Presidio tidal station was supervised, supplies were forwarded to vessels and parties in the Philippine Islands, and transportation was furnished when required to officers of the survey arriving in San Francisco.

Time was devoted to the preparation of a card index of maps, blue prints, and other data on file at the field station.

OREGON.

[Lieut. Commander R. F. LUCE, Commanding Steamer *Lydonia*.]

SUMMARY OF RESULTS.—Triangulation: 49 square statute miles of area covered; 5 signals erected, 11 stations occupied for horizontal measures; 14 geographic positions determined. Topography: 5.5 square statute miles of area surveyed; 17.7 statute miles of shore line surveyed; 0.7 statute mile of shore line of creeks, etc., surveyed. Hydrography: 291 square statute miles of area covered; 575.5 statute miles of levels run; 4 bench marks established.

The following officers were attached to the party while on this assignment: Lieut. R. P. Eyman, executive officer, Lieut. (Junior Grade), L. M. Mower, Lieut. (Junior Grade) C. D. Meaney, Lieut. (Junior Grade) E. F. Lewis, Lieut. (Junior Grade) R. F. A. Studds, and Harry Ely, chief engineer.

On July 1, 1922, the *Lydonia* was engaged in combined operations on the Oregon coast, with headquarters at Marshfield, Oreg. This work was continued until September 18, when the vessel was taken to San Francisco for repairs.

The work on the coast of Oregon assigned to this party called for a topographic survey of the shore line of Coos Bay and from Coos Bay to Cape Sebastian, the hydrography of the coast from as near the shore as practicable out to the 1,000-fathom curve, and such secondary triangulation as might be necessary for the control of the other work. The work accomplished prior to July 1, 1922, has previously been reported.

The triangulation done was secondary in character. A sufficient number of triangulation stations were located to control the work from Coos Bay to the

Coquille River and southward to Cape Blanco Lighthouse. All stations established were carefully marked and described.

The topography consisted in the mapping of the shore line and contiguous territory to an average distance of about a mile from the shore, including creeks, inlets, offlying rocks, and low-water line where possible of the coast between Coos Bay and the Coquille River. The southern half of this stretch was a sand beach, and therefore easy of execution; the northern half, however, was a very rocky and steep-to coast, frequently with high bluffs and overhanging cliffs, which made this part of the work difficult.

The hydrographic work was extended along the coast, so that when operations were closed on September 16 hydrography had been completed from a point about 4 miles north of the entrance to Coos Bay to the entrance to the Coquille River, and included the area from the 1,000-fathom curve to as close to the shore as safety would permit, which, in general, was about the 17-fathom curve.

Immediately off Coos Bay entrance the bottom was found to be very even, and it is believed that the charted results of this survey will be of assistance to vessels making Coos Bay in foggy weather.

From just below Cape Arago to the south the bottom was found to be very uneven as far out as the 75-fathom curve, and considerable development work was done in this area in addition to the regular system of sounding lines.

Inside the 75-fathom curve soundings were taken with a trolley apparatus with the vessel underway. Outside the 75-fathom curve vertical soundings were taken with the vessel stopped for each sounding. Locations for all soundings were obtained by sextant angles from the vessel on shore signals or natural objects previously determined.

The automatic tide gauge at Empire, Oreg., was continued in operation until the close of the season, and in addition a plain staff gauge was established at Bandon, at the mouth of the Coquille River, and was observed at such times as hydrography was in progress in that vicinity.

The vessel was swung for deviation of compass, once off the entrance to Coos Bay and once in San Francisco Harbor. Magnetic declination on course was observed at frequent intervals at various parts of the working grounds.

WASHINGTON.

[Commander R. B. DERICKSON, Inspector, Seattle Field Station.]

The Seattle field station, quartered on the second floor of the Burke Building, on the corner of Second and Marion Streets, Seattle, Wash., has been maintained in operation throughout the fiscal year. Among the functions of this field station are the supervision of the standard tide station at Seattle, the maintenance of a chart sales agency, and the gathering and submission to the Washington office of data pertaining to harbor improvements affecting the charts of that district and supplying to the local public such information as is requested and proper.

In addition this station serves as a connecting link between the Washington office and the surveying parties operating in Alaskan waters. The station is in a position to assist these parties and to facilitate their work in many ways, among which may be mentioned the purchase and forwarding of mess supplies, the forwarding of equipment required by emergency, the recruiting and transportation of men needed for replacements during the field season, assistance in arranging for the necessary repairs to vessels and launches, and the forwarding of mail matter.

During the latter part of the fiscal year 10 dory skiffs for the use of surveying parties in Alaska were built in Seattle under the supervision of the inspector of the Seattle field station.

OCEANOGRAPHY.

[Lieut. Commander H. A. SERAN, Commanding Steamer *Discoverer*.]

SUMMARY OF RESULTS.—157 deep-sea soundings obtained; 97 bottom temperatures obtained; 144 water temperatures at 200 fathoms depth obtained; 154 surface water temperatures obtained; 119 bottom specimens preserved; 142 water specimens for 200 fathoms depths preserved; 154 surface water specimens preserved.

This abstract covers oceanographic work incident to the cruise of this vessel from the Atlantic coast to her Pacific coast station via the Panama Canal.

The following officers were attached to this party and performed duties in connection with the oceanography: Lieut. J. H. Peters, executive officer; Lieut. (Junior Grade) H. W. Hemple; Lieut. (Junior Grade) R. W. Woodworth; Lieut. (Junior Grade) J. M. Smook; J. C. Herman, chief engineer; J. S. Lawrence, surgeon (temporary); J. F. Downey and P. H. White, deck officers.

On September 25 the *Discoverer* sailed from Norfolk, Va., and after adjusting compasses in Hampton Roads put to sea on the following day. A stop was made at Kingston, Jamaica, for fresh water October 4, and on October 8 the vessel arrived at Cristobal and on the following day passed through the canal. Certain necessary minor repairs were effected at Balboa, and the vessel again proceeded on October 12 and arrived at San Diego, Calif., on October 27. This completed the oceanographic cruise. Certain desirable soundings had been assigned to this vessel along the entire route of the cruise, and although considerable bad weather and unfavorable conditions were encountered the greater part of these soundings were obtained, furnishing much valuable oceanographic data with respect to the route traversed.

[Lieut. Commander R. R. LUKENS, Commanding Steamer *Pioneer*.]

SUMMARY OF RESULTS.—180 deep-sea soundings obtained; 64 bottom specimens preserved; 820 sea-water specimens preserved, including bottom, 200 fathom, and surface specimens; 266 sea-water temperatures obtained, including bottom, 200 fathom, and surface temperatures.

The following officers were attached to this party and assisted in the oceanographic work: Lieut. K. T. Adams, executive officer, Lieut. O. S. Reading, navigating officer, Lieut. (Junior Grade) J. A. Bond, Ensign A. H. Wagener, D. E. Morris, chief engineer, D. W. Taylor and C. F. Meyer, deck officers, and Dr. I. B. Hunt, surgeon (temporary).

Incident to the cruise of the steamer *Pioneer* from the Atlantic coast to the Pacific coast station, via the Panama Canal, a program of oceanographic work was assigned, supplementing that accomplished by various other Coast Survey vessels on similar cruises. This program was carried out in so far as weather conditions permitted. The conditions met with were unusually favorable, and the results obtained are valuable additions to the oceanographic knowledge of the route traversed. The *Pioneer* sailed from Norfolk, Va., on September 23, passed through the canal on October 6, sailed from Balboa on October 12, and arrived at San Diego, Calif., October 30.

One of the features of the work was a search for the bank reported 20 miles north of Manzanillo Point. The *Pioneer* ran three lines of soundings over the reported position of the bank, but no indication of the same was found. The soundings showed a smooth, gently sloping bottom of about 1,100 fathoms depth.

In general but little current was experienced on the voyage, but on two occasions narrow belts of strong current were encountered, the first case being off the coast of Costa Rica, where the ship was set to the northeast about 20 miles in 12 hours. Tide rips were observed all around, and it is probable that this current reached 2.5 knots at its maximum. Once out of this belt little or no current was noticed until south of the Gulf of California, where in longitude 105° W. a strong set to the south was observed. During this voyage the steamer *Discoverer* was about one day's steaming ahead of the *Pioneer*, and the former vessel encountered continuous favorable current which the *Pioneer* did not experience.

The lines of soundings laid out for the *Pioneer* passed directly over a 70-fathom sounding off the coast of Costa Rica, but no signs of any such a feature were found. The soundings showed smooth mud bottom at about 1,780 fathoms, and one sounding, which plotted directly on the supposed 70-fathom spot, gave 1,765 fathoms.

The *Pioneer* also determined the position of the Allijos rocks off the coast of Lower California. When the highest rock was first picked up, it appeared as a square rigger under full sail. When approached two more slender pinnacles and one flat-topped ledge became visible.

[Lieut. Commander R. F. LUCE, Commanding Steamer *Lydonia*.]

SUMMARY OF RESULTS.—69 deep-sea soundings obtained; 218 trolley soundings taken; 196 water samples taken; 58 bottom samples obtained; 207 water temperatures taken; 2 complete ship swings at sea.

The following officers were attached to the party during this cruise and had responsible duties in connection with the success of the oceanographic work:

Lieut. R. P. Eyman, executive officer, Lieut. (Junior Grade) L. M. Mower, Lieut. (Junior Grade) C. D. Meaney, Lieut. (Junior Grade) E. F. Lewis, Lieut. (Junior Grade) R. F. A. Studds, and Harry Ely, chief engineer.

The oceanographic work covered by this abstract was incident to the transfer of the steamer *Lydonia* from the Pacific coast station to work on the Atlantic coast and was in progress between October 11 and November 30, 1922.

On October 11 the steamer *Lydonia* sailed from San Francisco after swinging ship in the harbor. After a smooth trip, on which no soundings were taken, the *Lydonia* arrived in San Diego in the morning of October 18.

At San Diego coal sacks were purchased, the crew put up about 25 tons of coal in sacks, and this amount of coal in sacks was stowed on deck. In addition, the coal bunkers were filled by taking aboard about 64 tons in the bunkers, so that when the *Lydonia* left San Diego she had aboard approximately 137 tons of coal.

At 7.43 a. m. on October 18 the *Lydonia* sailed from San Diego, and at 8.22 that afternoon stopped for the first sounding. Practically perfect weather was experienced, and all soundings were taken as specified in the instructions until in the evening of October 23 bad weather from the southeastward was experienced, which, with rapidly increasing wind and sea, made it necessary to discontinue sounding, and in the morning of the 24th it was advisable to enter Manzanillo, Mexico, for shelter in order to conserve coal.

On the 25th, the weather having moderated, the *Lydonia* sailed from Manzanillo and resumed the sounding line. All along this coast exceedingly hot weather was experienced from off Mazatlan, Mexico, and on the stretch from Manzanillo to Salina Cruz it was most uncomfortable aboard the vessel, as what little breeze there was was directly astern.

In the afternoon of October 28 the *Lydonia* arrived at Salina Cruz, Mexico, in excellent condition, and found that the coal which had been shipped from San Francisco had arrived only a few days previously. After making the necessary arrangements the coaling of the vessel commenced at noon on the 30th and was finished on November 1, the ship having taken aboard at that time 87 tons of coal, 30 tons of which was in sacks on deck; this made 109 tons aboard altogether.

On November 2 the *Lydonia* left the inner harbor of Salina Cruz, but on account of a norther blowing anchored in the outer harbor until the next morning, when, the weather apparently having abated, she sailed from Salina Cruz.

Soon after leaving the wind again increased, and with the large amount of coal on deck and with the long run ahead, with coal which burned more rapidly than other coal which had been used, it was considered best to hug the shore and not resume the sounding line, which was well offshore, until it was found that coal enough to make the trip to Balboa was assured.

During the night of the 6th sounding was again resumed and continued until Balboa was reached on the evening of November 9. With the exception of the first 24 hours out of Salina Cruz very good weather conditions were experienced.

At Balboa supplies were received, various small repairs were made, and on November 13 the ship passed through the Panama Canal, arriving at Cristobal that evening. On the 14th the ship took aboard coal, and on the morning of the 15th, after swinging ship in the harbor, sailed from the Canal Zone and commenced sounding on the line specified.

Sounding was continued until on the morning of the 16th very heavy weather, with rain and northeast to east gales, was met with, which continued with slight interruption until the morning of the 18th, when sounding was again resumed and continued until Kingston was reached late in the evening of the 18th.

Coal was taken aboard at Kingston, 47 tons altogether, 15 tons of which were in sacks on deck on November 21, and on the morning of the 22d the *Lydonia* sailed from Kingston and immediately resumed the line of soundings.

Excellent weather was experienced all through the Windward Passage, up to abreast Rum Cay, when a westerly gale made it desirable to anchor in the lee of Rum Cay for shelter at about noon of the 25th. Soundings were taken on all this run from the time the vessel left Kingston until Rum Cay was reached.

In the morning of the 26th, the weather having improved, the vessel got under way and proceeded on its course, resuming the line of sounding where it had been broken off.

Early in the morning of the 27th westerly gales were met with, which prevented all sounding and made progress by the ship very slow. Owing to the

distance to Jacksonville and the amount of coal remaining aboard, the ship was headed toward port, though little progress was made. During the night of the 27th the weather got much worse, and for the whole of the 28th the vessel was hove to with a heavy sea running, the wind at times exceeding 60 miles an hour, and in one heavy squall the anemometer blew away. During the 27th and 28th the vessel only made good 133 miles in the 48 hours.

The vessel was hove to until the morning of the 29th, but bad weather still persisted all the remaining distance to the St. Johns River, which was entered during the beginning of another blow (a northeaster) at noon on the 30th. During all the period from the 27th to the 30th it was impossible to continue sounding on account of the heavy weather prevailing. The vessel arrived at Jacksonville late in the afternoon of Thanksgiving Day, November 30.

Soundings were taken by means of a standard Sigsbee deep-sea sounding machine, mounted near the bow of the vessel on the port side. At all soundings the ship was kept with the bow headed into the wind or sea, and with little difficulty the sounding wire was kept up and down while the sounding was being taken. In addition, by means of an electric-sounding machine on the quarter deck, water temperature and a sample of the water at a depth of 200 fathoms was taken at each sounding.

Very little difficulty was experienced in taking the soundings, probably because of the fact that the officers and crew had been accustomed to the work through having done similar work during the previous seasons on the California and Oregon coasts.

GEODETIC WORK.

TRIANGULATION, RECONNAISSANCE, AND SIGNAL BUILDING.

IDAHO AND MONTANA.

[Lieut. (Junior Grade) W. M. Scaife, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Precise triangulation: 10,000 square miles of area covered; 13 stations in main scheme occupied for horizontal measures, 41 stations marked; 15 stations in supplemental schemes occupied for horizontal measures; 42 elevations determined trigonometrically; 42 geographic positions determined; 22 observing tripods built, 2 scaffolds built of 91 feet height.

About the middle of May, 1922, work was started near Pocatello, Idaho, on the arc of precise triangulation which will extend northward to the Canadian boundary. The stations of the Utah-Washington arc of precise triangulation started from were Caribou, Middle Butte, and Putnam. Previous to July 1, 1922, due to the fact that many of the stations are on high peaks, difficult of access, and the winter being late, the progress was slow.

At the beginning of the season the party was divided into three sections: (1) The main observing party and the light-keeping force, in charge of Lieut. (Junior Grade) W. M. Scaife, assisted by Earl C. States, extra observer; (2) the building party, in charge of Walter J. Bilby; and (3) the subparty assigned to cooperate with the General Land Office in locating selected corners of that survey, in charge of Lieut. W. H. Overshiner. This organization was changed slightly when the building was completed.

After the completion of the first quadrilateral, which contained the longest lines of the season, the progress was more rapid. The last observations were made on November 6, at Bozeman northwest base, in zero weather, the light-keepers working in more than 30 inches of snow.

In accordance with arrangements made between the Coast and Geodetic Survey and the General Land Office for cooperation work for the purpose of connecting verified corners of the General Land Office with the triangulation of the Coast and Geodetic Survey, E. H. Kimmel, of the General Land Office, made the detailed reconnaissance and marked the stations in a permanent manner. Lieutenant Overshiner did the necessary observing from the Land Office corners. The main observing party made the necessary supplemental observations from the main scheme stations. Five automobile trucks and a number of pack horses were used for the transportation of the observing party, light keepers, and equipment.

WASHINGTON.

[WILLIAM MUSSETTER, Extra Observer, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Precise triangulation: 30 square miles of area covered; 6 signals built, of aggregate height of 220 feet; 8 stations in main scheme occupied for horizontal measures; 6 stations occupied for vertical measures; 8 geographic positions determined; 2 new elevations determined trigonometrically. Base line, precise: 1 base measured 1½ miles in length.

After the arc of precise triangulation in Puget Sound from Tacoma, Wash., to the Canadian boundary was completed a preliminary computation of the field observations was made. This showed that the length discrepancy between the old triangulation at Tacoma and the next measured base above was too great for precise work.

Immediately south of Des Moines, Wash., a base line about 2,400 meters in length was measured between stations Zenith and Launch 2 of the 1921 triangulation. The staking, taping, and leveling of the base were done under very adverse conditions and took from April 11 to April 26.

After the completion of the base measurement signals were built and observations made at six of the stations of the 1905 and 1921 triangulations and at two new stations introduced on account of changed conditions and to avoid excessively high signals. These observations were made to check up the connection of the new triangulation with the old around Tacoma. The observing was completed May 22.

The chief of party was assisted by Dan W. Taylor, signalman, and four foremen. Ensign A. H. Wagener assisted only during the measurement of the base.

TEXAS AND OKLAHOMA.

[Lieut. (Junior Grade) EARL O. HEATON, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Precise triangulation: 1,000 square miles of area covered length of scheme, 70 miles; 1 signal 20 feet high built; 22 stations in main scheme occupied for horizontal measures; 22 stations in main scheme occupied for vertical measures; 60 geographic positions determined; 60 elevations determined trigonometrically. Primary triangulation: Length of scheme, 25 miles; 125 square miles of area covered. Secondary triangulation: 1,500 square miles of area covered. Azimuth: 2 stations occupied for determination of precise azimuth.

This work is being done to supply geodetic control for the survey of boundary line between Texas and Oklahoma, which is being done under the direction of two commissioners appointed by the Supreme Court.

The observing started on May 19 at station Monument, a station on the Ninety-eighth meridian established in 1902. The other two old stations recovered were Cube and Benton. The angle Cube-Benton measured at Monument agreed with 0.50 second of the value determined in 1902.

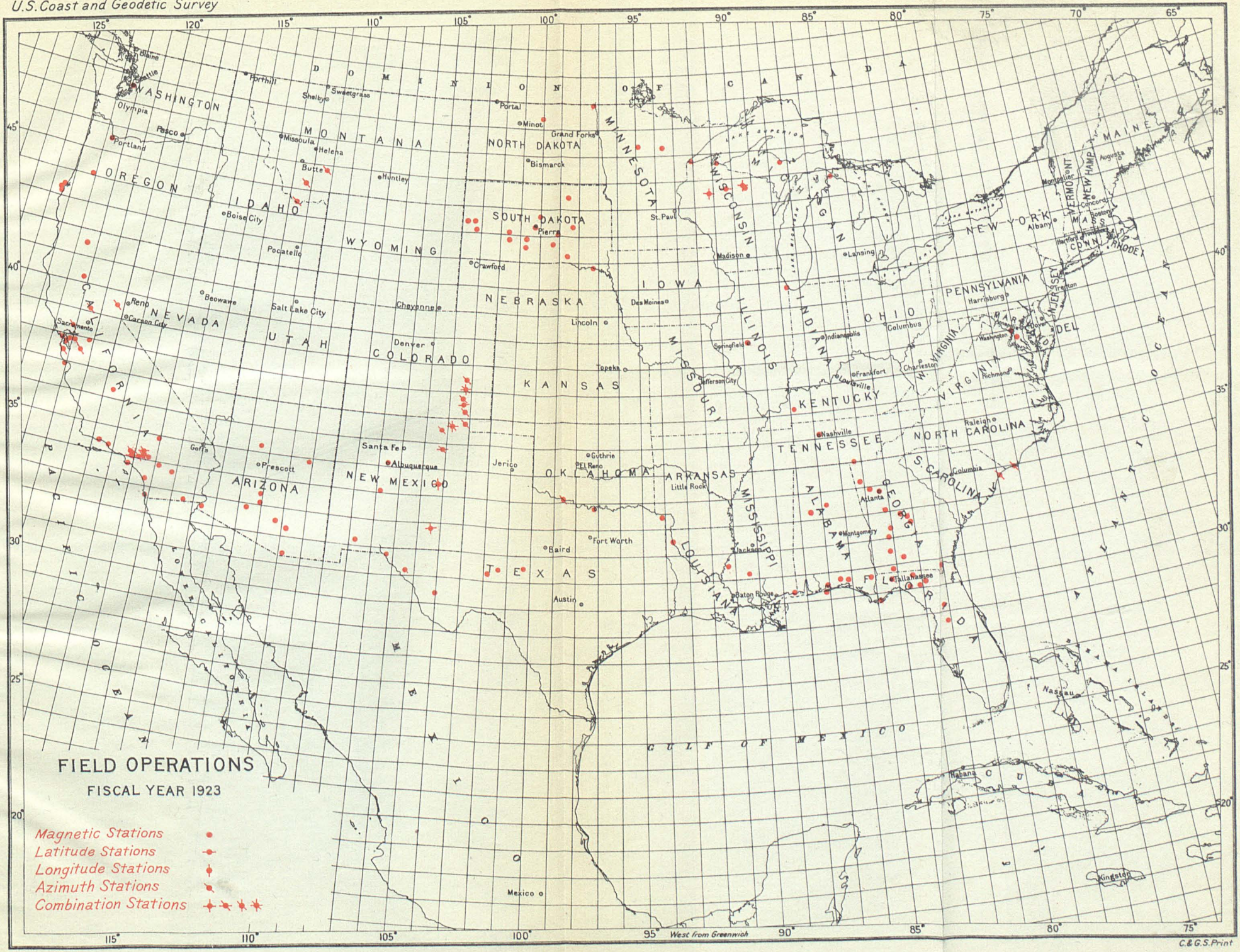
The triangulation will extend from these three stations westward astride the Red River to the one hundredth meridian, then north to a connection with stations Vinson, Coon, and Branson of the Oklahoma-California arc of precise triangulation in the vicinity of Wellington, Tex.

[J. S. BILBY, Signalman.]

SUMMARY OF RESULTS.—Reconnaissance: Length of main scheme, 160 miles; 1,860 square miles of area covered; 38 points selected for main scheme; 9 points selected for supplemental scheme; 19 points of the boundary connected; 10 stations with tripod and scaffold signals of aggregate height 210 feet; 37 stations with tripod stands of aggregate height 148 feet; 47 stations marked with tripod stands of aggregate height 148 feet; 47 stations marked with standard tablet station marks set in concrete.

The prime object of this work was to supply geodetic control for the survey of the boundary line between Texas and Oklahoma, which is being done under the direction of commissioners appointed by the Supreme Court.

The work starts from stations Cube, Benton, and Monument of the ninety-eighth meridian triangulation, Cube being south of the Red River, in Texas, and Benton and Monument north of this river, in Oklahoma. Starting from these three stations, the work extends westward astride the Red River to the one hundredth meridian, then north to a connection with stations Vinson, Coon, and Branson of the Oklahoma-California arc of precise triangulation near the thirty-fifth parallel, in the vicinity of Wellington, Tex. Connection was made with two stations of the U. S. Geological Survey in the vicinity of Burkburnett. A connection was also made with the Red River longitude station in the vicinity of Kirk-


FIELD OPERATIONS
FISCAL YEAR 1923
Magnetic Stations
Latitude Stations
Longitude Stations
Azimuth Stations
Combination Stations
DOMINION OF CANADA
WASHINGTON
OREGON
CALIFORNIA
IDAHO
NEVADA
MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
S. CAROLINA
N. CAROLINA
VIRGINIA
W. VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VERMONT
NEW HAMP.
MASS.
CONN.
R. I.
N. J.
DEL.
MD.
Olympia
Seattle
Portland
Spokane
Pasco
Kalispell
Missoula
Helena
Butte
Bismarck
Minot
Grand Forks
Portal
Sweetgrass
Shelby
Huntley
Boise City
Pocatello
Beowawe
Reno
Carson City
Sacramento
Salt Lake City
Cheyenne
Denver
Crawford
Pierre
St. Paul
Des Moines
Lincoln
Topeka
Jefferson City
Springfield
Madison
Lansing
Indianapolis
Columbus
Frankfort
Louisville
Nashville
Little Rock
Jackson
Baton Rouge
Atlanta
Montgomery
Tallahassee
Columbia
Raleigh
Charleston
Richmond
Washington
Harrisburg
Trenton
Albany
Augusta
Concord
Boston
Montpelier
Hartford
Providence
Dover
Santa Fe
Albuquerque
Jerico
Guthrie
El Reno
Fort Worth
Baird
Austin
Prescott
Gorfa
Mexico
Nassau
Habana
Kingston
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
West from Greenwich

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land, Tex., the Initial monument of the Texas-Oklahoma boundary, about one-fourth mile north of Red River, Kidder monument, 4,000 feet east of the Initial monument, and three known marks on the Texas-Oklahoma boundary between Initial monument and the thirty-fifth parallel.

John A. Peacock, foremen hand, had charge of the building and marking of stations.

COLORADO AND NEW MEXICO.

[Lieut. CASPER M. DURGIN.]

SUMMARY OF RESULTS.—Precise triangulation: 3,900 square miles of area covered; 29 stations in main scheme occupied for horizontal measures; 9 stations in supplemental scheme occupied for horizontal measures; 49 stations occupied for vertical measures; 72 geographic positions determined; 40 elevations determined trigonometrically. Base line, precise: 2 bases measured, one 7½ miles, the other 12½ miles in length. Azimuth: 12 stations occupied for determination of precise azimuth.

On July 1, 1922, work was in progress on the arc of precise triangulation along the one hundred and fourth meridian extending from the line Ingle-Round, Texas-California arc of precise triangulation near Pecos, Tex., to the line Aroya-Adobe of the transcontinental arc of precise triangulation along the thirty-ninth parallel. At this time the work had reached about the thirty-sixth parallel, about half of the line being completed. This arc is tied in with the El Reno-Needles arc of precise triangulation by the line Louisiana-Hill.

The party cooperated with the General Land Office by connecting to the scheme of triangulation 40 section corners. The connections were sometimes made by means of traverse and at other times by means of triangulation with a measured base.

During the measurement of the two bases, J. S. Bilby, signalman, was attached to the party and was of great assistance in expediting the work.

Transportation was made by five motor trucks, one of which was used to help in making connections to the General Land Office section corners.

ILLINOIS, KANSAS, AND COLORADO.

[J. S. BILBY, Signalman.]

SUMMARY OF RESULTS.—Recovery and remarking of precise triangulation stations; 59 stations visited; 42 stations recovered and remarked.

At the end of June 30, 1922, the recovery and remarking of stations on the precise triangulation along the thirty-ninth parallel was in progress; at this time the work had been completed from the vicinity of St. Louis, Mo., to Salina, Kans.

The work was carried from Salina, Kans., westward to the El Paso base net in the vicinity of Colorado Springs, Colo., which was completed on September 13.

No work was done on the recovery of stations from September 14 to October 16, as this time was spent by the chief of party in traveling and assisting in the measurement of the Artesia base line in New Mexico.

From October 17 to 31 the chief of party was engaged in the recovery and the remarking of stations along the ninety-eighth meridian from Waldo to Lyons, Kans.

All stations recovered were remarked in a permanent manner with a tablet station mark and tablet reference marks.

VIRGINIA, NORTH CAROLINA, AND SOUTH CAROLINA.

[Lieut. L. P. RAYNOR and Lieut. (Junior Grade) HERMAN ODESSEY.]

SUMMARY OF RESULTS.—Reconnaissance: 13 stations selected for the main scheme; area of scheme 14 square miles, length of scheme 6 miles. Triangulation, primary: 14 square miles of area covered, length of scheme 6 miles; 16 tripods built, aggregate height 100 feet; 3 scaffolds built, aggregate height 20 feet; 16 stations in main scheme occupied for horizontal measures; 64 geographic positions determined. Traverse, primary: 88 miles of line completed; 28 principal stations occupied for horizontal measures; 104 supplementary stations occupied for horizontal measures; 144 geographic positions determined. Azimuth: 3 stations occupied for determination of azimuth.

On October 1, 1922, work was started on a line of primary traverse along the Atlantic coast from Cape Henry, Va., to Currituck Sound, N. C. The traverse started from Cape Henry Lighthouse, with an azimuth to Cape Charles Light-

house, and at Currituck Sound was connected by a quadrilateral with Currituck Beach Lighthouse, Gray, and Woodhouse. This work was completed on November 25, and the party moved to Southport, N. C.

On November 27 reconnaissance was started for triangulation along the Cape Fear River. This triangulation extended from the line Snow Marsh-Federal Point to the mouth of the river, connecting with several old stations en route, and at the mouth of the river was directly connected in both length and azimuth with the traverse which was run along the coast to the south. The observing for this triangulation was completed on January 13, 1923. Lieut. (Junior Grade) Herman Odessey was chief of party from December 14, 1922, until January 16, 1923, during which time most of this triangulation was completed.

Starting from station R (U. S. E.) of this triangulation, traverse was run along the coast to the southward. On April 19, the date of closing work, this traverse had been completed to Myrtle Beach, S. C. An observed azimuth at the end of the line is the only check on this work, as no connection was made with old stations. It is planned to extend this work by traverse and triangulation through Charleston to Beaufort, S. C., thus giving control points along the entire coast of South Carolina.

The primary object of this work was to furnish control for the topographic and hydrographic surveys being made along this coast. It was the first attempt to run traverse by modern methods along the coast. From Cape Henry Lighthouse to Virginia Beach the traverse was run over the electric line of the Norfolk & Southern Railroad, but all the rest of the traverse was run directly along the beach.

In general, the usual traverse methods were used; stakes were driven for the support of the tape and the ends of the tape marked by pins. It was found that small tripods about 18 inches high were very useful in crossing inlets where there was a wide tide flat and also along the beach where the truck could be driven at low tide. However, tripods could be used only under ideal conditions, and stakes are better for general use. Considerable time was saved in leveling over the stakes and tripods by using a rod graduated in meters on one side and feet on the other. Readings were taken in both feet and meters instead of running a double line of levels. All observations at main scheme stations were made at night with an 8-inch direction instrument. Two automatic lamps were used on part of the work and found to be very satisfactory. Inlets too wide to traverse across at low tide were crossed by triangulation.

Transportation was furnished by motor truck, supplemented by a hired launch. At some places the beach at low tide formed an almost perfect driveway, but at other places there was quicksand in which the truck would stick. Great difficulty was experienced in getting the trucks across the inlets, and at some places they could not be used at all. Their depreciation was very high, as driving them through salt water and soft sand was very bad on tires, gears, etc. The party lived in tents and abandoned houses.

The chief of party was assisted by Lieut. (Junior Grade) W. H. Overshiner, Ensigns E. B. Roberts and E. P. Morton; G. H. Dell, junior engineer; W. J. Bilby, signalman; and J. A. Peacock, foreman hand.

NORTH CAROLINA.

[Lieut. L. P. RAYNOR.]

SUMMARY OF RESULTS.—Six tall type hydrographic signals were erected.

During the period April 10 to June 4, 1923, six tall-type hydrographic signals were erected along the North Carolina coast in the vicinity of the Cape Fear River, to be used by the steamer *Lydonia* in offshore hydrography. The actual work of erecting these signals was done by a subparty in charge of Walter J. Bilby, signalman, working under the direction of Lieutenant Raynor. These signals were of the standard type, each about 100 feet high.

CALIFORNIA (PASADENA BASE).

[Lieut. Commander C. L. GARNER and Lieut. (Junior Grade) E. O. HEATON.]

SUMMARY OF RESULTS.—Triangulation, precise: 200 square miles of area covered; length of scheme 22 miles; 7 stations in main scheme occupied for horizontal measures; 7 stations in the main scheme occupied for vertical measures; 24 geographic positions determined; 21 stations described and marked; one precise base of 22 miles measured; 7 precise azimuths determined and 4 latitudes observed.

This scheme of triangulation was observed to determine the distance between Mount Wilson and San Antonio Peak to be used by Prof. A. A. Michelson in a

redetermination of the velocity of light by the use of the interferometer. A base line of approximately 22 miles in length was measured in the valley south of the mountains, and the length was carried to the points selected by a strong chain of triangles.

The work was begun on October 16, 1922, with Lieut. Commander C. L. Garner in charge of the party; on March 1, 1923, the party was transferred to Lieut. (Junior Grade) E. O. Heaton, who finished the work on April 15, 1923. The officers in the party were Lieut. (Junior Grade) F. W. Hough, Extra Observer William Mussetter, and Signalmen J. S. Bilby and Dan W. Taylor.

Much difficulty was encountered on account of poor observing weather and from unusual horizontal refraction.

CALIFORNIA (EARTHQUAKE TRIANGULATION).

[Lieut. Commander C. L. GARNER.]

SUMMARY OF RESULTS.—Triangulation, precise: 12,000 square miles of area covered; 13 stations in the main scheme recovered and occupied for horizontal measures; 7 precise azimuths observed.

This work was begun on July 21, 1922, and ended for the season on January 15, 1923. This triangulation is being reobserved to test the stability of the earth's crust in the earthquake region of California. Much delay was caused by weather unfavorable for observations, and unusual examples of horizontal refraction were encountered.

This work will be extended in the next fiscal year with Dan W. Taylor, signalman, in charge of the signal building and with Lieut. (Junior Grade) Floyd W. Hough in charge of the observing party.

MONTANA.

[WILLIAM MUSSETTER, Extra Observer, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Triangulation, precise: 1 station in main scheme occupied for horizontal measures. Base line, precise: 1 base measured 18 miles in length.

This is the continuation of the arc of precise triangulation begun by Lieut. (Junior Grade) W. M. Scaife, which is to extend from Pocatello, Idaho, to the Canadian boundary. A precise base line of 18 miles in length was measured, and one main scheme station was occupied for horizontal measures. The report on this work will be continued in the next fiscal year.

[Lieut. JACK SENIOR.]

SUMMARY OF RESULTS.—Base line, precise: 1 base measured, 12 miles in length.

The season began June 10, 1923, to extend an arc of precise triangulation along the forty-ninth parallel. A precise base was measured at Havre, Mont., and signals were erected at three stations. The report on this work will be continued in the next fiscal year.

LEVELING.

VERMONT, NEW HAMPSHIRE, AND MAINE.

[H. G. AVERS, Mathematician, and D. B. PHELEY, Junior Engineer.]

SUMMARY OF RESULTS.—Leveling, precise: 277 miles of levels run; 136 permanent bench marks established.

On July 1, 1922, work was in progress in the vicinity of Swanton, Vt., under H. G. Avers, mathematician, on a line of levels extending from Rouses Point, N. Y., to Portland, Me. The route of the work followed the Central Vermont Railway from Rouses Point, N. Y., through Swanton, Vt., to St. Armand, Quebec; the St. Johnsbury & Lake Champlain Railroad from Swanton to Sheldon Junction, Vt.; the Central Vermont Railway from Sheldon Junction to Richford, Vt.; the Canadian Pacific Railway from Abercorn, Quebec, through Richford to Newport, Vt.; the Boston & Maine Railroad from Stanstead, Quebec, through Newport to St. Johnsbury, Vt.; the Maine Central Railroad from St. Johnsbury, Vt., to Whitefield, N. H.; the Boston & Maine Railroad from Whitefield to Gorham, N. H.; the Grand Trunk Railway from Gorham, N. H., to Yarmouth Junction, Me.; and thence along the Maine Central Railroad

to Portland, Me. The party was transferred to D. B. Pheley, junior engineer, on August 2, 1922.

At St. Armand, Abercorn, and Stanstead, Province of Quebec, connections were made with the bench marks established by the Geodetic Survey of Canada at those places.

At Newport, Vt., and between Newport, Vt., and Stanstead, Province of Quebec, connections were made with four bench marks established by the public-works department of Canada.

At Portland, Me., tidal bench marks to which the tidal station is referred were incorporated into the line.

The field work was completed at Portland, Me., December 22, 1922.

CONNECTICUT, MASSACHUSETTS, AND RHODE ISLAND.

[Ensign ELLIOT B. ROBERTS, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Leveling, precise: 176 miles of levels run; 104 permanent bench marks established.

The precise leveling in these States, which is being done at the request of the U. S. Geological Survey, was started on April 16, 1923, at New Haven, Conn. The route of the work is as follows: From New Haven northward along the New York, New Haven & Hartford Railroad through Meriden, New Britain, Hartford, and Thompsonville, Conn., to Springfield, Mass.; from New Britain along the New York, New Haven & Hartford Railroad and across country through Terryville to East Morris, Conn.; from Hartford eastward along the New York, New Haven & Hartford Railroad through Willimantic and Plainfield, Conn., toward Providence, R. I. At the close of the fiscal year the work had been completed to the Connecticut-Rhode Island State line.

At East Morris, Conn., a connection was made with the bench marks established by the engineering department of Columbia University.

At Springfield, Mass., a connection was made with the Van Orden line of levels between Boston, Mass., and Albany, N. Y.

NEW YORK, CONNECTICUT, AND RHODE ISLAND.

[Lieut. (Junior Grade) HERMAN ODESSEY.]

SUMMARY OF RESULTS.—Leveling, precise: 142 miles of levels run; 179 permanent bench marks established.

On September 16, 1922, work was started on a line of precise levels at Yonkers, N. Y. The first 7 miles of the line were run through the streets of Yonkers and Mount Vernon. Beginning at Mount Vernon, the line followed the New York, New Haven & Hartford Railroad to Westerly, R. I., where work was closed on account of unfavorable weather on November 27, 1922.

Connections were made with the principal tidal bench marks at New Rochelle, N. Y., Greenwich, Bridgeport, Madison, and New London, Conn.

About 100 bench marks established by the United States Engineers at various places along the line were recovered and incorporated into the work.

Considerable field work was done in all the large cities passed through. About 11 miles of leveling was done in Bridgeport, where a large number of bench marks were established in different parts of the city at the request of the city engineer. In New Haven and New London also several bench marks were established to meet the needs of the city engineers.

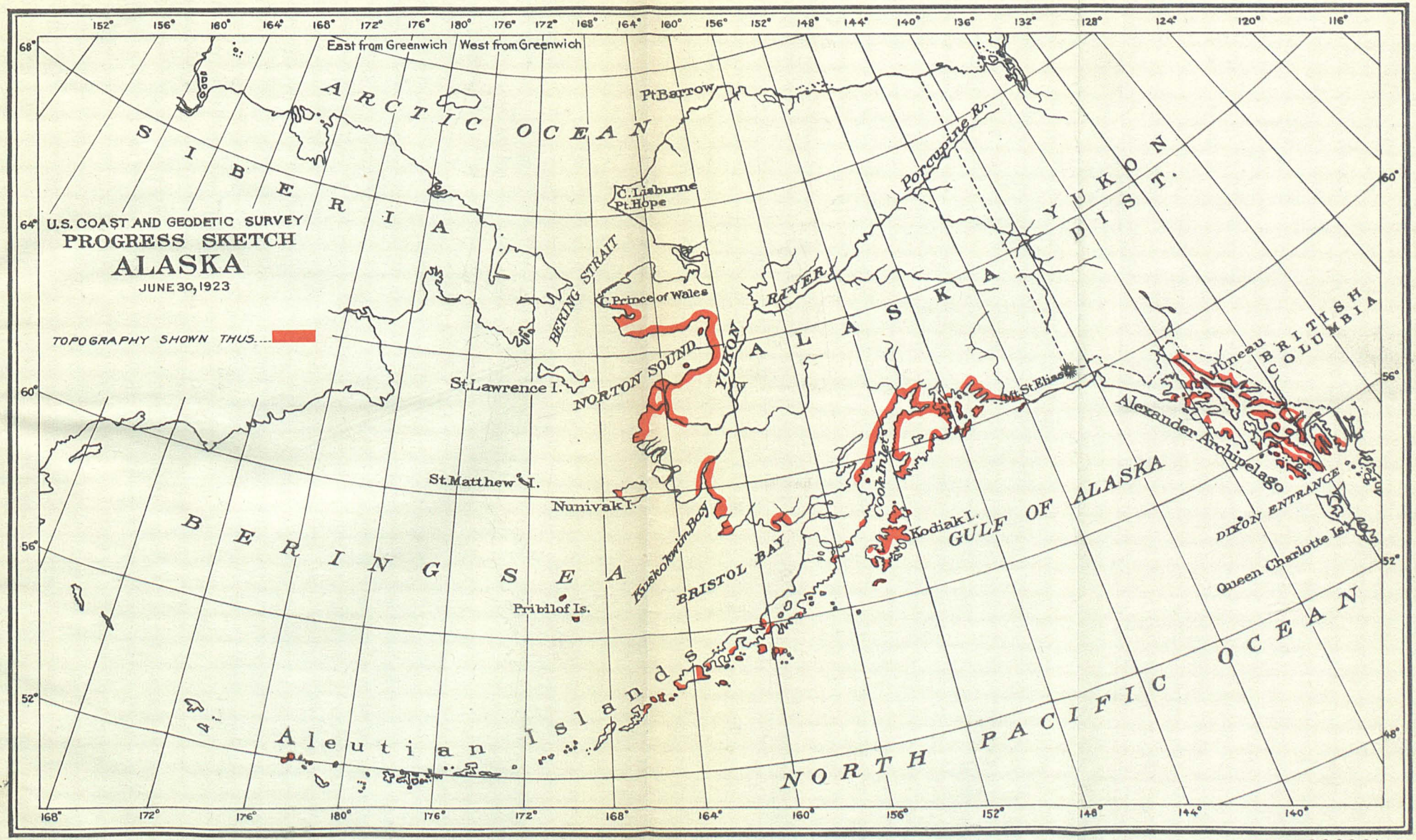
CALIFORNIA.

[Lieut. Commander CLEM L. GARNER and Lieut. (Junior Grade) EARL O. HEATON.]

SUMMARY OF RESULTS.—Leveling, precise: 60 miles of levels run; 59 permanent bench marks established.

Between January 17 and March 27, 1923, precise levels were run over the Pasadena base and a revision was made of a short section of precise leveling between Burbank and Glendale, Calif. The work was done at odd times when the base-measuring party was not otherwise occupied with the measurement of the base.

The leveling along the base started from bench marks of the U. S. Geological Survey at Alhambra and San Gabriel. All triangulation stations along the base were connected with the work and the elevations of all tape ends were de-


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1923
TOPOGRAPHY SHOWN THUS....
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
Porcupine R.
YUKON DIST.
BERING STRAIT
C. Prince of Wales
YUKON RIVER
ALASKA
BRITISH COLUMBIA
Juneau
St. Lawrence I.
NORTON SOUND
Mt. St. Elias
Alexander Archipelago
St. Matthew I.
Nunivak I.
BERING SEA
Kuskokwim Bay
BRISTOL BAY
Cook Inlet
Kodiak I.
GULF OF ALASKA
DIXON ENTRANCE
Queen Charlotte Is.
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN
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termined for the purpose of applying the inclination correction to the tape lengths. Spur lines of levels were run to the towns of Monrovia, Azusa, Covina, and San Dimas, and after leaving the eastern end of the base the leveling was continued through Ontario to the U. S. Geological Survey bench marks at Pomona, Calif.

The leveling between Burbank and Glendale, Calif., was run for the purpose of checking bench mark I–32, which was reported to have been disturbed. It was found that the concrete structure in which the bench-mark tablet was embedded had cracked and that consequently the bench mark had settled nearly 40 millimeters. A new bench mark was established to replace I–32. In Burbank two new bench marks were established to replace G–32, destroyed.

WASHINGTON.

[Ensign WILBUR O. MANCHESTER.]

SUMMARY OF RESULTS.—Leveling, precise: 25 miles of levels run; 17 permanent bench marks established.

Between November 21 and December 6, 1922, a line of precise levels was run along the Great Northern Railway from Burlington to Anacortes, Wash. The work started on bench marks established at Bulington in 1915 and ended on the bench marks to which the tide gauge at Anacortes is referred. A connection was also made with the tide staff.

ILLINOIS.

[GEORGE H. DELL, Junior Engineer.]

SUMMARY OF RESULTS.—Leveling, precise: 116 miles of levels run; 52 permanent bench marks established.

Between October 13 and November 27, 1922, a line of precise levels was run along the Illinois Central Railroad between Centralia and Carlo, Ill. This is along the same route followed by Coast Survey parties in 1885, 1888–89. Evidences of the old work were very few, as all the bench marks had been destroyed except bench mark N–8 at Centralia. Practically all the old bench marks were square cuts in culverts and stone sills of buildings.

Connections were made with the U. S. Geological Survey bench marks at Duquoin and with the bench marks established by the United States Engineers at Cairo, Ill.

WISCONSIN.

[Lieut. (Junior Grade) HERMAN ODESSEY and GEORGE H. DELL, Junior Engineer.]

SUMMARY OF RESULTS.—Leveling, precise: 271 miles of levels run; 258 permanent bench marks established.

On July 1, 1922, work was in progress on a line of levels extending from Duluth, Minn., to Green Bay, Wis., under Lieut. (Junior Grade) Herman Odessey, who continued in charge until September 11, 1922, when the party was transferred to G. H. Dell, junior engineer. The work followed the Minneapolis, St. Paul & Sault Ste. Marie Railway through Ladysmith to Laona Junction, Wis., and the Chicago & Northwestern Railway from Laona Junction to Green Bay, Wis., where connection was made with two bench marks established by the United States Lake Survey. This route is identical with the route followed by the line of precise traverse, which was run during the preceding year.

All of the traverse stations along the route were used as bench marks and additional bench marks were established in cities and towns where they were apt to be most frequently used.

The line was completed October 3, 1922.

MONTANA AND WYOMING.

[Ensign E. P. MORTON.]

SUMMARY OF RESULTS.—Leveling, precise: 26 miles of levels run; 14 permanent bench marks established.

On May 29, 1923, work was started on a line of precise levels at Livingston, Mont., to extend along the Northern Pacific Railroad to Gardiner, Mont., and thence along the roads through Yellowstone National Park. At the end of the fiscal year the party was in the vicinity of Pine Creek.

GRAVITY AND ASTRONOMY.

KANSAS, OKLAHOMA, AND TEXAS.

[Lieut. (Junior Grade) FRED E. JOEKEL.]

SUMMARY OF RESULTS.—Eighteen gravity stations occupied.

On July 1, 1922, Lieutenant Joekel was making observations at the first station of his season's work at Wilkins Well, Kans. After completing three more stations in Kansas he moved his party by truck to southern Oklahoma, where he occupied six stations. The remaining eight stations of the season are located in Texas. All of the 18 stations were selected by the U. S. Geological Survey to test the effect of certain geological formations on the intensity of gravity.

Invar pendulums were used throughout the season and were tested by duplicate determinations with the bronze pendulums at several of the stations. Excellent results were obtained. At many of the stations a tent formed the only protection against temperature variations and it would have been impossible to use the bronze pendulums without constructing constant temperature rooms.

At most of the stations the receiver was mounted on an aluminum tripod partly embedded in the ground. This resulted in large flexure corrections, and it is probable that this method of mounting the receiver will be discontinued.

Wireless time signals were used throughout the season. Static conditions interfered seriously with the automatic wireless recording device, especially during the hot summer months. Several changes were made in the receiving set in an attempt to overcome this trouble.

Lieutenant Joekel was assisted by E. P. Morton after November 1. The field work was completed early in January, 1923.

COLORADO, NEW MEXICO, AND WISCONSIN.

[Lieut. GEORGE D. COWIE.]

SUMMARY OF RESULTS.—Latitude and longitude: 10 precise latitude stations established; 6 differences of longitude (radio) determined. Gravity: 8 gravity stations occupied.

On July 1, 1922, a combined astronomic and gravity party under Lieutenant Cowie was at work in Wisconsin. Near the end of July the party moved by truck to New Mexico and began work there about the middle of August. The main work of the party was the determination of longitudes on the arc of precise triangulation along the one hundred and fourth meridian. Lieutenant Cowie was assisted by E. P. Morton, extra observer, who made the gravity observations.

Wireless time signals were used for both the longitude and gravity work and gave very satisfactory results. The probable errors of the longitude determinations varied from +0.003 to +0.011 seconds, which are smaller than those usually obtained by the telegraphic method.

Static conditions were especially bad in New Mexico during August, and electrical storms caused numerous delays throughout the season. Static interference was most severe about sundown each day and was the smallest in the early morning hours. Considerable experimental work was done with the receiving set during the season and several improvements made. Much information on the best methods of operation was also obtained.

The new invar pendulums were used again this season for gravity determinations and proved entirely satisfactory. At many of the stations a tent was the only protection against temperature changes. At several stations where constant temperature rooms were available, the bronze pendulums also were swung to test the invar pendulums.

When the pendulums were standardized at the end of the season the periods obtained differed considerably from the preseason standardization periods. The final results for the gravity stations occupied during the season, therefore, have not been computed.

Field work was completed on October 31, 1922.

INSPECTION DUTY.

[Lieut. Commander C. V. HODGSON.]

On October 2, 1922, the assistant chief of the division of geodesy went to Norfolk, Va., for the purpose of inspecting the party of Lieut. L. P. Raynor,

who was engaged in running a primary traverse line along the Atlantic coast between Cape Henry Lighthouse, Va., and Currituck Sound, N. C.

When the assistant chief of the division left the party on October 11, a section of 6 miles along the electric railroad from Cape Henry to Virginia Beach had been completed.

On his way back to Washington, the assistant chief stopped at Richmond, Va., for the purpose of consulting with the director of public works of that city in regard to the geodetic survey which was being made in that city. Two days were spent at Richmond with the officials of the Board of Surveys of that city and with representatives of the company who had the geodetic survey in charge. Some suggestions were made as to the details of the work. The assistant chief returned to the office on October 14.

MAGNETIC WORK.

MARYLAND (CHELTENHAM MAGNETIC OBSERVATORY).

[Magnetic Observer GEORGE HARTNELL.]

The regular work of the observatory was continued throughout the year. The two magnetographs were kept in continuous operation without changes of adjustment; absolute observations were made once a week, scale value determinations once a month, and meteorological observations daily. The chronometer corrections were determined daily by means of the radio-time signals sent out from Arlington.

The seismograph was in continuous operation and 19 earthquakes were recorded.

Comparison observations were made with several field magnetometers and dip circles and a new earth inductor intended for field use. Intensity constants were determined for the dip circle used in the investigation of iron-ore deposits in Alabama.

The buildings and grounds have been kept in good condition. The buildings were being painted at the close of the year. Two 40-foot poles were erected to support the radio aerial, to take the place of the old flagpole, which had rotted away. A building 14 by 10 by 8 feet has been erected for experimental purposes, with piers on which to mount variation instruments.

During May, Mr. Gish, of the department of terrestrial magnetism of the Carnegie Institution of Washington, was at the observatory making tests of a new earth potential apparatus to be installed at its observatory at Watheroo, Australia.

MARYLAND AND ALABAMA.

[Magnetic Observer WILLIAM WALTER MERRYMON.]

STATIONS OCCUPIED.—Alabama, Birmingham (2) and Tuscaloosa; Maryland, Cheltenham.

The season's work was designed to determine whether or not deposits of nonmagnetic iron ore could be located by means of observations with magnetic instruments. The work was undertaken at the request of Dr. W. R. Crane, of the Bureau of Mines.

After two weeks spent in preliminary study and standardization of instruments at Cheltenham the observer reached Birmingham on July 17; he closed work for the season on September 30. The work included dip and dip with loaded needle at 34 stations in the brown iron ore district about 30 miles southwest of Birmingham; at 10 stations over a deposit of red iron ore near Red Mountain Gap, near Birmingham; detailed observations of the same kind near a large specimen of red iron ore and a large specimen of brown iron ore on the grounds of the University of Alabama at Tuscaloosa. Complete magnetic observations were also made at the old stations at Tuscaloosa and Birmingham and at a new station at Birmingham, where further observations were made to determine the constants of the dip circle.

The results indicate that iron ores of the character under investigation do not produce an effect on the earth's magnetism large enough to be detected by ordinary magnetic instruments, even when the observations are made with great care under favorable conditions.

GEORGIA, ILLINOIS, KENTUCKY, MICHIGAN, MINNESOTA, NORTH DAKOTA, SOUTH DAKOTA, TENNESSEE, AND WISCONSIN.

[Magnetic Observer WALLACE M. HILL.]

STATIONS OCCUPIED.—Georgia, Atlanta;[1] Illinois, Springfield;[1] Kentucky, Princeton;[1] Michigan, Marquette[1] and St. Ignace;[1] Minnesota, Bemidji[1] and Grand Rapids; North Dakota, Pembina[1] and Rugby;[2] South Dakota, Aberdeen,[1] Chamberlain, Deadwood, Gannvalley, Huron,[1] Kadoka,[2] Lake Andes, Murdo, Onida,[2] Philip, Pierre,[1] Rapid City,[1 2] Sturgis, White River, and Yankton;[1] Tennessee, Nashville;[1] Wisconsin, Rhinelander,[1] Superior,[1] and Washburn.[1]

Between July 1 and October 30 observations of declination, dip, and horizontal intensity were made at the stations listed above. Old stations were reoccupied and meridian lines were established as indicated by the footnotes. At Pierre the old station was no longer suitable, so a new one was established. At Murdo and Chamberlain the old stations were no longer available. At Huron the old station was not available at the time because of construction work on a new courthouse.

Very few county surveyors or engineers could be found at the county seats, but those seen were interested in the work and glad to be of assistance.

FLORIDA, GEORGIA, AND TENNESSEE.

[Magnetic Observer WILLIAM H. CULLUM.]

STATIONS OCCUPIED.—Florida, Apalachicola, Bushnell, Crestview, De Funiak Springs, Live Oak, Madison, Marianna, Mayo, Milton, Ocala, Pensacola, Perry, and Tallahassee; Georgia, Albany, Americus (Atlanta), Barnesville, Cairo (Calhoun), Dallas (Dalton), (Folkston), (Forsyth), (Griffin), Irwinton, Jeffersonville, (Jonesboro), Macon, Moultrie, (Perry), (Ringgold), and Rome; Tennessee, Chattanooga.

Between January 15 and June 30 observations for declination, dip, and horizontal intensity were made at the places listed above except those inclosed in parentheses. At these places the old stations were found in good condition and it was only necessary to determine the true bearings of additional azimuth marks to take the place of those which had disappeared. At Folkston declination observations were made. Observations had not been made before at Bushnell, Milton, or Barnesville. The old stations were reoccupied at Mayo and Tallahassee, but the results at the latter place indicate that there has been a change in the immediate surroundings since the former observations in 1914.

Meridian lines were established at Apalachicola, De Funiak Springs, Madison, Ocala, Pensacola, Perry, and Americus.

A small truck was purchased at the beginning of the season and used to transport the observer and his outfit. Where the stations are not far apart this arrangement results in a material saving of time and money, as the observer is not dependent upon train schedules in getting from place to place nor upon draymen in getting his outfit from express office to observing station.

A further saving resulted from the use of a glazed sewer pipe filled with concrete, with one of the regular bronze disks set flush with the top as a station marker. Material for several of these could be carried in the truck and a marker made at the spot where it was needed.

ARIZONA (TUCSON MAGNETIC OBSERVATORY).

[Magnetic Observer WILLIAM H. CULLUM, July 1 to August 31; Magnetic Observer ALBERT K. LUDY, September 1 to June 30.]

The routine work of the observatory was continued throughout the year. The magnetograph has been in continuous operation and very few changes of adjustment have been required. Absolute observations were made once a week (except for three weeks in October, when the observer was ill), scale-value determinations once a month, and meteorological observations daily. The chronometers were kept rated by means of weekly comparison in Tucson with telegraphic time signals from Mare Island.

The seismograph was in continuous operation and 22 earthquakes were recorded. Some trouble was experienced with lost motion on the east-west component during the first part of the year, but this was largely overcome.

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[1] Old stations reoccupied.
[2] Meridian lines established.

Satisfactory dip observations could not be made for several weeks in the first half year because of failure of the substitute earth inductor to work properly. After the regular earth inductor was returned from the office a dip circle was added to the observatory equipment and observations were made with it once a month so that it would be available for use in an emergency. The clock of the magnetograph recording apparatus is not entirely satisfactory and the instrument will be sent to the office for overhauling as soon as another one is available. The deflection observations for determining the scale values of the variometers have been materially facilitated by placing collars on the deflection bars to act as stops in setting the deflector at the proper distances.

During the illness of the observer in October the magnetograph and seismograph were kept in satisfactory operation by his young son.

ARIZONA, LOUISIANA, NEW MEXICO, OKLAHOMA, AND TEXAS.

[Magnetic Observer WILLIAM H. CULLUM.]

STATIONS OCCUPIED.—Arizona, Ashfork, Holbrook, and Phoenix; Louisiana, Shreveport; New Mexico, Albuquerque, Deming, and Socorro; Oklahoma, Marietta; Texas, El Paso, Marfa, Rankin, San Angelo, Sierra Blanca, Stiles, and Texarkana.

Between September 1 and November 20 observations for declination, dip, and horizontal intensity were made at the places listed above. Observations had not been made before at Rankin and Stiles. Old stations were reoccupied at Ashfork, Holbrook, Deming, El Paso, and Sierra Blanca. At the other places the old stations were no longer available and new stations had to be established to replace them. The work at the end of the season was delayed by bad weather.

ARIZONA, CALIFORNIA, AND MISSISSIPPI.

[Magnetic Observer WALLACE M. HILL.]

STATIONS OCCUPIED.—Arizona, Gila Bend, Maricopa, Nogales, and (Red Rock); California, Banning, El Centro, Oceanside, Pasadena (2), San Francisco, Santa Barbara, Santa Cruz, and Ventura; Mississippi, Magnolia, (Mayersville), Natchez, and (Pascagoula).

Between January 23 and May 1, observations for declination, dip, and horizontal intensity were made at the stations listed above, except Pascagoula, Mayersville, and Red Rock. At these places the old stations were re-marked or recovered and the true bearings of additional objects determined. At Pascagoula declination observations were made. Meridian lines were set at Pasadena, Santa Barbara, Magnolia, Mayersville, and Natchez. Two stations were established at Pasadena, one for the use of Prof. R. C. Tolman in his investigations concerning the mass of the electron. At other places new stations were established at the request of local surveyors, to replace old stations no longer available.

In cooperation with the division of geodesy, triangulation stations in the vicinity of the magnetic stations were inspected and reported upon.

ARIZONA, CALIFORNIA, OREGON, AND WASHINGTON.

[Magnetic Observer ALBERT K. LUDY.]

STATIONS OCCUPIED.—Arizona, Yuma; California, Barstow, Gazelle, Hanford, Indio, Red Bluff, San Bernardino, San Francisco, San Diego, and Stockton; Oregon, Eugene and Portland; Washington, Seattle.

Between July 1 and August 21, on the way from the Sitka Observatory to the Tucson Observatory, observations of declination, dip, and horizontal intensity were made at the stations listed above. Old stations were reoccupied, except at Barstow, Hanford, Indio, and San Diego, where the old stations could no longer be used. Upon arrival at Tucson simultaneous observations were made for comparison with the observatory instruments.

Local surveyors and engineers were visited whenever it was possible and the nature of the work explained to them. In most cases they showed great interest and desired to be furnished with results and publications.

ILLINOIS.

[Magnetic Observer WILLIAM WALTER MERRYMON.]

STATION OCCUPIED.—Illinois, Chicago.

On June 16 work was begun on the occupation of repeat stations and the replacement of old stations reported defective by local surveyors in the northeastern part of the country from Illinois to Maine. Preparations for the work had been made and a new station at Chicago established at the end of the fiscal year. This observer is provided with a new earth inductor for use in determining dip, which is expected to insure greater accuracy and facilitate the work.

INSPECTION DUTY.

[Commander N. H. HECK.]

During February the chief of the division of terrestrial magnetism paid a visit of inspection to the magnetic observatory at Vieques, P. R., in order to secure first-hand information on local conditions as they affect the question of the continuance of the observatory. The living conditions for the observer at Vieques were found to be decidedly unsatisfactory and growing worse and the removal of the observatory to some other site would be justified on that account if for no other reason. It is probable that the owner will prefer to resume occupancy of the land at Vieques when the present lease expires two years hence.

Transportation from San Juan to Vieques and return was furnished by the steamer *Ranger* and this provided an opportunity to inspect the work being done by the party on that vessel.

ALASKA.

HYDROGRAPHIC AND TOPOGRAPHIC WORK.

SOUTHEASTERN ALASKA.

[Lieut. Commander T. J. MAHER, Commanding Steamer *Surveyor*.]

SUMMARY OF RESULTS.—Triangulation: 215 square miles of area covered; 66 observing tripods built; 66 stations in main scheme occupied for horizontal measures; 7 stations in supplemental scheme occupied for horizontal measures; 3 stations occupied for vertical measures; 98 geographic positions determined. Leveling: 10 permanent bench marks established; 3.3 miles of levels run. Magnetic work: 13 auxiliary stations occupied; 1 old station reoccupied; ship swung at 6 stations at sea; 34 course observations made. Topography: 45 square miles of area surveyed; 91.8 miles of detailed shore line surveyed; 1 topographic sheet finished, scale 1:10,000. Hydrography: 1,375 square miles of area covered, 3,729 miles run while sounding, 17,782 positions determined, double angles; 33,741 soundings made; 6 tidal stations established; 1 current station occupied; 6 hydrographic sheets finished, scales 1:5,000, 1:10,000, 1:50,000, and 1:120,000. Physical hydrography; 10 deep-sea current stations occupied.

The following officers were attached to this party (the principal nature of the surveying duties of each is detailed); Lieut. Jack Senior, executive officer, triangulation and topography; Lieut. C. K. Green, triangulation, topography, and hydrography; Lieut. (junior grade) A. G. Katz, hydrography; Lieut. (junior grade) L. C. Wilder, triangulation and hydrography; Ensign H. E. Finnegan, hydrography and topography; H. G. Locke, chief engineer; R. W. Healy, mate, hydrography; Dr. F. J. Soule, surgeon; H. L. Bloomberg, deck officer, topography and miscellaneous; M. Weisman, deck officer, hydrography and miscellaneous; and A. L. Mathews, draftsman, hydrography.

From July 1 until November 27, 1922, this party was engaged in general surveys in southeastern Alaskan waters, in the vicinity of Noyes, Anguilla, Warren, Coronation, Hazy, and Spanish Islands and in El Capitan Pass.

Areas surveyed: The inshore hydrography from Cape Addington, Noyes Island, to the south end of Warren Island has been completed. To the southward it joins work previously done and on the north, at Warren Island, connects with former surveys; it extends up the channel between Warren and Coronation Islands, joining former surveys at the north end of Warren Island. Along the

east coast of Coronation Island a very narrow strip of inshore hydrography is unfinished. The survey of the Anguilla Group has been completed.

The ship hydrography connects with the inshore hydrography near Warren Island, extends westward, passing south of the south end of Coronation Island at a distance of about 2½ miles, passes south of the southernmost of the Hazy Islands at a distance of three-fourths of a mile, and stops about 45 miles west from Coronation Island. Extending northward from this survey, passing between Hazy and Coronation Islands, a lane about 4 miles wide has been surveyed to the south end of Chatham Straits; from this a surveyed lane runs to Egg Harbor, Coronation Island.

Egg Harbor and Aats Bay, Coronation Island, Warren Cove, and the false cove north of it, in Warren Island, have been surveyed. The topographic survey of Warren Island has been completed, but that of Coronation Island only partly finished.

The survey of El Capitan Pass has been completed from Shakan to Brockman Pass. Near Brockman Pass and close to shore on each side are two small sections which have not been surveyed. The topographic sheet covering the section from Brockman Pass to Hub Rock is about 70 per cent completed. A very close survey was made of Dry Pass. Drills were driven into the bottom for distances of about 6 feet at various places to determine the character of the bottom.

Tidal stations were established at Steamboat Bay, Shakan, Anguilla Islands, Egg Harbor, and three in El Capitan Pass. Current observations were made at night when the vessel was anchored in depths of over 40 fathoms, and the drift of the ship was observed when hove to.

Magnetic observations were made in accordance with instructions.

Equipment: Three gas launches and steam launch *No. 47* were carried on deck. The steam launch *Cosmos* was attached to this party. In addition to this, a motor sailor was used.

At the close of field work the party proceeded to Ketchikan, where the launch *Cosmos* was hauled out and stored for the winter. The *Surveyor* arrived in Seattle on December 11 and at once proceeded with the completion of field records and arrangements for annual repairs.

[Lieut. Commander T. J. MAHER, Commanding Steamer *Surveyor*.]

SUMMARY OF RESULTS.—Triangulation: 110 square statute miles of area; 10 signal poles erected; 14 observing tripods built; 24 stations occupied for horizontal measures; 25 geographic positions determined. Leveling: 7 permanent bench marks established; 1.3 statute miles of tidal levels run. Magnetic work: 6 new auxiliary stations observed; 9 complete ship swings at sea. Topography: 10 square statute miles of area surveyed; 53 statute miles of detailed shore line surveyed; 1 topographic sheet finished, scale 1:10,000. Hydrography: 1,506 square statute miles of area sounded; 2,606 statute miles run while sounding; 6,176 positions determined (double angles); 8,737 soundings taken; 2 tidal stations established.

The following officers were attached to this party: Lieut. J. H. Peters, executive officer; Lieuts. C. K. Green and A. G. Katz; H. G. Locke, chief engineer; R. W. Healy, mate; F. J. Soule, surgeon; and Ensigns H. E. Finnegan, A. W. Skilling, and H. L. Bloomberg.

The party arrived on the working grounds March 31 and took up combined operations in the vicinity of Coronation Island, Baranof Island, and El Capitan Pass.

At the termination of the fiscal year hydrographic surveys were practically complete to the latitude of Cape Ommaney, and the offshore hydrography was carried north almost to the latitude of Whale Bay. The sea bottom in the section north of Coronation Island is very irregular. A close survey has been made of the greater part of this section, but considerable time will be spent there in investigating soundings suggestive of shoal areas. The hydrography has been carried as close to the east and west coasts of Coronation Island as it is safe to take the ship, and the same applies to the Hazy Island group. Four triangulation stations on the Hazy Islands have been located and stations have been established in the vicinity of Cape Decision to control the topographic survey of that section. The topographic survey of Coronation Island and of the Spanish Island group has been completed. Work at the southern end of El Capitan Pass has been resumed, that at the northern end being completed.

An automatic tide gauge was maintained at Port Walter, Baranof Island, and a plain tide staff was maintained at Egg Harbor.

The launch equipment consists of the steamer *Cosmos* and four gas launches.

[Lieut. A. M. SOBERIALSKI, Commanding Steamer *Wenonah*.]

SUMMARY OF RESULTS.—Reconnaissance: 13 points for scheme selected; length of scheme, 27 statute miles; area, 135 square statute miles; 1 base site selected. Triangulation, precise: 160 square statute miles of area covered; 19 signal poles erected; 18 observing tripods built of aggregate height of 56 feet; 5 observing scaffolds built of aggregate height of 64 feet; 18 stations in main scheme occupied for horizontal measures; 3 stations in supplemental schemes occupied for horizontal measures; 3 stations occupied for vertical measures; 21 geographic positions determined. Base lines: 1 precise base line measured; length, 3.9 statute miles; name, Dry Strait base. Leveling: 8 permanent tidal bench marks established; 3.9 statute miles of base line levels; 3 statute miles of tidal levels. Magnetic work: 8 new auxiliary stations established and observed; 1 old station reoccupied, 1 complete ship swing at sea. Topography: 241 square statute miles of area surveyed; 253.8 statute miles of detailed shore line surveyed; 6 topographic sheets finished, scales 1:20,000 and 1:10,000. Hydrography: 114.4 square statute miles of area sounded; 1,117.9 statute miles run while sounding; 5,424 positions determined (double angles); 12,930 soundings made, 2 tidal stations established, 5 hydrographic sheets completed, scales 1:20,000 and 1:10,000.

The following officers were attached to the party (the principal survey work of each is detailed): Lieut. C. A. Egner, executive officer, triangulation; Lieut. (Junior Grade) J. D. Crichton, topography and triangulation; Lieut. (Junior Grade) W. T. Coombs, hydrography; John Wyer, chief engineer; Ensign W. G. Fielder, topography and hydrography; and W. C. Aegerter, deck officer, miscellaneous.

The following launches were attached to and used by this party: Launch *Audwin*, launch *Delta*, launch *No. 117*, wire-drag tender *No. 2*, and a 20-foot United States Navy motor dory.

At the beginning of the fiscal year the steamer *Wenonah* was engaged in combined operations in Ernest Sound and preparations for precise triangulation in Dry Strait.

Triangulation, precise.—This work was performed by a subparty in charge of Lieut. C. A. Egner, assisted by Lieut. (Junior Grade) J. D. Crichton. The launch *Audwin*, supplemented at intervals by such minor launches as were necessary, was used. This scheme is the connecting link between the 1921–22 triangulation from the Canadian boundary through Clarence Strait and the 1917 triangulation which terminated on the south near Frederick Point. The reconnaissance was through a difficult country. The preliminary plan for expansion from the line Ryn-Kad was found to be impracticable. All difficulties were eventually overcome, however, with a resulting scheme of satisfactory strength of figure. An admirable base-line site was found on the grassy Stikine River Delta. The line runs in a straight line for 3.9 statute miles. The ground is quite firm and level. The actual work on the base was accomplished in less than two weeks in spite of rainy, disagreeable weather. The work called for in the supplementary instructions of June 17, 1922, was completed.

Topography.—The topography was carried up both sides of Clarence Strait from Casmano Point and Gridall Island to Tolstoi Bay and Ernest Sound.

Both shores of Ernest Sound were surveyed from Lemesurier Point and Onslow Point to a connection with completed work in the vicinity of Point Warde, including Union Bay, Vixen Inlet, Seward Passage, Santa Anna Inlet, Canoe Passage, Menefee Inlet, Southeast Cove, and Southwest Cove, and the numerous islands in Ernest Sound.

Zimovia Strait was surveyed from Ernest Sound to Chichagof Passage.

All the work was done on a scale of 1:20,000 except one 1:10,000 sheet in Zimovia Strait.

Special attention was given to the determination, wherever possible of numerous elevations in order to make the form lines as accurate as possible.

Hydrography.—The hydrography of Ernest Sound was completed from Lemesurier Point and Onslow Point to Point Warde. As the main channel in this area had been dragged, the work consisted principally of short lines from the limits of the drag work to the shore, and the detailed survey of the various bays and inlets, including Union Bay, Viven Inlet, Seward Passage, Santa Anna Inlet, Canoe Passage, Menefee Inlet, Southwest Cove, Southeast Cove, and Fools Inlet.

Two dangerous rocks were discovered and a report forwarded to the inspector at Seattle, which was published in the Notices to Mariners.

The survey of Vixen Inlet shows this to be an excellent harbor which had previously been avoided.

Some soundings were taken with the ship in the area covered by the wire drag in order to furnish additional information for charts.

Zimovia Strait was surveyed from Menefee Inlet to Anita Bay, including Thoms Place, Olive Cove, and Anita Bay. The narrow part of the strait was surveyed on a scale of 1:10,000.

Nothing new was developed by this survey, as the channel had been shown by the survey of 1916. The least water at the critical part of the channel is 2 fathoms at mean low low water. There is a considerable demand for a chart of this strait, and it would probably be used by vessels of the type of the *Jefferson*, as it shortens the distance between Wrangell and Ketchikan, besides being much better protected than the usual route. The *Wenonah* used the passage, but only on a flood tide. It would be advisable to drag the 10 miles between Menefee Inlet and Olive Cove, as there are bowlders on the bottom, and something might be discovered which the lead has failed to reveal.

Tides.—The automatic tide gauge at Menefee Inlet was continued in operation until the close of the season. In addition, observations were made at one or more auxiliary tide stations whenever hydrography was in progress.

Revision work.—The topography of the water front of Ketchikan and adjacent territory was extensively revised. Many new docks and other improvements were located.

In addition to such work as has been previously mentioned, the party compiled and submitted desirable coast pilot information with respect to the locality of the working grounds.

Valuable recommendations with respect to the desirability and importance of additional field work in this and adjacent localities was also submitted.

[Lieut. Commander J. H. HAWLEY, Commanding Steamer *Explorer*.]

SUMMARY OF RESULTS.—Triangulation: 280 square miles of area covered; 24 signal poles erected; 13 stations in main scheme occupied for horizontal measures; 2 stations in supplemental scheme occupied for horizontal measures; 27 geographic positions determined. Leveling: 7 permanent bench marks established; 4 miles of levels run. Magnetic work: 29 land stations occupied for magnetic observations; ship swung at one sea station for compass deviation. Topography: 144 square miles of area surveyed; 142 miles of detailed shore line surveyed; 5 topographic sheets finished, scale 1:20,000. Hydrography: Wire drag, 328 square miles of area dragged; 506 miles run while dragging; 2,207 positions determined (double angles); 84 sountings made (over shoals); 45 supplemental soundings made; 2 tidal stations established; 2 hydrographic sheets finished, scale 1:40,000.

The following officers were attached to this party (the principal surveying duties of each are detailed): Lieut. G. C. Jones, executive officer, wire drag; Lieut. (Junior Grade) F. L. Gallen, wire drag and hydrography; Lieut. (Junior Grade) H. C. Warwick, triangulation, wire drag; Lieut. (Junior Grade) B. H. Rigg, topography; Ensign A. J. Hoskinson, topography; A. N. Loken, chief engineer; and C. E. Christopherson, draftsman, drafting, plotting, recording.

Triangulation.—The secondary triangulation along the southern part of Lynn Canal from a junction with precise triangulation near Point Whidbey to the eastern end of Icy Strait, done during June, was continued west through Icy Strait to Point Adolphus. As only a few of the old stations could be recovered and numerous new stations were needed for control of the hydrographic and topographic revision, practically a new scheme was run. This scheme is considerably stronger than the old, but has a simple triangle for one figure just west of the Sisters Islands. This part of the work can be strengthened if considered desirable by about two days' work clearing a line of sight on Hoonah Island so that the line Cut 2–Sophia 2 can be observed.

Topography.—From the limits of work completed prior to July 1, 1922, the topography was continued northward to the heads of Chilkat, Chilkoot, and Taiya Inlets. Satisfactory results could not be obtained in revising the old work in this region, which was done by photography on a scale of 1:80,000, and this locality was resurveyed on a scale of 1:20,000.

In the southern part of Lynn Canal the shore line was run on the west shore from a junction with previous work at Point Whidbey south to Couverden Island and form lines were obtained south to a point about opposite Point Retreat. The form lines south of this point and about 2 miles of shore line remaining to be done on Couverden Island can be surveyed on sheet 2566 when the revision work on this sheet is taken up. On the east side of the canal the shore line was surveyed from a junction with previous work near Point Retreat south to and including Funter Bay.

The party also revised previous topography at Point Bridget and on Glass Peninsula and verified the form lines in the vicinity of Point Coke, Stephens Passage.

Hydrography.—Wire-drag work was completed north to Skagway during the latter part of June and the party then returned to Juneau and from the 1st to the 8th of July was engaged in dragging splits in previous work south of Douglas Island to Stephens Passage. This work was done with the launches while the ship cleaned boiler at Juneau.

Upon the completion of the work mentioned above drag work was started in the southern part of Lynn Canal. From a junction with previous work off Point Whidbey the drag work was extended south through Lynn Canal to Point Marsden, overlapping previous work at the west end of Saginaw Channel. After being extended as far south as Point Marsden dragging was continued to the westward through Icy Strait and at the end of the season had been extended approximately to a line from Point Sophia to Noon Point, Pleasant Island. Several changes in charted depths and three rocks dangerous to navigation were found in Icy Strait. The decrease of deep-water areas in Icy Strait afforded fewer opportunities to use the sweep, and the progress of the work was slower than in other localities.

During the latter part of the season the party covered three splits in previous work near Sail Island in Stephens Passage, and located a rock in Hood Bay reported by the steamer *Spokane.*

A comprehensive attempt to test the depths of the sweep was made during the latter part of the season and considerable valuable information was obtained.

Tidal work.—During the first part of July old bench marks at Juneau were recovered, two new marks established, and all marks connected by spirit levels. An automatic gauge was established at Funter Bay, Lynn Canal, on July 25 and continued until the end of the season. The old bench mark in this bay was recovered and three new marks established. During the latter part of the season a staff gauge was installed at Hoonlah and connected with the old bench mark there. Two new marks were established.

Magnetic work.—Twenty-nine shore stations were occupied with the compass declinometer after July 1, as well distributed as possible in Taiya and Chilkoot Inlets, Lynn Canal, and Icy Strait. The ship was swung in Icy Strait just outside Port Frederick on September 29 and the compass declinometer was tested by observations at Seward Park, Seattle, after the close of the season.

Miscellaneous.—The chart agency at Hoonlah was inspected by an officer of the party during September.

Field work was closed for the season on September 30. After the end of the season the launches *Helianthus* and *Scandinavia* were hauled out at the Ketchikan boathouse, the tender being left in the water for use by the station keepers. Piles were purchased and the use of a pile driver obtained to drive eight piles, two for a dolphin off the end of the ways for tying up launches and three on each side of the ways to aid in centering the launches on their cradles when about to be hauled out.

[Lieut. J. H. HAWLEY, Commanding Steamer *Explorer.*]

SUMMARY OF RESULTS.—Triangulation (secondary): 145 square statute miles of area covered; 24 signal poles erected; 31 old stations recovered and re-marked; 34 stations in main scheme occupied for horizontal measures; 29 geographic positions determined. Base lines: 1 secondary base line measured; length, 3.1 statute miles; name, Point Gustavus base. Leveling: 10 permanent bench marks established; 6 statute miles of tidal levels run. Magnetic work: 4 observations on land; 1 ship swing at sea. Hydrography: 273 square statute miles of area wire-dragged; 500 statute miles run while dragging; 1,442 positions determined (double angles) 52 soundings taken; 4 tidal stations established; scale of hydrographic sheets 1: 40,000.

The following officers were attached to the party during the period covered by this abstract, March 30 to June 30: Lieut. Charles Shaw, executive officer; Lieut. (Junior Grade) W. T. Combs and A. M. Weber; Ensign D. E. Whelan, jr.; Adolph Loken, chief engineer; C. D. Baker, deck officer; and H. E. MacEwen, draftsman.

The work of this season is a continuation of that of the previous season accomplished by this party and represents field work in Icy Strait, Cross Sound, and Port Frederick.

From March 31 to April 3 the party was in Juneau making general preparations for field work. On April 3 one officer and five men left in the *Helianthus,* completed the triangulation necessary for control of drag work on June 12, and then took up the survey of Port Frederick, which was continued until the end of the year.

Following are the details of the work accomplished:

Triangulation.—From the line Boss 2–Adolphus 2, the western limit of the work done in 1922, triangulation was extended westward to a junction with work done in 1901, connecting with the old work at stations Damp, Bad, Dash, and False. From this junction practically all the old stations were recovered and re-marked west to Cape Spencer. Signals were built over these stations and a few additional points were located in Cross Sound.

A base about 3.1 statute miles long was prepared and measured along the sand and mud flats at Point Gustavus and was connected with the tringulation.

After the completion of the above work triangulation was extended into Port Frederick, starting from the line Scraggy–Quill 2 of the 1922 work and continuing through six figures to a point about two-thirds of the distance to the head of the port.

Wire-drag work.—From the western limit of completed work in Icy Strait drag work was completed to Lemesurier Island with the exception of Icy Passage and Gedney Channel. West of this limit a considerable area was swept, including the greater part of the deep-water area between Lemesurier Island and the Inian Islands, North and South Passages, North Inian Passage, and about half the deep water of Cross Sound.

In addition to the above work, additional dragging required near Sentinel Island in Lynn Canal was done and drag work was extended closer to Point Lena, Favorite Channel.

Tidal work.—An automatic gauge was established at the cannery near the entranec to Port Frederick on April 5 and continued in operation through the end of the year. Supplemental staff gauges were established in Excursion Inlet, Mud Bay, Port Althorp, and Auke Bay. Bench marks were installed at each gauge.

Magnetic work.—The ship was swung off Point Adolphus to determine the compass error and observations were obtained with the compass declinometer at four stations in the vicinity of Lemesurier Island.

[Lieut. H. B. CAMPBELL, Commanding Launch *Wildcat*, and Ensigns MAX LEFF and C. M. THOMAS.]

SUMMARY OF RESULTS.—Triangulation: 1 station in main scheme occupied for horizontal measures, 2 stations in supplemental schemes occupied for horizontal measures. Leveling: 8 permanent bench marks established; 3 statute miles of tidal levels run. Topography: 41 square statute miles of area surveyed; 44.3 statute miles of shore line surveyed; 1 topographic sheet finished, scale 1:10,000. Hydrography: 5 square statute miles of area sounded; 104.6 statute miles run while sounding; 2,262 positions determined (double angles); 2,353 soundings taken; 2 tidal stations established; 1 hydrographic sheet finished, scale 1:10,000.

The work covered by this abstract consists of detailed surveys of that portion of El Capitan Pass extending to the east and south from Signal Point. This work was performed under the general supervision of the commanding officer of the steamer *Surveyor* between October 7 and November 25. The *Surveyor's* party furnished necessary additional equipment, launches, and personnel.

The weather during this period was exceedingly wet and rainy. Considerable trouble was experienced with the sounding launches. Only foggy weather was permitted to halt field work, both topography and hydrography proceeding during rain. The chief of party, assisted by Ensign Thomas, executed the hydrography. Ensign Leff observed the triangulation measures and executed the topography.

An automatic tide gauge was operated at Shakan during the period of this survey. In addition, a plain tide staff located just south of Devilfish Bay was observed during the progress of sounding in that vicinity.

WESTERN ALASKA.

[H. B. CAMPBELL, in Charge of Launch *Wildcat*.]

SUMMARY OF RESULTS.—Triangulation: 90.9 square miles of area covered, 7 stations in main scheme occupied for horizontal measures, 7 stations occupied for vertical measures, 27 geographic positions determined, 11 elevations determined trigonometrically. Leveling: 10 permanent bench marks established, 3.5 miles of levels run. Azimuth: 1 azimuth station occupied, observations of azimuth on three nights. Topography: 68 square miles of area surveyed, 36.3 miles of general coast line surveyed, 13 miles of ponds and sloughs surveyed, 3 topographic sheets finished, scale 1:10,000. Hydrography: 43.22 square miles of area covered, 577.9 miles run while sounding, 3,093 positions determined (double angles), 9,278 soundings made, 1 tidal station establisbed, 1 current station occupied, 2 hydrographic sheets finished, scales 1:10,000 and 1:20,000.

On July 1, 1922, the party on the launch *Wildcat* was engaged in the survey of Icy Bay, Alaska. By that date a base line 1,702 meters in length had been

measured and the observing in the triangulation scheme was nearly completed. The topography on the east side of the bay was nearly done. A hydrographic reconnaissance had been made and a scheme decided upon for developing the bay and approaches. An automatic tide gauge had been in operation since June 22.

The latitude and longitude of station South Base, which was selected as the initial point in the triangulation, was determined by a computation of the three-point problem from angles measured between Mount St. Elias, Mount Cook, and Mount Seattle, which are from 30 to 70 miles distant. The distance from South Base to Mount Elias, 30 miles, was checked by independent observations.

The azimuth of the base line was determined by eight sets of observations.

Expansion from the base line was made with two good figures in such a way as to include the whole bay.

Topography was done on a scale of 1 : 10,000. Sheets were laid out so that there was one sheet for each side of the bay and one sheet for the head of the bay. These sheets were completed. The entire shore line of the bay was located very carefully, and the face of the glacier was located by cuts and tangents. Traverses were run east and west of the bay to or beyond the limits of the sheets, and the connection of the new shore line with that shown on the chart is excellent. But little contouring is shown on the sheets.

The instructions for the hydrography called for a scale of 1 : 10,000. Practically nothing was known even of the general depths.

Four well-separated sounding lines carried straight offshore gave a good idea of the bar and channel, and three lines across the bay and one down the center showed what might be expected there. The water in the parts that would be most needed varied from about 6 to 50 fathoms.

The work offshore was done on the scale of 1 : 20,000, and that inside the bay on the scale of 1 : 10,000.

Sounding lines inside the bay were run straight across. The offshore lines were run perpendicular to the beach and around the spits and the direction of the lines was varied to give the best development.

Sounding was done with the hand lead to about 13 fathoms and beyond that with the sounding machine. For hand lead work the lines were spaced about 100 meters apart. The work on the bar was made as close as practicable under the conditions. In the anchorages the distance between the lines was reduced to 50 meters. The machine sounding lines were spaced 200 meters apart and the soundings taken about 150 meters apart.

In general the bay is deep and clear, the bottom rising gradually from the center to the south until the bar is reached and then apparently sloping slowly downward to the greater depths of the sea.

To the north from the center of the bay the water appears to continue deep to the face of the glacier. In the southern half there is a shelf 1 mile or more in width on each side with depths up to 12 fathoms. The spits extend from these shelves.

The bar is in the form of a crescent or half circle. It connects the two sand spits, extends nearly 6 miles offshore, and is about 3 miles wide at its outer point. From the 8-fathom channel, which is the best and which is located in the approximate center of the bar, the bottom rises very gradually toward the west spit. From the channel to the east spit the bottom is more irregular. The bar has apparently been formed from the material that has pushed out of the bottom of the bay and from the moraine brought down by the ice. The top of the bar is generally level but is irregular in places.

The bottom of the bay is generally of soft glacial clay or silt, but in places sand or gravel are found and near the west side a great deal of hard clay.

There are three anchorages in Ice Bay which are of value under different conditions.

An automatic tide gauge was in operation at Riou Bay during the progress of the work.

Currents were observed for 18 hours at a station just outside the line connecting the two sand spits.

Field work in this vicinity was closed at the end of September.

[Lieut. Commander H. A. SERAN, Commanding Steamer *Discoverer*.]

SUMMARY OF RESULTS.—Triangulation: 108 square statute miles of area covered; 21 signal poles erected; 13 stations in main scheme occupied for horizontal measures; 2 stations in supplementary schemes occupied for horizontal measures; 33 geographic positions determined. Leveling: 18 permanent bench marks established. Magnetic work: 11 new auxiliary stations occupied; one ship swing at sea. Topography: 122 square statute miles of area surveyed; 126 statute miles of detailed shore line surveyed; 3 topographic sheets completed, scale 1:20,000. Hydrography: 79 square statute miles of area sounded; 429 statute miles run while sounding; 2,256 positions determined (double angles); 6,306 soundings obtained; 4 tidal stations established.

The following officers were attached to this party:

Lieut. Commander C. L. Garner, executive officer; Lieuts. M. O. Witherbee and H. W. Hemple; Lieuts. (Junior Grade) J. A. Bond, F. E. Joekel, and J. M. Smook; Ensigns J. F. Downey and P. H. White; J. C. Herman, chief engineer; and Dr. W. R. Scroggs, surgeon (temporary).

This abstract covers combined operations in the vicinity of Shekikof Strait. Field work began April 30 and was in progress at the end of the fiscal year.

The work in Kachemak Bay was done by a subparty working from camp in Halibut Cove. This subparty consisted of 3 officers and 10 men.

Triangulation.—A scheme of secondary triangulation was extended from Homer Spit to the head of the bay, starting from 3 stations of the 1910 triangulation. This scheme consisted of four quadrilaterals and a final closed triangle. There were 11 stations occupied and each officer in the subparty occupied at least 2 of the stations. The average triangle closure was about 3 seconds.

Magnetic work.—Each of the triangulation stations was occupied with compass declinometer for determining the declination. In addition to this, the ship was swung completely on 24 points, both rudders, in Kachemak Bay.

Topography.—Three topographic projections were laid out to include the topography of this bay from a junction with previous work, about 4 miles northwest of Homer west base on the north shore and about 3 miles southwest of Gull Island on the south shore, to the head of the bay. Two of these sheets have been completed. The completed topography extends from the western limits mentioned above to the entrance to Bear Cove. In order to give the officers diversified experience, each topographic sheet was executed by a different officer and the remaining sheet will be executed by the third officer.

Hydrography.—Two hydrographic projections were laid out for the hydrography of the bay from Homer Spit to the head of the bay. A junction is made at Homer Spit with the hydrography of 1910. Inside the 10-fathom curve the hydrography of 1910 has been rerun. The western one of these two sheets is practically completed and some work has been done on the eastern sheet.

Tides.—A multiple tide staff was erected in Halibut Cove and connected with a tide staff erected on the cannery wharf in Seldovia Harbor by two days simultaneous observations. The staff at Seldovia was connected with the bench marks in that vicinity by leveling and the mean lower low-water datum plane established in 1908 and 1910 adopted for this year's work. Three bench marks were established in Halibut Cove and their elevations with reference to the zero of the tide staff determined. A search was made for the three bench marks established at Homer Spit in 1910. Only one of these could be recovered, the other two having been destroyed. In accordance with instructions, five additional bench marks were established in Seldovia Harbor and their elevations with reference to the old bench marks and the zero of the tide staff determined.

The work in Portage Bay, on the western side of Shelikof Straits, was assigned to a subparty of 3 officers and 14 men, using the launch *Yukon*. This subparty arrived in that bay on May 30 and since that time some work has been done. Progress has been necessarily slow on account of exceedingly adverse weather conditions.

Triangulation.—Five stations of the 1919 and 1920 work were recovered and signals built to start the hydrographic and topographic work. Four stations have been occupied to determine supplemental points for this work. It is expected that the extension of the triangulation to the westward through Wide Bay will be started in July.

Topography.—Five topographic projections for the coast from Cold Bay to and including Wide Bay were laid out. The first of these projections is the one including Portage Bay and extends from Cape Kanatak to Cape Igvak. This sheet has been completed except for some of the contours.

Hydrography.—The inshore hydrographic sheets were laid out to correspond with the topographic sheets. On the first of these sheets the inshore hydrography of Portage Bay north of a line extending southwest from Cape Kanatak has been completed.

An examination of the vicinity off Anchor Point was made on June 30. This examination was made on account of a rock or shoal having been reported by Capt. A. O. Johansen. No depths less than the charted depths were obtained. This vicinity is full of tide rips on a flood tide, due undoubtedly to the uneven bottom, and it is possible that these rips gave rise to the suspicion that a shoal existed there.

During the period from May 3 to 21 the ship was at Uyak and the personnel was engaged in putting the launch *Yukon* in commission. This launch had been hauled out on the ways of the Northwestern Fisheries Co. since the fall of 1920. A great deal of work was necessary in putting her in working condition. The entire hull below the water line had to be recalked, considerable ship's carpenter work was necessary about and below decks, and there was a large amount of work in the engine room.

While the *Discoverer* was at Uyak an automatic tide gauge was established on the cannery wharf. A search was made for the bench marks established in 1908 in Uyak and on Harvester Island. The two bench marks in Uyak have been destroyed and of the four established on Harvester Island only one could be recovered. Two new bench marks were established on Harvester Island and three marks were established on the Uyak side in the vicinity of the gauge. The elevations of these new bench marks and the zero of the tide staff in connection with the automatic gauge were determined by reference to the recovered bench mark on Harvester Island.

In addition to this tidal work, a topographic revision of the wharves at Uyak was made and a sheet showing the new wharves forwarded to the office; two bench marks at the Kodiak Mining Co. near the head of the bay were recovered and standard disk bench marks installed.

[Lieut. R. R. LUKENS, Commanding Steamer *Pioneer*.]

SUMMARY OF RESULTS.—Reconnaissance: Length of scheme 13 statute miles; 50 square statute miles in area; 8 stations selected for scheme. Triangulation: 106 square statute miles of area covered; 4 signal poles erected; 12 observing tripods built, total height 192 feet; 10 stations in main scheme occupied for horizontal measures; 2 stations occupied for vertical measures; 16 geographic positions determined. Leveling: 4 permanent bench marks established; 1.5 statute miles of tidal levels run. Magnetic work: 2 sets of observations on land; 2 new auxiliary stations occupied; 1 complete ship swing at sea. Topography: 8 square statute miles of area surveyed; 17.1 statute miles of detailed shore line surveyed; 1 topographic sheet finished, scale 1:10,000. Hydrography: 101 square statute miles run while sounding; 591 positions determined (double angles); 1,363 soundings obtained; 2 tidal stations established; scale of sheets 1:60,000 and 1:20,000.

The following officers were attached to this party: Lieut. H. B. Campbell, executive officer; Lieut. O. S. Reading; Lieuts. (Junior Grade) R. W. Woodworth and L. C. Wilder; Ensigns A. J. Hoskinson, R. W. Byrns, and D. W. Taylor; William E. Greer, chief engineer; Dr. F. P. Nevius, surgeon; and H. W. Tyler, deck officer.

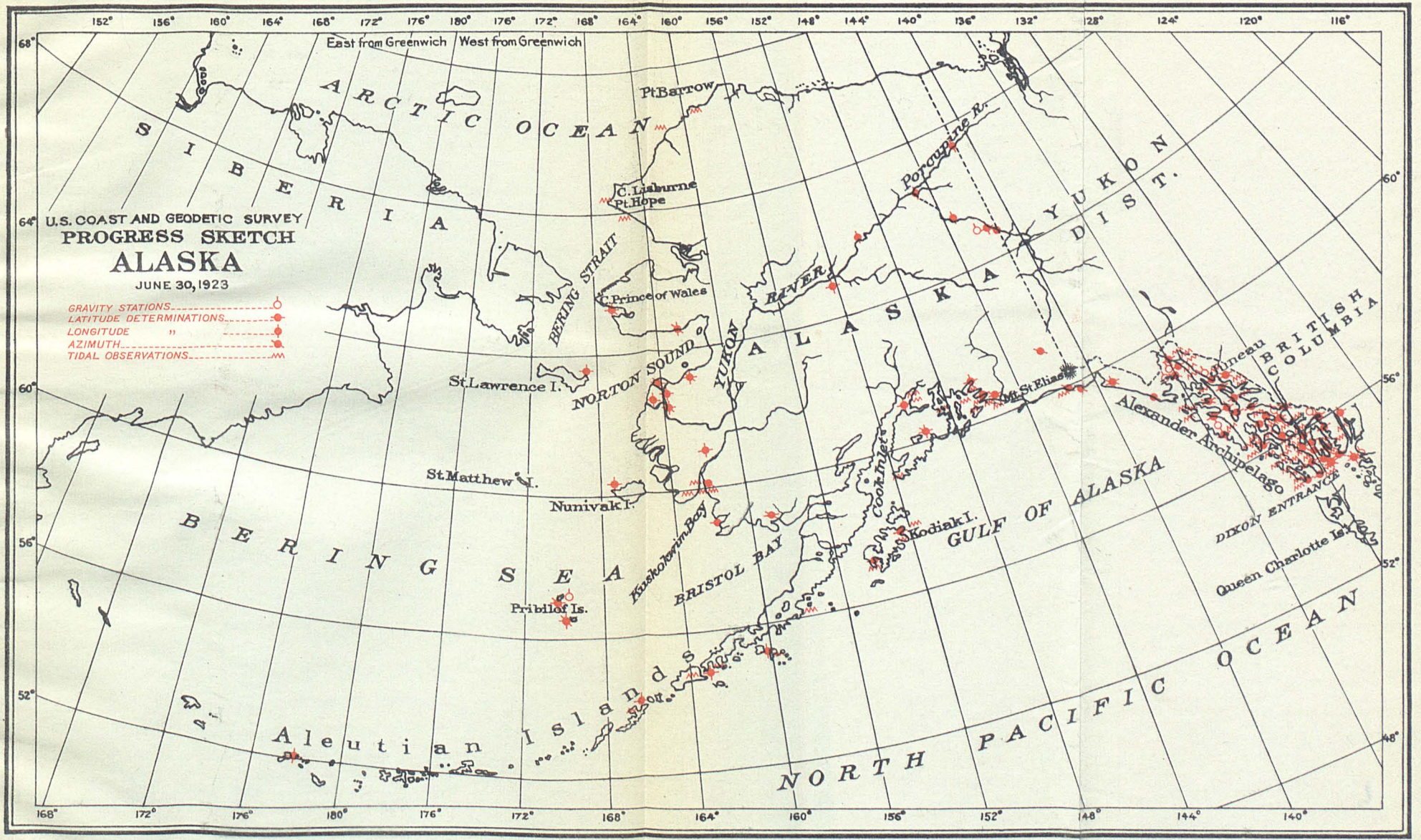
After making final preparations for the season's work, the steamer *Pioneer* sailed from Seattle, Wash., on April 20, en route to working grounds in the vicinity of Cape Pankof, western Alaska. A stop was made at Ketchikan to put the launch *Wildcat* in commission and this launch was then convoyed from that place to the working grounds for work in conjunction with the party on the *Pioneer*. The party arrived on the working grounds on May 19, and immediately started combined operations in that vicinity. Unfavorable weather retarded the progress of the party during the first few weeks. Work was in progress at the close of the fiscal year.

GEODETIC WORK.

[Lieut. L. C. DYKE.]

SUMMARY OF RESULTS.—Reconnaissance: 4 stations selected for main scheme, area of scheme 30 square miles, length of scheme 11 miles. Triangulation, precise: 490 square miles of area covered, length of scheme 45 miles; 8 signal poles erected; 2 tripods built, aggregate height 80 feet; 2 scaffolds built, aggregate height 80 feet; 10 stations in the main scheme occupied for horizontal measures; 10 stations occupied for vertical measures; 27 geographic positions determined; 27 elevations determined trigonometrically.

On July 1, 1922, reconnaissance and signal building were in progress on an arc of precise triangulation which is to extend from Anchorage to Fairbanks.


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1923
GRAVITY STATIONS
LATITUDE DETERMINATIONS
LONGITUDE "
AZIMUTH
TIDAL OBSERVATIONS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt Barrow
C. Lisburne
Pt. Hope
C. Prince of Wales
BERING STRAIT
Porcupine R.
YUKON DIST.
YUKON
RIVER
ALASKA
BRITISH COLUMBIA
Juneau
St. Lawrence I.
NORTON SOUND
Mt. St. Elias
Alexander Archipelago
St. Matthew I.
Nunivak I.
BERING SEA
Kuskokwim Bay
BRISTOL BAY
Cook Inlet
Kodiak I.
GULF OF ALASKA
DIXON ENTRANCE
Queen Charlotte Is.
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN

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This arc will eventually be extended to the point where the one hundred and forty-first meridian boundary between Canada and Alaska crosses the Yukon River. There it will connect with the arc of precise triangulation, now in progress, which extends northward from Puget Sound and which is being done by cooperation between the Geodetic Survey of Canada and U. S. Coast and Geodetic Survey.

The work of the party was very much delayed by excessive rains, but on an average one station per week was completed. The observing was finished on October 4, at station Witna, at about latitude 62°.

Five days were then spent in travel by pack train to the railroad, which was reached on October 10. The party made its headquarters at Eklutna, a station on the Alaska Railroad, and cleared the line of brush and tall grass for the measurement of the base. The clearing of the line took 10 days and the measurement of the base 4 days, the last taping being done on October 30. The base site is located on the south shore of Knik Arm on a long grassy flat at about the elevation of extreme high water.

The observing was done with an 8-inch Wanschaff (No. 2) with vertical circle attached. Vertical measures were taken both in the afternoon and night, and it was found that there was practically no difference between these verticals. Bad weather prevented much experimenting with these observations. If, however, the above coincidence were conclusively proved to be a fact, it would do away with the daytime observations in the Alaska region and furnish some interesting side lights on the effect of refraction.

Transportation was furnished for the party by pack train, consisting of six mules and nine horses, purchased from the Alaska Engineering Commission.

The chief of party was assisted by Lieut. (Junior Grade) Earl O. Heaton and S. O. White, signalman.

[Lieut. F. W. HOUGH.]

SUMMARY OF RESULTS.—Leveling, precise: 253 miles of levels run; 89 permanent bench marks established.

At the close of the fiscal year ending June 30, 1922, work was in progress, in the vicinity of Hurricane Siding, on a line of levels along the Alaska Railroad from Anchorage to Fairbanks. The line was finished to Fairbanks and then extended 50 miles southeast over the Valdez Trail to the Fox Farm Roadhouse, where, winter coming on, it was necessary to close work on October 26.

This line was run at the request of the U. S. Geological Survey and of other Federal map-making bureaus for the control of detailed mapping operations.

The bridge over the Tanana River at Nenana was in course of construction, and the method of simultaneous reciprocal observations was used to extend the level line across the river which, at this point, is 700 feet wide. The rods were clearly visible at this distance and targets were not required.

The staff of the automatic tide gauge at Anchorage was connected, at the beginning and at the end of the season, with the tidal bench marks to test the stability of the dock supporting the gauge. The results showed that the dock raised slightly during the period.

Knik Arm west base was connected by precise levels with the bench marks at Birchwood.

[Lieut. (Junior Grade) HERMAN ODESSEY.]

SUMMARY OF RESULTS.—Leveling, precise: 120 miles of levels run; 46 permanent bench marks established.

At the close of the fiscal year work was in progress on a line of precise levels to extend along the Fairbanks-Valdez trial from Fox Farm Roadhouse, about 50 miles south of Fairbanks, to Valdez. This work is the extension of the line which was carried to this point the preceding season.

[Lieut. GEORGE D. COWIE.]

SUMMARY OF RESULTS.—Latitude, longitude, and azimuth: 2 precise latitude stations established; 2 differences of longitude (radio) determined; 3 precise azimuths observed. Gravity: 2 gravity stations occupied.

During the latter part of April, a combined astronomic and gravity party under Lieutenant Cowie, started work in southeast Alaska. Wireless time

signals sent out from the Naval Observatory through the Annapolis radio station were used in connection with the longitude and gravity work. As the distance from Annapolis to southeast Alaska is about 3,000 miles, the successful automatic recording of these signals is a noteworthy achievement.

Work was in progress at the end of the fiscal year. Lieutenant Cowie is assisted by D. B. Pheley, aid, and Charles Pierce, junior engineer.

A launch is used for transporting the party.

MAGNETIC WORK.

SITKA MAGNETIC OBSERVATORY.

[Magnetic Observer F. P. ULRICH.]

The routine work of the observatory was continued throughout the year. The magnetograph was kept in continuous and satisfactory operation, no change of adjustment being made until June 30 and then only to the vertical intensity variometer. Absolute observations were made once a week, scale value determinations once a month, and meteorological observations daily. The scale values remained very nearly constant throughout the year. The chronometers were kept rated by means of time signals received by cable at the local office of the Signal Corps of the Army.

The seismograph was in continuous operation except for a short break in March, when it was being cleaned, and 31 earthquakes were recorded.

Late in the year arrangements were made for a systematic record of auroras and of difficulties experienced by radio and cable stations in Alaska, but no auroras were observed because of the short nights at that time of year.

PORTO RICO.

[Lieut. F. B. T. SIEMS, Commanding Steamer *Ranger*.]

SUMMARY OF RESULTS.—Triangulation: 50 square statute miles of area covered; 17 signal poles erected; 128 feet observing tripods built; 136 feet observing scaffold built; 15 stations in main scheme occupied for horizontal measures; 13 geodetic positions determined. Leveling: 5 permanent bench marks established; 2 statute miles of tidal spirit levels run. Hydrography: 215 square statute miles of area wire dragged; 575 statute miles run while dragging; 2,350 positions determined (double angles); 90 supplementary soundings taken; 1 tidal station established; 6 hydrographic sheets finished, scale of sheets 1:2,000.

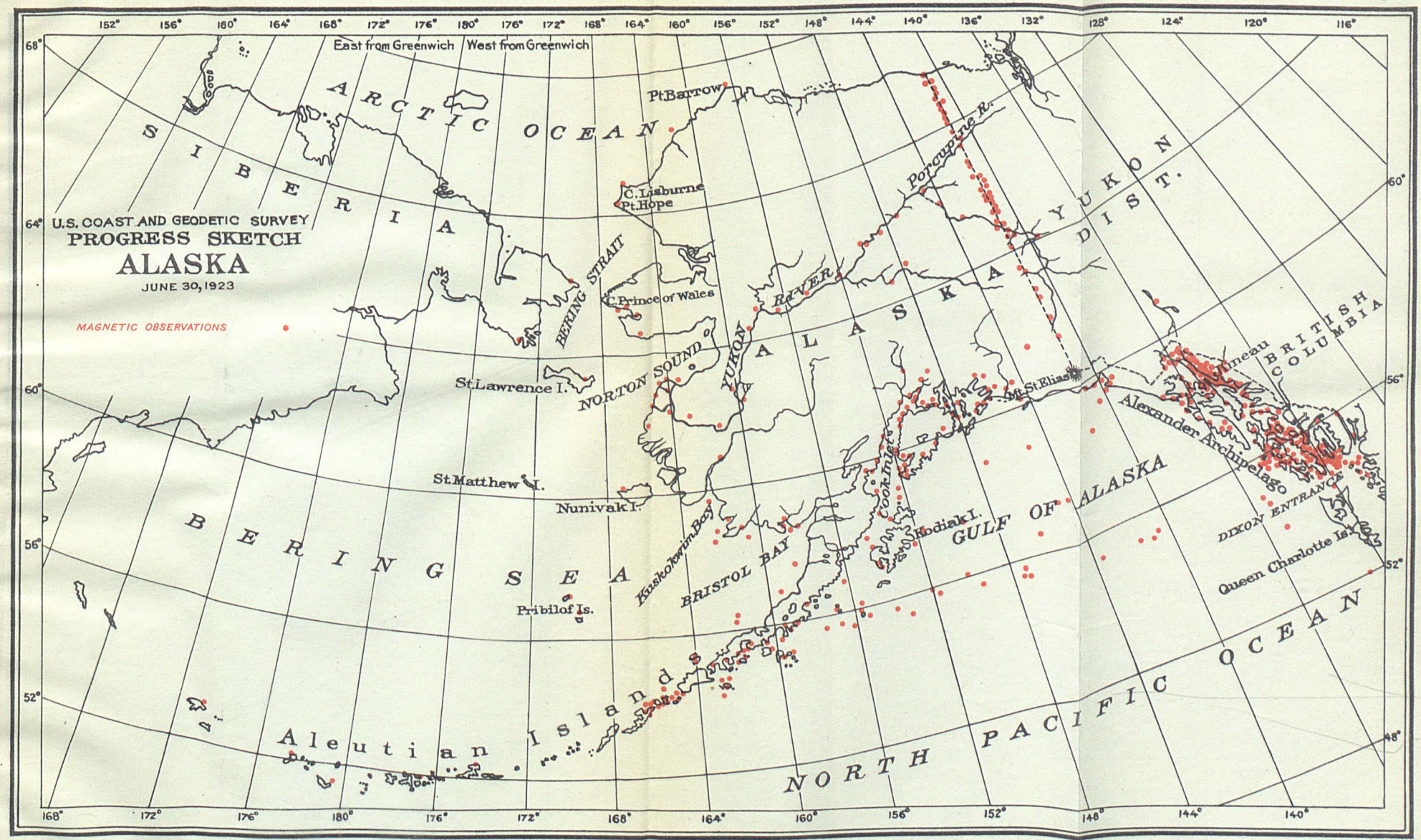
The following officers were attached to this party: Lieut. R. J. Auld, executive officer; Lieuts. (Junior Grade) R. R. Moore and A. P. Ratti; Ensigns Nathan November and Max Leff (last of season), and H. W. Peerce, chief engineer.

The steamer *Ranger* and drag fleet consisting of wire-drag launches *Marindin* and *Mitchell* and tender *No. 4*, continued wire-drag operations in Porto Rican waters during the fiscal year ended June 30, 1923.

The wire-drag work accomplished during the period of this report covers the waters off Culebra Island and islands to the westward, Grampus Shoals, east and central parts of Vieques Sound, waters along the north coast of Vieques Island and along the southeast coast of Porto Rico, the latter from Cabras Island to Point Quayanes, and ineffective drag areas previously covered; a total of 215 square miles. This, together with the former year's work completely covers Vieques Sound and the passages along the east and southeast coasts of Porto Rico.

The shoals found were mostly of small area and of coral formation. A large number of these were discovered along the southeast coast of Porto Rico and along the north shore of Vieques Island west of Port Mulas. The greater part of Vieques Sound, especially the eastern half of the sound, was found clear of obstructions with a drag set to 60 feet.

The automatic tide gauge at Fajardo was kept in operation. A subsidiary staff was established at Port Yabucoa, and the staffs at Ports Arenas, Ensenada Honda, and Culebita Island were read during the progress of work in the respective localities.


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1923
MAGNETIC OBSERVATIONS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
Porcupine R.
YUKON DIST.
BERING STRAIT
C. Prince of Wales
YUKON RIVER
ALASKA
BRITISH COLUMBIA
Juneau
Mt. St. Elias
St. Lawrence I.
NORTON SOUND
Alexander Archipelago
St. Matthew I.
Nunivak I.
Cook Inlet
Kodiak I.
GULF OF ALASKA
DIXON ENTRANCE
Queen Charlotte Is.
Kuskokwim Bay
BRISTOL BAY
BERING SEA
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN

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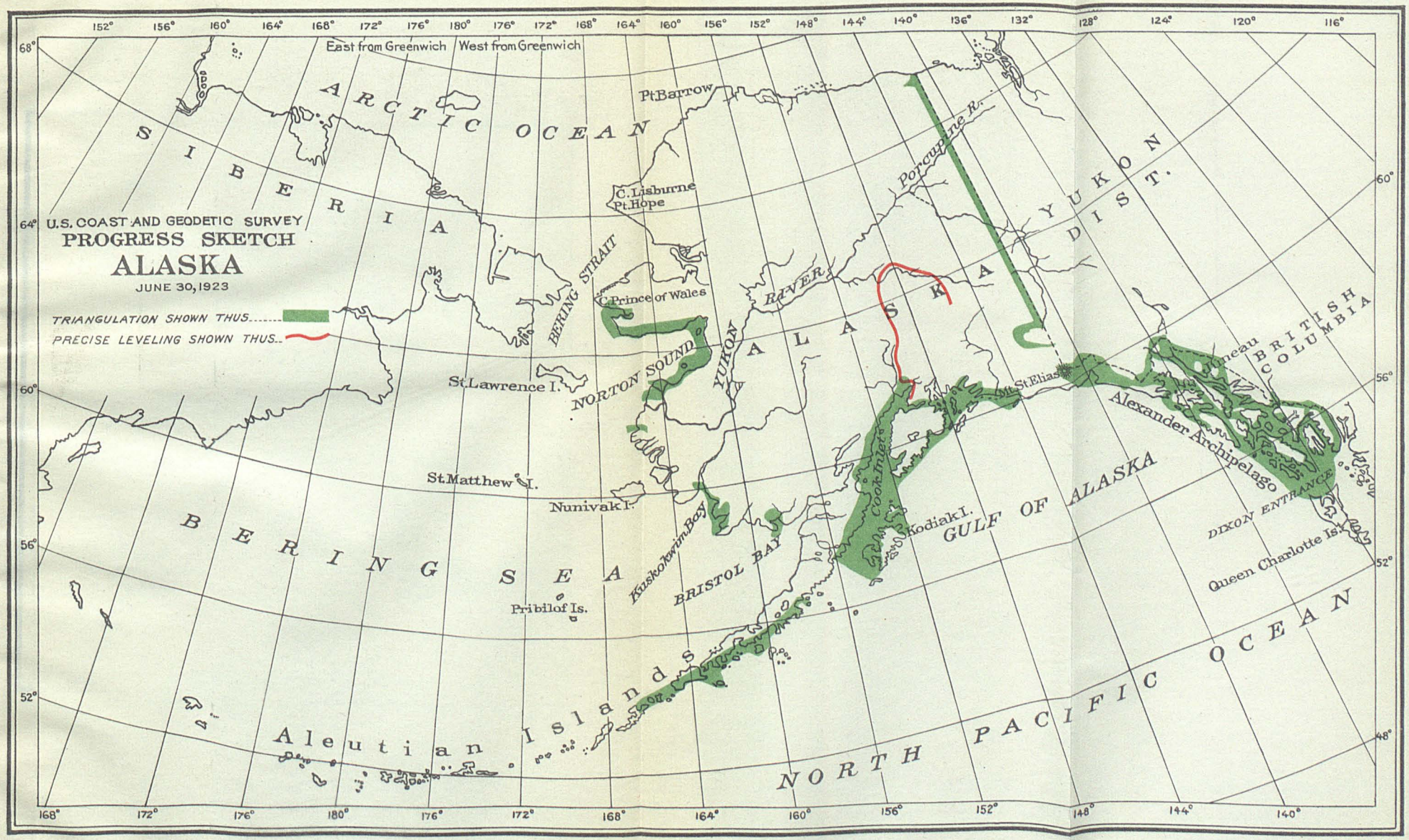
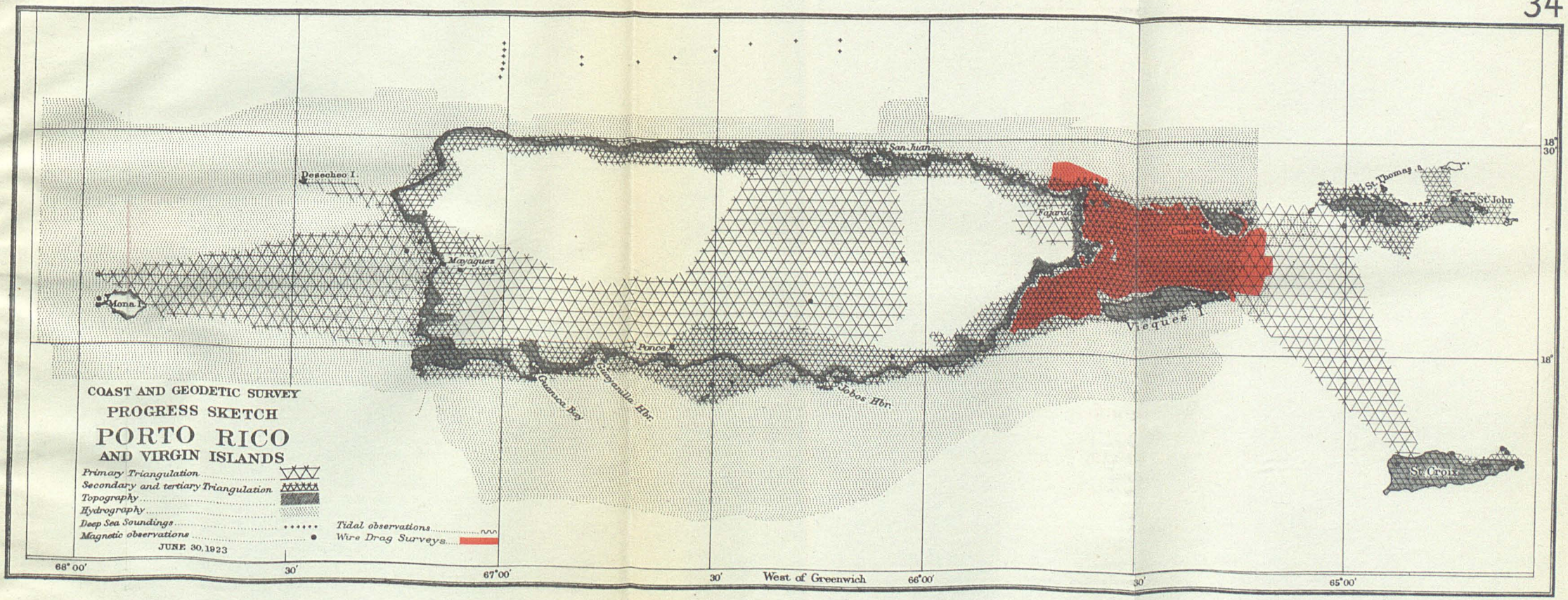

U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1923
TRIANGULATION SHOWN THUS
PRECISE LEVELING SHOWN THUS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt Barrow
C. Lisburne
Pt. Hope
C. Prince of Wales
BERING STRAIT
NORTON SOUND
St. Lawrence I.
St. Matthew I.
Nunivak I.
BERING SEA
Pribilof Is.
Kuskokwim Bay
BRISTOL BAY
Aleutian Islands
Porcupine R.
YUKON
DIST.
YUKON RIVER
ALASKA
Mt. St. Elias
Cook Inlet
Kodiak I.
GULF OF ALASKA
BRITISH COLUMBIA
Juneau
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
NORTH PACIFIC OCEAN

C. & G. S. Print


COAST AND GEODETIC SURVEY
PROGRESS SKETCH
PORTO RICO
AND VIRGIN ISLANDS
Primary Triangulation
Secondary and tertiary Triangulation
Topography
Hydrography
Deep Sea Soundings
Magnetic observations
JUNE 30, 1923
Tidal observations
Wire Drag Surveys
Desecheo I.
Mayaguez
Mona I.
San Juan
Fajardo
Culebra
Vieques
St. Thomas
St. John
St. Croix
Ponce
Guanica Bay
Guayanilla Hbr.
Jobos Hbr.
18° 30'
18°
68° 00'
30'
67° 00'
30'
West of Greenwich
66° 00'
30'
65° 00'

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VIEQUES MAGNETIC OBSERVATORY.

[Magnetic Observer RALPH R. BODLE.]

The routine work of the observatory was continued. The magnetograph was kept in continuous operation except for a period of 18 days when the driving clocks of both recording apparatus broke down. As soon as another recording box was received from the office, these two were sent in for repairs. There were also minor losses of record incident to adjustments of the variometers. The vertical intensity variometer continued to show a tendency to drift, necessitating periodic changes in adjustment. A new fixed mirror was installed in the horizontal intensity variometer. Absolute observations were made once a week, scale value determinations once a month, and meteorological observations daily. Time was determined once a week by the method of equal altitudes of the sun up to the end of May. In that month a radio receiving set was installed and during June the time signals sent out from Arlington were received daily under varying meteorological conditions.

The seismograph was in continuous operation and 15 earthquakes were recorded. Grading was done about the seismograph house to turn away the surface water and the space around the piers was filled with sand.

Masts were erected to support the radio aerial. One of them was attached to the office building and it was necessary to put additional braces under the east end of the building to insure proper support.

Necessary repairs were made to the various buildings including new roofing for the three buildings housing the instruments. A new pier for the galvanometer added to its efficiency. The cistern was repaired and cleaned out.

HAWAIIAN ISLANDS.

HONOLULU MAGNETIC OBSERVATORY.

[Magnetic Observer H. E. MCCOMB from July 1 to May 31; Magnetic Observer WALLACE M. HILL from June 1 to June 30.]

The routine work of the observatory was carried on throughout the year. The magnetograph was kept in continuous operation, absolute observations were made once a week, scale-value determinations once a month, and meteorological observations daily. The chronometers were kept dated by means of time signals sent out daily by radio from the naval station at Pearl Harbor.

The seismograph was kept in continuous operation but portions of the record of the east-west component were lost because of the crowding together of the lines on the seismogram. This trouble was ascribed to the effect of changes of temperature on the instrument or pier and after various experiments it was eliminated to a large extent by placing sawdust in the loft of the seismograph house. During the year 103 earthquakes were recorded.

The magnetograph driving clock was overhauled, repaired, and cleaned, but its rate is not yet entirely satisfactory. The deflection observations for determining the scale values of the variometers were facilitated by placing collars on the deflection bars to act as stops in setting the deflector at the proper distances. A change in the wave length used in sending out time signals from Pearl Harbor made it necessary to remodel the receiving set at the observatory. After some experiments this was done by Mr. McComb with very satisfactory results.

PHILIPPINE ISLANDS.

MANILA FIELD STATION.

[Commander E. H. PAGENHART, Director.]

The Manila field station is charged with the direct supervision of all surveys in the Philippine Islands. It maintains a computing division, a drafting division, a chart section, and a photolithographic section. These subdivisions are equipped to do all the necessary work in making the completed charts of Philippine waters from the data turned in by the surveying parties.

This important field station has been maintained in successful operation throughout the fiscal year. During this period, 72 charts of Philippine waters have been printed and delivered, in editions of from 180 to 550 copies each.

NORTHEASTERN COAST OF PALAWAN.

[Lieut. Commander F. G. ENGLE, Commanding Steamer *Pathfinder*.]

SUMMARY OF RESULTS.—Triangulation: 225 square statute miles of area covered; 12 signals and scaffolds erected; 9 stations occupied for horizontal measures; 18 stations occupied for vertical measures. Magnetic work: 13 land stations occupied. Topography: 64.4 square statute miles of area surveyed; 155 miles of shore line surveyed; 29 statute miles of rivers and creeks surveyed; 3 topographic sheets finished, scale of sheets 1:2,000. Hydrography: 1,086 square statute miles of area sounded; 3,794 miles of shore-line soundings, 33,914 soundings obtained, 3 hydrographic sheets finished, scale of sheets 1:20,000.

The following officers were attached to this party: Lieut. L. D. Graham, executive officer; Lieuts. (Junior Grade) L. M. Zeskind and J. S. Resenthal; F. B. Shekell, chief engineer; and Dr. J. V. Tormery, surgeon.

The work covered by this abstract is a continuation of the season's work started on April 5, in the previous fiscal year. The shore-line topography was completed from Cadlao Island to Malampaya Sound. The offshore area along this part of the west coast of Palawan Island consists of a submarine plateau extending about 25 miles offshore covered by usual depths of 30 to 50 fathoms. There are, however, numerous shoals on this plateau, some of them near the outer edge. To develop these, it was necessary to use floating water signals for control. A very successful and economical water signal was designed by the party and used for this purpose. All the launch hydrography was executed under the immediate direction of Arthur Hunycutt, chief writer. The other officers executed the ship hydrography, topography, and triangulation.

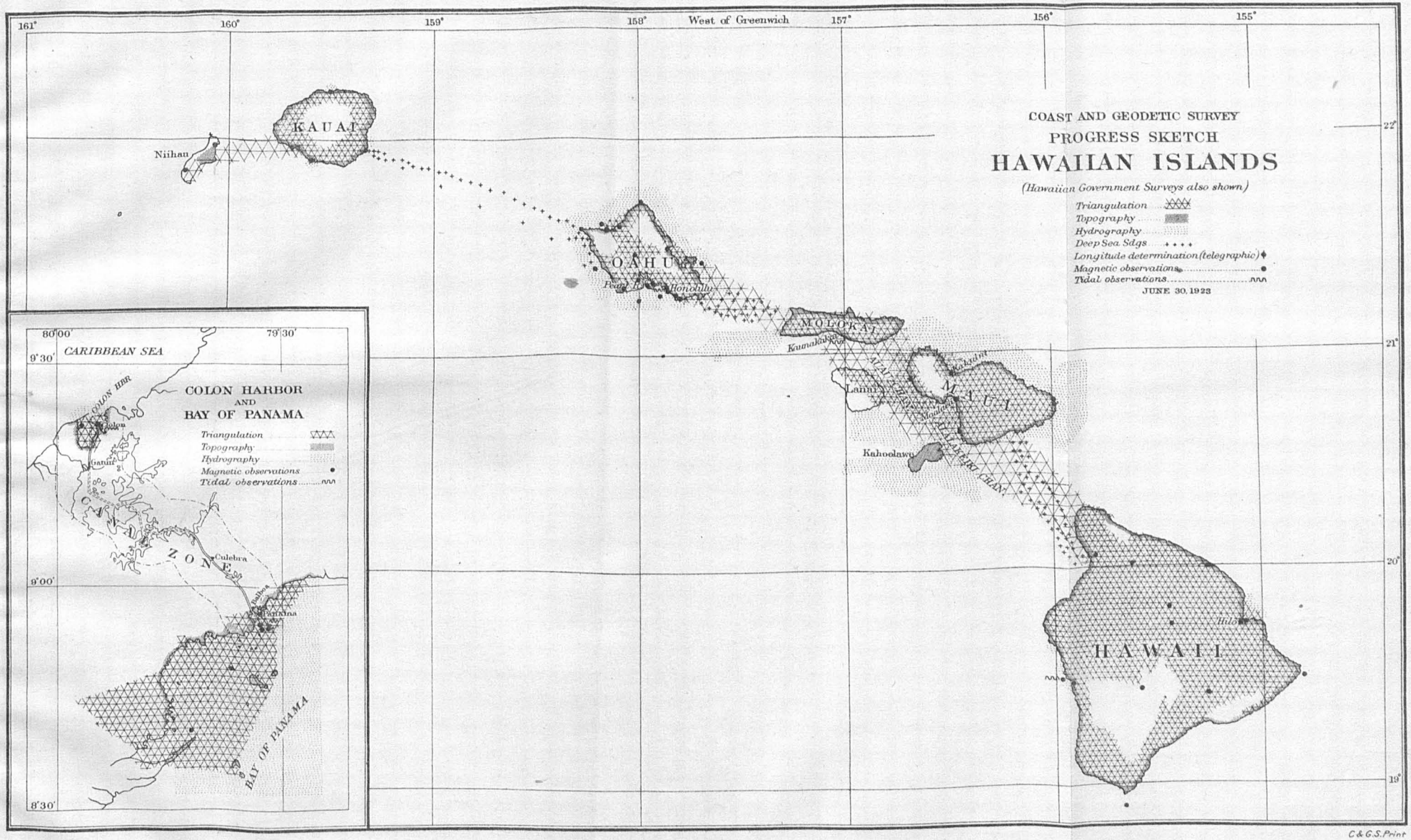
[Lieut. F. G. ENGLE, Commanding Steamer *Pathfinder*.]

SUMMARY OF RESULTS.—Reconnaissance for triangulation: Length of scheme, 60 statute miles; 4,500 square statute miles of area covered; 17 points selected for main scheme. Base line, secondary: Name of base, Sarangani Bay base line; length, 7 statute miles. Traverse, secondary: 85 statute miles in length; 20 principal stations occupied for horizontal measures; 269 supplementary stations occupied for horizontal measures; 36 geographic positions determined. Triangulation, secondary: Length of scheme, 35 statute miles; 1,400 square statute miles of area covered; 15 signal poles erected; 2 observing tripods built of a total height of 40 feet; 3 observing scaffolds built of a total height of 225 feet; 7 stations in main scheme occupied for horizontal measures; 1 supplemental station occupied for horizontal measures; 7 stations occupied for vertical measures; 54 geographic positions determined; 47 elevations determined trigonometrically. Leveling: 10 permanent bench marks established; 85 statute miles of traverse levels run; 1 statute mile of tidal levels run. Azimuth stations: 2 azimuth stations occupied, namely, Kay 2 and Cliff. Magnetic work: 3 new auxiliary stations occupied; 1 complete ship swing at sea. Topography: 17 square statute miles of area surveyed; 13 statute miles of detailed shore line surveyed; 1 topographic sheet finished, scale 1:10,000. Hydrography: 14 square statute miles of area sounded; 102 statute miles run while sounding; 663 positions determined (double angles); 1,878 soundings obtained; 2 tidal stations established; 3 current stations occupied; 1 hydrographic sheet finished, scale 1:10,000. Physical hydrography: 269 statute miles run in deep-sea sounding; 29 deep-sea soundings obtained; 25 bottom specimens preserved.

The following officers were attached to this party during the fiscal year (the principal surveying duties of each are listed): Lieut. E. W. Eickelberg, executive officer, traverse and base measurements and azimuth observations; Lieut. Roland D. Horne, leveling, signal building, and topography; Lieut. (Junior Grade) J. S. Rosenthal, base measurement, triangulation; Lieut. (Junior Grade) Benjamin H. Rigg, hydrography, traverse, and triangulation; John Collins, chief engineer; Dr. J. T. Tormey, surgeon; and R. C. Overton, mate, signal building.

After extensive repairs to the steamer *Pathfinder* at Manila, which occupied the greater part of the months of January and February, the party on the steamer *Pathfinder* began combined operations on the southern coast of Mindanao Island on March 6. Work in this vicinity was in progress at the close of the fiscal year.

The major operation during the period of this report was the establishing of control along the coast southeastward from Tatayan Island to a junction with previous triangulation at the mouth of the Davao Gulf. Triangulation along this stretch of coast would have proven a very expensive and time-consuming operation on account of the high, heavily wooded mountain ranges which parallel the coast. Fortunately, the shore line was well adapted to traverse operations and the greater part of the control was accordingly established by that method. A scheme of triangulation was, however, laid out and executed covering Sarangani Bay, which will furnish adequate control for the surveys


COAST AND GEODETIC SURVEY
PROGRESS SKETCH
HAWAIIAN ISLANDS
(Hawaiian Government Surveys also shown)
Triangulation
Topography
Hydrography
Deep Sea Sdgs
Longitude determination (telegraphic)
Magnetic observations
Tidal observations
JUNE 30, 1923
West of Greenwich
161°
160°
159°
158°
157°
156°
155°
22°
21°
20°
19°
KAUAI
Niihau
OAHU
Honolulu
MOLOKAI
Kaunakakai
LANAI
MAUI
Kahoolawa
HAWAII
Hilo
COLON HARBOR
AND
BAY OF PANAMA
Triangulation
Topography
Hydrography
Magnetic observations
Tidal observations
CARIBBEAN SEA
80°00'
79°30'
9°30'
9°00'
8°30'
Colon
Gatun
Culebra
Panama
CANAL ZONE
BAY OF PANAMA

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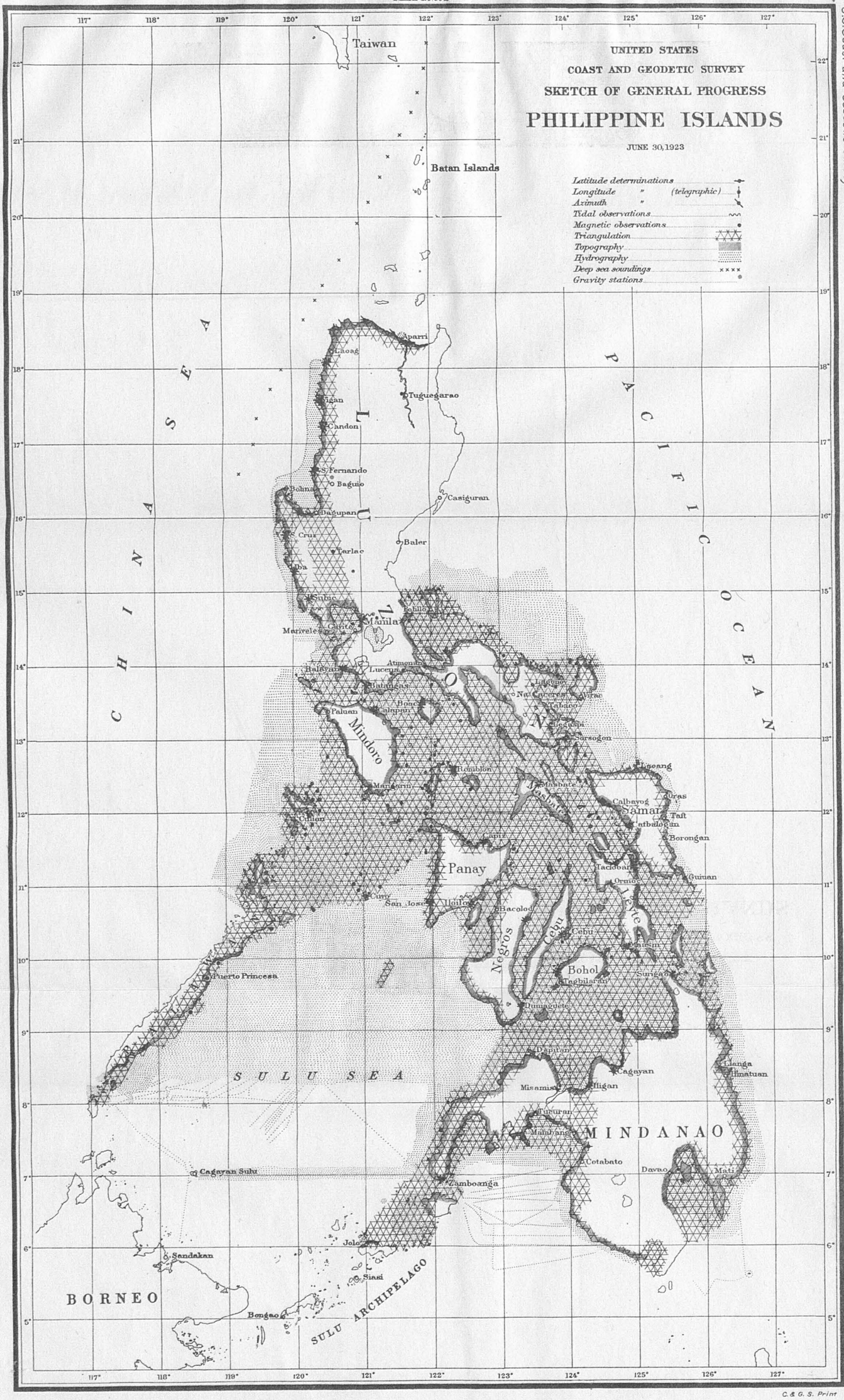

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of that bay. A very satisfactory base site was found at the head of this bay. A base a little over 11,000 meters long was laid out, measured and connected to the Sarangani Bay triangulation. This base commands two important valleys, through which, at some future time, it may be desirable to extend triangulation.

A topographic and hydrographic resurvey of Milbuk Harbor was accomplished on a scale of 1 : 10,000. An automatic tide-gauge station was established at Milbuk and kept in operation throughout the period of work. A plain tide staff was established at Glan, in Sarangani Bay and compared with the Milbuk station by a series of simultaneous observations.

Two lines of deep-sea soundings in the Celebes Sea were run at times when the vessel was en route from the field to Zamboanga for fuel.

The commanding officer has furnished the Washington office with some very interesting data with respect to the character and habits of the wild tribes which inhabit this region and with respect to the development of commercial enterprises along this coast.

[Lieut. H. A. COTTON, Commanding Steamer *Fathomer*.]

SUMMARY OF RESULTS.—Triangulation: 650 square statute miles of area covered; 30 signal poles erected; 4 observing scaffolds and tripods built, of a total height of 153 feet; 29 stations in main scheme occupied for horizontal measures; 8 supplemental stations occupied for horizontal measures; 39 geographic positions determined. Leveling: 8 permanent bench marks established; 2.8 statute miles of tidal levels run. Magnetic work: 28 land stations occupied; 2 sea stations occupied; 2 ship swings at sea. Topography: 24.5 square statute miles of area surveyed; 64 statute miles of detailed shore line surveyed; 10 statute miles of shore line of creeks surveyed; 2 topographic sheets completed, scale of sheets 1 : 20,000. Hydrography: 911 square statute miles of area sounded; 6,784 statute miles run while sounding; 31,199 positions determined (double angles); 101,993 soundings obtained; 2 tidal stations established; 7 current stations occupied; 1 tall hydrographic signal erected, height 125 feet; 4 hydrographic sheets finished, scales of sheets 1 : 20,000, 1 : 30,000, and 1 : 60,000.

The following officers were attached to this party during the fiscal year (the principal surveying duties of each are listed): Lieut. Payson A. Perrin, executive officer, signal building, triangulation, and hydrography (part of season); Lieut. Carl A. Egner, hydrography (part of season); Lieut. G. L. Bean, signal building, triangulation, hydrography, and topography; Lieut. E. H. Bernstein, signal building, triangulation, hydrography, and topography (part of season); G. W. Hutchison, chief engineer; R. P. Bush, mate, hydrography (part of season); and W. Weidlich, mate, signal building (part of season).

Except for the time spent in effecting the necessary repairs to the vessel, the party on the steamer *Fathomer* spent the entire fiscal year in combined operations in the Samales group of the Sulu Archipelago. From the beginning of the fiscal year to the end of August, the party concentrated on the establishing of the triangulation control throughout this group of islands. The work executed was based on four stations of previous work by the steamer *Pathfinder*, namely, Bancao, Bolod, Bulan, and Tandu.

The *Fathomer* then proceeded to Manila for repairs and overhauling and returned to the field November 16, at which time the topographic and hydrographic work was taken up. Field work was continuous from that time until June 1, when the vessel returned to Manila for semiannual repairs and overhauling.

Topography of the following islands was executed: Tonguyl, Bulan, Bucutua, Tatalan, Mamad, East Bolod, West Bolod, Diplolod, and Little Diplolod.

An automatic tide gauge station was established in Ton Sandungun Channel on November 20 and was continued in operation until June 1. A plain staff, located in the West Bolod Islands, was observed from May 17 to 19. Seven current stations were occupied at various times during the season.

The greater part of the area sounded lies to the north of the Samales group and to the south and west of Basilan Island. It is bounded on the east by the deep water of the Celebes Sea. This area contains numerous shoals and, in general, the depths vary between 5 and 40 fathoms.

Strong currents were experienced throughout the greater part of the area sounded. At times, and in certain localities, the velocity approached 4 knots. Their trend and behavior in the vicinity of shoals was very erratic and could not be anticipated, causing considerable difficulty in executing the hydrography.

In accordance with the advice of the provincial governor of Zamboango, Philippine constabulatory guards accompanied all parties when engaged upon work ashore.

[Lieut. RAY L. SCHOPPE, Commanding Steamer *Marinduque*, July 1 to June 14, 1923; Lieut. C. A. EGNER, Commanding Steamer *Marinduque*, June 14 to June 30, 1923.]

SUMMARY OF RESULTS.—Triangulation: Length of scheme, 16 statute miles; 264 square statute miles of area covered; 5 signal poles erected; 4 observing tripods and scaffolds built, total height of 90 feet; 10 stations in main scheme occupied for horizontal measures; 17 geographic positions determined. *Magnetic work*: 25 new auxiliary stations occupied. Leveling: 7 permanent bench marks established. Topography: 26 square statute miles of area surveyed; 94 statute miles of detailed shore line surveyed; 12.6 statute miles of shore line of creeks surveyed; 8 statute miles of roads surveyed; 4 topographic sheets finished, scales of sheets 1:20,000, 1:10,000. Hydrography: 515 square statute miles of area sounded; 7,493 statute miles run while sounding; 37,668 positions determined (double angles); 134,962 soundings obtained; 4 tidal stations established; 1 current station occupied; 4 hydrographic sheets finished, scales of sheets 1:10,000, 1:20,000, and 1:60,000.

The following officers were attached to this party during the fiscal year: Lieut. R. D. Horne, executive officer, July 1 to February 15; Lieut. L. D. Garham, executive officer, February 15 to June 30; Lieut. G. L. Bean, September 3 to November 10; Lieut. (Junior Grade) L. M. Zeskind, February 13 to June 30; Lieut. (Junior Grade) H. C. Warwick, January 19 to June 30; Lieut. (Junior Grade) J. S. Rosenthal, February 21 to March 26; F. H. Chamberlin, chief engineer, July 1 to June 30; H. A. Arnold, mate, April 12 to June 30; and R. P. Bush, mate, July 1 to November 10.

During the entire fiscal year the party on the steamer *Marinduque* was engaged in combined operations in Basilan Strait and on the west and north coasts of Basilan Island, except for such periods as necessary repairs to this vessel were in progress. The principal feature of the work in this region was the strong and erratic currents encountered, which interfered, to a marked extent, with the execution of the hydrography. An extensive current survey will be necessary before any accurate and extensive knowledge of the laws governing these currents can be had.

Field work was in progress at the close of the fiscal year.

SPECIAL DUTY.

SECOND ANNUAL MARINE EXPOSITION, GRAND CENTRAL PALACE, NEW YORK, N. Y.

[Commander J. T. WATKINS.]

At the second annual Marine Exposition held in the Grand Central Palace, New York, N. Y., from November 4 to 11, 1922, an exhibit was made illustrative of the field and office work of the U. S. Coast and Geodetic Survey. As the fund allotted to defray the usual expense of an exhibit of this character was inadequate, the cost of the display was reduced to a minimum. The relatively few items provided were as follows:

A complete set of charts bound in 15 bundles of about 45 charts each. Two portable stands, or racks, provided storage for eight bundles each and were so arranged that any chart of the entire series could be displayed readily in a vertical position with the center of the chart a little below the height of the eye.

About 100 large royal bromide prints illustrating operations and equipment, grouped round small subject signs in the following order: Triangulation, topography, hydrography, terrestrial magnetism, wire drag, tides and currents, and publication.

Diagrams and sketches illustrating methods and results.

A complete file of coast pilots, inside routes, tide and current tables, and magnetic publications.

Special publications and others of recent issue and general interest, including the ephemeris, nautical almanac, Bowditch, and line of position tables.

Miscellaneous typical charts, progress sketches, isomagnetic charts and diagrams.

Decorations consisting of national ensigns, departmental and bureau flags and pennants, and one set of code signal flags.

These items, packed for shipment weighed a little over 1,000 pounds. They left the office in the afternoon of October 30 and were delivered by the forwarding express company at the booth in the Grand Central Palace on the forenoon of November 1, 1922.

About 100 feet of wall space was provided for the exhibit.

The officer in charge as the representative of the director gave attention to various matters affecting the other bureaus of the department and rendered assistance when possible.

The exhibit received considerable attention and was the object of intelligent interest and appreciation on the part of many visitors.

The New York field station rendered valuable assistance in installing the material in its care and attendance at the booth in packing and shipping the exhibit after the close of the exhibition.

The management of the exposition responded readily to numerous requests for labor and material.

All business at New York in connection with the exhibit was closed on November 14, and the officer in charge reported at the office in Washington on the morning of November 15.

DISTRICT OF COLUMBIA.

[Lieut. (Junior Grade) DONAL B. PHELEY.]

SUMMARY OF RESULTS.—Leveling, precise: 6 miles of levels run; 24 permanent bench marks established.

This work was done for the purpose of connecting old bench marks, which had been used as tidal reference marks some years ago, with the standard bench marks of the precise level net. A number of new bench marks, consisting of a standard tablet, were set in advantageous locations for the reference of future tidal work. The work was in the vicinity of the Capitol, navy yard, National Museum, Engineers' wharf, Washington Monument, and Key Bridge, and was done at odd times between February 14 and March 24, 1923.

[Lieut. L. O. STEWART.]

During the month of December, 1922, a plan survey of the grounds of the U. S. Bureau of Standards was made for the use of that bureau, the survey consisted of detailed topography locating all buildings, roads, fences, and the boundary line on a scale of 1 inch to 80 feet. No contouring was done. Control was obtained in the following manner: A point on top of one of the large buildings was located by triangulation methods and connected to a measured base line on the grounds. From this base line plane table triangulation was carried over the entire area surveyed.

AERIAL SURVEYING.

LOUISIANA.

[Lieut. G. C. MATTISON.]

Practically the entire time of the above-named officer throughout the fiscal year has been devoted to carrying on toward completion the mapping of the Mississippi River Delta from the data secured with the aerial surveys of the previous fiscal year. One of the first necessary steps was the making of over 3,000 prints. These were made in the photographic laboratory of the Navy Department under the direct supervision of Lieutenant Mattison.

During the period, September 26 to November 12, Lieutenant Mattison was in the field executing a scheme of triangulation for control of the aerial photographs across the northern portion of the delta. This scheme made triple connection with previous triangulation and completed all control necessary. While still in the field, Lieutenant Mattison identified all the new control points in the photographs. Upon his return to Washington the completion of control computations was effected.

The work of constructing mosaics, transferring the data to topographic sheets and inking the same, and assembling data for publication of the results of the survey was then taken up and was in progress at the end of the fiscal year.

Respectfully,

E. LESTER JONES, *Director.*

To Hon. HERBERT HOOVER,
Secretary of Commerce.

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INDEX.

U.S. COAST AND GEODETIC SURVEY

CONDITION OF FIELD OPERATIONS
UNITED STATES
1923

Wire drag surveys	Triangulation completed
Unchangeable areas, surveyed	Triangulation begun
Unchangeable areas, partly surveyed	Precise traverse completed
Changeable areas, surveyed and requiring future resurveys	Precise leveling completed
Reconnoissance or unsurveyed	Precise traverse and precise leveling completed
	Gravity stations, positions

Statute Miles 100 0 100 200 300

Nautical Miles 100 0 100 200 300

C. & G. S. Print

90° 85° 80° 75° 70° 65°

45° 40° 35° 30° 25°

95° 90° 85° 80° 75°

CANADA

LAKE SUPERIOR

LAKE MICHIGAN

LAKE HURON

LAKE ONTARIO

LAKE ERIE

ATLANTIC OCEAN

GULF OF MEXICO

MINNESOTA

WISCONSIN

MICHIGAN

NEW YORK

VERMONT

NEW HAMP.

MAINE

MASS.

CONN.

R.I.

PENNSYLVANIA

NEW JERSEY

DEL.

MD.

W. VIRGINIA

VIRGINIA

OHIO

INDIANA

ILLINOIS

IOWA

MISSOURI

KENTUCKY

TENNESSEE

NORTH CAROLINA

S. CAROLINA

GEORGIA

FLORIDA

ALABAMA

MISSISSIPPI

LOUISIANA

ARKANSAS

BAHAMA ISLANDS

CUBA

DULUTH

MINNEAPOLIS

ST. PAUL

MADISON

MILWAUKEE

CHICAGO

DES MOINES

LANSING

DETROIT

BUFFALO

CLEVELAND

PITTSBURGH

WHEELING

COLUMBUS

INDIANAPOLIS

SPRINGFIELD

CINCINNATI

KANSAS CITY

JEFFERSON CITY

ST. LOUIS

EVANSVILLE

LOUISVILLE

FRANKFORT

CHARLESTON

NASHVILLE

FORT SMITH

LITTLE ROCK

MEMPHIS

ATLANTA

BIRMINGHAM

MONTGOMERY

JACKSON

MERIDIAN

MOBILE

BATON ROUGE

NEW ORLEANS

GALVESTON

TALLAHASSEE

JACKSONVILLE

TAMPA

KEY WEST

HABANA

ALBANY

BURLINGTON

MONTPELIER

PORTLAND

AUGUSTA

CONCORD

PORTSMOUTH

BOSTON

WORCESTER

PROVIDENCE

HARTFORD

NEWPORT

NEW HAVEN

NEW YORK

NEWARK

TRENTON

HARRISBURG

PHILADELPHIA

WILMINGTON

DOVER

BALTIMORE

ANNAPOLIS

WASHINGTON D.C.

RICHMOND

NORFOLK

RALEIGH

WILMINGTON

COLUMBIA

CHARLESTON

SAVANNAH

ARCTIC OCEAN

BERING SEA

GULF OF ALASKA

NORTH PACIFIC OCEAN

BARROW

NOME

ST. MICHAEL

KOTLIK

TANANA

NENANA

YUKON RIVER

MT. MCKINLEY NATIONAL PARK

CURRY

ALASKA R.R.

KUSKOKWIM RIVER

MATANUSK

ANCHORAG

SEWARD

NUSHAGAK

KATMAI NAT'L. MON.

AFOGNAK I.

KODIAK

KARLUK

CHIGNIK

P. MOLLER

KING COVE

UNIMAK I.

AKUTAN

DUTCH HBR.

SANAK IS.

ST. PAUL I.

PRIBILOF IS.

ST. GEORGE I.

ATTU I.

KISKA I.

176° 178° E. of Greenwich 180° W. of Greenwich 178° 176° 174° 172° 170° 168° 166° 164° 162° 160° 158° 156° 154° 152° 150° 148°

68° 66° 64° 62° 60° 58° 56° 54° 52°

168° 166° 164° 162° 160° 158° 156° 154° 152° 150°

174° 176° 178°

52°

C. & G. S. Print

Scale 2500000 Lambert Conformal Conic Projection

OUTLINE MAP
ALASKA

Statute Miles
50 0 50 100 150

Nautical Miles
50 0 50 100 150

CONDITION OF SURVEYS
U. S. COAST AND GEODETIC SURVEY
1923

- Wire drag surveys
- Unchangeable areas, surveyed
- Unchangeable areas, partly surveyed
- Changeable areas, surveyed and requiring future surveys
- Reconnoissance or unsurveyed

Areas tinted red show portions of the main steamer route made safe by the use of the wire drag.

C E A N

R I V E R

YUKON ALASKA

FAIRBANKS
NENANA
DAWSON
MT. McKINLEY NATIONAL PARK
ALASKA R. R.
CURRY
MATANUSKA
ANCHORAGE
VALDEZ
CHITINA
C. R. & N. W. RY.
KENNICOTT
CORDOVA
SEWARD
WHITEHORSE
YUKON
BRITISH COLUMBIA
SKAGWAY
JUNEAU
BRITISH COLUMBIA
ALASKA
SITKA
PETERSBURG
WRANGELL
KETCHIKAN
PRINCE RUPERT

GULF OF ALASKA

NORTH PACIFIC OCEAN

ALEUTIAN ISLANDS

KISKA I.

East of Greenwich — West of Greenwich