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ANNUAL REPORT

OF THE

DIRECTOR, UNITED STATES COAST AND GEODETIC SURVEY

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Annual Report of the Superintendent of the Coast Survey

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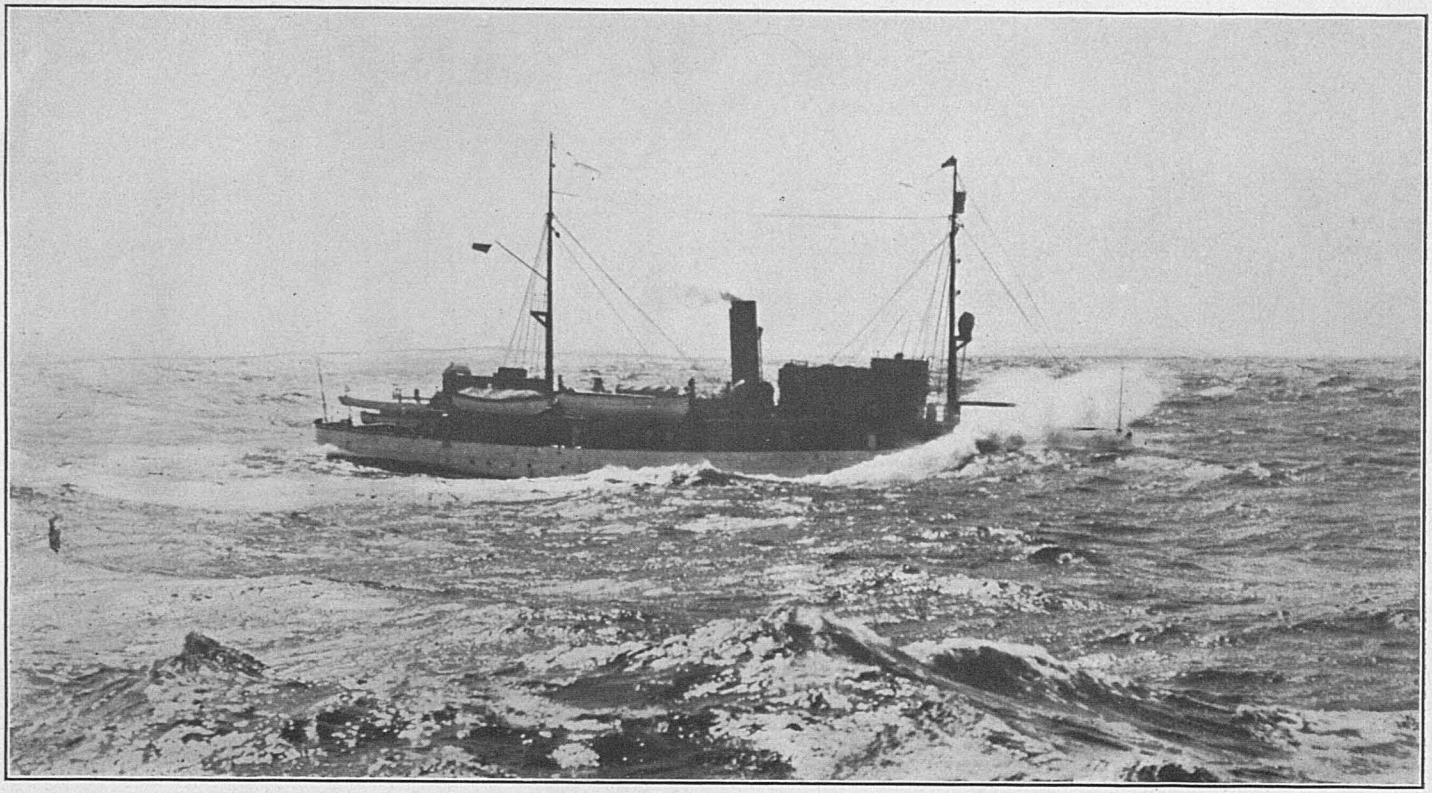


THE "DISCOVERER" ON DUTY CHARTING THE COAST OF ALASKA

REPORT

OF THE

DIRECTOR, U. S. COAST AND GEODETIC SURVEY

DEPARTMENT OF COMMERCE,
COAST AND GEODETIC SURVEY,
Washington, October 6, 1924.

SIR: There is submitted herewith my tenth annual report. This report is for the fiscal year ended June 30, 1924, and is the ninety-third annual report of this bureau.

INTRODUCTION

The Coast and Geodetic Survey has just closed the one hundred and eighth year of its active existence and, as in the case of last year, it has been a successful one. The fact that the bureau has a generally well-satisfied, high-class personnel, and the elimination of a majority of its inefficient ships replaced by modern ones, is in a large way responsible not only for various successful accomplishments, but also for a much greater amount of work being completed at a lower unit cost than ever before.

In this introduction I will endeavor to point out briefly some of the accomplishments, and in Part I indicate our most pressing needs combined with reasons, from an economical standpoint, why they should not be put off from year to year.

THE EFFECT OF INCREASED SALARIES

In my report last year reference was made to the effect on the Government personnel due to legislation making it possible for the increase of salaries; that is, the legislation generally known as the reclassification act.

Since this legislation became effective there has been a problem of concentrated effort on the shoulders of those charged with putting the machinery in operation to give every immediate benefit to every individual that properly could be benefited under this law.

It is not strange that the act itself, which might be considered in its various stages as having been worked over for nearly half a century, should contain discrepancies resulting in some confusion, but to those who have studied the history of this legislation and understood both sides of the many questions that have arisen it is really gratifying that Congress was able to offer so much relief at the start to the underpaid Government employees. The whole mat-

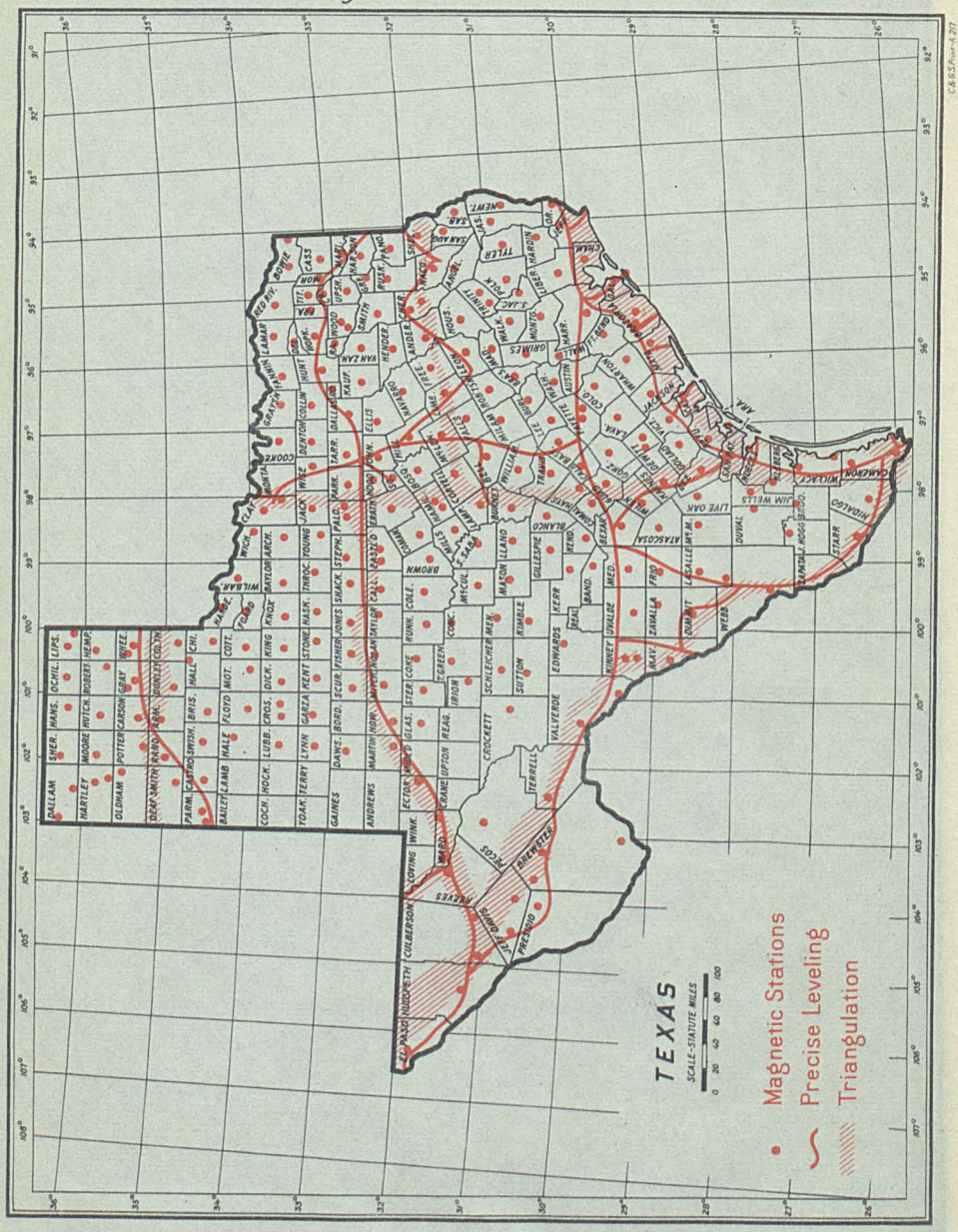
ter should appeal to all as a great constructive step taken by the late President Harding and Congress, which certainly has paved the way for ultimate uniformity and fairness to all the civil employees in the Federal Government.

It is a fact, and necessarily so, that everybody could not be satisfied with the first results of an interpretation of the act, but it seems, considering the comparatively short limit of time that those in charge have had to work over this tremendous problem, that their untiring efforts and conscientiousness should bear a mark of approval and appreciation by those who have been materially benefited by this act of Congress. The conclusion is that Congress has made it possible for a happier and more substantial existence for the Government employees and that the machinery for interpreting the authority given by Congress has been generally well handled, considering the great task and the time within which to do it, and I have not a doubt in view of the facilities that are offered by Congress to hear those who see inequalities, injustices, and ambiguities in the act but they will be ready to consider changes that will carry in full force later the full intent of Congress when it passed the bill. The results of this legislation are far-reaching. Not only has it taken the Government worker from a mere existence to a state of contentment of mind and body, but the investment that the Government has made by this or any other salary increase will be returned to the country at a higher rate of interest than almost any other investment the country has or can make.

PRESENT RETIREMENT INADEQUATE

Closely interlocked with the relief of the Government employee by increased salaries is the question of retirement. Under the present law the method, as well as the terms of retirement, are inadequate and inequitable. The civil employee to-day who serves the Government for 30 to 50 years must retire at 70 years (and in some cases at 65 or 62) at the meager sum of not exceeding $60 per month. This arbitrary and meager amount must be accepted irrespective of what the value of the employee has been to the Government or what range of salary he might have received during the various stages of his activity.

A concrete instance, which tells by true facts a sad case, which no doubt has been repeated over and over again throughout the Government, is brought out in the case of Ernst G. Fischer, who was the mechanical engineer of this bureau for 35 years. In 1922 he had reached the salary of $3,000 per annum and he had also come to the retirement age of 70. With his passing out the Government recognized this valuable servant of the people by giving him retirement pay at the rate of $720 per annum for the balance of his life. Anyone can see at a glance that his salary during his active service was so small that it was practically impossible for him to save anything, and so just in this case the two striking unjust elements that stand out in our present retirement law are these: Mr. Fischer during his connection with the Government, through his ingenuity and inventive mind, contributed instruments to the Government that from a commercial basis alone benefited this country in many



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ways to the extent of many hundreds of thousands of dollars, for which no recognition was ever given to him; and the other outstanding point is that his retirement should not have been based on an average sum fixed for all, but on a basis of what he had earned in active service, that would assure him of a comfortable living during the remainder of his days, as well as a recognition for unusual public service.

As I stated above, there are many other cases similar to Mr. Fischer's where underpaid employees have saved the country thousands of dollars, and it is hoped that at an early date legislation will be enacted whereby a fairer basis of retirement pay can be given to all the civil employees of the Government.

EFFECTIVE DISTRIBUTION OF DATA RESULTING FROM SURVEYS MADE BY THE BUREAU

Three years ago a plan was inaugurated in this bureau of placing more readily at the disposal of county surveyors, land surveyors, city engineers, and other civil engineers the data resulting from surveys made by this bureau. This plan had its inception in the realization that in making surveys for the establishment of arcs of triangulation and precise level nets across the country to provide geographic positions and elevation bench marks primarily for controls in mapping the country the resulting data would be of immense practical use to those engaged in making local surveys or in other engineering work in areas covered by the control surveys. Some investigation was made before the plan was attempted and this investigation disclosed that many local engineering projects were being undertaken within the areas covered by these control surveys without knowledge of the existence of the control surveys, and thus at considerable extra cost in providing controls and elevations for the local projects. The publications of this bureau containing the results of the national surveys were compiled with the purpose of placing the information in them in shape that would be readily available for map-making organizations operating on a large scale and covering large areas of the country. The data they contained were not indexed by the smaller subdivisions of the country.

To make these data available for county surveyors, city engineers, and others interested generally in making surveys of smaller proportions, it was apparent that the classes of information necessary for use in making local surveys must be segregated from those necessary for map making on a large scale, and that some means of showing quickly what are available in a small area must be devised. This was accomplished by undertaking to make a digest of the publications of this bureau for each State. This digest contains a base map of the State for which made, which shows graphically the kinds of work done in the State and what areas are covered. See illustration No. 1 opposite, showing what has been done in the State of Texas. The digest contains an alphabetical arrangement of the counties in the State and an index of the places in each county where reference marks have been established. A digest has been prepared and published for each of the following States: Alabama, Arkansas, Colo-

rado, 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. Digests will be prepared for the remaining States as the results of the national surveys become available in published form.

MODERN VESSELS MEAN MONEY SAVED

Hydrographic surveys off our coasts require seaworthy vessels. For a number of years the survey was forced to use old and weak vessels, and during that period the operations were confined, in a large measure, to sheltered waters or close to good harbors. As stated in my previous reports, during the last few years four adequate vessels have been acquired, namely, the *Surveyor*, *Discoverer*, *Guide*, and *Pioneer*. The former was built for the bureau in 1917, but as it was soon after assigned to war service it was not engaged in surveying work until 1919. The latter three vessels were Navy mine sweepers, which upon transfer to the survey were altered for their work and placed in service in 1922 and 1923.

These vessels are capable of withstanding all stresses of weather which they may encounter in the regions of their work on the Pacific coast and in Alaska. They are completely fitted with such apparatus as has been found by long experience to be best adapted for the examination of those areas.

The *Surveyor* carries three special-type hydrographic launches for work close inshore in the numerous indentations of the southeastern Alaska coast line. The *Guide* is equipped with a depth finder for sounding by the sonic method and a radio acoustic sound ranger for the determination of the vessel's position while sounding. The latter apparatus is especially valuable on the California and Oregon coasts on account of the large percentage of weather of low visibility.

All the vessels are furnished with electric sounding machines and carry several open boats fully equipped for work by detached parties. Burning fuel oil, the supply and storage of fuel for a large steaming radius is entirely solved. Their size permits accommodations for a large officer and crew personnel to carry on the various classes of work necessary in completely surveying a given section.

The value of modern, adequately equipped surveying vessels such as these is reflected in the volume and completeness of the data collected by them during the past year.

SPECIAL SURVEYS REQUESTED FOR MILITARY AND OTHER PURPOSES

The demands upon this bureau for special surveys for the military arms of the Government are steadily increasing, and during the past year these surveys have constituted no small part of the field work. Mention was made in my last annual report of special surveys requested by the Secretary of the Navy on which the bureau was engaged during that year. Most of these surveys were completed during the period covered by this annual report, but some of the work will extend over into the next fiscal year. To those surveys have been added several more for which requests were received this year.

Some of these surveys are strictly of a military nature and are for the construction of defense maps or for the efficient location of

defense works, and consequently are confidential. Others are not strictly of a military nature, but are for the convenient and safe operation of naval vessels in waters little used by commercial vessels or for the mapping and description of military reservations or the location of cables and the like. Requests for the early survey of certain heretofore unsurveyed areas do not place any particular additional burden upon the bureau, but rather cause a rearrangement of the bureau's surveying plans so as to give precedence to the survey of those areas. In other cases, however, the work desired by the military authorities is such as would not be done by this bureau unless specially requested. Some of this work is a little out of the line of the usual activities of the bureau, but such as the engineering personnel of the bureau is equipped to handle.

The wire-drag survey of Vieques Sound, requested by the Navy some years ago, was completed early in this fiscal year, and the party engaged upon that work took up the survey of the waters of the Virgin Islands. The latter survey is not strictly for military operations, but in the matter of detailed hydrography and wire-sweeping operations this survey has been extended far beyond the needs of the merchant marine in order to safeguard naval vessels which may, in connection with annual maneuvers, have occasion to enter those waters which are as yet of little importance to commerce.

A cadastral survey was made of the naval reservation on Culebra Island for the purpose of fixing and describing the bounds of the Government's property. This survey was performed by Coast Survey personnel and financed by the Navy Department.

In Alaska one of the largest survey vessels was employed throughout the fiscal year on a special survey for the Navy. It is expected this work will be completed in the fall of 1924.

At the request of the Signal Corps of the Army the bureau cooperated in the laying of the new military cable to Ketchikan, Alaska. Fortunately, the waters through which the cable must pass in entering from the Pacific Ocean had been surveyed recently and for that part of the work it was necessary only to select from the data on file in this office the most suitable location for the cable. There was one section of the cable, however, which must be laid through unsurveyed waters, and at the request of the War Department a vessel was taken off of her regular work and sent into those waters in advance of the cable ship. The survey was completed in time to supply the master of the cable ship with sufficient data to enable him to safely lay the cable. In this connection the Secretary of War stated: "The safe navigation of the cable ship *Dellwood* of Twelve Mile Arm and Trocadero Bay could hardly have been successfully accomplished without the assistance received from the *Explorer*."

In the Hawaiian Islands special work was performed for both the Army and the Navy. The work desired by the Navy was performed under the direction of an officer of this bureau, but with personnel, vessels, and boats provided by the Navy. In the case of the survey for the War Department some of the personnel, the equipment, and transportation were provided by the War Department. The work was in charge of an officer from the bureau but conducted in accordance with the wishes of the War Department.

PROGRESS IN ALASKA

Excellent progress in Alaskan surveys has been made during the past year and will depend in the future largely upon proper equipment. It has been found that a large, stanch ship, mothering several launches which are self-sustaining for a reasonable period of time and able to operate in the restricted and dangerous areas where the ship can not go, makes a most effective and economical combination. The three large ships now employed on Alaskan surveys are all that the bureau can utilize efficiently at this time, but there is a pressing need for launches of from 60 to 70 feet in length with accommodations sufficient for one or two detached parties. Two such launches could well be attached to each ship. At present, there are not enough of these larger launches available for the assignment of even one to a ship, and in the near future it will be necessary to condemn and dispose of two that are now old and dangerous.

For a number of years this bureau has followed the policy of making its surveys continuous. The value of continuity in survey operations is illustrated by the surveys in southeastern Alaska, where work along the outside coast has been extended northward from season to season and has shown marked progress. Wire-drag operations along the main ship channel routes have likewise been expedited by the same policy.

Wire-drag operations have been confined to the commercially important bays adjacent to the steamship lanes previously dragged. At the request of the War Department, a detailed survey and wire drag has been made of Kasaan Bay and Twevle Mile Arm. This work was essential to the successful laying of the Alaska cable, as stated in a letter to this bureau by the Secretary of War. The work on the outside coast of Alaska, has, as previously stated, been continuous and now has reached a point 25 miles north from Cape Omaney. This work not only includes the surveys of the shore line, bays, and inshore areas, but has been carried westward to the 1,000-fathom curve, and in the course of the work many fishing banks have been accurately located.

The extension of the extremely important work in western Alaska, which could not be undertaken earlier, owing to lack of equipment, has been made possible by the three vessels of the mine-sweeper type now in operation. One vessel, the *Pioneer*, has been engaged in continuous surveys in the vicinity of Morzhovoi and Cold Bays and is progressing eastward. In addition a survey is being made of the passage from the Pacific to the Bering Sea, generally known as False Pass, and at the end of the fiscal year the shallow Bering Sea entrance has been surveyed. The *Discoverer* has completed Wide and Jute Bays and extended the surveys at the entrance of Portage Bay. This project is of great importance, owing to the fact that the oil fields lie immediately behind and these bays are the normal outlet for this district. The survey of Castle Bay, located at the entrance to Chignik Bay, has been completed and marks the beginning of the systematic surveys which will be carried eastward progressively and joined to already completed work.

SOME OTHER IMPORTANT HYDROGRAPHIC SURVEYS ACCOMPLISHED

Along the Atlantic coast, hydrography, including offshore work, was extended southward as far as Ormond, Fla., and a hydrographic survey was made in the vicinity of Cape Fear. The offshore work on this coast is now complete from Cape Fear on the North Carolina coast to the vicinity of Ormond on the Florida coast, with the exception of a gap on the South Carolina coast northward from Winyah Bay, which is yet to be done.

On the Gulf coast the survey of the approach to Sabine Pass was completed.

A hydrographic survey of the waters of the Virgin Islands was begun in this fiscal year and at the close of the year was about half finished.

A survey of Lake Okeechobee, Fla., was begun during the year. A triangulation net of control stations has been extended entirely around the lake and connected with the Atlantic coast control by a high-grade geodetic traverse. This will be followed by a topographic and a hydrographic survey.

A survey of Scituate Harbor, Mass., and a resurvey of Baltimore Harbor, Md., were in progress at the close of the fiscal year and were nearly completed.

On the Pacific coast offshore hydrographic surveys were accomplished northward of and extending nearly to Cape Blanco. On the southern California coast offshore hydrography was extended northward from the work of last year to a point about halfway between San Diego and San Pedro. The passage of the survey steamer *Guide*, the newest of the survey fleet, from the Atlantic coast to her station on the Pacific coast was marked by a further extension of the ocean surveys mentioned in my last report. The track of the *Guide* was so laid that the soundings taken by this party supplemented the ocean work of the steamers *Discoverer*, *Pioneer*, and *Lydonia*, and of the vessels which performed similar work in earlier years, so as to fill gaps and complete the ocean survey from the Atlantic coast to the Pacific coast via the Panama Canal.

In the Philippine Islands the most important work of the year was the beginning of a hydrographic survey of the waters north of the island of Luzon. Because of the peculiar difficulties attending surveys in these localities and because of the relative unimportance of these waters from a commercial standpoint the survey of the north and northeast sides of Luzon and of the adjacent waters has been deferred until other more important parts of the archipelago were surveyed. The beginning of the work this year on the northern coast of Luzon marks the initial step in a project for the completion of the survey of the Philippine Archipelago.

A marked accomplishment of the bureau during the year was the introduction of acoustics in hydrographic surveying. During the year the bureau perfected and adopted appliances making use of the velocity of sound for measuring distance both vertically and horizontally. The bureau is now not only measuring the depth of the ocean but is determining the exact position of each depth measurement by means of apparatus which records the distance in terms of the velocity of sound waves through the water.

SURVEY OF THE WATERS OF THE PHILIPPINE ISLANDS NEARLY FINISHED

During the past year the owners and operators of deep-sea ships of American and other registry have found it desirable to send their ships directly to hitherto unused ports of the Philippine Islands, and there load the local export of sugar, hemp, and copra instead of loading only at such ports as Manila, Cebu, Iloilo, or Zamboanga. Previously, it was necessary that the small interisland vessels collect and carry to those ports all cargoes for overseas shipments. This departure has resulted in a reduction in freight costs and also has created a new demand for Philippine charts to insure the safety of these larger ships.

From the beginning of surveys by this bureau in 1900, the Federal and Insular Governments have cooperated in the work of charting the Philippine Islands. At this time approximately 75 per cent of the original survey has been completed and within this area ships may safely go. There remain, however, several areas where no reliable charts exist and for which but little information is available. (See fig. 2 opposite.)

These unsurveyed regions have had little or no development of their resources, consequently they are unimportant commercially. This fact increases the difficulty of surveying them. Local bases for coal and supplies will have to be established to avoid long runs.

North and northeastern Luzon present difficulties not found elsewhere. The long stretches of coast without harbors will compel the vessels operating on surveys to put to sea and ride out the storms that frequent this coast during the only season of the year when work may be done. Between storms the sea is smooth and landing on the beach easy. The wooded mountains which rise abruptly from the coast are extremely unfavorable for the establishment of coastal control. Western Palawan and the Sulu Archipelago present much less difficulty, although a vast amount of hydrography will be required in both of these areas properly to develop the many shoals known to exist.

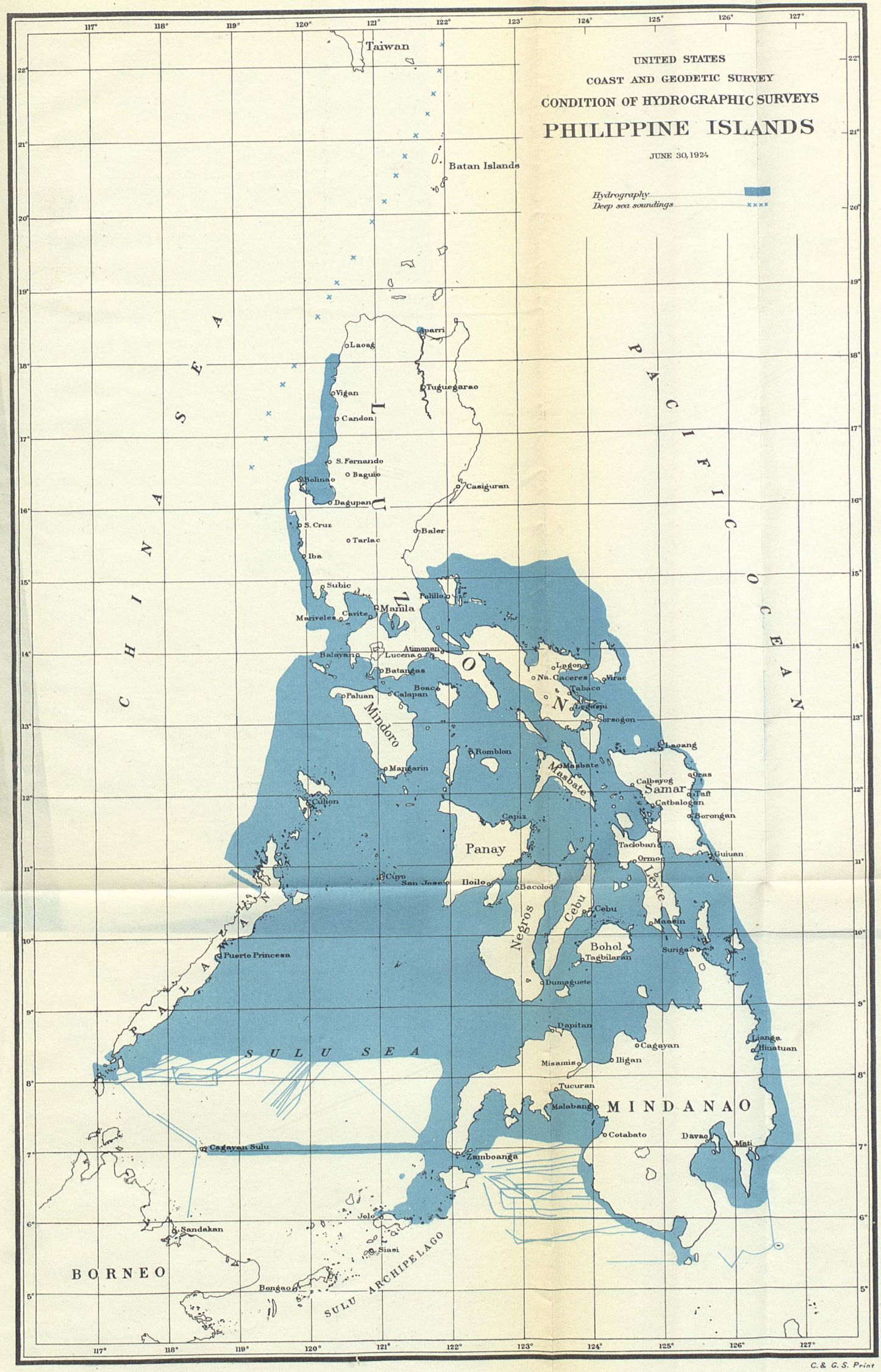
The objective of this bureau has been the completion of the original surveys of the entire group and practically all of its efforts, limited by the ships and equipment available, have been and will continue to be directed to this end. Any plans for keeping the charts up to date after the completion of the original surveys may well be left for later consideration.

WIRE DRAG, PORTO RICO, COMPLETED

During the first part of the fiscal year wire-drag work in Vieques Sound was completed, and the surveys of Porto Rico are now adequate to meet the present requirements of navigation.

GEODETIC WORK ACCOMPLISHED

For the past two years the major portion of the bureau's geodetic activities has been directed to the completion of three general projects: First, the subdivision of the three or four immense areas in the West which were without triangulation control by arcs of tri-


UNITED STATES
COAST AND GEODETIC SURVEY
CONDITION OF HYDROGRAPHIC SURVEYS
PHILIPPINE ISLANDS
JUNE 30, 1924
Hydrography
Deep sea soundings
Taiwan
Batan Islands
CHINA SEA
PACIFIC OCEAN
LUZON
Aparri
Laoag
Tuguegarao
Vigan
Candon
S. Fernando
Baguio
Bolinao
Dagupan
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Hinatuan
SULU SEA
Misamis
Iligan
Tucuran
Malabang
MINDANAO
Cotabato
Davao
Mati
Cagayan Sulu
Zamboanga
Jolo
Sandakan
Siasi
BORNEO
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angulation across them; second, the triangulation along the forty-ninth parallel, which is being executed in accordance with an informal cooperative agreement with the Geodetic Survey of Canada, whereby each country executes triangulation or traverse along about half the boundary from Lake Superior to the Pacific; and third, the extension of an arc of precise triangulation from the vicinity of Seattle northward through British Columbia and southeast Alaska, the Geodetic Survey of Canada executing the portion lying within Canadian territory.

Gratifying progress has been made on all three projects when consideration is given to the difficulties of terrain and the small number of parties which the limited funds permitted to be put into the field. The eastern section of the boundary triangulation assigned to the United States, extending from Lake of the Woods to Lake Superior will be almost, if not quite, finished during the field season of 1924. Slower progress was made on the western end in northern Montana, due largely to the very short working season. In southeast Alaska a party was engaged at the end of the fiscal year in connecting across Dixon Entrance the Canadian triangulation to that already executed by this bureau, thus completing one of the longest belts of precise triangulation in the world, reaching from San Diego, Calif., to near the head of Lynn Canal, Alaska, though two or three bases still remain to be measured near its northern end.

The cooperation of this bureau with the Geodetic Survey of Canada on these major projects has saved each nation a large amount of money, since each benefits by the work done by the other.

Besides these major projects several minor ones have been prosecuted or completed. Reobservation of the old triangulation in California has shown movements of the earth's surface of such magnitude that they become of prime importance not only to scientists but also to the entire population of that region, presaging as they do the possibility of predicting the localities which are in greatest danger from earthquake shocks. The geodetic location of two boundaries was completed, and 800 miles of precise levels were run in various portions of the country. A complete list of field projects is given on pages 53 and 54 of this report.

COOPERATION WITH OTHER ORGANIZATIONS

Elsewhere in this report is described the cooperative work with the Geodetic Survey of Canada, with the commissioners appointed by the Supreme Court of Arizona for the demarcation of the boundary between Maricopa and Yavapai Counties of that State, and with the commissioners appointed by the Supreme Court of the United States for the location and demarcation of the boundary between Texas and Oklahoma along the Red River. Assistance in an advisory way has also been rendered engineers from various cities with reference to precise control city surveys.

On the other hand, this bureau has received material assistance from other Government organizations. The Bureau of Standards has been of especial help in standardizing tapes and other apparatus used on our geodetic work and in making valuable experiments on the stability of the invar used in base tapes. The Naval Observatory, through the Bureau of Navigation, has sent out special time

signals for the use of our longitude parties at work on the Pacific coast where the usual 10 p. m. eastern standard time signals could not be used, and has furnished this bureau with the final values of the errors of such signals. The Alaska Railroad and the Alaska Road Commission assisted our parties working in that region in the transportation of supplies, and in many other ways has the work of this bureau benefited by the cordial spirit of cooperation which is prevalent almost everywhere among the executive departments of the Government.

RECENT PROGRESS IN MAGNETIC SURVEYS

The prime purpose of the magnetic survey of the United States and regions under its jurisdiction and the waters adjoining them is to furnish information which makes it possible to place correct compass roses on the charts. The mariner considers the compass rose, which shows him how to lay off a correct magnetic course, as one of the most important features of the chart. Determinations of the earth's magnetism are made both along the coasts and some distance into the interior to accomplish this result. The further extension of the magnetic work to the interior of the United States has had very practicable and valuable results. One of the most striking results is brought out by the recent successful around-the-world cruise of the Army Air Service planes. These airplanes were equipped with magnetic compasses of the earth inductor type. This bureau during the last year furnished magnetic information for the new aviation map of the United States.

County and local surveyors are making constant use of the magnetic information supplied by this bureau to rerun old lines and also to make new surveys in forest lands and other places where precise methods are not called for.

To render the results of magnetic observations of continued value, five observatories are kept in constant operation, so placed that they cover the region from Porto Rico to Hawaii and from Arizona to Alaska. These observatories, together with repeat observations at regular intervals at a number of points throughout the United States, form the source of our knowledge of the continuous changes in the earth's magnetism. The results of observations at these observatories are being furnished to organizations interested in cable and radio transmission in their study of various forms of interference with the reception of signals. At Sitka the relation between magnetic disturbances and the aurora and such transmission difficulties are being investigated.

RECENT MAGNETIC SURVEYS

During the year repeat stations were occupied in the Middle Western and Middle Atlantic States; in the Southeastern and Western Mountain States and in California. Steady progress was made in the complete resurvey of North Carolina with the cooperation of the State, and this survey is now near completion. Urgently needed replacement of stations was carried on in Texas, Georgia, and California. A start was made in southern California on a

magnetic survey of the coast, which should eventually be extended to the entire coast of the United States.

The outstanding need at present is to modernize the observatories, including the replacement of the observatory at Vieques, P. R., by one on the main island, and to extend the field work to meet the needs of the mariners and local surveyors. An extension of our magnetic work in Alaska is urgently needed to meet the growing demands of navigation and to keep pace with the development of that territory.

VALUE OF THE SAN FRANCISCO HARBOR CURRENT AND TIDE SURVEY

For a number of years, owing to insufficient funds for detailed current and tide surveys, it has been necessary for this bureau to make predictions of the future state of the current in the various harbors for the use of the mariner from meager instrumental observations. Obviously, the results could only be approximate since the prediction of currents is very complex even with a considerable amount of data upon which to base conclusions and from which to prepare constants for these advance predictions.

Congress realized the value to the mariner of the accurate advance knowledge of the state of the current in our important harbors, and for the fiscal year 1922 appropriated $15,000 to cover the cost of a current and tide survey of New York Harbor. The following year a like amount was appropriated for a similar survey of San Francisco Harbor.

The latter survey was made during the fiscal year 1924, and definite knowledge of the tide and current phenomena for that harbor is now available. To the navigator the current tables issued by this survey are of invaluable aid, since they inform him in advance of the time of slack water and the time and velocity of the strength of current—the first of considerable importance in the berthing of large vessels; the second, in keeping account of the position of the vessel in thick weather.

Aside from the importance of the survey to the mariner, the by-products which are obtained at no increased cost are of importance to the engineer engaged in harbor improvement (both of a civil and a military nature), or in wharf construction, etc., who can undertake his work with a better knowledge of the current and tide conditions under which the operations will be carried on.

The data from the survey of New York Harbor have been computed and the results interpreted and discussed. The manuscript of a publication covering in detail the tide and current phenomena of each section of the harbor is now in press. The data from the San Francisco survey are now being computed and, after being correlated with the various scattered observations made at different times in previous years, the conclusions will be issued in a publication similar to that for New York Harbor.

IMPORTANCE OF INSTRUMENTS TO THE BUREAU'S WORK

The progress of this bureau as a whole is directly related to its advancement in the development of its instruments, as they are

the tools with which the basic work is performed. Stagnation in such development, or neglect to make use of the most modern and efficient equipment and materials, would be immediately reflected in the efficiency of the bureau.

Constant work is carried on in improving the existing apparatus and in developing new instruments to meet the survey's ever-increasing requirements, making use of new materials and methods which render the equipment more efficient and durable and reduce the cost of field operations.

Such work often involves prolonged scientific investigations regarding the properties of metals and alloys, magnetism, electricity, light, gravitation, etc., and the result of such researches has made possible the development of instruments of precision whose accuracy has never been surpassed. Many of these instruments have been adopted by other governments and are being widely used by other branches of our own Government, municipalities, and private organizations. We are frequently in receipt of requests for information regarding the construction and procurement of our instruments and for the results of our investigations.

The field activities have been increased manyfold during the past two decades but no change has been made in the number of employees provided for instrument development. The force is so busily occupied with performing the current repairs to the instrument stock that work on new devices must perforce progress but slowly and the survey is now seriously hampered in this important branch of its work by lack of personnel.

Geodetic Leveling Rod.—A device was perfected which puts the invar metal strip of the level rods under tension, thereby eliminating a slight error which was found to occur due to the sagging of the strip under its own weight. This is a comparatively simple device consisting chiefly of a spring bearing upon a shoulder at the top of the strip. This device has proven to be very effective.

Portable Automatic Tide Gauges.—During the past year a small portable tide gauge was designed and built which differs radically from the portable gauge used heretofore in that the train of gears and the screw traversing mechanism is replaced by a direct-acting rack and gear, thereby eliminating several possible sources of lost motion and making a somewhat less complicated gauge to construct.

Several improvements were made in the older type of portable gauge which removed various sources of friction and clogging, and made the gauge easier to operate and adjust. These improvements eliminate practically all objectionable features of construction of this gauge and it has given satisfactory records throughout the year.

Automatic Lighting Device for Signal Lamps.—A small switch was designed for use in conjunction with a standard type of clock for the purpose of lighting signal lamps. This switch, which weighs less than 2 ounces, is of simple and rugged construction and is so designed that the current from a small battery will light the lamp for any desired period of time after setting the switch.

The mechanism is entirely automatic and will cause the lamp to burn for a given number of hours, beginning at any predetermined time, over a period of one week without attention. A number of these lighters have been used during the present season and have

given excellent results, are much lighter, less expensive, and more reliable than the devices used for this purpose heretofore.

RADIO ACOUSTIC RANGE FINDER.—Work with the radio acoustic range finder was continued and a simple and inexpensive bomb was designed by this bureau after a series of tests were conducted, using various types of bombs and exploders under varying conditions. The bomb as finally designed consists of a commercial type of tin can loaded with trinitrotoluol to which a standard form of exploding device has been attached. This bomb has functioned satisfactorily in the field and has been an important factor in the success of the radio acoustic work.

ELECTRIC SOUNDING MACHINE.—Two types of electrically operated sounding machines were designed and built during the year, and the larger of these has been put into operation. The results so far indicate that it is greatly superior to the former types of sounding machine. It is of simple and rugged construction, and the electric-motor drive gives it a smoothness of operation which not only increases the speed, permitting a greater number of soundings to be taken in a given time, but allows the ship to be run at higher speed. A vessel equipped with this type of machine will be able to obtain sounding data over a considerably greater area during the season. A marked reduction in breakage of the sounding wire has also been noted, evidently due to the steadiness with which the sounder operates. A similar but smaller type of sounding machine has been designed for operation in comparatively shallow water and will be to this type of work what the larger machine is to the greater depths.

DIVIDING MACHINE.—A machine has been designed and partially built for the purpose of applying the accurately spaced checker work painting to the Geodetic level rods. This work was formerly done by hand and was a slow and laborious process and it has been impossible to obtain by hand methods the desired accuracy of division or sharpness of dividing lines. The machine as designed wholly eliminates the necessity of accurate hand work. It will space the checker work with an accuracy in excess of that which is necessary and the actual painting is done by mechanical means. It is estimated that this machine will reduce the time required to paint a rod by 75 per cent.

Part I.—THE BUREAU'S GREATEST NEEDS

CHAPTER I

NEW BUILDING NEEDED

Much has been said in my past annual reports regarding the handicap under which the bureau is operating in its present quarters and the extent to which production of nautical charts is retarded, due to the utter impossibility of organizing production units so that the maximum results or results that ought reasonably to be expected shall be attained. This is due to the fact that the bureau is housed in a group of eight buildings, more or less detached from each other, each, with the exception of one, built for purposes other than the housing of this bureau and not at all adapted to the efficient use of the bureau.

The subject has been discussed so thoroughly in the various annual reports that there is little additional to offer except to urge that the importance of the matter shall have the consideration it merits by the legislative branch of the Government and that steps be taken to provide a building in which the maximum of production can be realized at the minimum of cost per unit.

CHAPTER II

NEW VESSELS NEEDED

PACIFIC COAST

As mentioned previously in this report, the survey is fortunate in having four modern surveying vessels adequate for the extension of surveys offshore and in the more remote waters of Alaska. It would be extremely hazardous, however, to permit these large vessels to attempt the surveying required close to shore. Therefore, tenders are assigned to them for the particular work of sounding in shoal areas alongshore and among submerged reefs.

These tenders occasionally strike uncharted rocks in the course of their work, which, if encountered by the vessels, might result in a total loss of these expensive units. The damage to the tenders, however, is unimportant, and their size permits repairs to be made on the working grounds.

For example, the *Cosmos* has on numerous occasions been stranded on unknown reefs, submerged by rising tide, raised, repaired, and replaced in service by the party to continue work in the same section for the remainder of the season.

On account of the hazard in which these tenders have been forced to operate, their condition at the present time is extremely poor. Three of them have been in service in Alaska for over 20 years. Considering their age, it is remarkable that they have been able to remain in service during the past year. This has been possible only by limiting them to work in favorable weather, as they could not survive in heavy seas. Consequently, their original usefulness is gone.

Without these units the large vessels are operated at a serious disadvantage. If open boats must be used to do their work, the vessel must halt other work to stand by them. Moreover, only the most favorable weather conditions would permit the use of small open boats on such work. It can therefore be seen that unless these tenders are replaced by similar vessels their work must be accomplished in an inefficient manner. For these reasons the need for new tenders is most apparent and is without question the most vital need in the matter of new equipment for the prosecution of surveys along the Alaskan coast.

ATLANTIC COAST

On the Atlantic coast the *Bache*, a vessel 23 years old, reached the condition some years ago where her annual cost of repairs and upkeep amounted to a sum out of proportion to the original investment in the vessel and made her a liability. She may continue to

operate with considerable repairs for some time longer, but only in comparatively smooth water. There is needed to replace this vessel a new one of about 600 tons displacement.

The *Hydrographer*, a vessel 24 years old, is in the same predicament as the *Bache*, and she should be replaced as soon as possible.

Efforts are being directed to meet the increasing demand for large-scale charts of those inland waterways traversed by motor boats. At the present time large launches are used which base upon cities adjacent to these waterways. As the work progresses, however, these bases will become less accessible and time will be lost from field work by the necessity for long runs for fuel and supplies. For the purpose of connecting these surveys there should be constructed a shallow-draft, self-propelled boat provided with quarters for surveying personnel, storage for fuel, and repair equipment for maintaining several launches.

DEMANDS FOR HYDROGRAPHIC WORK

There is an increasing demand for hydrographic work, and the accuracy of the chart of to-day is more essential than ever for safe navigation of the large and expensive modern vessels.

In 1885 one of the largest vessels afloat was the sailing ship *Great Republic*, of approximately 3,357 tons and carrying a crew of 65 men. On her maiden voyage to London there was no dock at the port large enough for this vessel. Comparing her with the *Leviathan* of to-day, of 59,956 gross tons and carrying a crew of 1,200 men, will give some idea of the great development of ocean-going vessels.

A chart adequate for the safe navigation of the *Great Republic* would no more meet the requirements of the *Leviathan* than the original surveys of New York City made with inferior instruments when property values were low would meet the requirements of to-day.

The great development in the size and value of shipping, together with the development of modern navigational instruments, necessitates that the old hydrographic surveys be supplemented by additional work, and that sea areas formerly unimportant be thoroughly developed. The advent of the submarine has necessitated that the chart shall be adequate to protect subsurface navigation.

During the last year two new instruments have been successfully used by this bureau in hydrographic surveying—radio acoustic method of position determination and the sonic depth finder. The hydrographer's duty is not only the determination of depth but also the actual location of that depth. The first-named instrument is used for the determination of the position of the sounding and its use has made it feasible to do hydrographic work in foggy and misty weather where heretofore it has been impossible to work, owing to the necessity of seeing signals. The second instrument has been successfully used in the determination of depths and has the great advantage of being able to make frequent soundings without stopping the vessel, as has heretofore been necessary in deep water.

Instruments for the measurement of depth by the sonic method are being devised in this and foreign countries by governmental

and private agencies, and such instruments will most likely be used in navigation. The use of these instruments on vessels will greatly increase the importance of the chart to the navigator and will necessitate additional hydrographic work to thoroughly develop the bottom so all characteristic submerged valleys, ridges, etc., may be shown on the chart in their correct positions. A vessel equipped with such instruments will be able to get many soundings during a minute and by having charts showing not only the depth, but the accurate location of different characteristic features of the bottom, the navigator can locate the vessel by comparing the soundings obtained with the information shown on a correct chart.

IMPORTANCE OF COMPLETING WIRE-DRAG SURVEYS ALONG THE ATLANTIC COAST, ESPECIALLY THE NEW ENGLAND COAST

The importance of completing the drag work along the New England coast, where the existence of bowlder and pinnacle rocks is most often not indicated by soundings taken with a lead line, has been stressed in previous annual reports. During the first part of this year appropriations warranted doing some of this work and the area along the outside coast from Portland south to Biddeford, Me., was completed by a wire-drag party. It will be impossible, owing to lack of appropriations, to continue this very important work during this fiscal year. In addition to the work along the coast of Maine, areas in Long Island Sound and in the vicinity of Nantucket Shoals and the important area between Key West, Fla., and Dry Tortugas where coral shoals are prevalent, should be dragged at as early an opportunity as appropriations will warrant.

HYDROGRAPHY, ATLANTIC COAST

The important work along the Atlantic coast necessary to the protection of shipping is a resurvey of certain changeable areas and an extension of the work to the 100-fathom curve. Vessels in trans-Atlantic voyages and approaching this coast are often uncertain of their positions and the detailed information furnished by a survey extending to the 100-fathom curve is especially important to the navigators of these vessels and, as mentioned before, will be especially important when the sonic method for measuring depths is commonly used on vessels. The most urgent areas of this character are from Winyah Bay north to Chesapeake Bay entrance and southward from the completed work in the vicinity of Ormond Beach, Fla., to Cape Canaveral.

The *Lydonia*, one of our ocean-going vessels has been carrying on this work during the entire fiscal year, working in the vicinity of Cape Fear River during the summer months and southward along the Florida coast during the winter months when it is impossible to carry on economical work farther north. During the latter part of the fiscal year the *Bache*, together with the launch *Elsie*, has been engaged in the inshore surveys along the coast from St. Augustine, Fla., northward and will continue this work during this fiscal year northward to Winyah Bay. Most of the work upon which this party is engaged is over changeable areas and includes the development of the bars and entrances to ports along the coast.

HYDROGRAPHY, GULF COAST

The nature of the hydrographic work needed along the Gulf coast is similar to that mentioned for the Atlantic coast. During the fiscal year the steamers *Bache* and *Hydrographer* completed a survey of the approaches to Port Arthur, Tex., extending this work from the beach to a distance of 30 to 35 miles offshore, where 25 fathoms of water were obtained. Many changes were found in this important body of water, emphasizing the necessity of this and similar surveys. Upon completion of work in this vicinity the *Hydrographer* began a survey of Tampa Bay and the offshore work from Tampa Bay northward along the Florida coast, which will be continued during the coming fiscal year.

HYDROGRAPHY AND WIRE-DRAG SURVEYS, VIRGIN ISLANDS

Since these islands were obtained by the United States a detailed topographic survey has been completed, and during this fiscal year the steamer *Ranger*, together with the launches *Mitchell* and *Marindin*, has been continuously engaged in making a hydrographic survey. As coral shoals are prevalent in this area, most of the dangerous areas are being covered by the wire drag, so upon completion of the work a complete modern hydrographic survey of these islands will be accomplished. It is hoped to complete this work during the next fiscal year.

HYDROGRAPHY, PACIFIC COAST

In marked contrast to the work along the Atlantic coast, which previously has been surveyed, comparatively little work has been accomplished along the Pacific coast, and the surveys being executed by this bureau are in most cases original surveys. With the addition of the three seagoing vessels of the mine-sweeper class, mentioned in my previous reports, it has been possible to keep one of these vessels, the *Guide*, continuously engaged on surveys of the west coast, working in the winter months along the southern California coast and in the summer months along the coast of northern California and Oregon in the vicinity of Cape Blanco, which is a very important turning point for all coasting vessels, and where previously only a very few scattering soundings were charted. This vessel is equipped with the sonic depth finder and has established stations for the radio acoustic method of position finding, both of which methods have added materially to the output of the party. Owing to the character of the continental shelf along the Pacific coast, it has been planned to extend the surveys to the 1,000-fathom curve along the entire length of the coast. Owing to the prevalence of fog these surveys are extremely important, as the navigator is more dependent upon the accuracy of his charts for the safe navigation of his vessel. Disasters have occurred in the past owing to incomplete surveys, and now that the bureau has adequate equipment it is planned to expedite this extremely important work. In addition to the *Guide*

two of the Alaska vessels will be employed in extending these surveys during the winter months.

WIRE-DRAG SURVEYS IN ALASKA

It is very gratifying indeed to be able to report that the wire-drag surveys of the main ship channels of southeast Alaska from Dixon Entrance to Cape Spencer were completed during the year. Owing to improved methods and equipment devised entirely by this bureau, we were able to complete this most important project at least two years sooner than estimated when the work was undertaken in 1914. The steamer *Explorer*, together with the launches *Helianthus* and *Scandinavia*, have been employed during the year in drag work of the important harbors and bays along the main steamship channels through southeast Alaska, which work will be continued next year.

OUTSIDE COASTS OF SOUTHEASTERN ALASKA

The party on the steamer *Surveyor*, assisted by the launch *Cosmos*, has been continuously employed during the year in extending the survey work along the outside coast of southeastern Alaska northward so that this work is completed from the boundary line at Dixon Entrance to a position approximately 25 miles north of Cape Ommaney, the southern point of Baranof Island. The necessity for this work is emphasized by the discovery of many important fishing banks, the development of many harbors and bays, and the fact that up to this time the best surveys of this great section of the coast are those made by Vancouver in his voyages of exploration. This project will be continued by this party during this fiscal year.

CHARTING WESTERN ALASKA OF GREAT IMPORTANCE

A stupendous task confronts the bureau in charting the coasts of western Alaska, comparatively little of which has yet been surveyed. Owing to the lack of adequate equipment, it was impossible for a number of years to do work in this area, but with the addition of the three mine sweepers it has been possible to assign two of them—the *Discoverer* and *Pioneer*—to this task. Each of these vessels has one additional large launch to work in conjunction with the ship along this dangerous and treacherous coast. Work was accomplished last year by the party on the steamer *Pioneer* in the vicinity of Morzhovoi and Cold Bays, and the work is to be continued this fiscal year, including Pavlof and Ikatan Bays and Isanotski Strait, and the approaches to these areas. The *Discoverer* was engaged on surveys on the southern coast of the Alaska Peninsula in the vicinity of Portage Bay, Shelikof Straits, where important oil fields have been developed. The work in this vicinity will be completed this year and the party will take up the surveys of Chignik Bay and its approaches. If possible, the 100-foot motor vessel *Natoma* will take up urgently needed additional work in Prince William Sound during this fiscal year.

HYDROGRAPHY, HAWAIIAN ISLANDS

Considerable work remains to be done in these islands, the importance of which has been called to the attention of the bureau by numerous requests for surveys from other Government departments, commercial firms, and individuals. In addition to the work in the vicinity of the larger group of islands, there is need for the examination and correct charting of islands and shoals extending westward to the Midway Islands. One shore party has been engaged during the fiscal year in executing work in these islands and will be continued on this work during the next fiscal year. It is hoped at an early date to undertake more work in these islands.

CHARTING THE PHILIPPINE INLANDS

Three vessels, the *Pathfinder*, *Fathomer*, and *Marinduque*, are continuously engaged in advancing the first surveys of the Philippine Islands which are nearing completion. Work has been accomplished this year by two of these vessels in the southern part of the Sulu Sea and one of these vessels has been engaged part of the time in surveys of the south coast of Mindanao and the west coast of Palawan. At the beginning of the fiscal year the hazardous work north of Luzon was taken up by the latter vessel and will be continued in the next fiscal year during the periods between the northeast monsoons, when work can be economically executed. It is essential that this work be completed at as early a date as possible during the useful life of the present equipment and to insure the continuance of the present financial assistance received from the Philippine Government.

DEMAND FROM OTHER BUREAUS FOR CONTROL SURVEYS

Committees of Congress and special committees of other organizations have spent a vast amount of time in investigating the overlapping of functions and duties in the various Government bureaus. Their recommendations have in some instances resulted in actual or contemplated improvements, yet at the same time a most important economic corollory is being lost sight of.

From the standpoint of efficiency a concentration of duties of a similar character in a single bureau must be followed by a granting of the means of performing that function. The Coast and Geodetic Survey is charged with the duty of furnishing accurate elevations and geographical positions for other mapping agencies as well as for its own charts in order to avoid the duplication of expensive instrumental equipment and specialized personnel. The appropriation for such work remains woefully inadequate for the needs of all agencies concerned.

A few of the results of this policy will be briefly pointed out, so far as they affect other bureaus and the public interests which they serve.

PUBLIC ROADS.—At first glance there appears to be little connection between road construction and the latitudes and longitudes of points, or their elevation above sea level. Yet construction must be

preceded by location surveys; and preliminary location surveys can, in most cases, be avoided altogether where modern topographic maps are available. Satisfactory topographic maps can be based only upon data supplied by precise triangulation or traverse and leveling. The savings to the nation's road-construction program alone would, in a few years, pay for the completion of the topographic map together with its basic control surveys.

General Land Office.—Connecting the monuments of the public land surveys to the general triangulation scheme of the country insures the permanency of property surveys. If the latitude and longitude of a section corner are once known accurately, it can always be exactly relocated by triangulation. Cadastral engineers of the General Land Office cooperate with the field parties of the survey in tying together the two great survey systems of the country.

In Alaska there is even more urgent need by the General Land Office for precise triangulation surveys, to remove the necessity of a large number of local land survey systems, each with its own reference meridian and parallel, for when such local cadastral survey systems join there are unavoidable gaps and overlaps of large extent. During the past three summers a party of this survey has extended a system of precise triangulation from Cook Inlet to the Tanana Valley, but the smallness of the appropriation for such work will necessitate the removal of even that party during the summer of 1925, although the economic demands of that region would warrant the maintenance of at least two parties for a number of years.

Forest Service.—One of the chief sources of revenue of the Forest Service arises from its grazing permits. To administer them and to lay out the necessary roads and trails, the reserves must be mapped. In the absence of a standard topographic map it carries on extensive mapping operations. Many large forests are lacking in adequate control surveys upon which such maps can be based. Year after year requests have been made upon this bureau for triangulation data in forest reserves which have not been supplied because of lack of funds.

Geological Survey.—Upon the topographic branch of the Geological Survey devolves the duty of making the standard topographic map of the country and as such it is by far the largest user of geodetic data. Specifications adopted by the Federal Board of Surveys and Maps prescribe that precise triangulation stations and precise level bench marks shall be so distributed that no part of an area to be mapped shall be more than 50 miles from such a point. Yet there are three areas in the United States proper, each exceeding 200,000 square miles, without a single precise triangulation station in them, and one area of 265,000 square miles without a precise level bench mark in it. Many smaller areas are so deficient in control surveys that any extensive mapping operation in them is practically prohibited.

Where Duplication Exists.—To sum up, the real duplication lies in many organizations, both Federal and private, making partial surveys in a region, each of which is adequate for only one particular purpose, whereas a standard topographic map would suffice for all.

The early completion of the standard topographic map is an economic necessity recognized and urged by many great interests

throughout the country. The mapping can not be done with even approximate accuracy without precise control surveys. It can not be done economically unless the scheme of control surveys is completed in advance of the topographic mapping. These control surveys are years behind even the present demands of the topographic mapping program, and their acceleration should by no means be further delayed. They are the foundation of the map structure of the Nation and can not be neglected just because they do not show on the printed map.

CHARTING OUR COASTAL WATERWAYS

My annual report for 1923 stressed the growing importance of the motor-boat traffic through the sheltered inside waters which fringe our Atlantic coast from New York to Key West. These waters constitute a highway for a large and constantly increasing volume of traffic, for fishermen and oystermen, for freight carriers serving a vast adjacent territory to which other adequate transportation facilities are not yet available, and for motor-boat men, who find in cruising these waters renewed vigor with which to meet the rigorous exactments of modern life.

COAST EROSION AND PROTECTION

The problem of the protection of our coasts from the unrelenting attacks of the waves and currents is one that is rapidly increasing in importance to the States and municipalities that border our Atlantic and Gulf seacoasts.

The many requests that have recently come into this office regarding the condition of our shores, the demands that are constantly being made for new surveys in changing areas, have served to emphasize the justification for pioneering in this field of work.

To the lay observer the meeting place of land and sea is but a fascinating playground whose elements are unchanging in their relation to each other. Little does he know of the pent-up forces that every incoming wave carries with it, to be released on its relentless work of destruction.

The physiographer and engineer, on the other hand, fully appreciate the impress left by every wind and wave that beat against an exposed shore. They see in this meeting place not a playground but a battlefield where land and sea are constantly struggling for supremacy and where too often the sea has been the victor. It is to them that we must ultimately look for a solution to the intricate and perplexing problems of coastal evolution.

Not only has the natural formation of our coast line been encroached upon but costly protective structures, some a monument to engineering skill, have been swept away by the fury of an unchecked sea.

With the development of better transportation facilities both on land and sea, comparatively unimportant beaches are fast being transformed into pleasure resorts and other centers of increasing commercial and economic value. Sooner or later these communities will find themselves confronted with the vexing problem of pre-

serving their water fronts. Their first step in the direction of checking the destructive work of the sea will be to appeal to this bureau for information regarding the successive changes that their particular portion of the coast has undergone. We can be in a position to furnish such information only by anticipating this future development.

The broad scope of the work, the need for a proper coordination of the many sources of information, the necessity of studying the effects of similar conditions on different localities, all make it imperative that the work be lodged in some central agency. And there is no organization in this country to-day that is better fitted to undertake this far-reaching problem than the Coast and Geodetic Survey. This bureau, through its corps of highly trained engineers and cartographers, is in a position to make invaluable contributions to the study of the protection of exposed shore lines with but slight additional expenditures.

First and foremost in the study of coast erosion and protection we require a series of adequate surveys showing changing conditions over a long period of years. From these observations, combined with data regarding weather, currents, shore forms and materials, a detailed study of the fluctuations can be made and the laws governing shoreline changes deduced. With these laws definitely established the engineer would be in a position to apply them to the particular project under consideration. For this purpose a comprehensive study should be made of the entire erodable shore along the Atlantic and Gulf coasts from existing surveys, supplemented by additional surveys from time to time where changes are frequent, as in the various inlets that connect the successive bays and sounds with the ocean.

There are at present but few places along the Atlantic and Gulf coasts where periodic surveys have been made. In many instances but one survey exists; and in other places two surveys comprise the entire number made in the last 100 years, a condition wholly inadequate for satisfactory study.

NECESSITY OF COMPASS INFORMATION

The charts issued by the survey have on them about 2,000 compass roses, each of which shows the present direction of magnetic north with regard to true north for the point indicated, and the annual rate of change in the direction. Every year 300 of these are furnished for new editions of the charts or for new charts. It is therefore of great importance that magnetic surveys on which this information is based should be continuously in progress and, necessarily, cover a very great area. There are in the United States 3,067 counties, and in a very large number of these counties the county and other local surveyors are called upon to make magnetic surveys or to retrace old lines of which the magnetic bearing at some date is known. Practically the only reliable source of information for these surveys and for correcting the instruments with which they are made is the magnetic survey of the United States made by this bureau. The survey made for this purpose also served to meet the recent demand for magnetic information for use in aviation charts.

The around-the-world cruise, carried out by the planes of the Army Air Service, emphasizes a new use for our knowledge of terrestrial magnetism. These planes were equipped with earth inductor compasses and, accordingly, knowledge of the dip as well as of the declination was of use. The results of the magnetic work of the bureau are thus used on earth, air, and sea.

The collection of the needed information for the United States has been carried on for many years and intensively during the last 25 years. Information is now available for all parts of the United States and the regions under its jurisdiction. As the earth's magnetism is constantly changing, it is necessary to make observations to record the changes. Observations are made at five fixed observatories and at numerous points or stations. 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 their vicinity. Accordingly, the observer must live in seclusion and suffer many inconveniences.

Any suspension, even though temporary, of the work at any of the observatories is a serious matter. Accordingly, as the expiration of the lease of the land occupied by the observatory on Vieques Island, P. R., will expire on June 30, 1925, every effort is being made to replace it without undue delay with an observatory on the main island of Porto Rico. The willingness that has been shown by the present governor to cooperate is going to make it possible to start the erection of the necessary buildings during the present fiscal year. It is hoped that a site on public land will be obtained, so that future interference with the work by the expiration of a lease can be avoided. Not only are the results at this observatory essentially needed for the charts for those regions, because of the exceptionally rapid change in the direction of the earth's magnetism, but scientists consider that an observatory in this region gives exceptionally valuable results for a study of the earth's magnetism. The limited appropriations make it especially difficult to carry out this project in an adequate manner.

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.

The general program of field work in the United States includes the regular occupation at five-year intervals of about 200 stations throughout the country in order to determine the changes in the earth's magnetism. Additional stations are needed, especially in the Western Mountain States, as they are at present too far apart to give adequate knowledge. While the surveys along the coasts are fairly complete, a much closer survey than has been made heretofore is needed along the entire coast. This has been carried on during the past season along the coast of southern California with very satisfactory results. Another urgent need is the replacement of magnetic stations at county seats throughout the country. These are

utilized by county 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. It is hoped that cooperation with the Coast Guard will make it possible to do magnetic work in the Aleutian Islands during the next fiscal year and at the same time to secure additional information. 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 chart.

The needed resurvey of the Philippine Islands will start during the next fiscal year and be carried on to completion. This will be made possible by the cooperation of the insular government. Repeat stations will also be occupied in the Hawaiian Islands.

It is hoped that the needed occupation of repeat stations in Porto Rico and on Vieques Island can be accomplished during the present year.

The work that is being accomplished is far from adequate to meet all demands. The coastal and interior surveys are large projects and each will require steady work for a long period. Many surveys which have been requested have been postponed indefinitely. A great deal is being accomplished with the funds available but they have been wholly inadequate for years to meet the demands of the public as they should be met.

WHY SYSTEMATIC SEISMOLOGICAL WORK IS NEEDED

Within the last three years earthquakes have been felt in 28 States and in Canada near the border; both under the sea off the coast of Oregon, and in Porto Rico, Hawaiian Islands, the Philippines, and Alaska. Some of these caused more or less local damage. In this same region during historic times there have been at least eight major earthquakes which caused widespread damage and loss of life. Earthquake study is therefore important to the country as a whole.

The first real attack of this problem in the United States is the investigation now going on in California, carried on by the Carnegie Institution of Washington, with the cooperation of this and other Government bureaus. This investigation is beginning to give excellent promise of practical results, as well as solving problems which are of interest to the seismologist. The part of this bureau in this investigation has been the precise determination of changes in posi-

tion of triangulation stations, resulting either from earthquakes or from movements of the earth which result in earthquakes. An important part of the California investigation is the determination of the point of origin of the earthquake by instrumental methods, and this is being made possible and practical by the development of new and inexpensive instruments.

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.

NEED OF A CURRENT AND TIDE SURVEY IN DELAWARE RIVER AND BAY

The current and tide surveys of the various harbors are being taken up in the order of their importance from a civil and military standpoint and with reference to the needs of the mariner. The Federal engineers charged with the development of the harbor of and approaches to Philadelphia have requested that that port be the next taken up in order that the data obtained may be applied to the study of the dredged channels, with a view to so laying out these channels as to take advantage of all natural flow and therefore decrease the cost of maintenance.

What has been done in New York and San Francisco Harbors in the past two fiscal years is now planned for Delaware Bay and tributaries, for in addition to the value of such a survey to the Federal engineers, a knowledge of the behavior of the currents is of great importance to shipping. Beginning in July, 1924, a comprehensive current and tide survey is to be made in Delaware Bay and tributaries and, as soon as possible with the small force of mathematicians in the division of tides and currents, the results of this survey will be made available.

IMPORTANCE OF SURVEYS IN ALASKA

One of the greatest tasks which confronts this bureau is the completion of the survey of Alaskan waters. Alaska may be considered as the last American frontier, and as it is not connected by railroad with the continental United States, it is entirely dependent upon water-borne transportation for its development. It is known that Alaska is extremely rich in its vast and varied amount of natural resources, which includes such much needed products as crude oil, coal, timber for paper pulp, marble, lumber, and enormous quantities of food fish. The greater part of Alaskan waters still remains unsurveyed, even though the bureau's activities throughout the past years have extended to the limits of the appropriations of Congress, available for such work, and great headway has been made.

By far the largest proportion of the Alaska waterways is extremely deep; in many cases 25 to 50 yards from the high-water

mark there is a depth in excess of 100 fathoms of water. However, to the hydrographer the survey of these waters presents one of the most difficult problems on account of the prevalence of pinnacle rocks which rise abruptly from the bottom to near the surface, the existence of which can not, in most cases, be determined by the usual method of sounding. To meet this problem it is necessary to be assured that all dangers to navigation are located and accurately determined, that these waters be covered with a wire drag. In 1914 the dragging of the main ship channels of southeast Alaska, through which most of the vessels entering and leaving the Territory pass, was commenced and completed during the year 1923, and a similar survey of the different bays which are now of commercial importance is being executed this year and will be continued next year. The survey of the thousands of miles of shore line of western Alaska presents an extremely difficult and important problem, which heretofore, owing to lack of proper equipment, could not be economically undertaken. During the last fiscal year it was possible, owing to the addition of seaworthy vessels, to commence work in this vast area, which will be continued to the limit of the available appropriation during this fiscal year and in the future. Only the roughest sort of reconnaissance has been done in the Aleutian Islands, which lie westward of the Alaska Peninsula, and it is hoped this year to be able to make at least a reconnaissance of this area so that a definite plan may be adopted to chart adequately these many islands and shoals. As mentioned in my report of last year, numerous requests for surveys in this vast territory are received by the bureau, all of which are given very careful consideration, and emphasize the importance and magnitude of the tasks which confront this bureau with the limited equipment and apparatus available for the work, as well as the comparatively short duration of time when work can be economically executed. During the present fiscal year the survey has made a careful wire-dray survey of Kasaan Bay and Twelve Mile Arm at the request of the War Department for its use in laying the Alaskan cable. Extensive surveys have been and are now being executed at the request of the Navy Department in this vast area. Every request which is received from steamship companies operating vessels in Alaskan waters, or from private citizens and corporations, is given very careful consideration and is executed at as early a date as possible. For the completion of the work in southeastern Alaska two main projects have been borne in mind and work will be continuously carried on until they are completed. The first and most important is the wire-drag development of the important waterways. As stated above, this fiscal year saw the completion of the most important part of this project when the inside passage from Dixon Entrance north of Cross Sound via Wrangell Straits, was completed, and now the different important harbors and bays along this steamship route will be dragged at as early a date as possible. The other project is the completion of the survey of the outside coast of southeastern Alaska from Dixon Entrance northward and extending from the beach to the 1,000-fathom curve. The largest of our vessels has been engaged on this work for the last four seasons and should be kept on this project until this area is completed.

CHAPTER III

SUPPLY BASE FOR WESTERN ALASKA

For many years I have strongly advocated the purchase of a Government supply base in western Alaska. Up to the present time there has been no action taken for securing such a reservation for the use of Government vessels. With the increasing commercial and governmental activities in western Alaska and the very great need for a place where vessels can take on fuel, water, make repairs, and for other purposes, we are not only facing the difficulty of getting a suitable place but we are certainly each year by the postponement making it certain that we will have to pay a large price to secure a proper location when such action is finally forced upon us.

Twelve years ago the Government could have purchased a suitable place for a nominal sum in an excellent harbor in the Aleutian Islands and a property that would meet the full needs for years to come. Whether this can be purchased now is a question. In any event it would be an economical move for the Government to consider seriously the wisdom of securing such a base in Bristol Bay or Dutch Harbor.

CHAPTER IV

BETTER REPRESENTATION AT CONFERENCES

The policy of this country to send delegates to a few of the several international scientific conferences and congresses has proved the wisdom of such practice, this country receiving in return much valuable data that have been useful to the various departments which have benefited from such contact.

With the many millions of dollars that are being spent each year by the Government, private institutions, and individuals it does seem that the comparatively small expense of sending delegates to all of the principal international scientific and engineering gatherings would prove a matter of economy and certainly much benefit to the whole Nation. It is of prime importance during the present change in methods and of affairs of countries that the Government be present to contribute, as well as receive, benefits that are developed at such meetings.

In this connection the same arguments exist for our being represented by duly authorized delegates to international meetings as prevail for foreign delegates attending international gatherings held in our country. These meetings are reciprocally helpful in many ways to all of the nations who fortunately have the opportunity to participate in them. Many countries have already recognized this fundamental fact of contact, mutual advantage, and helpfulness in the facilities that are given their leading men for attending such conferences and congresses.

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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 for office expenses, including the purchase of supplies for the office, for chart printing work, and to some extent for the field, the care of most of the original records of the field surveys, as well as the library of printed publications; the general supervision of all matters relating to the personnel work, including reports of leaves of absence; the custody and accounting for the receipts from the sale of charts, publications, etc.; and the direction of the engineer, electrician, watch, messenger, labor forces, and other employees engaged in the care, maintenance, and protection of the buildings occupied by the bureau in the District of Columbia.

The more important accomplishments during the year have been a continuation of the thorough renovation of the buildings. While this work is still in progress and it is a lengthy program with the small force of employees and funds available, the improvements and sanitation that are necessary, the present accomplishments in the way of painted rooms and modern fixtures offer a very pleasing contrast when compared with conditions and equipment previously existing.

During the year plans were perfected for the installation of all-metal storage racks in which to place the copper plates from which are printed navigation charts issued by the bureau, and racks for one storage room were completed. These racks are to replace old wooden racks that constitute a fire hazard, besides having become so weakened by necessary overloading, due to lack of other storage space, that they are collapsing under the load they are carrying.

Storage space for records which are not used frequently but are of such importance that they must be within access when needed has always been considerable of a problem, due to the lack of adequate housing quarters. During the year consideration was given to the utilization of an inclosed attic in the chart, instrument, and archives building. The matter of the structural strength of the framework of the building was placed before the Supervising Architect of the

Effective Oct. 15, 1915
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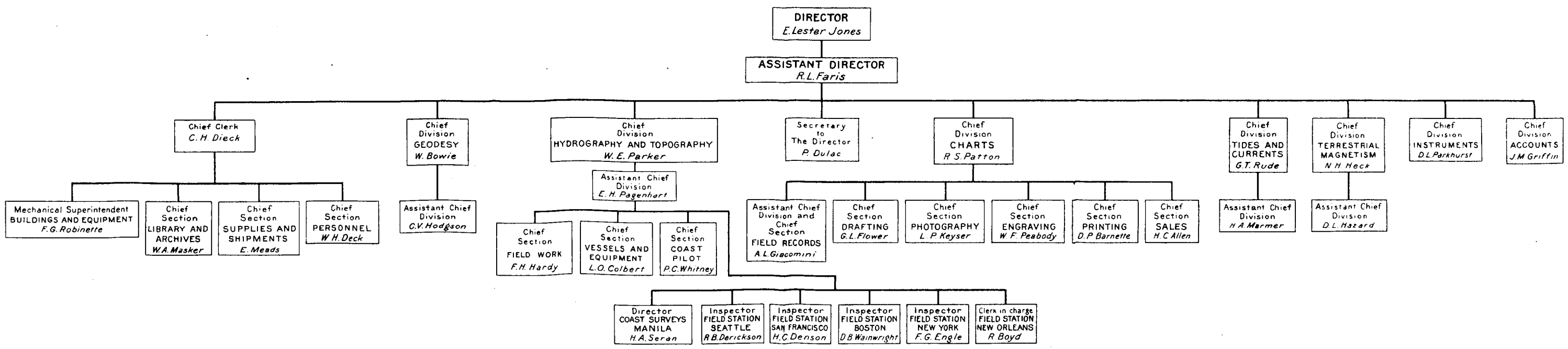
CHART SHOWING ORGANIZATION OF THE
U.S. COAST AND GEODETIC SURVEY
1924



Treasury Department which office made suggestions regarding strengthening the steel framework. At the close of the year a stairway and opening admitting ready access to the attic had been provided, the installation of strengthening steel framework as suggested by the Supervising Architect's Office and flooring was in progress, and contracts had been let for supplying storage equipment. When this space is available records will be removed from three rooms that are suitable for office purposes. Besides giving additional office space, the storage of records in the attic of the new building will make them more readily accessible.

The cost of care, maintenance, upkeep, and operation of the buildings occupied by the bureau was 31 cents per square foot.

As time has permitted the chief clerk has cooperated with the division of terrestrial magnetism in awakening the interest of county and other surveyors in the magnetic stations established at various localities throughout the country. This effort was centered on the States of Arizona, California, Florida, Georgia, Louisiana, Mississippi, Missouri, New Mexico, New York, Oklahoma, South Carolina, and Texas. Illustratiton No. 7, opposite page 56, shows graphically what this cooperation has accomplished.

In the library and archives 114 hydrographic and 32 topographic sheets, each representing new surveys made by the bureau, were received. Other additions were blue prints (mostly showing surveys made by Army engineers), 1,341; maps, 1,998; charts, 4,107; field, office, and observatory records, 3,278; photographs (negatives and prints), 673; lantern slides, 110; books accessioned and catalogued, 443; books catalogued but not accessioned, about 500.

During the year the expenditures for general expenses of the bureau were $95,187.86.

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, 214; field force, 184; total, 398. These figures do not include the persons engaged as rodmen, chainmen, heliotropers, and others in the field parties nor any enlisted men on vessels.

The statistics in regard to leaves of absence during the calendar year are: Annual leave, 7,771 days; sick leave, 1,595 days; without-pay leave, 770 days; and accrued leave, 1,814 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, 1924, as a basis of computation, the average annual leave taken during the year by each employee was approximately 19.53 days, and sick leave 4 days.

The receipts from the sale of charts, publications, etc., amounted to $49,907.95.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY

This is distinctly a field division, nearly all the personnel being employed continuously in the field on hydrographic and topographic surveys. With the exception of those in the coast-pilot section, who are employed about half time in the office, the personnel regularly stationed at the office has been limited to barely enough persons to

plan and supervise the field surveys, handle personnel matters, make administrative examinations of accounts, supervise the purchase and upkeep of floating and other equipment, and attend to such other administrative duties as are necessary for the efficient management of the ships, field stations, and field parties which operate under the direction of the division. This involves about 75 per cent of the entire personnel of the bureau and something over 60 per cent of its cost of operation. Consequently, the accomplishments of this division in the Washington office have been largely of an administrative and routine nature, which are evidenced only by the efficiency of the field operations.

However, beginning two years ago and continued through this last fiscal year, a few additional field officers were given short details to the office from time to time, as they could be spared from the field, to assist in the solution of some of the problems of the division. With such assistance it has been possible to carry on some research in subjects pertaining to hydrographic surveying.

The study of position finding at sea by means of radio and subaqueous sound waves begun last fiscal year was continued to a satisfactory solution. Apparatus was constructed and installed upon one of the vessels of the bureau, the *Guide*, which is now surveying the Oregon coast. With this radio acoustic apparatus, the position of the ship can be determined with sufficient accuracy for hydrographic surveying at any time of day or night regardless of weather so long as the vessel is, at present, within about 60 miles of the shore and possibly, eventually, at a much greater distance when operators become more expert. A special publication entitled "Radio Acoustic Method of Position Finding in Hydrographic Surveying" was prepared jointly by the officer of this bureau and the officer of the Bureau of Standards who contributed most toward the development of the method and apparatus. This publication is now in the hands of the printer.

With the adoption of this apparatus, and also of a machine devised by the Navy for determining ocean depths by sound echo from the bottom, it became evident that existing information on the velocity of a sound wave in sea water was inadequate for accurate work. Accordingly experiments were made at sea to determine the velocity of sound under different conditions of temperature, pressure, and salinity. From these data an equation was evolved and tables were constructed from which a velocity value suitable to the depth and characteristic of the water can be selected so that depths determined by the so-called sonic depth finder (echo sounding method) will agree with actual measurements within 1 per cent of the depth. These tables are now in the hands of the printer in a special publication entitled "Velocity of Sound in Sea Water."

A deep-sea sounding machine designed by and constructed under the supervision of this division two years ago proved so efficient that it was decided to adopt this general type and to scrap all of the older types as early as they could be replaced. During the past year some minor changes in the design of the original machine were made, to effect further improvements, and all ocean-going vessels were equipped with one such machine.

A type of sounding machine suitable for navigation and for surveying in depths up to 500 fathoms was designed and constructed during the year. The latter machine will be used for navigation and for surveying up to the limit of its capacity. It is much smaller and cheaper than the deep-sea machine both in cost of construction and operation.

That the time which has been devoted to these investigations and experiments and the cost have been fully justified by results can not be questioned. The art of hydrographic surveys has been materially advanced by this work and the future should show a marked decrease in the unit cost of such work. Some of the apparatus is rather costly, so that it will not be possible to equip all vessels at once, but as funds become available additional equipment will be purchased and installed upon other vessels of this fleet.

The office work on the aerial phototopographic survey of the Mississippi River Delta, on which an officer was engaged at the time of my last annual report, was completed early this year. A complete report of the methods used and the results obtained will be found in special publication No. 105, Aerial Survey of the Mississippi River Delta.

At the request of the Signal Corps of the Army, the division prepared special charts showing the most practicable location for a submarine cable from Ketchikan, Alaska, to deep water of the Pacific along a prescribed route. This involved careful study of all field notes and unpublished data in this office to find the shortest track as free as possible from rock and abrupt changes in depth. Where adequate information was not available this was obtained by a special survey by one of the parties then in the field.

The section of vessels and equipment maintained supervision over the floating equipment of the bureau and directed repair and upkeep work to the limit of the available funds. Preliminary plans were prepared for the construction of a vessel of about 600 tons to replace two small vessels on the Atlantic and for two tenders for Alaska duty to replace two no longer fit for operation. This section designed the sounding machines mentioned above. The temporary detail of an additional field officer to the section for three months assisted greatly in the preparation of plans for reducing the cost of maintenance of the vessels. This officer also made a thorough inspection of all surveying instruments in this office which are commonly used by parties working under the direction of the division, and all instruments worth repairing were put in serviceable condition.

The coast-pilot section completed field work on Coast Pilot, Section C, Sandy Hook to Cape Henry, and brought out a new edition. Field work was also completed on Coast Pilot, Alaska, Part I, Dixon Entrance to Yakutat Bay; compilation and write-up of field notes are now in progress. Supplements of the following volumes were compiled and printed during the year: Section A, Section B, Section D, Porto Rico and Virgin Islands; California, Oregon, and Washington, Alaska, Part II; Philippine Islands, Parts I and II; and Inside Route Pilot, New York to Key West. This section also prepared for publication a new edition of the Regulations for the Government of the United States Coast and Geodetic Survey.

DIVISION OF GEODESY

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

The computation and adjustment of the following pieces of triangulation:

1. Louisiana.
2. Red River (for furnishing control for Texas-Oklahoma boundary).
3. Maricopa-Yavapai County boundary survey.
4. Tacoma, Wash., to Canadian boundary.
5. Maryland.
6. Oblique arc to Sanford, N. C.
7. Hawaii.
8. Pasadena, Calif.
9. El Reno, Okla., to Needles, Calif., and one hundred and fourth meridian.
10. Forty-ninth parallel and one hundred and eleventh meridian.
11. Dry Strait, Alaska.
12. Lake Okeechobee, Fla.
13. San Diego, Calif., milestone.
14. California earthquake.

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

1. Pasadena, Calif.
2. Havre, Mont.
3. Bozeman, Mont.
4. Boundary, Mont.
5. Des Moines, Wash.
6. Wide Bay, Alaska.
7. Point Gustavus, Icy Strait, Alaska.

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

1. Warroad-Fort Frances, Minn.
2. Palm Beach-Lake Okeechobee, Fla.
3. Charleston-Beaufort, S. C.
4. Fort Frances-Namakan Lake, Minn.

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

1. Fairbanks to Valdez, Alaska, and spur line, Willow Creek to Chitina.
2. Seward to Anchorage, Alaska.
3. Hartford, Conn., to Auburn, R. I.
4. Westerly, R. I., to Boston, Mass.
5. Portland, Me., to Boston, Mass.
6. Poughkeepsie to Dover Plains, N. Y.
7. Livingston, Mont., through Yellowstone Park, Wyo., to Idaho Falls, Idaho.
8. Los Angeles to San Gabriel, Calif. (connection with Pasadena base).
9. Revision leveling from Weed, Calif., through Portland, Oreg., to Centralia, Wash., and between Knappa and Fort Stevens, Oreg.

The computation of the following astronomic work:

1. Azimuths: 21 stations in connection with the California earthquake investigation; 3 stations along the Red River, Tex.; 1 station, Tacoma, Wash., north to Canadian boundary; 2 stations, Palm Beach to Lake Okeechobee traverse, Fla.; 4 stations along the Minnesota traverse; and 1 station along the Savannah-Norfolk traverse.
2. Latitude: Five stations along the Wisconsin traverse and 2 stations in Alaska.
3. Longitude: Seven stations in Alaska; 3 stations in Wisconsin; and 1 station in Washington.

The computation of results for all gravity stations established in 1923 has been completed, except for applying the restandardization corrections. The topographic and isostatic compensation reductions for about half of these stations have been made. Numerous miscellaneous computations and investigations of gravity and isostasy were made during the year.

Investigations were carried on during the year in the following subjects:

1. Interior of the earth.
2. California earthquake.
3. Effect of change of spheroid on triangulation.
4. Variation of latitude.
5. Tape standardization.
6. Base measurement.
7. Least squares adjustment of triangulation.
8. Gravity in Hawaii.

DIVISION OF CHARTS

During the fiscal year the division of charts continued its task of furnishing to the maritime public correct and up-to-date charts on which were incorporated the data obtained in the mass of information reaching this office from sources both within and without the service. It also made gratifying progress in the production of new charts resulting from the recent completion of surveys by our field parties or from the policy of replacing certain existing charts with others conforming to our present-day standards.

The quantity of the division's service is measured in the long run by the volume of charts issued. It should be noted, however, that the function of the bureau is largely limited to the passive one of supplying a demand which is determined by factors over which it has no control. The demand is determined by economic conditions, and the quality of the product has little to do with the number sold. We have a monopoly of a product indispensable for certain purposes, and the chart-using public must take what we give it. Therefore the distribution of charts in any one year is not a measure of their value in comparison with that of some alternative product, but rather an indication of the relative activity of certain agencies of the Federal Government and of the fluctuations in economic conditions as they affect merchant shipping and those classes of our people who look to the sea for recreation.

The total number of charts disposed of during the year was 221,543. This total constitutes a slight increase over that for 1922 and 1923. The sales, however, are slightly less than in 1923, the increase being in the free-issue column, particularly in the issue of charts to the Navy Department.

In the improvement of the quality of our charts we have made continued progress. Every new or reconstructed chart which comes off the press results in a better quality of service to the mariner. Last year's program of 27 new and 17 reconstructed charts was an unusually heavy one, and the results accomplished constitute a most gratifying achievement.

Up-to-date Charts.—An item deserving major emphasis is the frequency with which our charts are printed. Our coasts and harbors are undergoing constant and rapid evolution. Radical changes in certain of the areas covered by the charts are constantly being reported. These changes result to a minor extent from the operation of natural forces but in much greater degree from artificial improvements. The prompt charting of these changes is considered of such importance to the safety of navigation that it is given precedence over all other work. In order that the charts may be kept correct with respect to these changes they are printed frequently in small editions; before each reprint the printing plate is corrected to show the new data received since the last preceding print; and finally, before the chart is allowed to leave the office, it is corrected by hand to show still later information of major importance.

Thus, during the year just ended, while the number of charts disposed of was 221,543, the average stock carried was only 89,293. The resulting turnover of stock is 2.5 times for all charts. As a matter of fact, the actual service rendered is even more creditable than is indicated by these figures. Charts of remote or unchangeable areas are printed in quantities to last several times the five months average, and that average is reduced to the figure given by a still greater frequency of printing of those charts where the changes occur. For example, chart 8550, Prince William Sound, Alaska, covers an important but unchangeable area. This chart has been printed only twice during the last four fiscal years. Conversely, chart 369, New York Harbor, was printed five times during the past fiscal year and was in hand for a sixth printing at the close of the year.

I think we may fairly assert that our service in this respect is unequaled by any other principal maritime nation, although it is proper to add that probably no other nation is confronted to the same extent with this problem of rapid and constant evolution.

During the year the division undertook two new projects, each representing an improvement in the quality of service to the public. These projects were, first, charts showing results of wire-drag work in Alaska, and second, a new series of charts of the inland waters from Norfolk to Key West, prepared with special reference to the needs of motor boatmen.

Wire-Drag Charts.—For the past 20 years the Coast and Geodetic Survey has been making wire-drag surveys of those areas of the United States and its possessions where are found abrupt inequalities of depth. The dangers discovered during the course of this work have been charted promptly and to that extent we have afforded additional security to vessels. We have also told the mariner in a general way that certain waters have been dragged and the dangers discovered charted, but we have not heretofore informed him definitely as to the areas to which that assurance applied.

Until this last item of information has been furnished the mariner we have not rendered him all possible service. Wire-drag work can not mean as much to him as it should until he is in a position to know definitely the exact location and extent of the waters it has rendered secure. For example, a vessel sailing between two ports may have an alternative of two routes, one of which has been dragged, while the other has not. On the basis of the information heretofore furnished the mariner could not choose the safer route, no matter how strong his inclination to do so.

The problem of charting the results of wire-drag work in a way that will be readily comprehensible to the mariner is a difficult one. Various factors make it impossible to pass on to the public any conception at once comprehensive and accurate of the effective depths at low tide to which all areas covered by the drag have been swept.

Those difficulties constitute an explanation of the fact that the results have not sooner been shown on the published charts. However, last year it was decided that even though we can not give the mariner everything, we can give him enough to be of material help to him. Accordingly during the year the survey adopted a method of showing on the charts of southeast Alaska the areas which had been swept in such a manner as to safeguard navigation. The

method used was to indicate on the chart by a green overprint all areas which had been swept to an effective depth of 30 feet or more at mean lower low water. Alaska was chosen for this first attempt, because the great depth and ample width of channels had greatly simplified the results obtained. The easiest task was chosen first in the hope that our experience there might aid in the sloution of the problem in more difficult areas elsewhere.

A number of the charts of southeast Alaska have now been issued containing this information, and it is being applied to the remaining charts of that area as rapidly as they come up for reprint.

INSIDE ROUTE CHARTS.—The program of chart production for the year included a new series of 10 charts showing the inside route from Norfolk to Key West. The series was designed especially to meet the requirements of motor boatmen cruising in this section. There has been a tremendous increase in recent years in the number of craft of this character, both in those engaged in fishing, oystering, or local transportation, and in the pleasure boats which annually make this cruise or some portion of it.

On the series of general coast charts these waters are covered by 25 charts, scale 1:80,000. In this series the number was reduced to 10 charts on the same scale by charting the route in strips, usually three strips to the chart, thus eliminating much general detail of no particular value to boats making this trip. The charts are printed on thin paper so as to be readily folded into compact space.

DIVISION OF TERRESTRIAL MAGNETISM

Special emphasis was placed during the year on certain phases of the work; this included:

Maintenance of information service to local surveyors on practically the same basis as last year. The bureau is now in touch with 2,000 local surveyors who use magnetic methods, and has obtained information in regard to the usefulness to the local surveyor of about 33.3 per cent of its magnetic stations.

Among other purposes for which magnetic information has been furnished are data for aviation maps of the Army; information in regard to magnetic storms to the American Telephone & Telegraph Co. and the Experimental Publishing Co.; magnetic declination tables for the World Almanac; tables for Manual for Northern Woodsmen for use in the Forest Service; data for the Carnegie Institution in its investigation of magnetism by rotation; results of special observations for the use of Doctor Millikan, of the California Institute of Technology, in his determination of the mass of the electron; seismological data for Prof. Bailey Willis, of Leland Stanford University, in connection with the investigation of the Chilean earthquake.

There has been continued improvement in the methods of computing and preparing for publication its observatory publications; economics and new devices developed within the division during the last two years have reduced the cost of the biennial publications of its observatory results at each of the five observatories by 62 per cent and have removed much of the drudgery and eyestrain previously suffered from the work.

Special attention has been given to the improvement and replacement of observatory instruments, much of this work having become imperative on account of defects that have developed. Instruments long in use have been remodeled so that they are as satisfactory as new instruments at a very slight cost, through the effective work of the instrument division.

The observatory situation has been studied and special attention has been given to modernizing the conditions of the various observatories. The transfer of the Porto Rico observatory from Vieques Island to the main island of Porto Rico has been carefully studied, in order to keep the cost at a minimum. The replacement of obsolete and unsatisfactory seismographs at the magnetic observatories is being studied and the installation of a single component of the new type at the Tucson observatory is expected to meet the information that will be needed for this eventual replacement.

Members of the division have taken part in the work of the American Geophysical Union and the International Geodetic and Geophysical Union, and hold positions in these organizations. Contact with the work of other institutions and countries is particularly useful, as all of the work of the division is related to the study of the earth as a whole. Close cooperation has been maintained with the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.

The following publications have been issued during the year:

Magnetic Declination in Arkansas. (This is the first of the publications of magnetic data by States.)

Horizontal Intensity Variometers. (Useful in observatory operation and improvement in observatory instruments.)

Observatory Results for 1919–20 for Porto Rico, Tucson, and Sitka. (Permanent record of changes in the earth's magnetism.)

Instructions for the Compensation of the Magnetic Compass, prepared jointly with the division of hydrography and topography. (Instructions to officers of the survey in the use of the magnetic compass in hydrographic and magnetic work.)

Results of Observations at the Time of the Solar Eclipse on September 10, 1923 (which was published by the Journal of Terrestrial Magnetism and Atmospheric Electricity).

The following publications were in the hands of the printer but not issued at the close of the fiscal year:

Magnetic Surveys. (A pamphlet for distribution to the public to meet demands for information which is now given with some detriment to field and office work.)

Observatory Results for 1921–22 for Honolulu, Cheltenham, and Sitka.

Magnetic Declination in Florida.

Results of Observations made by the Bureau in 1923. (This makes available in convenient form the results of the year's work.)

An intensive campaign by the chief clerk to get in touch with local surveyors was extended to Alabama, Florida, Mississippi, South Carolina, Georgia, and New York. Reports received from North Carolina made the campaign unnecessary. It may therefore be considered that the contact with local users of magnetic data is now on a satisfactory basis in 13 States. The new series of State publication has proved most useful in furnishing information in a satisfactory form and in reducing the amount that has to be furnished by letter.

PERSONNEL.—The need for an additional mathematician, two computers, and an additional clerk in this division is extremely urgent. The strong demand for its results has been indicated. It has only been possible to meet this demand by the temporary assignment of two computers normally assigned to another division. It is no longer possible to spare computers from that work, and unless relief is offered very soon the office work will begin to fall in arrears and the service to the public will have to be curtailed.

DIVISION OF TIDES AND CURRENTS

The work of the division of tides and currents is comprised under the following heads: Tidal observations and computations; current observations and computations; predictions of tides and currents and preparation of annual tables of tide and current predictions; current and tidal surveys of our principal harbors; computation of data and discussion and interpretation of the results of such surveys; physical oceanography; and the preparation of technical publications dealing with tides, currents, and related phenomena.

Tidal observations were made at seven principal stations on the Atlantic coast, four on the Gulf coast, five on the Pacific coast, three in Alaska, and one at Honolulu, Hawaii. The tidal marigrams as they are received at this office have been tabulated as to hourly readings for the definition of all tidal planes. As a by-product of the tidal work at these stations, these tabulations furnish a long period, sea-level datum for the use of engineers locally, and for initial or "tie-in" points for the net of precise levels which is being extended to all parts of the United States. The predictions of the tides for the calendar year 1925 were made during this fiscal year and the manuscript submitted for printing in three separate parts: Tide Tables, Atlantic Coast; Tide Tables, Pacific Coast; Tide Tables, United States and Foreign Ports. These tables have been printed and are ready for the mariner.

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

Tide tables for fiscal year—	United States and foreign ports tide tables	Atlantic coast tide tables	Pacific coast tide tables	Total
1915	2,425	2,050	10,775	15,250
1916	741	2,545	10,227	13,513
1917	1,508	3,852	13,246	18,606
1918	3,334	3,970	14,492	21,796
1919	4,217	4,398	14,768	23,383
1920	3,469	5,357	16,061	24,887
1921	3,577	5,678	14,957	24,212
1922	3,067	5,704	14,802	23,673
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 issued annually 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 by the Coast and Geodetic Survey.

Observations of currents were made at two light vessels on the Atlantic coast and one on the Pacific coast. Analysis of these observations have been made with regard to the relation between wind and current in order to correlate wind and current for the formulation of general rules on coastal currents for the aid of the mariner. The first results of this current work appeared as a separate current table for the calendar year 1923. These tables are being enlarged in scope and size from year to year. For the calendar year 1924 the current tables for the Atlantic and Pacific coasts included full predictions of slack water for every day in the year at 18 principal stations and data for 1,020 secondary stations, from which the times of slack water for these secondary places may be obtained by reference to the prediction of the currents for the principal stations. The predictions of the currents for the calendar year 1925 were made during this fiscal year and have been printed, ready for the mariner, in two separate parts—Current Tables Atlantic Coast, and Current Tables Pacific Coast.

The following table shows the number of copies of the current tables issued for the fiscal year 1923:

Current tables for fiscal year—	Atlantic coast current tables	Pacific coast current tables	Total
1923 [1]	2,029	1,786	3,815

[1] Prior to 1923, information on currents was contained in the three above-mentioned tide-table publications.

The manuscript of A Manual of the Harmonic Analysis and Prediction of Tides was completed and printed. This work is intended as a manual of instructions for the tidal mathematician and comprises 422 octavo pages of text, tables, and harmonic constants for the world, with 34 illustrations.

The manuscript of a publication on the currents and tides of New York Harbor was prepared during the fiscal year and submitted to the printer. It will comprise about 150 octavo pages, and constitutes the discussion and interpretation of the results from the recent current and tidal survey of New York Harbor, correlated with scattered observations made at various times in the past.

The sounding records as received from the hydrographic parties in the field have been checked promptly for tidal planes so that no delay has been occasioned the chart division in the publication of charts. .

The manuscript of a publication on tidal bench marks in the District of Columbia has been prepared during the fiscal year, and

it is expected it will be ready for printing about the middle of the next fiscal year.

In compliance with a program outlined in my annual report for 1923, an investigation was made during this year in connection with devising a large tide gauge for our principal tide stations, somewhat along the lines of the portable automatic tide gauge recently developed by this bureau for field parties, looking toward a more efficient gauge than the present large one, both from the standpoint of more accurate records and economy in tabulating the records. Upon investigation, it was found that a gauge had been developed recently for the Geological Survey by Carl H. Au, of Washington, D. C., somewhat along the lines of the gauge proposed for development by this bureau. One of this type gauge was purchased for testing as to its fitness for the purposes of this survey. It is planned to install the gauge at Washington soon after the beginning of the next fiscal year.

The observations obtained from the current and tide survey of San Francisco Harbor have been partly analyzed during this fiscal year as they came from the field. These analyses will be completed during the next fiscal year, the results discussed and interpreted, and the manuscript of a publication prepared similar to the one sent to press for the port of New York. In addition, the improvement to our present current predictions made possible by this survey are being incorporated in the present current tables for the use of the mariner.

During this fiscal year, in addition to the duties of his own division, the chief of the division of tides and currents has devised a new type of pressure-sounding tube and a graph for temperature and barometer corrections to soundings made with pressure tubes. This sounding tube has been tested, and the indications are that the necessary accuracy for surveying purposes has been obtained when the tube is used in connection with the correction graph for barometer and temperature conditions of the field. This tube will, if finally adopted, make for considerable accuracy on surveys in depths from 15 to 100 fathoms, since heretofore all tests have proven existing pressure-sounding tubes unsatisfactory and not of the desired accuracy for hydrographic surveys.

DIVISION OF ACCOUNTS

From July 1, 1923, to June 30, 1924, the actual disbursements on account of appropriations for the Coast and Geodetic Survey amounted to $2,128,984.97. It must be understood, however, that this does not represent the actual expenses of the survey for the fiscal year 1924, 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 divi-

sion, and accounts arising under such advances were submitted to and through this division to the Treasury Department.

The total appropriations for the fiscal year 1924 were $2,186,275.

INSTRUMENT DIVISION

The instrument division is charged with the duty of providing the instrumental equipment used by the survey which involves the acquirement of standard instruments and preparation of drawings and specifications for those of special design; repair and adjustment of instruments returned after use in the field; and issue and maintenance of a property record system. In addition this division designs new instruments and apparatus to meet the survey's unusual needs and makes any improvements in existing types which experience indicates advisable.

Efforts are constantly being made to improve the instrumental equipment in accuracy, portability, ruggedness, etc.; to make use of improved materials and methods of construction; and to reduce the cost.

During the past year several new instruments were developed, including a triangulation signal lamp for use in mountainous regions, which is smaller and lighter than those used heretofore; an automatic time switch for the above lamp which permits the lamp to burn for a given number of hours each night for a period of a week without attention.

Experiments were made in connection with the radio acoustic work and a simple and inexpensive bomb was perfected, using an explosive charge of trinitrotoluol.

Improvements were made in the designs of the Coast Survey model portable automatic tide gauge which resulted in practically total elimination of loss of records due to failure of the instrument and increased its sensitivity to the rise and fall of the tide.

This division cooperated with the division of tides and currents in development of the Rude-Fischer sounding tube and with the other divisions by analyzing and working out suggestions they have made for improvements.

NEW CHARTS ISSUED DURING THE YEAR

285. Kill Van Kull and northern part of Arthur Kill, N. Y. and N. J. February, 1924. Scale, 1:15,000; dimensions, 32 by 37 inches. This chart is published to meet the demand for larger scale charts of Arthur Kill and Newark Bay. It covers Arthur Kill north of Carteret, where it joins its companion chart No. 286, Kill Van Kull and Newark Bay, northward to a junction with chart No. 287. It is constructed on the Mercator propection and the soundings are in feet at mean low water. This chart supersedes No. 544 of Kill Van Kull.

286. Raritan Bay and southern part of Arthur Kill, N. Y. and N. J. January, 1924. Scale, 1:15,000; dimensions, 29 by 44 inches. This chart is published to meet the demand for large scale charts of Arthur Kill. It covers Raritan Bay and Arthur Kill north of Carteret where it joins its companion chart No. 285. The sounding are in feet at mean low water and it is constructed on the Mercator projection.

1253. East Cape to Mormon Key, Fla. March, 1924. Scale, 1:80,000; dimensions, 33 by 42 inches. This is one of the new series of coast charts on a scale of 1:80,000 and is based on the Mercator projection. The soundings are expressed in feet at mean low water. This chart supersedes No. 172 of the old series.

1254. Chatham River to Clam Pass, Fla. April, 1924. Scale, 1:80,000; dimensions, 32 by 42 inches. This chart is one of the new series of coast charts on a scale of 1:80,000 and is based on the Mercator projection. The soundings are expressed in feet at mean low water. This chart supersedes No. 173 of the old series.

1270. Chandeleur and Breton Sounds, La. February, 1924. Scale, 1:80,000; dimensions, 32 by 43 inches. This is one of the new series of charts on a scale of 1:80,000 and will supersede No. 192. It is constructed on the Mercator projection and the soundings are expressed in feet at mean low water. The area west of and including the Chandeleur Islands and most of Chandeleur and Breton Sounds are from recent surveys. The portion of the Mississippi Delta covered and adjacent waters are from old surveys.

INSIDE-ROUTE CHARTS, NORFOLK TO KEY WEST (SCALE, 1:80,000)

3252. Norfolk, Va., to Gull Shoal, N. C.
3253. Gull Shoal to Topsail Sound, N. C.
3254. Topsail Sound, N. C., to Midway Inlet, S. C.
3255. Midway Inlet to Charleston Harbor, S. C.
3256. Charleston Harbor, S. C., to Sapelo Sound, Ga.
3257. Sapelo Sound, Ga., to St. Augustine, Fla.
3258. St. Augustine to Titusville, Fla.
3259. Titusville to Jupiter Inlet, Fla.
3260. Jupiter Sound to Barnes Sound, Fla.
3261. Barnes Sound to Key West, Fla.

This new seriese of charts (Nos. 3252 to 3261, inclusive) is designed to meet the needs of yachtsmen, motor boatmen, and others navigating the inside waters between Norfolk, Va., and Key West, Fla. The route between these two ports is indicated by a red line. The charts show all lights and buoys corrected to date of issue and, when the scale permits, the principal beacons established by the Bureau of Lighthouses. They are published on bond paper, 24 by 38 inches, thin enough for folding, and the route, charted in strips of convenient widths, with three strips to each sheet. Each chart can be used as a whole, or the strips cut out and used in the same manner as automobile road maps.

4111. Nawiliwili Bay, Kauai, Hawaii. June, 1923. Scale, 1:5,000; dimensions, 16 by 25 inches. This chart shows the results of surveys made by the United States Engineers in 1911 and 1921. The soundings are charted in feet.

4275. Polillo Islands, east coast of Luzon, P. I. March, 1924. Scale, 1:80,000; dimensions, 32 by 42 inches. This chart shows complete information for harbor purposes and close-in navigation from surveys to 1921. The chart includes several anchorages which afford excellent protection to vessels during typhoon weather.

4356. Cagayan Islands, Sulu Sea, P. I. July, 1923. Scale, 1:60,000. Plan—Cagayan Anchorage, scale 1:10,000, dimensions 33 by 39 inches.

4605. Zamboanga Peninsula, Mindanao, P. I. August, 1923. Scale, 1:200,000; dimensions, 34 by 41 inches. This new chart shows results of surveys to 1922 published on a scale convenient for the use of the navigator. The information along the west coast of Zamboanga has previously been published only on the smaller scale charts.

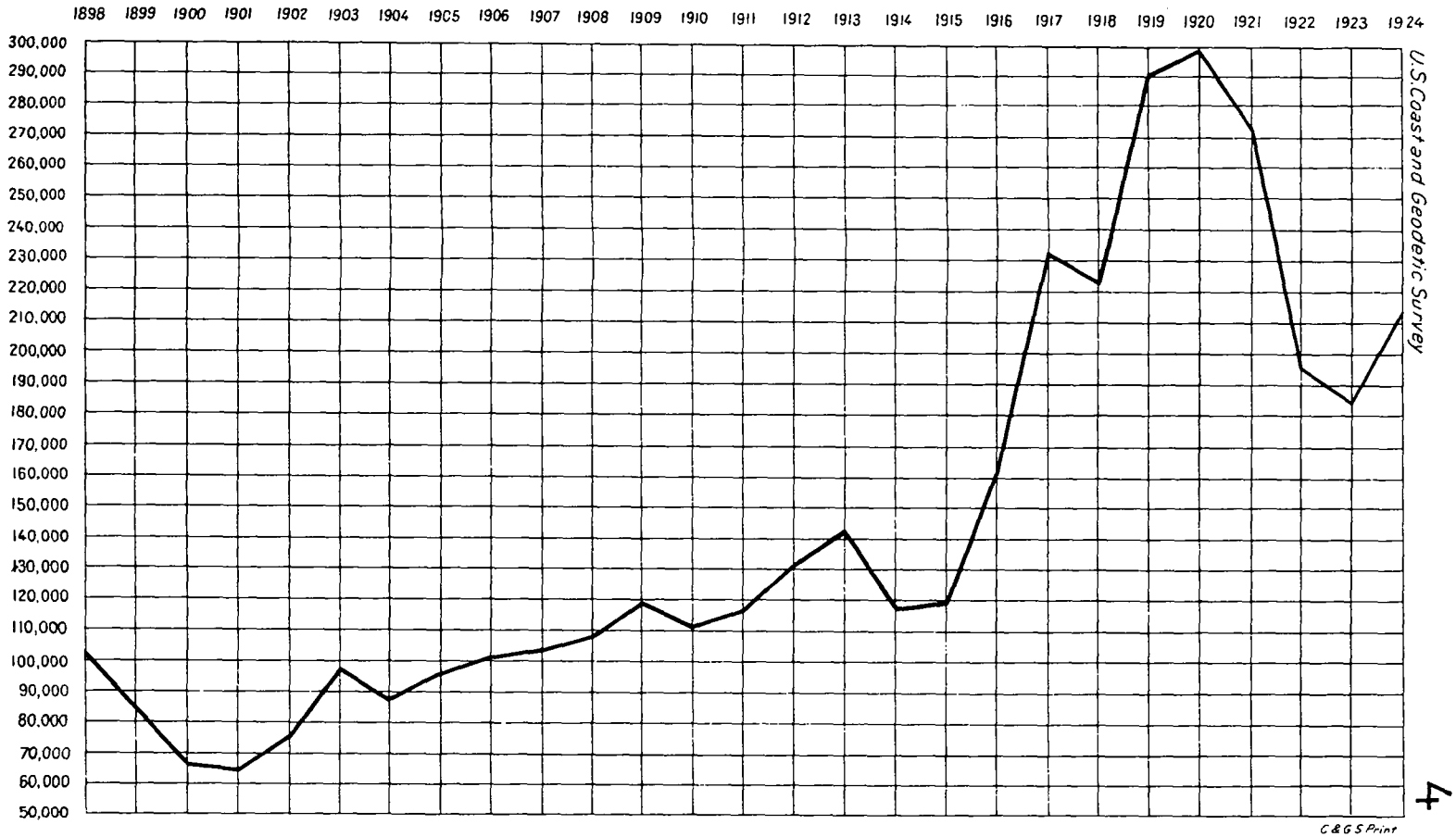
5001. Lake Tahoe, Calif. and Nev. July, 1923. Scale, 1:40,000; dimensions, 28 by 43 inches. This chart is issued to fill a demand for a navigational chart of the lake by Government organizations and others. The soundings are charted in feet and give the depths below the lowest lake level.

8147. Northern end of Cordova Bay and Hetta Inlet, Alaska. May, 1924. Scale, 1:40,000; dimensions, 33 by 41 inches. This is one of the series of 1:40,000 scale charts designed to cover the waters of the west coast of Prince of Wales Island and the islands and passages to the westward. It is constructed on the Mercator projection and the soundings are expressed in feet at mean lower low water.

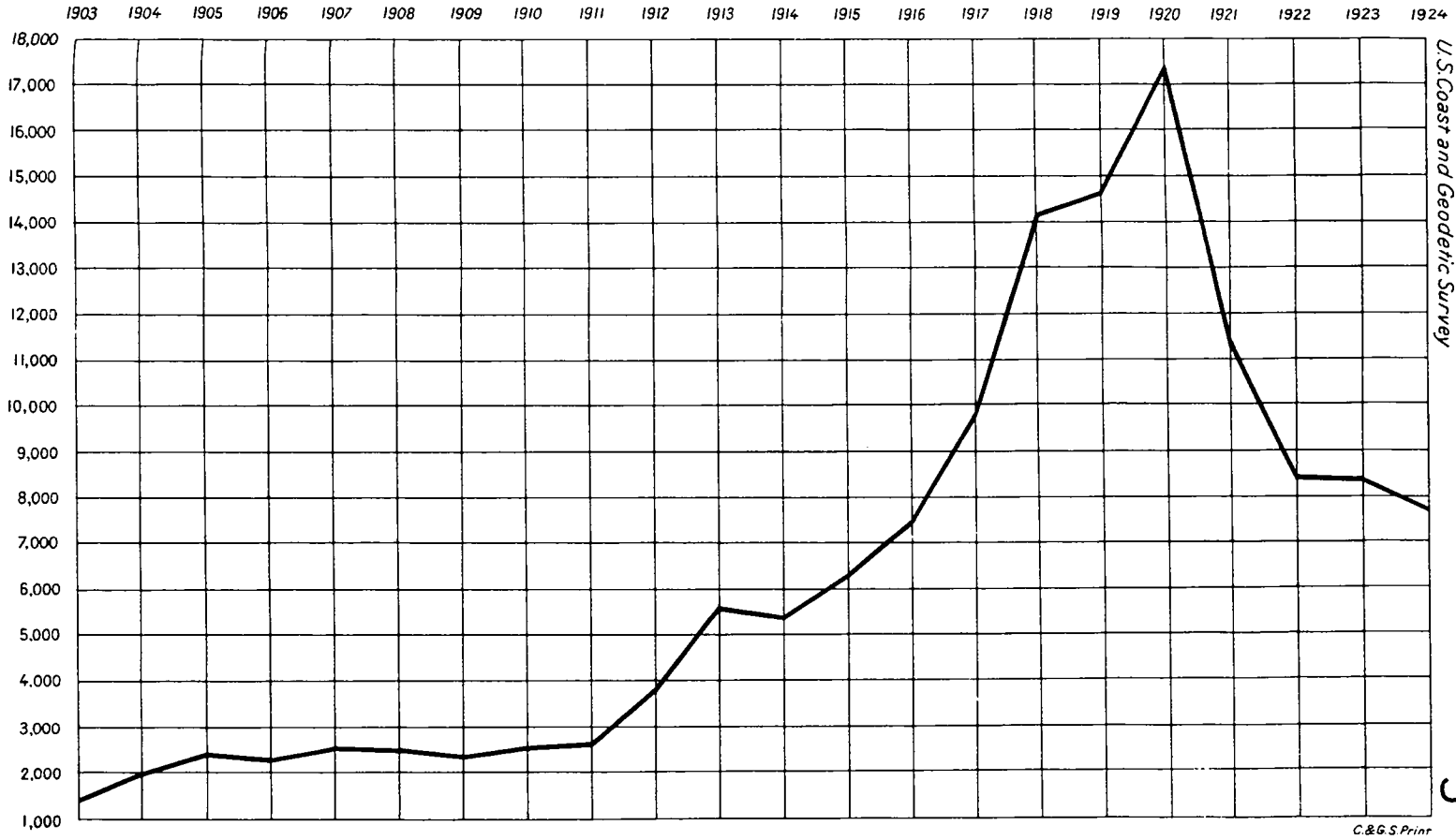
8158. Baker, Noyes, and Lulu Islands and adjacent waters, southeast Alaska. December, 1923. Scale, 1:40,000; dimensions, 32 by 43 inches. This is an addition to the series of 1:40,000 scale charts along the western coast of Prince of Wales Island. It extends westward from the western limits of

charts Nos. 8151 and 8155 and joins chart No. 8157 on the north. It is constructed on the Mercator projection and the soundings are in fathoms at mean lower low water. It gives the results of surveys made in 1915, 1921, and 1922.

8666. Portage and Wide Bays, Alaska. May, 1924. Scale, 1:50,000; dimensions, 30 by 34 inches. This chart is issued to meet the demand for a larger scale chart of the area covered. Portage and Wide Bays are on the southeast coats of Alaska Peninsula about 45 miles west of Kodiak Island and have attained commercial importance on account of the discovery of oil fields in their vicinity. The surveys from which the chart was made covered the bays and the channels leading to the bays. The waters covered outside the bays are as yet unsurveyed.



ISSUE OF CHARTS FROM 1898 TO 1924



ANNUAL DISTRIBUTION OF COAST PILOTS AND INSIDE ROUTE PILOTS

CHAPTER II

PROGRAM FOR THE CURRENT FISCAL YEAR IN THE WASHINGTON OFFICE

CHIEF CLERK

The program for this division will be, in addition to the routine duties of the division, the continuation of the renovation of the buildings occupied by the bureau, and the installation of fixtures and equipment that result in better sanitation, economy in operation, and increased production.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY

The program for this division for 1925 includes—

(*a*) Preparation of instructions for field work.

(*b*) Preparation of plans and specifications for new field equipment and for repairs of vessels and equipment.

(*c*) A plan of operation for the completion of the original survey of the Philippine Islands. This necessitates a thorough inspection of some of the unsurveyed and most difficult to survey areas, which inspection could not be made last year. Following such inspection, which has been planned for the spring of 1925, a definite program will be drafted for the completion of the present survey of the archipelago.

(*d*) Continued study of cost analysis of field work and an attempt to draw conclusions from the relative unit costs of work in different localities and by different parties.

(*e*) Preparation of service manuals of field work.

(*f*) Publication of a new edition each of coast pilots: Alaska, Part I, California, Oregon, and Washington, and Section E, Gulf Coast, field work having been accomplished already for Alaska, Part I, but not for the other two sections. Publication, after field revision, of a new edition each of inside route pilots: New York to Key West and Key West to New Orleans, the latter to include the entire navigable inside waters of the Gulf coast under a suitable modified title. Compilation and publication of supplements for all coast pilots, the editions of which will be a year or more old.

DIVISION OF GEODESY

The program of office computations for the division of geodesy for 1925 by project is as follows:

(*a*) TRIANGULATION AND TRAVERSE.—Mitchell to Chamberlain, S. Dak.; Green Bay, Wis., to Duluth, Minn.; Mansfield to Naples, La.; in Maryland; in Alaska; readjustment of triangulation west of ninety-eighth meridian.

(*b*) LEVELS.—In New Jersey and other precise leveling for which the field work is done during the year.

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

(*d*) GRAVITY.—Investigation of gravity in relation to density in Hawaiian Islands, completion of the computations and reductions for stations established in 1923, and computations of gravity observations on Mount Wilson made in connection with Prof. A. A. Michelson's redetermination of the velocity of light.

(*e*) PUBLICATIONS.—Triangulation in Maryland; Triangulation, Coast of North Carolina; Precise Leveling in Oregon; Precise Leveling in California; Triangulation Manual; Precise Leveling Manual; Precise Triangulation in Southwestern Part of United States.

DIVISION OF CHARTS

The division of charts, in its task of constructing new charts or reconstructing existing charts basing them on modern field surveys, is now so nearly caught up with the field work of the survey that the division can not lay out in advance a program of work of this character based on recently completed field work which will be adequate to tax its capacity for the coming year; nor can it anticipate the receipt of records of field work now in progress with sufficient certainty as to date of receipt and condition of records to justify a general inclusion of such field work in the program for the year.

A program of chart production calling for the completion of 16 charts has therefore been adopted tentatively. In addition, as much time as possible will be devoted to the following two items.

REPRODUCTION OF WORN-OUT ORIGINAL SHEETS.—As the result of age and frequent use, a considerable number of our early original sheets have reached a condition where their early redrawing becomes imperative if the records are to be preserved. As these records are invaluable and can not be duplicated, this task is one which should not be delayed any longer. It is hoped to make material progress with this task during the year.

CHARTING OF WIRE-DRAGGED AREAS.—During the year it is expected to complete the application to Alaska charts of the overprint showing areas which have been swept by the wire drag. Further study will also be given this subject with a view to extending the work to include areas on the Atlantic coast where the shallowness of the water and the consequent complication of the field records makes the task a much more difficult one.

DIVISION OF TERRESTRIAL MAGNETISM

The program for 1925 is as follows:

Complete the observatory publications of Tucson and Porto Rico for the printer.

Complete the publication for Missouri.

Prepare the State publications for North Carolina, California, and Texas.

Prepare for publication magnetic results obtained during 1924.

Prepare a new publication to replace Principal Facts of the Earth's Magnetism.

Furnish information to local surveyors and those persons or institutions investigating difficulties in radio, telegraph, and cable communication.

Furnish magnetic information for charts.

Direct and make plans for the transfer of the magnetic observatory at Vieques Island to the main island of Porto Rico.

Study the seismograph results from Tucson to determine whether an instrument of low cost is now available for replacing the obsolete instruments.

Begin the discussion of observatory results as a whole in cooperation with other organizations in an effort to solve some of the mysteries of the earth's magnetism.

Continue work on the preparation of observatory results for 1923–24, in so far as the limited personnel permits. This important part of the work will suffer seriously if additional personnel is not provided.

DIVISION OF TIDES AND CURRENTS

The program for the division of tides and currents for the fiscal year ending June 30, 1925, is as follows:

The predictions for the tide tables for the calendar year 1926 will be completed, the manuscript scanned to prevent errors creeping in, and submitted to the printer in time for issuance before July 1, 1925.

The predictions for the current tables for the calendar year 1926 will be made and the manuscript submitted to the printer.

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

The bench-mark records received from the field 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 currents and tides of San Francisco Bay and tributaries will be completed and sent to press toward the end of the fiscal year. This publication will include the results and the discussion and interpretation of the current and tide survey made in that harbor during this fiscal year, correlated with all observations made at various times in the past.

The manuscript of a publication on tidal bench marks in the District of Columbia will be completed and sent to press about the middle of the fiscal year.

As the depleted force of mathematicians becomes filled by reason of increased compensation due to the classification act, the study of mean sea level, an important matter, will be taken up and the manuscript of a publication prepared when results warrant.

A study of the efficiency of present methods of tabulating tidal records will be continued, looking toward a saving of time of mathematicians engaged on this work. An investigation will also be made as to the practicability of utilizing mechanical analyzers for the harmonic analysis of tidal curves.

At present, in the prediction of tides with the tide-predicting machine, the machine automatically locks when each high and each low water is indicated until the observer has recorded the prediction. The observer then unlocks the machine by a slight pressure on the

handle, which he turns until the next high or low water is indicated. Early in the next fiscal year it is planned, if practicable to do so, to install a light electric motor for the operation of the predicting machine and add an attachment which will print automatically the times and heights of the high and low waters in lieu of the locking of the machine. Should the plan prove feasible, a considerable saving in time will be accomplished and, in addition, an increased accuracy obtained by the elimination of the human-error factor.

The observations obtained on the current and tide survey of Delaware Bay and tributaries will be analyzed as soon as possible upon their receipt from the field, the results discussed and interpreted, and the manuscript on this important piece of work prepared for distribution to engineers and 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.

Heretofore the current tables have given the mariner the times of slack water only and the mean current velocity. Due to the diurnal inequality in the currents on the Pacific coast, it is also of value to the mariner to know the velocity of each flood and ebb current at strength and the time of such maximum strength, since the velocity at strength on one flood or ebb current may differ materially from that of the next. It is planned, therefore, during the next fiscal year to prepare constants for the tide-predicting machine from such data as may be available and include in the Current Tables, Pacific Coast, the additional information relative to the prediction of the time and velocity at strength of each flood and ebb current at the principal current stations for every day in the year.

A publication detailing the methods of determining tidal datum planes will be begun, and it is hoped that it will be possible to complete it during the coming fiscal year. It will be of very considerable assistance to engineers in the establishment of datum planes that can be reestablished in the future, and thus correlate surveys made at various times.

The foregoing constitutes the outstanding features of the program for the next fiscal year in addition to the normal routine work of the division of tides and currents. In general the work 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 the tidal and current tabulations and computations up to date and to issue in the form of publications the large mass of material that has accumulated and which is of considerable value to the navigator, engineer, scientist, and 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 the 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.

INSTRUMENT DIVISION

The program for the fiscal year 1924–25 will be to maintain the existing stock of instruments in readiness for use, making needed repairs, and replenishing depleted stocks; to make improvements in instrumental design and construction, and to design and build such new instruments and machines as may be needed; to construct about 100 new instruments of special types, including sounding clocks, automatic signal lamplighters, heliotropes, etc.; and to complete the machine designed and partially built during the previous year for applying the graduation on geodetic level rods. It is estimated that this machine, in addition to doing more accurate work than has been possible heretofore, will reduce the time for finishing a rod by 75 per cent.

PART III.—IN THE FIELD

CHAPTER I

ACCOMPLISHMENTS IN THE FIELD DURING THE FISCAL YEAR

HYDROGRAPHIC WORK

The fiscal year 1924 has been an exceptionally successful one in regard to the amount of hydrographic surveys accomplished. One of the most important advancements made in hydrographic work was the successful use of the sonic depth finder on the steamer *Guide*. During the early part of the fiscal year this vessel was undergoing repairs and testing out an apparatus for the determination of the ship's position by the radio accoustic method. Later the vessel left the east coast under orders to proceed to the coast of southern California via the Panama Canal. En route an extensive program of deep-sea soundings was carried out. On this trip the sonic depth finder was used with success in varying depths of water from 100 to 4,600 fathoms. The sonic soundings were supplemented by wire measurements, in which the serial temperatures of the water and samples of same were obtained, as well as samples of the bottom. From the results of this cruise an extensive study has been made of the velocity of sound in water under varying conditions of density, salinity, etc., which knowledge is essential for the successful use of the sonic depth finder in hydrographic surveying. The results obtained were exceptionally satisfactory, and a detailed study of them has been made. The instructions under which the oceanographic work was carried on by the party on the steamer *Guide* called for soundings in the deep north of Porto Rico, and all soundings were so arranged as to supplement the soundings taken previously by Coast Survey vessels along the sailing route from the east to the west coast via the Panama Canal.

On the Atlantic coast a party on one of our vessels has been employed in surveys off the coast of North Carolina during the summer months and the east coast of Florida in the winter. The survey of the approach to Sabine Pass, Gulf of Mexico, has been completed by two surveying vessels. The wire-drag work of Vieques Sound, P. R., was completed early in the fiscal year, and the hydrographic surveys, including wire-drag work, of the Virgin Islands were approximately 85 per cent completed. It was possible to continue the important work of wire dragging along the New England coast during the summer of 1923. Unfortunately it was not practicable to organize a wire-drag party for this work during May, 1924, as previously planned, as such a party could not operate after July 1, owing to insufficient funds appropriated for the fiscal year 1925. The triangulation of Lake Okeechobee, Fla., was executed during the

year. This will furnish control for making a detailed topographic and hydrographic survey of this important inside waterway. Detached launch parties were engaged in resurvey work in important areas such as Baltimore, Md., Cape Fear River, Hawaiian Islands, and Portsmouth, N. H.

Owing to the lack of adequate equipment and appropriations it has been impossible to accomplish much of the extremely important work along the Pacific coast. The arrival of the *Guide* marks a new epoch in the surveys of this important area. Upon her arrival at San Diego the party undertook work along the southern California coast during the winter months. This work marked the first successful use of the radio accoustic method of determination of the ship's position in actual hydrographic work. Owing to the prevalence of foggy weather along the Pacific coast the progress of the hydrographic parties in the past has been slow, as clear weather is necessary to accurately locate the position of soundings. The successful use of the accoustic method of the determination of the ship's position has made it possible to carry on hydrographic work in foggy and misty weather, which is so prevalent in this area. During the latter part of the fiscal year the party was also engaged in the execution of important surveys in the vicinity of Cape Blanco, an area in which few soundings have heretofore been made, and extremely important as one of the turning points on the main steamship route along the Pacific coast of the United States.

In Alaska four vessels have been operating during the fiscal year during all months when it was possible economically to accomplish survey work. The most important work in Alaska—namely, the wire dragging of the inside passage from the boundary line north to Cape Spencer, via Wrangell Strait—was completed during the fiscal year, and the vessel engaged in drag operations in the important bays and harbors along the main steamship route. This work included the completion of wire-drag work of Twelve Mile Arm and Kasaan Bay, which work contributed in no little degree to the successful laying of the Alaska cable. One of the surveying vessels accomplished a great deal of work in extending the surveys northward along the outside coast. At the end of the fiscal year this work was completed to a point about 30 miles north of Cape Ommaney. With the addition of the two mine sweepers it has been possible to undertake the much needed surveys in western Alaska. One of these vessels completed the survey of Kachemak Bay and bays in the vicinity of the oil fields in Shelikof Straits. The other completed surveys of bays along the Alaskan Peninsula, the survey of which is important, as the work previously shown on the chart is based on rough sketches and from the copy of the old Russian charts of this area.

In the Philippine Islands three vessels have been employed in extending the surveys of these waters. Two of these were executing work in the Sulu Sea, while one was engaged during part of the year on the south coast of Mindanao and later in the execution of surveys on the north coast of Luzon.

Detached Parties.—A wire-drag party was engaged in drag operations off the coast of Maine, south of Portland, from the first

of the fiscal year until October 29, when the season's work was completed and the launches laid up for the winter, the party returning to this office on November 2 to complete the field records.

The launch *Mikawe* was engaged in inshore hydrographic work in the vicinity of Cape Fear River, N. C., and also a survey of Frying Pan Shoal from the first of the fiscal year to November 15, on which date the work was discontinued and the launch laid up, the party returning to the office at Washington to complete the records of the season's work.

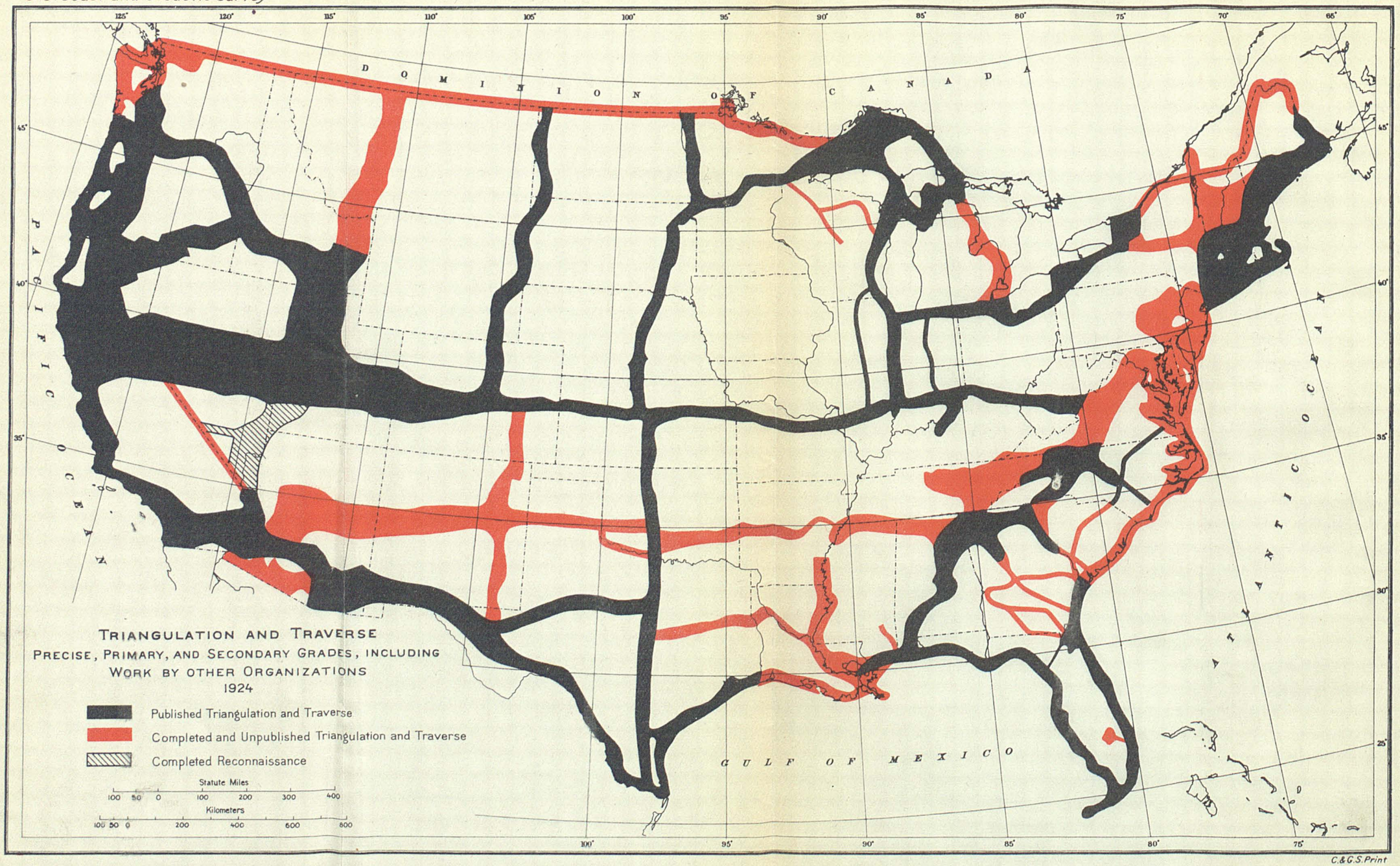
The launch *Elsie* was engaged in the triangulation work necessary for control for a topographic and hydrographic survey of Lake Okeechobee, Fla., from January 14 to March 17. Upon completion of this work the launch was used by the party on the steamer *Bache* in the execution of inshore hydrographic work in the vicinity of St. Augustine, Fla., on which work it was engaged at the close of the fiscal year.

A party was engaged upon a revision survey of Baltimore Harbor from February 6 to the end of the fiscal year. A wire drag examination of the entrance to Portsmouth Harbor was executed by the party in charge from June 7 to 13. A party was engaged in a resurvey of Scitutate Harbor from June 19 to the end of the fiscal year.

In addition to the above, small parties made a search for a rock reported in the harbor at Blaine, Wash., and a topographic revision in the vicinity of Long View, Oreg., and located the new wharves along the water front of Philadelphia, Pa. A party was also engaged in hydrographic and topographic surveys in the Hawaiian Islands from September 25 until the end of the fiscal year. These surveys are important and are being done at the request of other departments of the Government.

SHIP AND LAUNCH HYDROGRAPHY PERFORMED DURING THE FISCAL YEAR

	Area, square miles
Ship hydrography:	
North Carolina, off Cape Fear River	1,153
Florida, east coast	532
Texas, Sabine Pass and approaches	3,816
Virgin Islands and Porto Rico	492.5
California, southern California coast	1,530
Oregon, vicinity of Coos Bay	146
Alaska—	
Port Frederick and Icy Straits	30
Kachemak Bay and Shelikof Straits	177.8
Morzhovoi Bay and vicinity	1,026.2
West coast southeastern Alaska	996
Southeastern Alaska (bays and arms)	25
Philippine Islands	1,828.6
Total	11,753.1
Launch and small-boat hydrography:	
Maine, vicinity of Portland	61.5
Maryland, Baltimore Harbor	12.6
North Carolina, Cape Fear River	124.8
Hawaiian Islands	19
Total	217.9


TRIANGULATION AND TRAVERSE
PRECISE, PRIMARY, AND SECONDARY GRADES, INCLUDING
WORK BY OTHER ORGANIZATIONS
1924
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
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°

	Area, square miles
Wire-drag surveys:	
Maine, south of Portland	106.5
Southeastern Alaska	119
Porto Rico and Virgin Islands	155.1
Total	380.6
Oceanography	6,844

Topography	Shore line	Area	Topography	Shore line	Area
	Miles	*Square miles*		*Miles*	*Square miles*
Maryland, Baltimore	11.5	22	Alaska—Continued.		
North Carolina, Cape Fear	117.55	.17	Morzhovoi Bay and vicinity	144.8	227
Florida, east coast	66.3	8.8	West coast southeastern Alaska	269	130
Texas, Sabine Pass and approaches	45	3	Southeastern Alaska (bays and arms)	97.9	42
Oregon, vicinity Coos Bay	7	3	Hawaiian Islands	27.4	.8
Alaska:			Philippine Islands	301	273.4
Port Frederick and Icy Straits	90	35	Total	1,324.25	912.17
Kachemak Bay and Shelikof Straits	146.6	167			

GEODETIC WORK

	Length of scheme	Area covered
	Miles	*Square miles*
Triangulation, precise:		
Montana, one hundred and eleventh meridian and forty-ninth parallel	385	13,300
Texas and Oklahoma, Texas-Oklahoma boundary	65	500
Arizona, Maricopa-Yavapai boundary	105	2,400
California, earthquake investigations	330	9,240
Alaska, Cook Inlet-Fairbanks arc	40	330
Total	925	25,770
Triangulation, primary:		
Texas and Oklahoma, Texas-Oklahoma boundary	15	175
Arizona, Maricopa-Yavapai boundary	105	640
South Carolina, Charleston to Santee River	45	135
Total	165	950
Triangulation, secondary:		
Maine, Saco Bay	5	10
Massachusetts, Scituate Harbor	5	10
North Carolina, Cape Fear River	5	10
Florida, Lake Okeechobee	75	340
Louisiana, Calcasieu Pass	15	100
Texas, Sabine Pass to High Island	30	150
Oregon, Cape Blanco southward	70	350
Oregon and Washington, Columbia River	5	5
Washington, Tacoma to Olympia	40	80
Washington, Possession Sound to Skagit Bay	70	350
Alaska, Wide Bay	15	60

	Length of scheme	Area covered
	Miles	*Square miles*
Triangulation, secondary—Con.		
Alaska, Morzhovoi Bay	15	75
Alaska, Cold Bay and Lenard Harbor	30	130
Alaska, Kings Cove to Sannak Island	35	350
Alaska, Isanotski Strait	10	30
Alaska, Chatham Strait and Baranof Island	40	600
Alaska, west coast of Baranof Island	35	225
Alaska, Thomas Bay	10	30
Alaska, Gambier Bay	15	30
Alaska, Kasaan Bay	35	85
Alaska, Cold Bay	10	25
Total	570	3,045
Traverse, precise:		
Minnesota and Canada, Warroad to Fort Frances	96	.....
Minnesota and Canada, Fort Frances to Namakan Lake	50	.....
Total	146	.....
Traverse, primary:		
Florida, Palm Beach to Lake Okeechobee	61	.....
South Carolina, Charleston to Beaufort	60	.....
South Carolina, Myrtle Beach to Winyah Bay	25	.....
Total	146	.....
Traverse, secondary: Louisiana, Sabine Pass to Calcasieu Pass	17	.....
Base lines, precise:		
Alberta, Canada, boundary base	8.5	.....

GEODETIC WORK—continued

	Length of scheme	Area covered
	Miles	*Square miles*
Base lines, precise—Continued.		
Minnesota, Namakan Lake base	4.7	
Washington, Alki base (remeasurement)	2.0	
Alaska, Luck Point base	4.0	
Total	19.2	
Base lines, primary:		
South Carolina, Charleston base	1.1	
South Carolina, North Island base	2.8	
Total	3.9	
Base lines, secondary:		
Washington, Fox base	0.6	
Washington, McNeill Island base	0.7	
Washington, Itsami base	1.1	
Washington, Olympia base	1.2	
Alaska, Wide Bay base	3.0	
Total	6.6	
Reconnaissance:		
Montana, forty-ninth parallel	225	5,100
South Dakota, ninety-eighth meridian to one hundred and fourth meridian	275	2,300
Total	500	7,400
Precise leveling lines:		
Double lines—		
Hartford, Conn., to Auburn, R. I	13	
Fairbanks to Valdez, Alaska	195	
Livingston, Mont., to Mammoth Hot Springs, Wyo	35	
Westerly, R. I., to Boston, Mass	85	
Portland, Me., to Boston, Mass	163	
Precise leveling lines—Continued.		
Double lines—Continued.		
Poughkeepsie to Dover Plains, N. Y	25	
Willow Creek to Chitina, Alaska	39	
Seward to Anchorage, Alaska	114	
Los Angeles to San Gabriel, Calif	12	
Madison Junction, Wyo., to West Yellowstone, Mont	14	
West Yellowstone, Mont., to Idaho Falls, Idaho	106	
Total	801	
Single lines—		
In Yellowstone National Park, Wyo., and vicinity	250	
Revision work—		
Weed, Calif. to Siskiyou, Oreg	64	
Roseburg to Portland, Oreg	200	
Knappa to Fort Stevens, Oreg	24	
Portland, Oreg., to Centralia, Wash	95	
Townsend, British Columbia, to Seattle, Wash	127	
Total	510	
Total, all classes of leveling	1,561	
SUMMARY		
Precise triangulation	925	25,770
Primary triangulation	165	950
Secondary triangulation	570	3,045
Precise traverse	146	
Primary traverse	146	
Secondary traverse	17	
Precise base lines	19.2	
Primary base lines	3.9	
Secondary base lines	6.6	
Reconnaissance	500	7,400
Precise leveling lines	1,561	

The field projects, either completed or on which progress was made during the year, are as follows:

The triangulation from the vicinity of Pocatello, Idaho, northward to the Canadian boundary, begun in 1922, was completed during the fiscal year.

The triangulation was run along the forty-ninth parallel about 50 miles east and west of the one hundred and eleventh meridian. This work is part of the cooperative plan between the Coast and Geodetic Survey and the Geodetic Survey of Canada, by which precise triangulation will be extended from the Pacific coast along the international boundary to Lake Superior. A precise base has been measured at Boundary, Mont. Reconnaissance was continued along the forty-ninth parallel from Glacier Park to one hundred and eleventh meridian.

The triangulation begun in the fiscal year 1923 at the request of the commissioners of the Supreme Court for the boundary between Texas and Oklahoma was completed and a copy of the final results sent to the commissioners.

At the close of the fiscal year a reconnaissance was being made for a line of precise traverse which is to run from the ninety-eighth meridian in the vicinity of Mitchell to Chamberlain, S. Dak. Triangulation will be run westward from that point to the one hundred and fourth meridian.

Triangulation was run along the boundary line between the counties of Maricopa and Yavapai, Ariz. This work was requested by the officials of the two counties involved. Numerous disputes had arisen in regard to the boundary, which was originally based on astronomic observations for latitude. The work of the Coast and Geodetic Survey consisted of an arc of precise triangulation along the boundary, with triangulation of a lower grade connecting the precise stations with points on the boundary itself.

Toward the close of the fiscal year a precise triangulation party was being organized to operate along the international boundary between Minnesota and Manitoba. The triangulation started in 1922 in Alaska northward of Cook Inlet was continued toward Fairbanks.

A primary traverse was run from West Palm Beach to Lake Okeechobee, Fla., for the purpose of furnishing starting data for the triangulation of Lake Okeechobee. At the close of the fiscal year a primary traverse which is to run from Beaufort to Charleston, S. C., was in progress. This project also includes triangulation around Charleston and north along the coast to Winyah Bay. A primary traverse line from Myrtle Beach to Winyah Bay was also in progress. It is believed that this work will be completed during the fiscal year 1925.

The triangulation in California begun in the last fiscal year to detect, if possible, movements of the ground which have taken place since the first establishment of the triangulation stations about 30 years ago was continued. The operations were carried on from the vicinity of Mount Hamilton, on which is located Lick Observatory, southward to Santa Barbara Channel. It is expected that a junction will be made in the fiscal year 1925 of the triangulation to the north and that to the south.

A precise traverse was run along the Canadian National Railway from Warroad, Minn., to Fort Frances, Ontario, thence on the ice through Rainy Lake and Namakan Lake. At the eastern end of this line are two quadrilaterals of precise triangulation. This is a part of the cooperative work between the Coast and Geodetic Survey and the Geodetic Survey of Canada.

A party was operating in southeastern Alaska during the latter part of the fiscal year in measuring precise base lines and observing horizontal angles for the purpose of controlling the lengths of the triangulation and to connect the triangulation of southeast Alaska to that to the southward of Dixon Entrance made by the Geodetic Survey of Canada.

The geographic position of the Pacific milestone of the Lee Highway Association at San Diego, Calif., was determined by a short traverse from established triangulation.

Secondary triangulation was executed to furnish points for the control of a hydrographic survey of Lake Okeechobee, Fla. The starting datum was obtained from the line of traverse from West Palm Beach to the eastern shore of the lake.

The precise leveling in Montana begun in 1923 to provide elevations along a number of roads through the Yellowstone Park, Wyo., was completed during the year. This work was done at the request of the United States Geological Survey. Precise leveling was continued in the States of Connecticut, Rhode Island, and Maine, and also in the States of California and Oregon for revision purposes.

The precise leveling line begun in the summer of 1922 along the railroad which runs from Anchorage northward to Fairbanks, Alaska, and along the highway from the latter place southeastward to Valdez, was continued during the fiscal year. This leveling was requested by the United States Geological Survey.

A party determined the value of gravity at nine stations in southeastern Texas. These determinations were requested by the United States Geological Survey and were a continuance of the work started during the previous year.

A combined astronomic and gravity party operated in Alaska. Latitude, longitude, azimuth, and gravity were observed at seven stations. The new Eckhardt-Karcher radio recorder was used successfully in connection with the longitude and gravity work.

A party operating in the State of Washington determined the longitude of Alki Point, a Laplace station of the Puget Sound triangulation.

MAGNETIC WORK

The magnetic work accomplished during the year is as follows:

The magnetic resurvey of North Carolina, made with the cooperation of the Geological and Economic Survey of that State, was about 64 per cent completed at the end of the year.

A good start was made on the magnetic resurvey of Georgia, and observations were made at the county seats of seven new counties where there had been no previous observations; also a resurvey of Texas, particularly in the eastern part. Several stations were occupied in South Carolina.

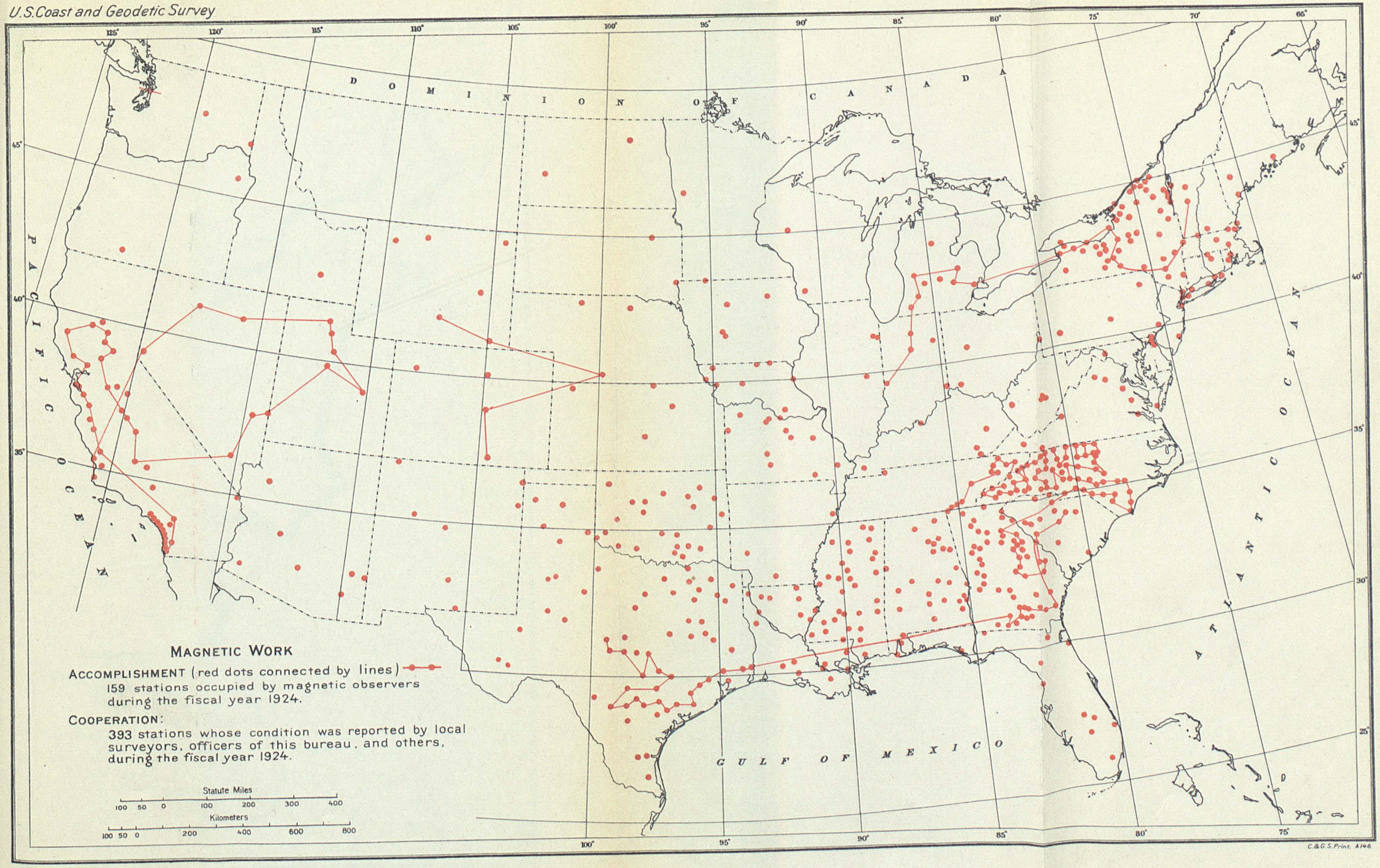
Considerable resurving with replacement of stations was done in California. The special survey to determine the existence of local disturbances was made along the coast from the Mexican border to San Pedro.

Repeat stations were occupied in the northern tier of States from Illinois to Vermont, and also in Nevada, Utah, Colorado, Nebraska, and Wyoming.

Observations were made at Lompoc, Calif., during the total solar eclipse of September 10, 1923, and special observations were made at all of the observatories at that time. Magnetic observations were made by the parties of the various vessels in Alaska.

Routine observations of all the magnetic elements were continued at all of the observatories during the year, as follows:

CHELTENHAM.—A small building for special observations was completed, and experimental work was started which it is hoped will result in future economies in the work. A tornado in June nearly wrecked the variation building, but serious damage to the instruments was escaped. A part of the roof was removed but was quickly replaced. During the year comparison observations were made with the instruments of the department of terrestrial magnetism of the



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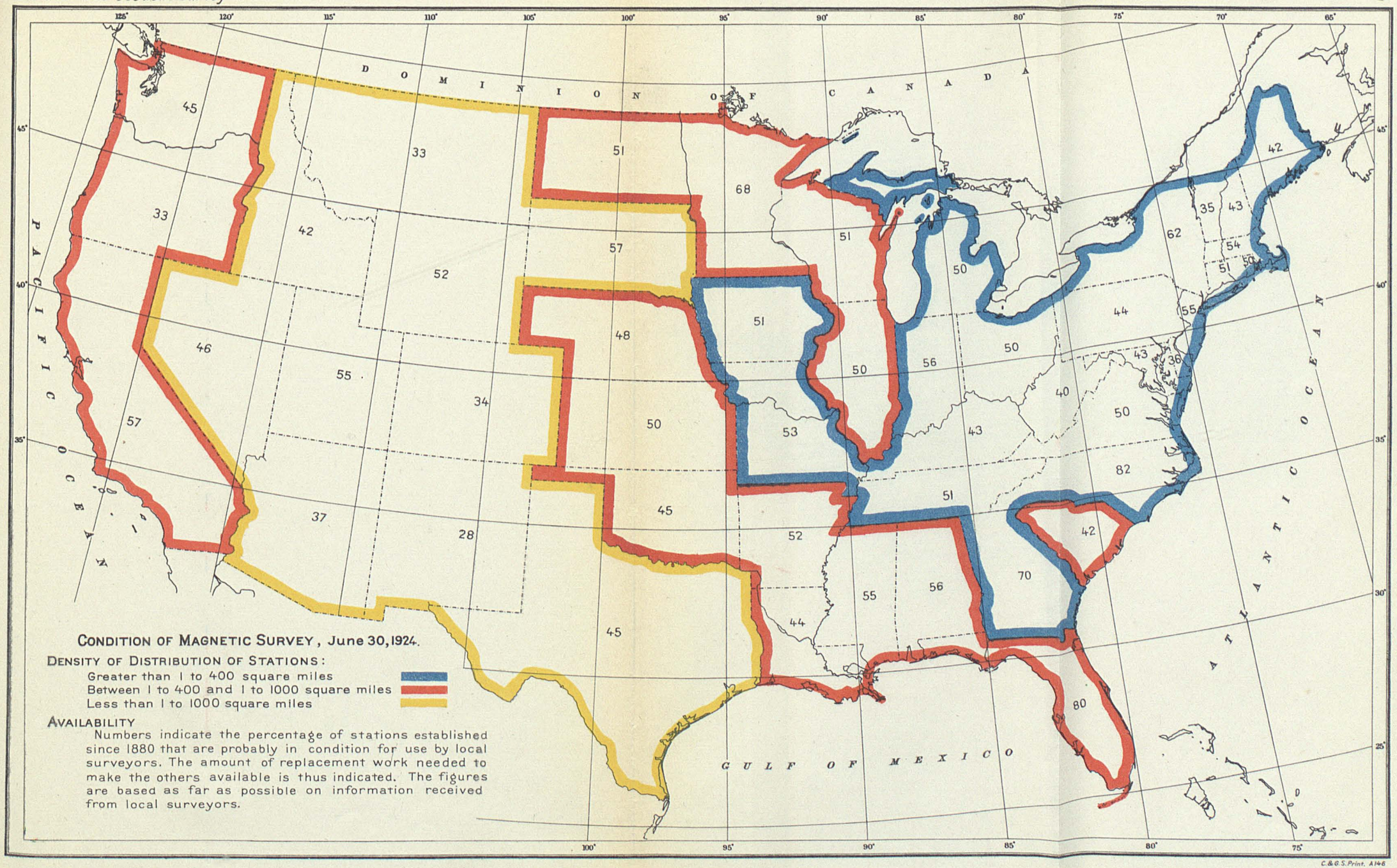

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Carnegie Institution of Washington. These are now of special importance, as the Cheltenham observatory and the standardizing laboratories of the Carnegie Institution at Washington jointly established the standardization for the United States and regions under their jurisdiction.

TUCSON.—The observer's quarters were enlarged and electric lighting was introduced in all of the buildings. An inexpensive new seismograph house was built, advantage being taken of the fact that it could be placed almost entirely under ground without excessive dampness from the desert.

SITKA.—Auroras and their relation to telegraph and cable disturbances was investigated. A new foundation was placed beneath the variation building.

PORTO RICO.—It was definitely determined that the lease of the ground the observatory at Vieques occupied could not be renewed, after June 30, 1925, and the work was carried on with the transfer to the main Island of Porto Rico in view. For this reason maintenance of buildings was kept down to the smallest possible amount.

HONOLULU.—The cause of defects in seismograms was located and removed.

TIDE AND CURRENT WORK

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

1. Portland, Me.
2. Boston, Mass.
3. Atlantic City, N. J.
4. Philadelphia, Pa.
5. Baltimore, Md.
6. Charleston, S. C.
7. Fernandina, Fla.
8. Key West, Fla.
9. Cedar Keys, Fla.
10. Pensacola, Fla.
11. Galveston, Tex.
12. San Diego, Calif.
13. San Francisco, Calif.
14. Seattle, Wash.
15. Anacortes, Wash.
16. Olympia, Wash.
17. Honolulu, Hawaii.
18. Ketchikan, Alaska.
19. Anchorage, Alaska.

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

1. Biddeford Pool, Me.
2. Cape Porpoise, Me.
3. Kittery, Me.
4. Old Orchard, Me.
5. Richmond Island, Me.
6. Barge Office, N. Y.
7. College Point, N. Y.
8. Fort Hamilton, N. Y.
9. Fort Montgomery, N. Y.
10. Fort Schuyler, N. Y.
11. Hell Gate Arch, N. Y.
12. Port Morris, N. Y.
13. Spuyten Duyvil, N. Y.
14. Willis Avenue Bridge, N. Y.
15. New Inlet, N. J.
16. Sandy Hook, N. J.
17. Breakwater Harbor, Del.
18. Bald Head, N. C.
19. Corncake Inlet, N. C.
20. Fort Caswell, N. C.
21. Wrightsville, N. C.
22. Castle Pinckney, S. C.
23. Fort Sumter, S. C.
24. Lighthouse Depot, S. C.
25. Gandy Bridge, Fla.
26. St. Augustine, Fla.
27. Summer Haven, Fla.
28. Sabine Bank Light, La.
29. Sabine Pass Light, La.
30. Sabine Pass, East Jetty, La.
31. Sabine Pass Coast Guard Station, Tex.
32. Culebrita Island, P. R.
33. Ensenada Honda, P. R.
34. Fajardo, P. R.
35. Great Harbor, P. R.
36. Punta Arenas, P. R.
37. Yabucoa, P. R.
38. Balboa, Panama.
39. Cristobal, Panama.
40. Yavisa, Panama.
41. Bay Farm Island, Calif.

42. Dumbarton, Calif.
43. High Street Bridge, Alameda, Calif.
44. Los Angeles Harbor, Calif.
45. Park Street Bridge, Alameda, Calif.
46. Suisun Point, Calif.
47. Blaine, Wash.
48. Duwamish River, Wash.
49. Knox Bay, British Columbia.
50. Quathiaski Cove, British Columbia.
51. Anchorage, Alaska.
52. Auk Bay, Alaska.
53. Bear Cove, Alaska.
54. Deweyville, Alaska.
55. Egg Harbor, Alaska.
56. Excursion Inlet, Alaska.
57. False Pass, Alaska.
58. Halibut Cove, Alaska.
59. Hooniah, Alaska.
60. Kings Cove, Alaska.
61. Lenard Harbor, Alaska.
62. Morzhovi Bay, Alaska.
63. Mud Bay, Alaska.
64. Portage Bay, Alaska.
65. Port Althorp, Alaska.
66. Port Frederick, Alaska.
67. Port Walter, Alaska.
68. Ruth Island, Alaska.
69. Seldovia, Alaska.
70. Shakan, Alaska.
71. Spray Island, Alaska.
72. Swansons Lagoon, Alaska.
73. Tenass Pass, Alaska.
74. Valdez, Alaska.
75. Wide Bay, Alaska.
76. Uyak, Alaska.
77. Halepalaoa, Hawaii.
78. Lahaina, Hawaii.

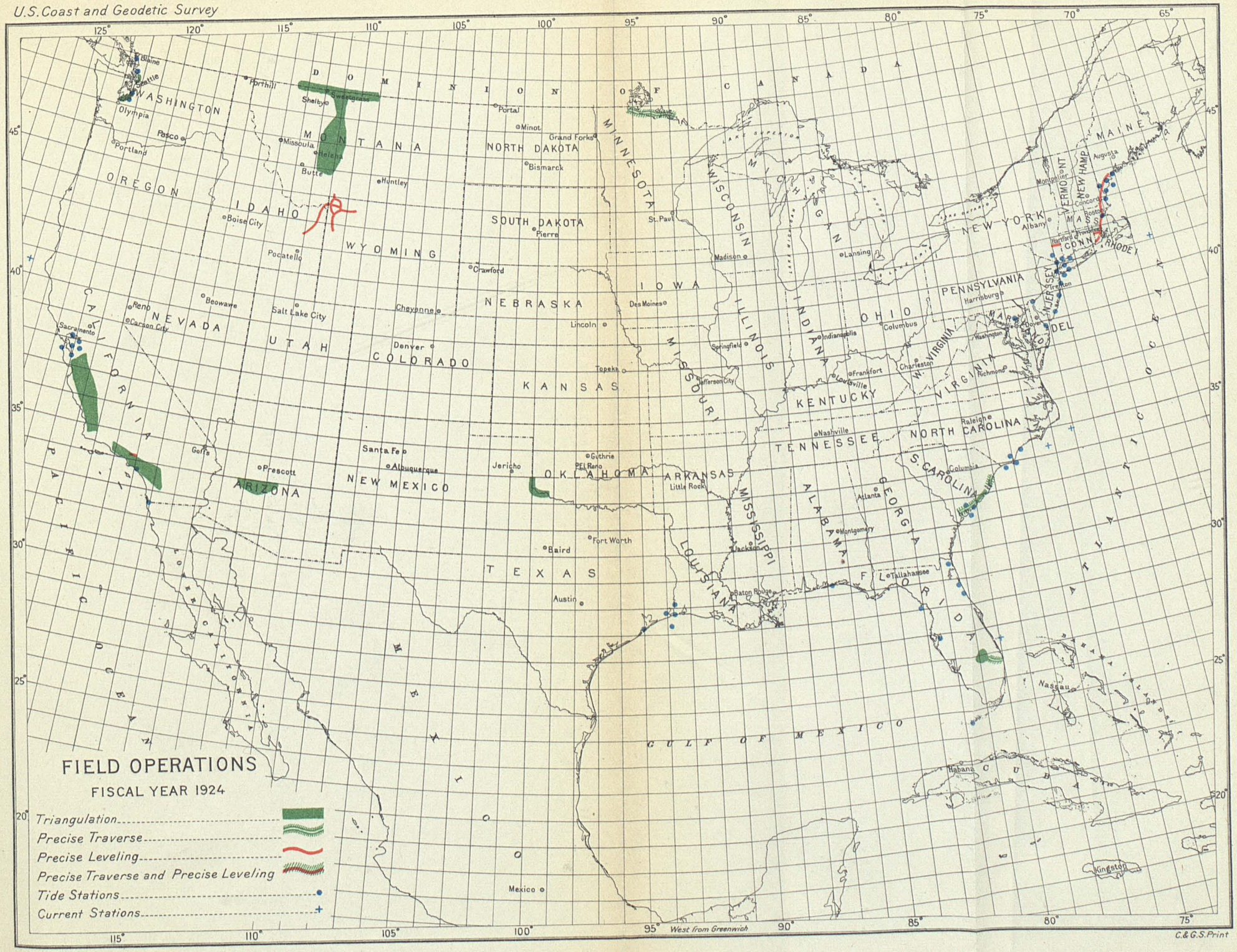
Automatic tide gauges were kept in operation throughout the year at 7 stations on the Atlantic coast, 4 stations on the Gulf coast, 5 stations on the Pacific coast, 1 in Alaska, and 1 in Hawaiian Islands, a total of 18 years of records. In additon, tidal observations in connection with hydrographic surveys were made at 23 stations in the United States, with a combined length of 2 years 4.2 months; 6 stations in Porto Rico, with a combined length of 1 year 8.1 months; 2 stations in Panama, with a combined length of 2 years: 26 stations in Alaska, with a combined length of 4 years 7.1 months; two stations in the Hawaiian Islands, with a combined length of 6.1 months; 19 stations received from outside sources, with a combined length of 18 years 0.9 month; making a grand total for observations at secondary stations of 96 stations, with a combined length of 47 years 2.4 months.

Valdez Tidal Station.—For the purpose of establishing a mean sea level datum plane for the adjustment of the precise level line from Anchorage to Valdez, Alaska, a tidal station was established, under date of September 5, 1923, at Valdez, Alaska, employing for the observations one of the portable type automatic tide gauges recently developed by this bureau. It is planned to maintain this station for a period of three years in order to secure a satisfactory datum plane.

Duwamish River Tidal Station.—On February 9, 1924, a tidal station was established on the Duwamish River, Wash., employing for the observations one of the portable type automatic tide gauges. It is planned to maintain this station for a period of 1 year in order to obtain data on tidal conditions in the Duwamish River.

Los Angeles Tidal Station.—At the request of the harbor board of the city of Los Angeles a portable automatic tide gauge was installed at San Pedro on November 28, 1923. This station will be maintained by the harbor board at no cost to this bureau, although the records are being forwarded for our use in return for the establishment of the gauge.

La Jolla Tidal Station.—In order to obtain the tidal conditions on the open coast similar to those being obtained at the tidal station


FIELD OPERATIONS
FISCAL YEAR 1924
Triangulation
Precise Traverse
Precise Leveling
Precise Traverse and Precise Leveling
Tide Stations
Current Stations
DOMINION OF CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
WYOMING
NEVADA
UTAH
COLORADO
CALIFORNIA
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
NORTH CAROLINA
VIRGINIA
W. VIRGINIA
PENNSYLVANIA
NEW YORK
VERMONT
NEW HAMP.
MAINE
MASS.
CONN.
RHODE I.
NEW JERSEY
DEL.
MARYLAND
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
West from Greenwich
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at Atlantic City, on the Atlantic coast, a contract was let on May 8, 1924, for the establishment of a principal tidal station on the ocean wharf of the Scripps Institute for Biological Research at La Jolla, Calif. The officers of the Scripps Institute have expressed a willingness to cooperate with the Coast and Geodetic Survey in the maintenance of this tidal station, to the mutual advantage of both organizations.

For the purpose of protecting the tidal series and insuring the safety of the tidal observations made along the Atlantic coast a precise leveling party began operations at Cape Charles, Va., on August 4 and continued to September 4, 1923, releveling between existing bench marks at all stations from Cape Charles, Va., to Southport, Conn. New standard disk bench marks were installed where found necessary or advisable.

In order to insure the proper functioning and efficiency of the tidal stations on the Pacific coast an officer of this bureau visited all of the stations along the Pacific coast during the past fiscal year, releveled to all existing bench marks, and where necessary installed standard disk bench marks.

The portable automatic tide gauge recently developed by this bureau, with a view to economy of installation and maintenance for short series of tidal observations, has been established during the past year at Biddeford Pool, Me.; Dumbarton, Suisun Point, and Los Angeles, Calif.; Duwamish River, Wash.; and Valdez, Alaska. The combined length of these observations is about 22 months, and the indications are that the instrument will prove a success for the purpose for which it was intended.

TEMPERATURE AND DENSITY OBSERVATIONS.—Temperature and density observations, frequently requested from this office by prospective builders in connection with cold-storage plants, by fishing concerns, and especially by men engaged in scientific investigation, are being made at Diamond Shoal Light Vessel, Nantucket Shoals Light Vessel, and at the following principal tidal stations:

1. Portland, Me.
2. Boston, Mass.
3. Atlantic City, N. J.
4. Philadelphia, Pa.
5. Baltimore, Md.
6. Charleston, S. C.
7. Cedar Keys, Fla.
8. Pensacola, Fla.
9. Galveston, Tex.
10. San Diego, Calif.
11. Los Angeles, Calif.
12. San Francisco, Calif.
13. Seattle, Wash.
14. Anacortes, Wash.
15. Olympia, Wash.
16. Ketchikan, Alaska.

In addition, short series of temperature and density observations were made at 51 stations during the tide and current survey of San Francisco Bay. Since these observations are obtained at no increased cost to the survey, 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 were made during the year on two light vessels on the Atlantic coast and two on the Pacific coast. In addition, short series of observations were made at six stations. The combined current observations total 3 years and 10 months of records.

The current observations on the light vessels were as follows:

Light vessel	State	Station	Time employed	
			Years	Months
Nantucket Shoals	Massachusetts	1	1	
Diamond Shoal	North Carolina	1	1	
Blunts Reef	California	1	1	
San Francisco	do	1		1.0
Total		4	3	1.0

Short series of tidal observations were made at the following locations:

Locality	Stations	Time employed (months)
Crescent Beach, Fla	1	0.1
Matanzas Inlet, Fla	1	.4
51 stations, San Francisco Bay, Calif	51	6.2
Frying Pan Shoals, N. C	1	.4
Cape Fear River, N. C	1	.1
Approaches to Sabine Pass, La. and Tex	1	1.8
Total	56	9.0

During the past year an important current and tide survey of San Francisco Bay and tributaries was made. This work, extending over a period of one and one-half months, was carried on from 51 current stations covering the entire bay and tributaries.

CHAPTER II

PRESENT CONDITION OF HYDROGRAPHIC, GEODETIC, MAGNETIC, AND TIDE 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.

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.

GEODETIC WORK

There are several phases on the subject of geodetic surveys which of necessity must be considered in any comprehensive report; but I wish to emphasize, first, that phase of geodetic surveying which is of great practical value to the people of this country. This is the money value of geodetic surveys to those engaged in commerce and industry or in the affairs of the various political units of the country.

A century or more ago the countries of Europe realized that the only way to safeguard the property rights of their citizens was to base the surveys of the private property lines on definite systems of coordinates. By this means there could never be any doubt as to the exact points which control the area of a farm or other pieces of property. It is easy to see that if the latitudes and longitudes of points on the earth's surface are determined those points can be found at any subsequent date even though the markers have been destroyed. Latitudes and longitudes must be shown on all sailing charts to enable the navigator to find his way from one port to an-

other. It is also necessary that latitudes and longitudes be used on the maps of the different parts of a large area, such as that of the United States, in order that a correct idea of the relative positions of different unit areas may be gained.

As far as private property surveys are concerned, latitudes and longitudes are not essential, for a system of plane coordinates for limited areas may be used, but it is necessary to have a survey based on latitudes and longitudes over the whole area in order that the local plane coordinate area may be correlated. It might also be noted that the connection of the farm survey, large or small, with the main triangulation of the United States, correlated as it is on a standard geodetic datum, would make the 20,000 and more points of the national survey witness marks for the local survey.

Although latitudes and longitudes are necessary for the proper correlation of maps of wide areas, it is impossible by observations on the stars alone to determine latitudes and longitudes with sufficient accuracy for surveying, mapping, and other engineering purposes. This is due to the fact that the plumb line is pulled away from the true vertical by mountain masses and other topographic features. There are a number of classic examples of the inadequacy of astronomical observations to determine the distances between points.

In Porto Rico the astronomic latitude was observed at Ponce, on the southern coast, and at San Juan, on the northern coast. Later these two stations were connected by an arc of triangulation which furnished the distance across the island with an error certainly less than 10 feet. The difference between the distance measured directly by triangulation and that computed from the difference in astronomic latitudes was more than a mile. The Spanish charts used prior to the acquiring of the island by the United States, some 26 years ago, had the island of Porto Rico 1 mile wider than it actually is. It is probable that this discrepancy led to disasters to ships navigating the surrounding waters. Certainly the distortions in the charts that were inevitable in trying to fit the surveys based on these two astronomic stations would be great.

In Thibet, in central Asia, the distance between two stations derived from astronomic latitudes was nearly a mile and a half shorter than the distance obtained from accurate triangulation. There are many cases in the United States where the astronomic position of a point differs one-fourth mile or more from its true position as determined by triangulation. These difficulties with astronomic observations and their inadequacy to properly control surveys and maps have led to the development of a system called triangulation for the determinations of latitude and longitude which meets all of the modern requirements and certainly will be adequate for conditions that may develop in the future.

The Coast and Geodetic Survey immediately on its organization more than a century ago laid plans to have the highest grade of triangulation extended along our shores in order to properly correlate the surveys and charts of our outer coasts and of the various harbors, bays, and rivers along it. The bureau has always realized the impossibility of extending surveys and charts over great areas without the control furnished by triangulation. It even went so far as to extend an arc of precise triangulation from the Atlantic to

the Pacific coast, approximately along the thirty-ninth parallel, in order to obtain the proper relation in geographic position between points on the east and west coasts of the country.

When maps were first made, in the interior of the country there were no triangulation stations available, and in consequence separate astronomical stations were used on which to base the several maps that were made. The result of this early work and especially the laying out of the boundaries between States and even between counties by astronomic observations has led to much confusion. There have been many cases where resort to courts was necessary to straighten out tangles in the records of boundary surveys. There are pending now a number of cases which may result in court action.

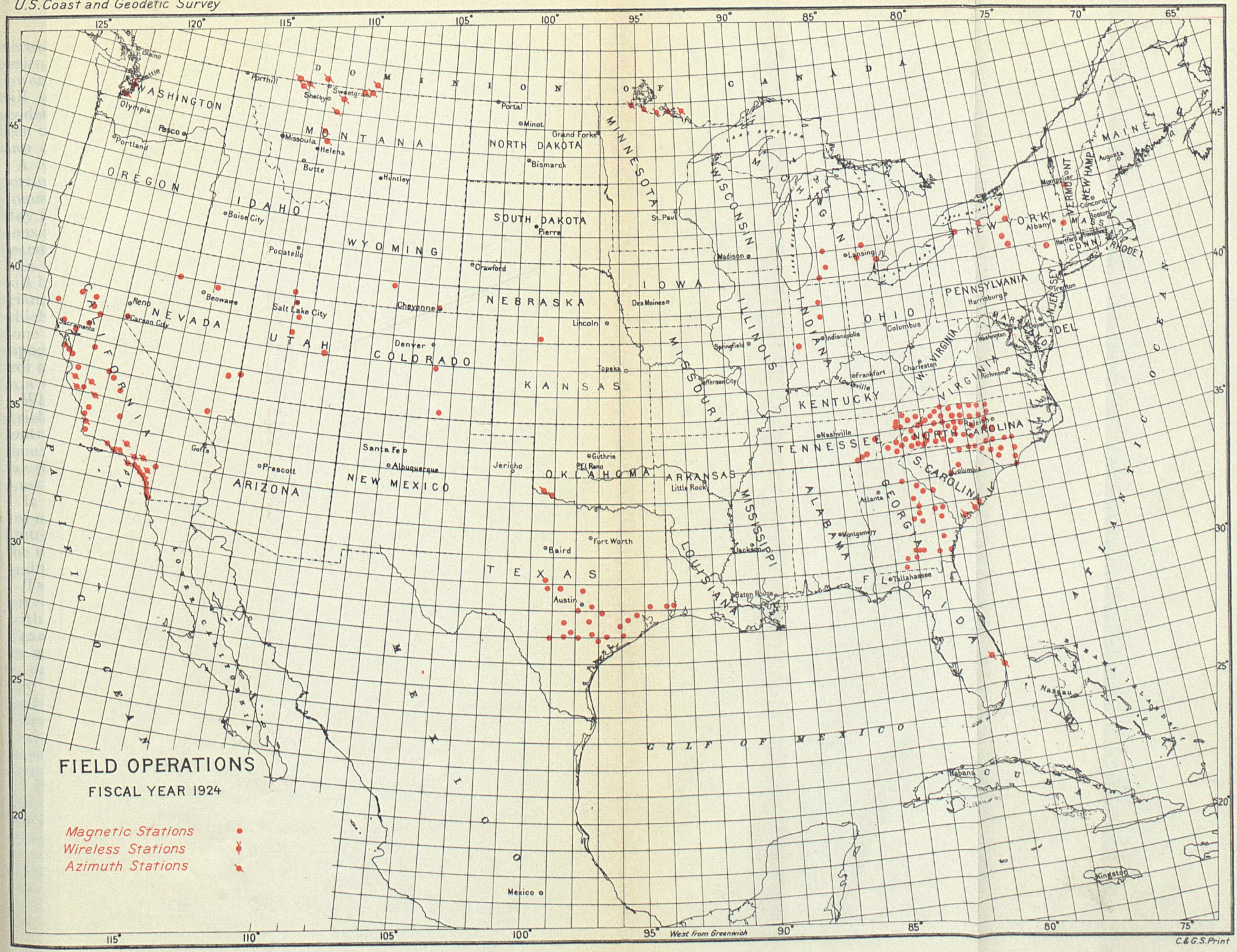
There is much confusion in the use of topographic maps which show the configuration of the ground as well as geographic positions and elevations of topographic features when they have been based on astronomic observations and assumed elevations. This may seem to be a small matter to one giving only casual thought to the case; but when we realize that these maps are the basis to-day for many engineering projects, including the extension, improvement, and upkeep of our vast highway system at a large cost per mile, it is realized that the distance, as shown by the maps, should have a high degree of accuracy. A small per cent of error in the length of a road, as scaled from a map, will affect the cost of the road proportionately. Either the county or the State or the contractor will suffer, and as is always the case where accurate data are not available the contractor must add to his estimated cost enough to guard against inaccurate data if the error should be against him.

The leasing of grazing lands and the utilization of the forest products of the country depend on the area involved. These areas should be accurately indicated on the map, and will be if the map itself is accurate. The map can not be accurate without the proper control which is supplied by the geodetic survey carried on by the Coast and Geodetic Survey.

After extension of the transcontinental arc of precise triangulation and the lines of precise levels which were run incident thereto there was almost immediately created a demand for similar accurate geodetic data in other parts of the interior of the country.

The control surveys of the country must be made at some time. They are needed now, and for any great degree of accuracy that is requisite for the uses to which the data are put one organization for the whole country should do the work. It would be a most wasteful procedure to force each State to have its own geodetic service, with its overhead expenses, office buildings, equipment for the office and field, including expensive instruments, and a trained staff to do the geodetic work within its borders. It is far better that the public should turn over some of its funds in the form of taxes to the Coast and Geodetic Survey to do something for it at a far smaller cost than would be possible if the work were divided among the several States.

Every geodetic survey that is made adds to the wealth of the country, not in a direct way but in an indirect way, and therefore the cost of making the surveys should not be considered as a part of the upkeep of running expenses of the Government but as an actual


FIELD OPERATIONS
FISCAL YEAR 1924
Magnetic Stations
Wireless Stations
Azimuth Stations
DOMINION OF CANADA
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
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
S. CAROLINA
NORTH CAROLINA
VIRGINIA
W. VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
MASS.
CONN.
RHODE I.
NEW HAMP.
VERMONT
NEW JERSEY
MARYLAND
DEL.
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
CUBA
Olympia
Seattle
Portland
Pasco
Portland
Blaine
Missoula
Helena
Butte
Huntley
Boise City
Pocatello
Beowawe
Reno
Carson City
Sacramento
Salt Lake City
Cheyenne
Denver
Goffs
Prescott
Santa Fe
Albuquerque
Jericho
Guthrie
El Reno
Fort Worth
Baird
Austin
Portal
Minot
Grand Forks
Bismarck
Pierre
Crawford
Lincoln
Topeka
Des Moines
Madison
St. Paul
Springfield
Jefferson City
Little Rock
Jackson
Baton Rouge
Lansing
Indianapolis
Columbus
Frankfort
Louisville
Charleston
Nashville
Atlanta
Montgomery
Tallahassee
Columbia
Raleigh
Richmond
Washington
Harrisburg
Trenton
Albany
Montpelier
Concord
Boston
Augusta
Nassau
Habana
Kingston
Mexico
West from Greenwich
C.&G.S. Print

increase in the capital of the country. Any engineer of wide experience with maps in extending highways, erecting dams and power plants, making city plans, and numerous other operations will testify as to the great value of maps based upon accurate geodetic control. He will also testify as to the losses which have been or may be incurred by having to work with poor or inadequate map data.

A long step toward securing topographic maps for the unmapped portion of the country was taken by the Interstate and Foreign Commerce Committee of the House of Representatives when, on May 27, 1924, hearings were granted to representatives of organizations interested in or using maps very extensively. The result of the hearings was a favorable report on the Temple bill by the committee.

In order that this mapping may be done properly, however, it will be necessary to have thousands of miles of new arcs of precise triangulation and lines of precise leveling connecting the areas which are to be topographically mapped. This work will have to be done by the Coast and Geodetic Survey, and it should precede the topographic mapping. In fact, it is necessary that the precise-control surveys should be done ahead of it if the mapping is to be done in a satisfactory manner.

While we may not know it, we are really losing money and restricting the activities of our people by not having had the geodetic control surveys completed before now. The facts set forth above should convince the appropriating officials of the Government that far more adequate provision for the control system of the country must be made than has been done in the past.

It should be remembered that when the precise control surveys are made over an area they do not have to be repeated in the future. Outcropping rocks and heavy concrete blocks are used in marking the triangulation and leveling stations, and these last for many years and make it unnecessary to reproduce the geodetic surveys.

Two notable cases of the use of geodetic methods in boundary surveys have occurred during the past year. One was in connection with the establishment of the boundary along the Red River between Texas and Oklahoma to the westward of the ninety-eighth meridian. It was desired by the commissioners appointed for that boundary to have the coordinates of the topographic features along the boundary determined with great accuracy. After careful consideration and consultation between the commissioners and the officials of the Coast and Geodetic Survey it was decided that the commissioners and the survey should cooperate in the extension of precise triangulation along that portion of the boundary for which surveys were immediately needed. This work was undertaken by the engineers of the Coast and Geodetic Survey and carried through to a successful completion at a very small cost. The field expenses, aside from the salaries of the regular employees of the Coast and Geodetic Survey, were paid from funds raised by the commissioners. The survey furnished all instrumental equipment and made the computations necessary to obtain the final geographic positions. This is the first instance, as far as this office is aware, of the use of precise triangulation along a boundary line between two States, to be used for the accurate location and perpetuation of the boundary line.

The great advantage of having precise triangulation for the control of boundary surveys is that it makes it possible to recover very accurately the position of any topographic feature, monument, or other mark essential to the proper identification of the boundary line should such mark be destroyed between the first and subsequent surveys.

The other instance of the use of geodetic methods for a boundary survey was that between Yavapai and Maricopa Counties, Ariz. This boundary was defined by law as following for most of its distance certain parallels of latitude and oblique lines between designated points. It was laid down by engineers of the two counties working separately and at different times. Necessarily the astronomic observations for latitude were affected by the mountain ranges in the vicinity of the work. As the two or more engineers involved in the surveys used different points for their latitude observations, their results were affected by different amounts. The result of this situation was that a strip of valuable territory was claimed by each of the counties.

After correspondence with officials of the Coast and Geodetic Survey the officials of the two counties involved decided to ask the survey to establish a line by geodetic methods. This consisted in carrying an arc of precise triangulation along the boundary and connecting the precise stations with points on the boundary itself by means of triangulation of a lower grade. The work was successfully carried out to the mutual satisfaction of the officials of the counties and the Coast and Geodetic Survey. The cost of the work was exceedingly small. The field expenses were paid from the county funds, while the Coast and Geodetic Survey paid the salaries of its regular employees connected with the work and furnished all instrumental equipment and automobile trucks and made the computations of the field observations.

It is believed that in the future there will be many cases where this bureau will be called upon by States and counties to establish accurately the monuments along their boundaries.

A broad field of surveying which is but now awakening to the great value of precise control covers the making of topographic and cadastral maps of our cities. What little has already been done in providing control for such uses has been largely with the cooperation, direct or indirect, of the Coast and Geodetic Survey. The first triangulation of a large city made as a major undertaking—the survey of Greater New York—was by direct cooperation, that survey being under the charge of an officer of the Coast and Geodetic Survey and the adjusted computations being made in this office. A little later a precise survey of Cincinnati, including triangulation, precise levels, and topography, was executed under the direction of a man who was wholly trained in the Coast and Geodetic Survey, but who at that time had no official connection therewith. This also was true in the case of the triangulation of the city of Richmond, Va., completed but two years ago. Frequent aid has also been given cities planning precise surveys in the way of conferences, inspections, and (in the case of Columbus, Ohio) the preparation of a set of specifications to meet the particular needs of that city.

Special Publication No. 91, The Use of Geodetic Control for City Surveys, was prepared especially as an aid to cities in the making of accurate surveys. When one considers that 51.4 per cent of the people of America live in cities, and that a little more than one-third of the taxes on real property is collected therefrom, one can not question the wisdom and justice of extending precise geodetic control over the areas of these cities in order that they may have accurate cadastral maps for all tax purposes and accurate topographic maps for all planning.

Geodetic surveys are a necessary part of the surveying and mapping and some of the other engineering activities of the Federal Government, States, cities, and private corporations and individuals. The geodetic work is not a prominent part of these various operations, but it is just as essential as the work done in a mine to strip away the surface material to make the ore available. Geodetic work may be likened to the steel fromework and foundation of a large modern building which are covered up by the various parts of the building but perform an essential function.

The country is losing money in two ways because of incomplete topographic mapping. One is that there are no maps in many critical areas in which engineering work is being undertaken. A lack of complete knowledge of the configuration of all of the area that influences engineering operations may result in money being spent in building plants of one kind or another which may be too large for the purpose served or totally inadequate for it. Take, for instance, a case of power development. The most complete information should be available in regard to the area drained, the rainfall, the rate of run-off, and the possibility of storing or holding back the waters during flood seasons in order to have a certain minimum flow requisite to operate the plant and supply the customers who use the product.

There are cases where forests and mines can not be economically worked because of a lack of knowledge of topographical conditions in their vicinity. The cost to the public in the form of losses in the operating of the projects are far greater than would be the cost of making the topographic map for the area involved. The money spent in many projects which fail would have been saved had adequate topographic information been available before the projects were started.

The second way in which the country is losing money because of inadequate maps is the direct loss owing to the fact that lack of data keeps concealed the possibilities of initiating and completing many enterprises which would be extremely profitable and useful. This is notably the case along watercourses which are susceptible of power development where, owing to a lack of knowledge of the configuration of the ground, the power is not developed.

Even where the private corporations make surveys before engaging in engineering operations the public really pays for that work. The corporation must add to its capital account or take from its surplus the costs of all private surveys, whether it is found that the proposition investigated is or is not suitable for industrial plants. These surveys serve no useful purpose after the corporation has

used them for their immediate needs. They are filed away or destroyed, and should some other organization wish to operate along the same or some other lines over the identical area the second corporation would have to make its own surveys and charge their cost to the capital account, and the public would pay interest on the cost for generations to come. All of these losses could be obviated if the topographic map based on accurate control surveys were rapidly extended over the country to meet all these needs.

It must be remembered that suitable topographic maps can not be made ahead of the geodetic control surveys. In fact, there are cases on record where the topographic branch of the United States Geological Survey would not undertake topographic maps in certain areas, even though the States involved offered to pay half of the expenses of the work, because the Coast and Geodetic Survey had not at the time extended its control surveys to those areas.

Investigations carried on by the Coast and Geodetic Survey during the past 25 years have resulted in a large increase in the knowledge of the earth's crust and the processes which change the elevation and geographic positions of points on its surface. The information used in these investigations has been largely the value of the attractive force of the earth, called gravity, determined at a number of stations in the country. The geologists engaged in both theoretical and practical work are using the results of these investigations, and it is reasonably certain that in the years to come the economic geologists on whom depends the development of our mineral resources will be able to work more effectively as a result of these investigations.

Much remains to be done, as, for example, the determination of the values of gravity at stations on islands and coasts near our borders. This does not apply to the Canadian border, for the Government of that Dominion, realizing the importance of determining the value of gravity, has established a number of gravity stations within its area. It is felt that the geological processes which have been at work in this country have extended to contiguous areas, and hence the necessity of collecting information from them.

The desirability of locating gravity stations in rugged, broken, mountainous country has long been recognized, but the difficulties of transporting the heavy instrumental equipment and in finding or building a suitable constant temperature room for the pendulum has made the cost almost prohibitive away from the railroads and telegraph lines. The new invar pendulums and the new radio recorder have done much to overcome these difficulties. The invar pendulums change so little with changes of temperature that a tent may be used in which to swing them, and the Naval Observatory time signals transmitted by the Annapolis radio station can be received and recorded with the new recording apparatus anywhere in the United States and at least in the nearer parts of Alaska.

A very interesting group of gravity stations was occupied in southeast Alaska during the season of 1923. This work was a very severe test for the radio recorder, as the distance from Annapolis is nearly 3,000 miles. Several of the stations are on small rocky islands surrounded by deep water, and all of them are in or near mountainous country. The anomalies at these stations are of unusual value for

making studies of the isostatic condition of the earth's crust and in learning more about the densities of rocks concealed in the crust.

In spite of recent improvements in the methods and apparatus the determination of the intensity of gravity is still a long and expensive process. Even when the stations are close together an observer can not average more than about four per month. The chief of the division of geodesy has for some time been studying the problem of a new type of apparatus which will be easier to transport and will not require so much time per station. His efforts along this line have induced several other scientists to tackle the problem, namely, Prof. A. A. Michelson, of Chicago University; Dr. F. E. Wright, of the Geophysical Laboratory; and Dr. Louis T. E. Thompson, of the Aberdeen Proving Grounds, and as a result there are now three new types of apparatus which have reached the experimental stage. One is based on a special form of interferometer, another on a quartz spiral spring, and the third depends on measuring the acceleration of a freely falling body by means of a quartz tuning fork. Doctor Wright expects to test his apparatus (the quartz spring) in the field in the very near future. The laboratory tests so far have been promising.

I wish again to call attention to the value of the triangulation which has been extended along the Mississippi River in times past by the commission appointed to control floods and build dikes along that river. This triangulation had its geographic positions based on separate astronomic stations, each of which was affected by the attraction of the nearby topography, and therefore these geographic positions do not fit into the triangulation system of the country as a whole. The results of the triangulation are really not now available to the surveyor and engineer, but they could be made available by a recomputation which would place the geographic positions of the stations on the national datum. A small amount of money made available in each of two fiscal years would enable the Coast and Geodetic Survey to recompute this valuable material. The Mississippi River Commission feels that it is not authorized by law to make a recomputation of its triangulation, as it claims that the positions now available meet all the needs of that body.

For two years Congress has appropriated money to make a computation and adjustment of the Hawaiian triangulation which was executed many years ago while Hawaii was a kingdom. This work is being carried on expeditiously, and it is believed that only a small sum will be needed during the fiscal year 1926 to complete the computations. The results of this work will be of great value to the Federal Government and to the Territorial government in the execution of surveying and engineering operations.

The outstanding accomplishments of the year in the geodetic operations of the bureau are indicated below:

A long step forward was made in the science and engineering of geodesy when an observer of the Coast and Geodetic Survey determined the astronomic longitudes of a number of stations in southeastern Alaska during the summer of 1923, using the Eckhardt-Karcher longitude apparatus for receiving and recording automatically the time signals which were sent from the Naval Observatory at Washington through the Annapolis radio station. The

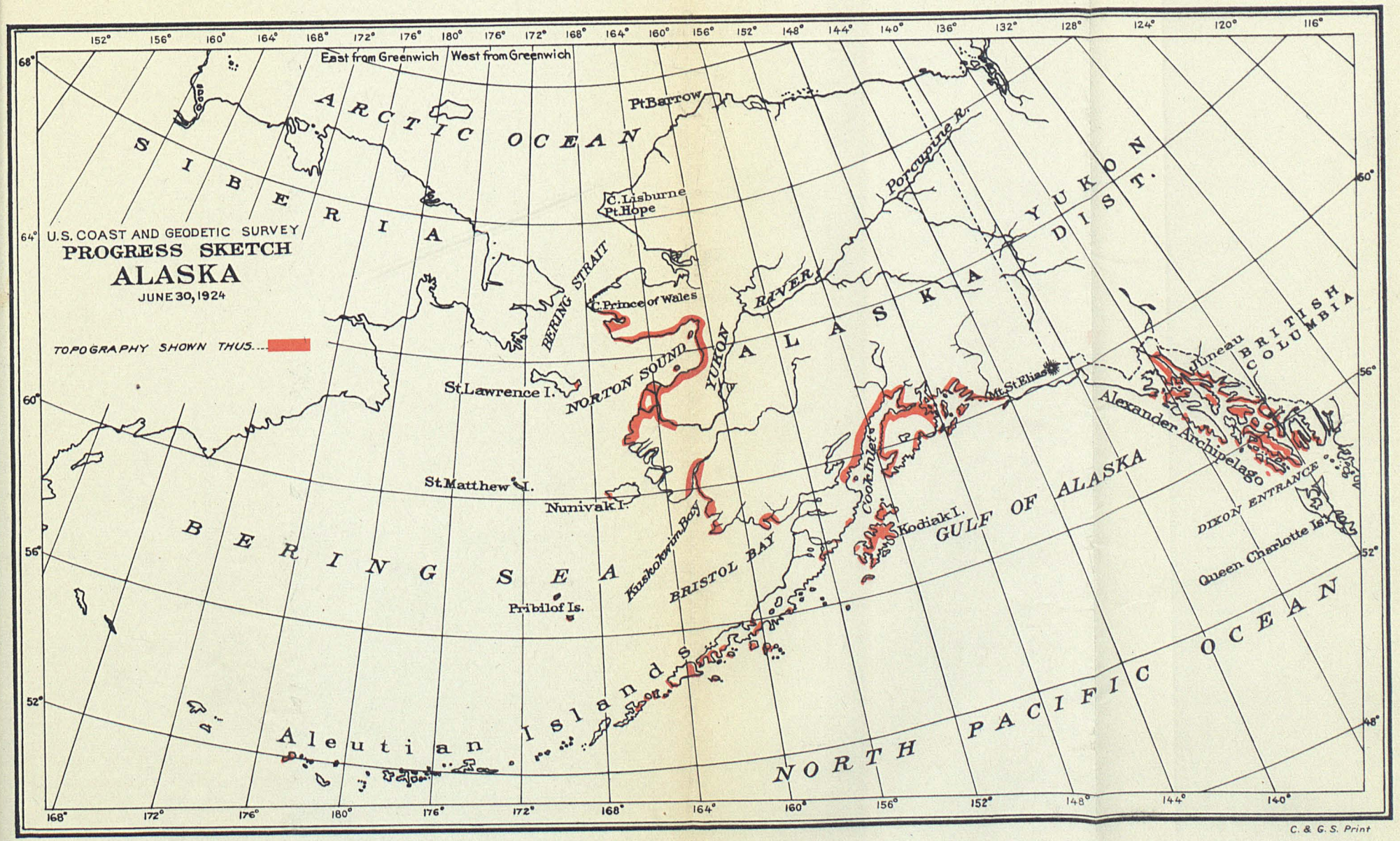
distance between Washington and the stations averaged about 3,000 miles, and the results obtained were as accurate as those for much shorter distances. A station was also established near Seattle, more than 2,000 miles from Washington, with the same apparatus. The success of this radio recording apparatus, which was made by Drs. E. A. Eckhardt and J. C. Karcher, of the Bureau of Standards, at the request of the Coast and Geodetic Survey, will make it possible to determine with great accuracy the longitudes of places which are not within reach of the land wires and oceanic cables. With so many high-powered sending stations distributed over the world, accurate geodetic longitudes can now be obtained almost anywhere. Thus, surveying and mapping operations may be greatly improved over what they were in the past.

The Coast and Geodetic Survey has continued throughout the year active geodetic cooperation with the Geodetic Survey of Canada on the arc of precise triangulation which will extend from Puget Sound northward to the head of Lynn Canal, near Skagway. This is part of the cooperative plan between these two organizations which, when further extended, will make it possible to compute triangulation in Alaska on the same datum that is used now in the United States, Canada, and Mexico. Continuous triangulation is of great benefit in avoiding discrepancies in the maps of two countries at their common border. The geographic positions of the topographic features shown on the two systems of maps will be the same, and thus confusion as to the location of the boundary is avoided

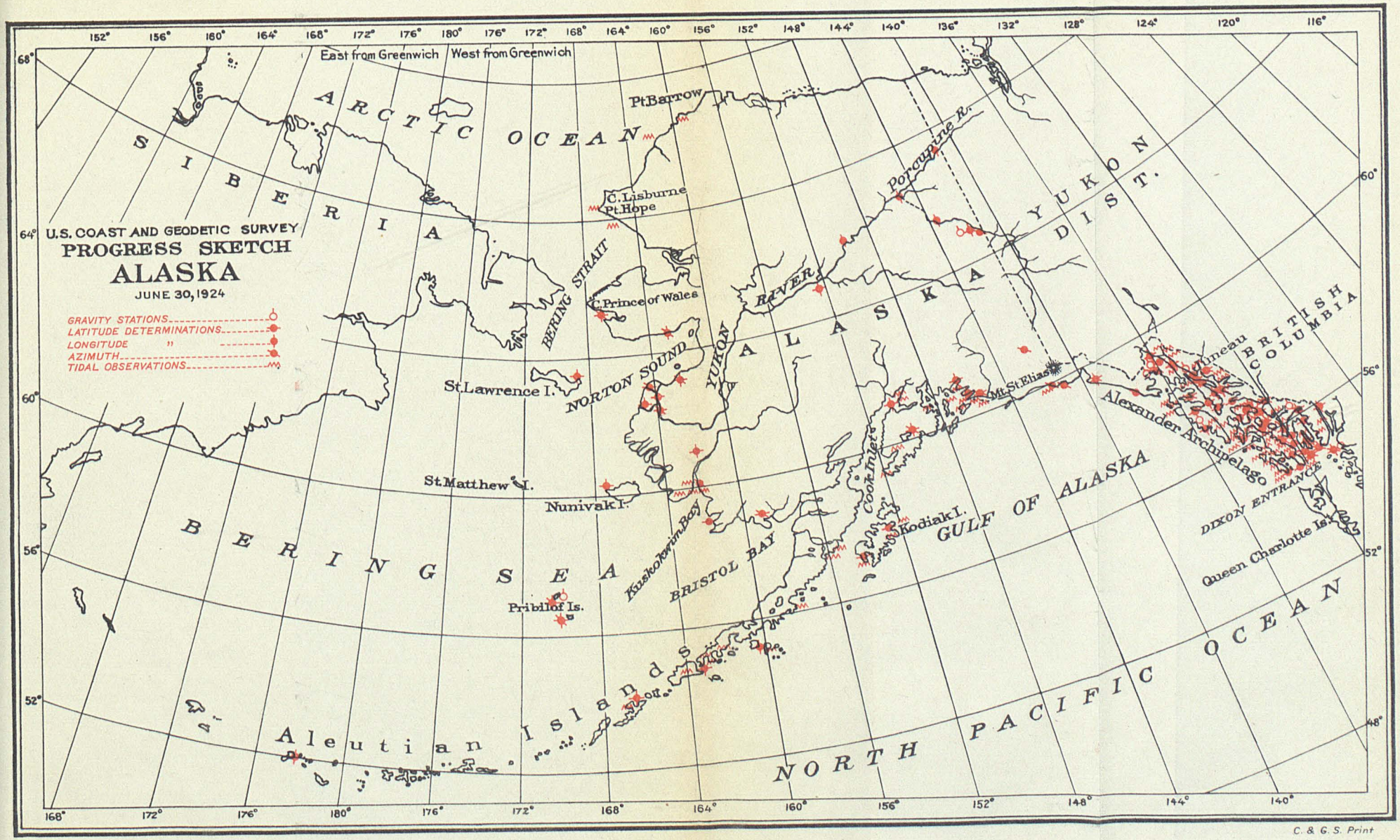
The cooperation between these two bureaus involves also the completion of an arc of triangulation which will extend from Lake Superior along our northern boundary to the Pacific coast. Each of the bureaus is doing approximately one-half of the work. The two bureaus have also cooperated in the coordination of the precise level lines of the two countries where they touch each other along the boundary between the Great Lakes and the Atlantic coast. The friendly spirit shown by the officials of the two bureaus in furthering the interest of the two countries in this geodetic cooperation is to be highly commended. They are working in the most unselfish and generous way.

A traverse party of the Coast and Geodetic Survey operated along the Rainy River and across Rainy Lake, part of the boundary between Minnesota and Canada, during the midwinter. The party measured distances over the ice between a number of observation stations located on small islands. The temperature was at times as low as 38° F. below zero, but in spite of this and many other hardships there was no injury to any member of the party, owing largely to the forethought of the chief of party and his assistants in planning for the work.

Horizontal angle observations had been measured at a number of the stations during the summer of 1923, but the water was too narrow to permit accurate triangulation to be carried along it, and the contiguous land areas were so swampy that triangulation with sides of reasonable length would have been exceedingly expensive. The shores of these bodies of water are so rugged and so overgrown with trees and brush that it was impossible to measure along them. The expedient of measuring over the ice was forced upon us, and


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1924
TOPOGRAPHY SHOWN THUS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
Porcupine R.
YUKON DIST.
YUKON RIVER
ALASKA
BRITISH COLUMBIA
Juneau
Mt. St. Elias
Alexander Archipelago
NORTON SOUND
St. Lawrence I.
St. Matthew I.
Nunivak I.
BERING SEA
Kuskokwim Bay
BRISTOL BAY
Pribilof Is.
Cook Inlet
Kodiak I.
GULF OF ALASKA
DIXON ENTRANCE
Queen Charlotte Is.
Aleutian Islands
NORTH PACIFIC OCEAN

C. & G. S. Print


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1924
GRAVITY STATIONS
LATITUDE DETERMINATIONS
LONGITUDE "
AZIMUTH
TIDAL OBSERVATIONS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
St. Lawrence I.
NORTON SOUND
YUKON RIVER
Porcupine R.
YUKON DIST.
ALASKA
BRITISH COLUMBIA
Juneau
Mt. St. Elias
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
Cook Inlet
Kodiak I.
GULF OF ALASKA
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BRISTOL BAY
BERING SEA
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN

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though it was something new in the way of geodetic work by this bureau the work was done very successfully, and the results were most satisfactory.

Triangulation in California for the purpose of detecting earth movements was continued during the summer and fall of 1923. The operations were carried on from the vicinity of Mount Hamilton, on which is located Lick Observatory, southward to the Santa Barbara channel. Owing to fog conditions late in August, which prevented observations along the Santa Barbara Channel, the party was moved to the southward, where observations were begun at the old triangulation station on Cuyamaca Mountain near the Mexican border and were extended northward along the coast into the Santa Barbara Channel. Exhaustion of the funds available for this work prevented a connection of this southern end with the work to the northward. This connection and other important triangulation will be undertaken during the fiscal year 1925.

The work in California is a remeasurement of the horizontal angles of the triangulation starting from stations Mount Lola and Round Top in the eastern part of the State and extending approximately along the thirty-ninth parallel of latitude to the Pacific coast and thence along the coast to the Mexican boundary. The geographic positions resulting from the new observations differ materially from those computed from the earlier observations made 30 or 40 years ago. Important discoveries in the form of unmistakable earth movements, some of which are as great as 10 or 15 feet, justify the continuation of this work to study the rates of movement of mountain peaks and other points in California. It is hoped that this work will result in a better knowledge of the laws which govern earthquake activities and will make it possible to determine within reasonable limits the place and time where earthquakes are most likely to occur.

This work was undertaken at the beginning of the fiscal year 1923 as a part of a cooperative arrangement made between the committee on seismology of the Carnegie Institution of Washington and the Coast and Geodetic Survey. It is believed by those who have investigated the accumulated data that the work is of exceedingly great importance in the attempt to solve certain major earth problems.

A party of the Coast and Geodetic Survey continued the triangulation in the interior of Alaska which was started two years previously. This triangulation begins at the coast at the head of Cook Inlet and will extend northward to Fairbanks and thence will branch in several directions in order to furnish accurate geographic positions for the use of the General Land Office, which is laying out public lands, and the United States Geological Survey, which is making topographic maps of Alaska. The work in Alaska is exceedingly difficult owing to the lack of roads, the many rivers and streams which must be forded, and the soft character of the ground. In many places the soft moss makes travel extremely difficult.

During the year four precise leveling projects were completed.

The work in Connecticut, which had been done at the request of the United States Geological Survey, was continued through Rhode Island, Massachusetts, and New Hampshire, to Portland, Me. This

is the first time that some of these States had been entered by the precise leveling operations of the Coast and Geodetic Survey and the work supplies a region greatly in need of accurate elevations.

At the request of the United States Geological Survey a system of precise levels was extended along the roads through Yellowstone National Park, Wyo. The system was connected with the precise level net of the United States in that locality and with the bench marks of the survey at Cody and Moran, Wyo.

The first link in the proposed precise level net of Alaska has been completed. This link, the result of two seasons of work, extends along the Alaska Railroad from Seward through Anchorage to Fairbanks, and thence along the Richardson Highway to Valdez. At Anchorage and Valdez the work was connected with mean sea level obtained from short series of tidal observations.

The precise leveling along the Southern Pacific Railroad between Weed, Calif., and Portland, Oreg.; along the Union Pacific Railroad between Portland, Oreg., and Centralia, Wash.; and a short section near Fort Stevens, Oreg., was revised during the year. This revision work makes possible the assignment of definite values to the elevations of the bench marks in this territory. It is proposed to publish the results of all precise leveling in Oregon during the coming year.

There has been effective cooperation between the Coast and Geodetic Survey and other organizations and individuals during the year. The Coast and Geodetic Survey has cooperated with the Geological Survey to the extent of determining the value of gravity at a number of stations in Texas for testing certain theories involved in economic geology.

In the isostatic investigations made by the Coast and Geodetic Survey it was found that the value of gravity at a station depends to a certain extent on the distribution of materials of different densities close to the station. As the earth's crust is in approximate equilibrium at all places as far as the investigations have been carried on, it is evident that if two gravity stations close together have decidedly different values, where theoretically they should be the same, the cause must be in the outer portion of the earth's crust rather than far below in the lower part of the crust or lower. Certain oil investigations indicate that there are decided differences in density in the material of the old fields. If gravity observations can detect these abnormal densities, the observations may be of very great economic importance. The Coast and Geodetic Survey has been cooperating with officials of the Geological Survey for a number of years in studying these very important phases of geology.

The Coast and Geodetic Survey has cooperated with the Seismological Commission of the Carnegie Institution of Washington by reobserving the angles of the triangulation in California for the purpose of detecting changes in geographic positions of mountain peaks and other places on which the old stations were established 30 or more years ago, with the commission appointed by the Supreme Court of the United States in establishing the boundary between Texas and Oklahoma along the Red River to the westward of the ninety-eighth meridian, and with Yavapai and Maricopa Counties, Ariz., by extending an arc of triangulation along their common boundary for the purpose of fixing the boundary line permanently.

The Bureau of Standards has cooperated with the Coast and Geodetic Survey in continued study of methods for recording graphically the radio time signals used in precise longitude and gravity determinations, and also in testing the stability of invar tapes used in precise base measurements.

The Superintendent of the Naval Observatory and his staff cooperated with the Coast and Geodetic Survey by sending special time signals between 3.55 and 4 o'clock a. m., eastern standard time, for use by the longitude party operating in Alaska. These special signals made it possible to compare the Washington time with the time observed at the Alaskan stations without having to depend on the chronometers for carrying time for several hours. Greater accuracy was the result of this effective cooperation.

L. A. McArthur has cooperated with the Coast and Geodetic Survey by checking manuscript prepared for publication to make the descriptions and the names of the stations conform to the information obtained by the Oregon Geographic Board as to names of places, mountains, streams, and other geographic features.

The Coast and Geodetic Survey has cooperated with many engineers and others in and out of the Government by furnishing geographic positions of thousands of triangulation and traverse stations and the elevations of thousands of bench marks, and with several cities in their efforts to secure geodetic control for their surveys.

The cooperation of individuals and organizations in carrying on the geodetic work of the survey has been very much appreciated by the officials of the bureau, and it is hoped that such cooperation may be even more extensive in the years to come.

Members of the Coast and Geodetic Survey have taken an active part in the American Geophysical Union during the past year. This organization is a branch of the National Research Council and is the National Committee for Geophysics for this country of the International Geodetic and Geophysical Union. Several members of the survey have held offices in the union and have been represented on its executive committee. The union serves a most useful purpose in bringing together the workers in geodesy, oceanography, meteorology, volcanology, seismology, and terrestrial magnetism and electricity, thus enabling them to cooperate in those phases of geophysics which have to do with more than one single branch. Members of the Coast and Geodetic Survey took an active part in the formation of this union in 1919, just after the World War.

PRESENT CONDITION OF THE MAGNETIC SURVEY

While the first magnetic survey of the United States began in 1843, a systematic survey covering the entire area was started in 1899 with the definite plan of establishing a magnetic station at every county seat in the United States. Out of a total number of 3,067 counties there remain only 131 county seats to be occupied, and these are being occupied as rapidly as conditions permit.

The magnetic survey as being carried on at the present time includes observations at the hitherto unoccupied county seats, additional observations in places of local magnetic disturbances, the occupation of repeat stations, and the resurvey 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 occupied at five-year intervals.

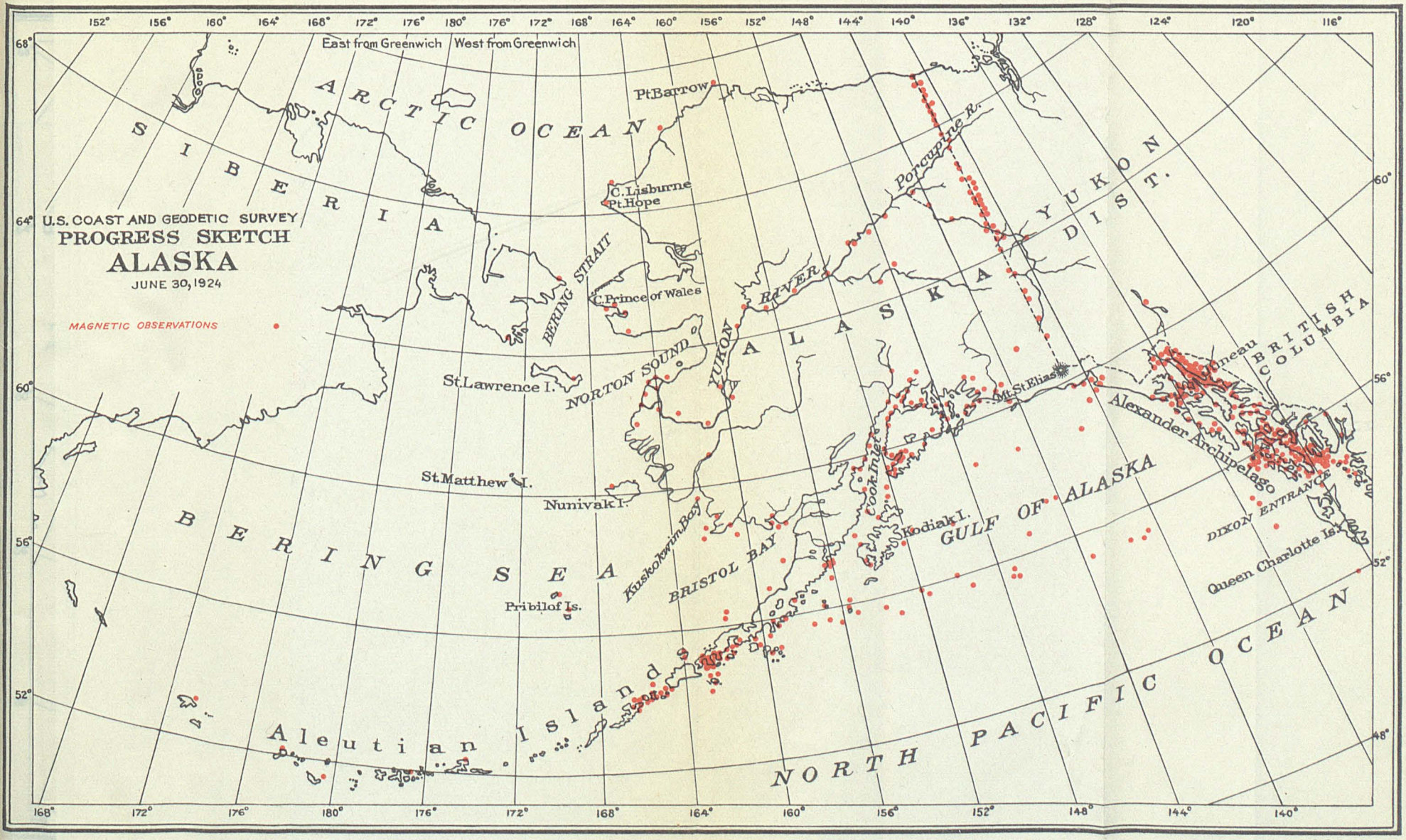
The effort which was started the previous year to get in touch with county and other surveyors was successfully continued, and the bureau is now in touch with about 2,000 local surveyors. As a result of information from these surveyors and the field operations of the bureau the condition of 1,241 out 3,743, or 33.3 per cent of the total number, is now known. This is an increase of 12 per cent over the previous year. Four hundred and ten of these stations need replacement either in part or entirely, in addition to 159 which have been replaced or inspected during the year. The replacement program is now a very important part of the work.

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 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 is 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 sea coast 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.

It has been definitely determined that during the next fiscal year the lease of the observatory grounds at Vieques, P. R., can not be extended beyond the next fiscal year. Plans are being made, therefore, to build an observatory on public land on the main island of Porto Rico, the replacement to extend over several years.

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. A test is being made at Tucson to find the proper type of seismograph to replace the obsolete ones in use.

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


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1924
MAGNETIC OBSERVATIONS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
YUKON RIVER
Porcupine R.
YUKON DIST.
ALASKA
BRITISH COLUMBIA
Juneau
Mt. St. Elias
Alexander Archipelago
NORTON SOUND
St. Lawrence I.
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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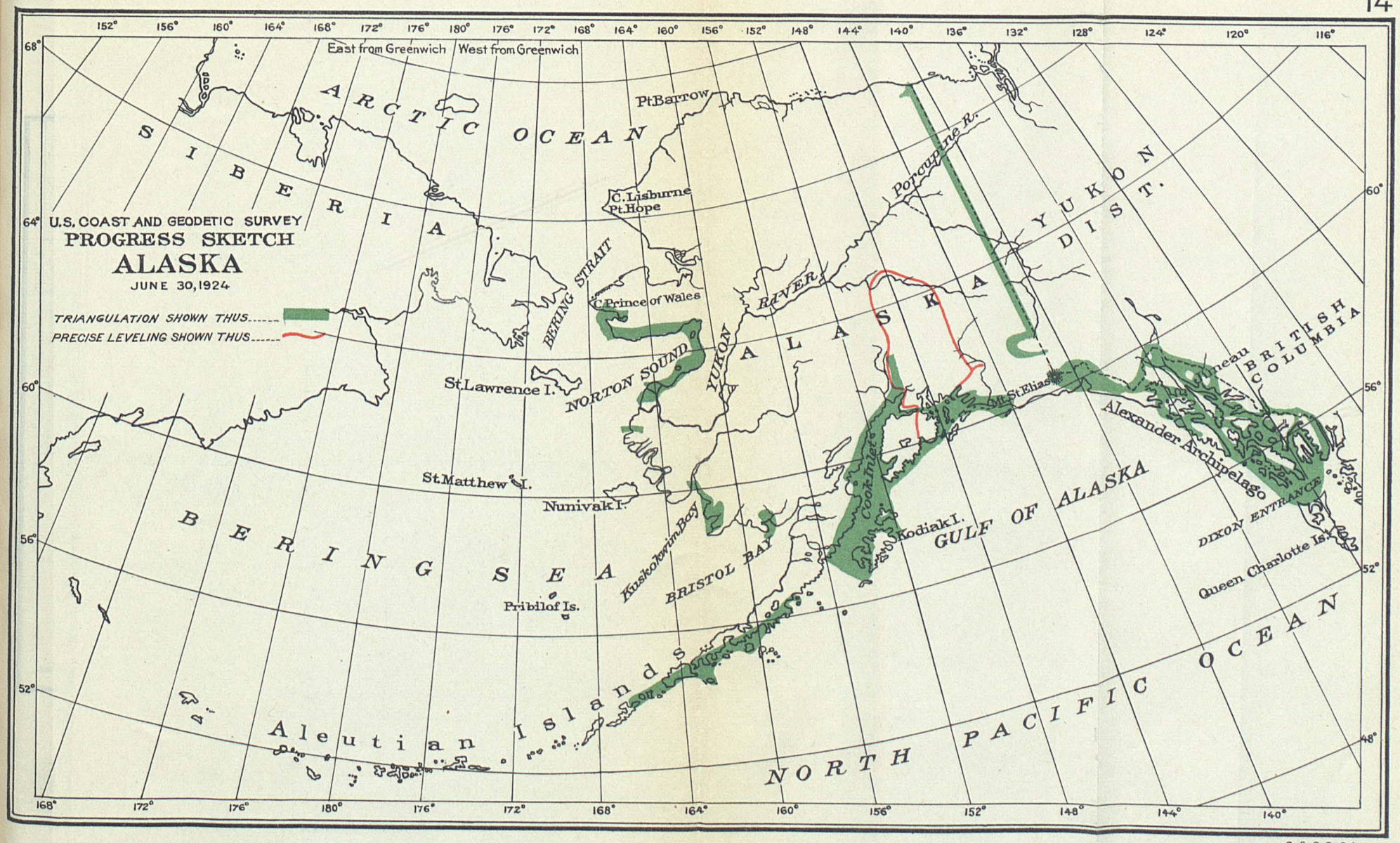
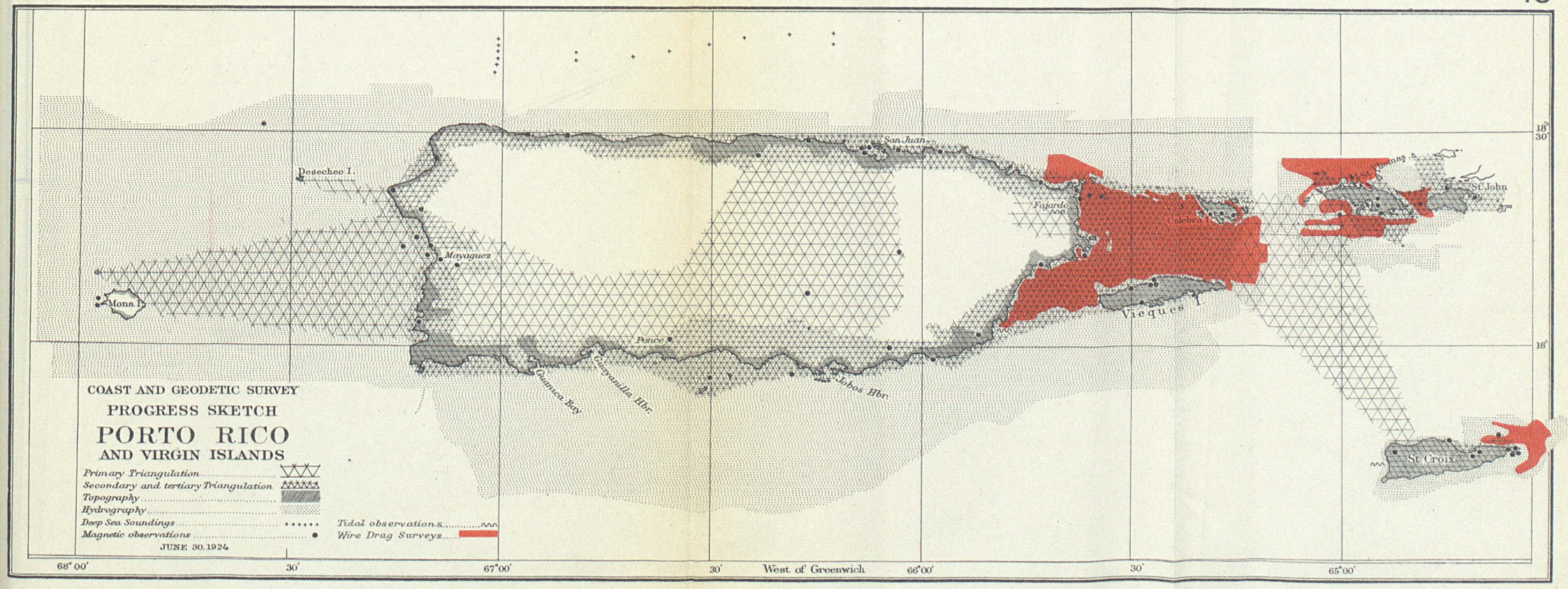

U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1924
TRIANGULATION SHOWN THUS
PRECISE LEVELING SHOWN THUS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
St. Lawrence I.
NORTON SOUND
YUKON RIVER
Porcupine R.
YUKON DIST.
ALASKA
Mt. St. Elias
Juneau
BRITISH COLUMBIA
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
St. Matthew I.
Nunivak I.
BERING SEA
Kuskokwim Bay
BRISTOL BAY
Cook Inlet
Kodiak I.
GULF OF ALASKA
Pribilof Is.
Aleutian Islands
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
Tidal observations
Wire Drag Surveys
JUNE 30, 1924
Desecheo I.
Mona I.
Mayaguez
Ponce
Guanica Bay
Guayanilla Hbr.
Jobos Hbr.
San Juan
Fajardo
Culebra
Vieques I.
St. John
St. Croix
18° 30'
18°
68° 00'
30'
67° 00'
30'
West of Greenwich
66° 00'
30'
65° 00'

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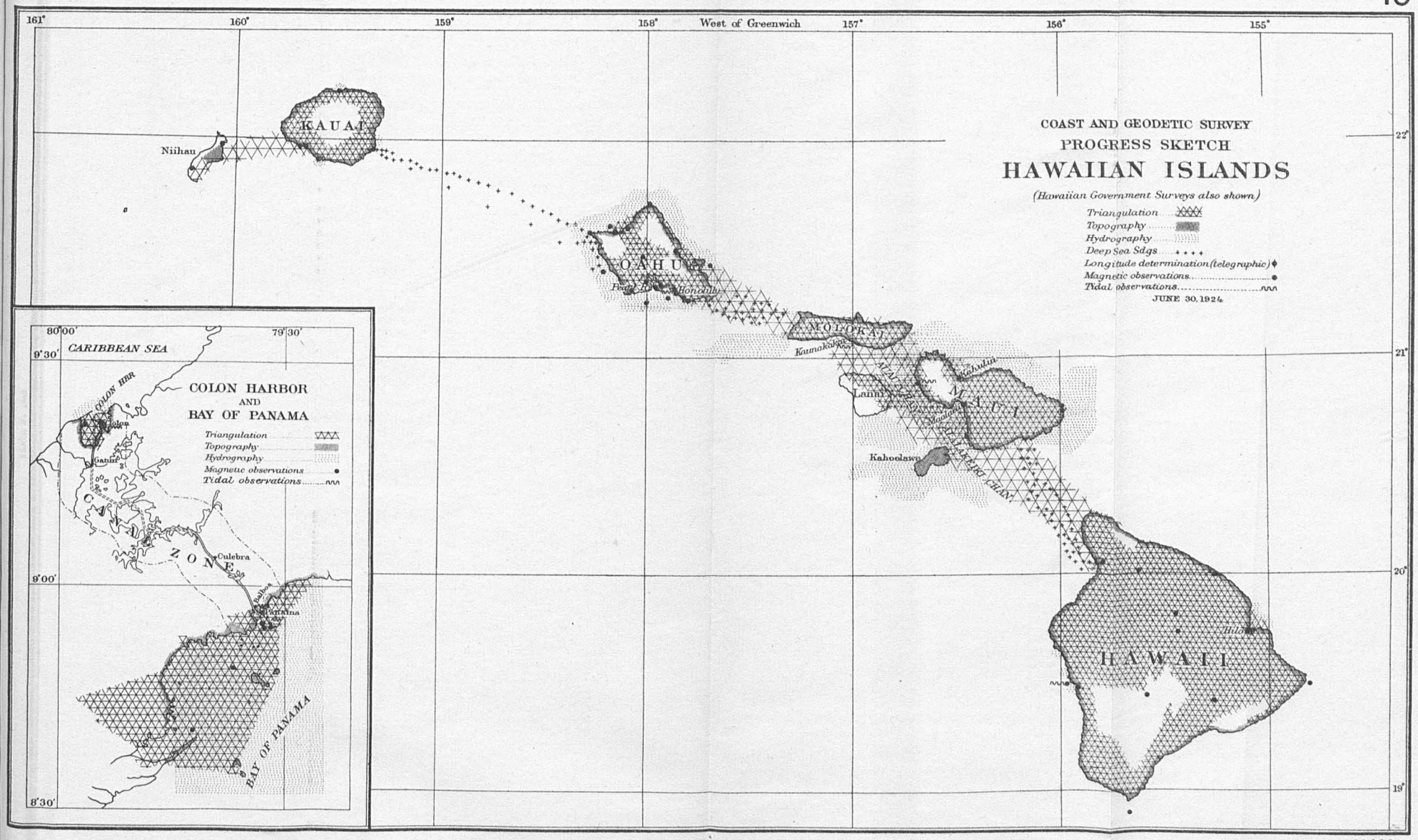
COAST AND GEODETIC SURVEY
PROGRESS SKETCH
HAWAIIAN ISLANDS
(Hawaiian Government Surveys also shown)
Triangulation
Topography
Hydrography
Deep Sea Sdgs
Longitude determination (telegraphic)
Magnetic observations
Tidal observations
JUNE 30, 1924
West of Greenwich
161°
160°
159°
158°
157°
156°
155°
22°
21°
20°
19°
KAUAI
Niihau
OAHU
Honolulu
MOLOKAI
Kaunakakai
Lanai
MAUI
Kahului
Kahoolawe
HAWAII
Hilo
CARIBBEAN SEA
COLON HARBOR
AND
BAY OF PANAMA
Triangulation
Topography
Hydrography
Magnetic observations
Tidal observations
COLON HBR
Colon
Ganin
CANAL ZONE
Culebra
Balboa
Panama
BAY OF PANAMA
80°00'
79°30'
9°30'
9°00'
8°30'

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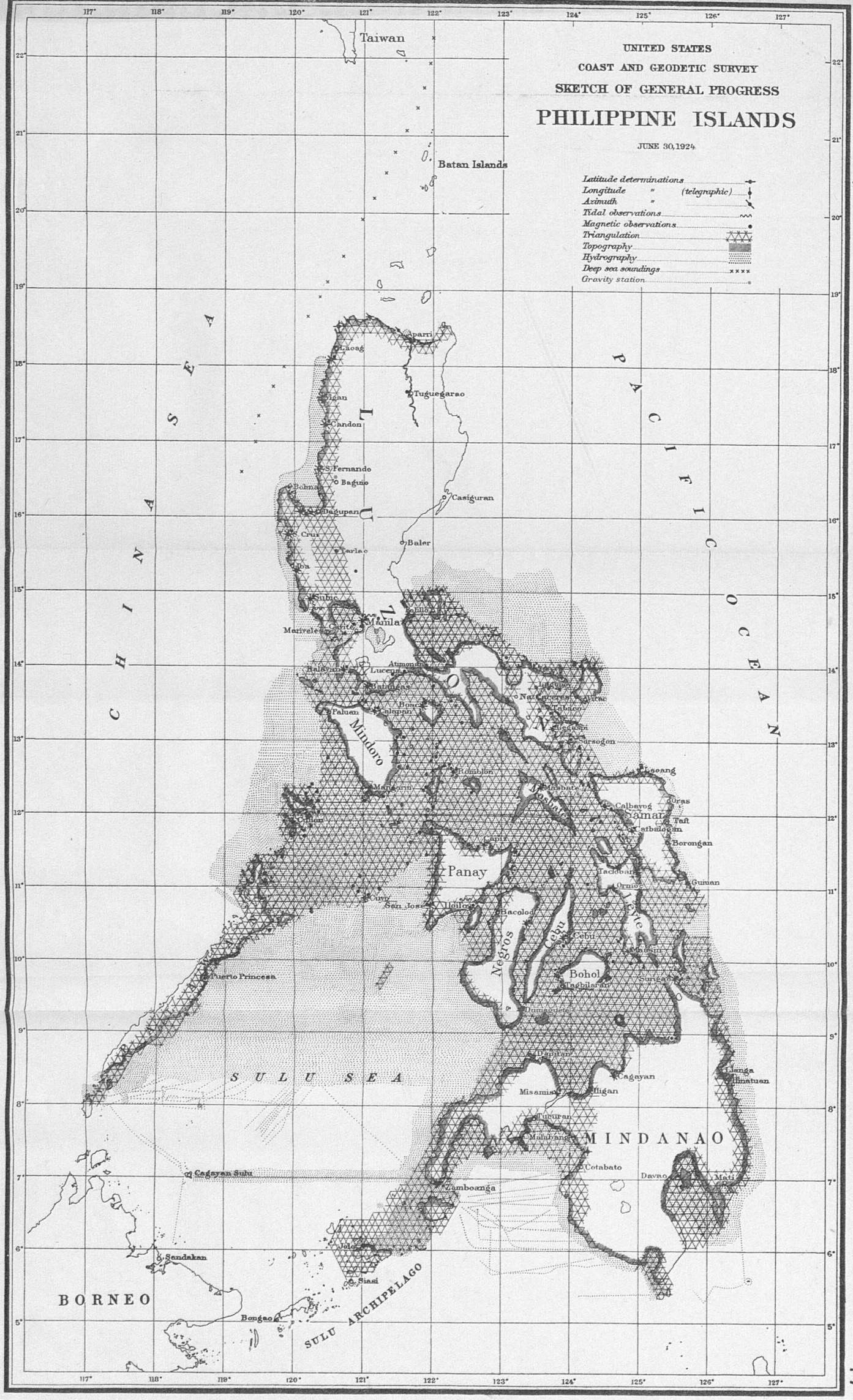
UNITED STATES
COAST AND GEODETIC SURVEY
SKETCH OF GENERAL PROGRESS
PHILIPPINE ISLANDS
JUNE 30, 1924
Latitude determinations
Longitude " (telegraphic)
Azimuth "
Tidal observations
Magnetic observations
Triangulation
Topography
Hydrography
Deep sea soundings
Gravity station
Taiwan
Batan Islands
CHINA SEA
PACIFIC OCEAN
LUZON
Aparri
Laoag
Tuguegarao
Candon
S. Fernando
Baguio
Casiguran
Dagupan
Baler
Tarlac
Iba
Subic
Manila
Cavite
Marivele
Balayan
Lucena
Batangas
Bosc
Calapan
Paluan
Mindoro
Romblon
Mangarin
Cullon
Panay
San Jose
Iloilo
Cuyo
Puerto Princesa
Bacolod
Negros
Cebu
Bohol
Tagbilaran
Dumaguete
Dapitan
Misamis
Iligan
Cagayan
Tucuran
Malabang
MINDANAO
Cotabato
Davao
Mati
Llanga
Ilinatuan
Zamboanga
Jolo
Siasi
Cagayan Sulu
Sandakan
BORNEO
Bongao
SULU ARCHIPELAGO
SULU SEA
Masbate
Calbayog
Samar
Oras
Taft
Catbalogan
Borongan
Tacloban
Ormoc
Guiuan
Leyte
Sorsogon
Tabaco
Vitac
Laoang
Lagonoy
Na. Caceres
Legaspi
Masbate
Capiz
Surigao
Dinagat
Cagayan
Iligan
Cotabato
Zamboanga
117° 118° 119° 120° 121° 122° 123° 124° 125° 126° 127°
22° 21° 20° 19° 18° 17° 16° 15° 14° 13° 12° 11° 10° 9° 8° 7° 6° 5°

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shore observations, and accordingly the charts do not show areas of local disturbances.

Unless it is found that the *Carnegie* can be put into active service and can find it possible to make more detailed observations in the waters adjoining the United States and the regions under its jurisdiction it will be necessary to provide a nonmagnetic vessel, preferably of moderate size. Pending such a solution of the problem it will be very desirable to continue along-shore determinations of declination, such as have been made during the year in California and Alaska.

TIDE AND CURRENT WORK

It has been recognized for a number of years that insufficient observations in tide and current work have been made in our principal harbors, and that the conditions, particularly in regard to currents, were not so well known as present engineering problems and sizes of modern vessels require. However, the surveys in New York Harbor in 1922 and in San Francisco Harbor in 1923, following during the coming fiscal year by surveys in Delaware Bay and tributaries and in the Inside Passage to Alaska in 1926, will bring this phase of the work fairly well in hand.

The field work of the New York Harbor survey was done in cooperation with the Army engineers charged with the development of that harbor, who stood half the expense of field operations, the Coast and Geodetic Survey making all office computations, discussing, interpreting, and publishing the resulting data. In the San Francisco survey the Army engineers in that district were unable to cooperate directly in the field work on account of shortage of personnel and equipment. The Navy Department, however, furnished a part of the floating equipment necessary to the survey.

Due to the fact that the currents in Seymour Narrows, British Columbia, are of the hydraulic type brought about by temporary differences of tidal action in head at the two ends of the strait, it is possible to make predictions on the tide-predicting machine of such currents by the analysis of tidal observations at the two ends.

While these straits are British Columbian waters, accurate predictions of the times of slack of the extremely strong currents are of considerable importance to United States vessels plying between our Pacific Northwest and southeastern Alaskan ports.

No satisfactory series of tidal observations for these analyses were available for each end of the Narrows, but the Canadian Tidal and Current Survey, with a fine spirit of cooperation and at the request of this bureau, obtained three months' of observations in the summer of 1923 and has furnished them to this office for analysis. From these observations it is expected to make a decided improvement in the predictions of slack water for this important thoroughfare.

Another example of cooperation in tidal and current work which has continued during this fiscal year between Canada, England, and the United States is the exchange of predictions for a number of ports, which are published both in the British Admiralty and the United States Tide Tables. Five stations were exchanged at the beginning of this arrangement; this number was increased to 9, and for the past fiscal year to 15 stations.

In order to obtain oceanographic data in the Arctic, this survey is cooperating with the National Geographic Society by the loan of a number of current and other oceanographic instruments to Capt. Robert A. Bartlett. Under the direction of the National Geographic Society, Captain Bartlett is going to northern waters on a summer cruise of the United States Coast Guard steamship *Bear*.

The Coast and Geodetic Survey is also cooperating with the department of operation and maintenance of the Panama Canal by the loan of instruments for the observations of currents on the lighthouse tender *Favorite* in the vicinity of Serrana Bank and Quita Suena Reef in the Caribbean Sea. The information obtained will be forwarded to this office for analysis.

The survey has had three requests from foreign countries for information relative to the portable automatic tide gauge recently developed by this bureau, with a view to its adoption in harbor work—from the Harbors Board of the Government of South Australia, at Adelaide; from the Rockhampton Harbors Board, Rockhampton, Queensland, Australia; and from the Harbor Department of Public Works, Rotterdam, Holland.

The funds available for tide and current work do not permit of extended observations in physical oceanography, comprising miscellaneous oceanographic observations and computations for the purpose of furnishing information on densities and temperatures of sea water, open ocean currents, and related matters, to navigators, engineers, and scientists. Little has been done on this subject except in a general way and of a reconnaissant nature. A study of the Gulf Stream is of considerable interest and value and may be considered as one of the most important matters in oceanography, not only to the United States whose shores it parallels, but to Europe as well. Considerable reconnaissance work was done for a number of years by this bureau in this important field, but lack of funds has held up any further work. Systematic current and other oceanographic observations should be continued by the survey in this oceanic river.

This office is using every available means for obtaining density and temperature of sea water along our coasts. They are being obtained at 18 of the principal tidal stations maintained by the bureau and on two light vessels, on which current observations are being made through the cooperation of the Lighthouse Service.

The officers charged with the work of the division of tides and currents are making every effort to reduce to a minimum the routine work necessary at this office. The desired results are gradually being accomplished by the devising of new instruments, methods, and forms for lessening this class of work. A burden on the division of this class of work, however, was added during the past fiscal year. Due to indications that some tide observers were being biased on entering comparative notes on marigrams due to their tabulating the records at the field stations, this tabulating has practically all been done at this office for the past year. The necessary means of precaution against the above practice having been worked out, the method of field tabulating has again been resumed at a number of tidal stations, and it is planned to allow all of this work to be handled by the field observers by the end of the next fiscal year.

CHAPTER III

PROGRAM FOR THE CURRENT FISCAL YEAR IN THE FIELD

HYDROGRAPHIC AND TOPOGRAPHIC WORK

ATLANTIC COAST.—*Offshore hydrography.*—The steamship *Lydonia* will be employed on offshore hydrography from Cape Fear to Winyah Bay during the summer season and southward of Matanzas Inlet on the Florida coast during the winter season. If funds are then available, the steamship *Ranger* will be employed upon similar work during the last part of the fiscal year after having completed the survey of the Virgin Islands.

Revisional surveys.—The steamship *Bache*, with one tender as an auxiliary, will be employed on a resurvey of the inshore waters along the coast from St. Augustine, Fla., to the Savannah River, Ga. This will include also a hydrographic survey of the sounds and bays along this stretch of the coast and a revision of the shore line and adjacent topography. The steamship *Hyrographer* will make a resurvey of Tampa Bay and approach, including tributaries. A resurvey of Baltimore Harbor and of a part of the coast in the vicinity of Fire Island Inlet, N. Y., are now in progress. Several small revisional surveys will be made along the northern Atlantic coast if funds are available.

Interior surveys.—A survey of Lake Okeechobee, Fla., begun last winter but discontinued late in the spring, will be resumed and carried to completion, if possible, next winter.

Virgin Islands.—The steamship *Ranger*, with three wire-drag launches, will continue the hydrographic survey of the waters of the Virgin Islands. This will include all harbors and the coastal waters to the seaward limit of all danger. It is believed that this survey will be completed before next spring, after which the vessel and launches will be available for work on the United States coast.

PACIFIC COAST.—*Offshore hydrography.*—The steamship *Guide* will be continued on the Oregon and California coasts, working in the vicinity of and southward from Cape Blanco during the summer season and northward of San Diego during the winter season. One of the western Alaska vessels, the *Discoverer* or *Pioneer*, will join the *Guide* on the southern California coast next winter, remaining on that work until time to take up work in Alaska next spring. The other western Alaska vessel will survey Monterey Bay and seaward to a depth of at least 1,000 fathoms during the winter months.

Revision surveys.—During the winter months several small revision surveys will be made at various places along this coast.

SOUTHEASTERN ALASKA.—The steamship *Surveyor* will be continued on original offshore and inshore hydrography, topography, and triangulation along the coast of Baranof Island. This work is part of

the project for the survey of the seacoast of southeastern Alaska. It begins at Dixon Entrance and should be completed to Sitka Sound this year. This survey will be continued each year until it has been completed to Cross Sound. The steamship *Explorer*, with three auxiliary launches, will be continued on detached surveys of the most important of the yet unsurveyed bays and arms within the so-called inside waters of southeastern Alaska.

WESTERN ALASKA.—The steamship *Discoverer* will continue on original hydrographic surveys, topography, and triangulation along the southern side of the Alaska Peninsula from Chignik northward. The *Discoverer* will be employed on similar work southward of Unga Island. Each ship will have one tender in addition to her regular launch equipment. It is desirable that both vessels be continued upon this work until the entire southern side of the peninsula and approaches from seaward have been surveyed. If funds are available for alterations and for operating expenses, the motor ship *Natoma* will be put in commission and used on original surveys in Prince William Sound.

HAWAIIAN ISLANDS.—Inshore hydrography will be continued by one party around the coast of Oahu, and if funds are available the work will be extended to other islands of the group.

PHILIPPINE ISLANDS.—Three steam vessels—the *Pathfinder*, *Fathomer*, and *Marinduque*—will continue the work now in hand until after a project has been adopted for the completion of the survey of the Archipelago. It is expected that before the close of this fiscal year such project will have been adopted. In general, the work for this year will be original surveys, triangulation, topography, and hydrography north of Luzon, between monsoons, and in the Sulu Sea and west of Palawan.

GEODETIC WORK

TRIANGULATION.—The work along the forty-ninth parallel will be continued during the fiscal year 1925. This is a 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 in running triangulation in northern Minnesota between Lake Namakan and Lake Superior. This project will complete the eastern section of the cooperative work with Canada, which provided for the execution of the traverse and triangulation by the United States from the Lake of the Woods to Lake Superior. A party will also run precise triangulation in Utah from Salt Lake to Needles.

Another project contemplated is a line of precise traverse in South Dakota, beginning at Mitchell and running to Chamberlin. From Chamberlin triangulation will be run westward to the one hundred and fourth meridian, thence to the one hundred and eleventh meridian.

Precise triangulation will be continued in Alaska along the arc beginning at the head of Cook Inlet and running to Fairbanks.

PRECISE TRAVERSE.—A precise traverse line will be run from the ninety-eighth meridian in the vicinity of Mitchell, S. Dak., to Cham-

berlin, S. Dak. Another line of traverse will be run in Texas from the vicinity of San Antonio westward to the Rio Grande River.

PRECISE LEVELING.—One leveling party will run a line of precise levels in New Jersey and Pennsylvania and another a line of levels in the earthquake region in California.

ASTRONOMY AND GRAVITY.—A number of Laplace stations will be established by a party working in California, Arizona, Texas, Oklahoma, and Colorado. No gravity work will be done during the fiscal year.

MAGNETIC WORK

PROPOSED FIELD WORK.—The magnetic resurvey of North Carolina will be completed during the first half of the year, work will be done in South Carolina and Georgia, and the magnetic resurvey and the occupation of county seats in Texas, where observations have not heretofore been made, will continue.

Repeat stations will be occupied in New England, the Middle Atlantic States, in the Northwestern States, and in the Hawaiian Islands.

A magnetic resurvey of the Philippine Islands will be made, with the cooperation of the insular government, and a survey of the Aleutian Islands, which will be carried on jointly with other work of the survey, will be started during the present fiscal year. This work is very urgently needed to meet the demands of vessels and to remedy defects in existing charts.

The observatories will continue their usual routine work. New construction in Porto Rico will make necessary the postponement of needed improvements at the other observatories. Their buildings and grounds will be maintained in as good condition as funds permit. Preliminary surveys of possible sites for the Porto Rico Observatory early in the year. The replacement of defective instruments will continue.

TIDE AND CURRENT WORK

During the months of July and August, 1924, it is proposed to make a comprehensive and final current and tide survey of Delaware Bay and tributaries 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 maintained at the following places:

1. Portland, Me.
2. Boston, Mass.
3. Atlantic City, N. J.
4. Philadelphia, Pa.
5. Baltimore, Md.
6. Washington, D. C.
7. Charleston, S. C.
8. Daytona, Fla.
9. Key West, Fla.
10. Cedar Keys, Fla.
11. Pensacola, Fla.
12. Galveston, Tex.
13. San Diego, Calif.
14. Los Angeles, Calif.
15. La Jolla, Calif.
16. San Francisco, Calif.
17. Seattle, Wash.
18. Duwamish River, Wash.
19. Olympia, Wash.
20. Honolulu, Hawaii.
21. Ketchikan, Alaska.
22. Valdez, Alaska.
23. Anchorage, Alaska.

These stations are for the purpose of determining the tidal planes of mean sea level for the control of precise level nets and for the

control also of hydrographic work on the coasts of the United States. Density and temperature observations will also be continued at these stations.

A tidal station will be established at Washington, D. C., for the purpose of obtaining tidal data for the upper reaches of the Potomac River and to furnish a means for testing new instruments and appliances for the observation of tides under the direct supervision of this office.

Preliminary arrangements have been made for establishing a tidal station at Daytona, Fla., when the new wharf being erected at that place is completed. This station will furnish tidal data for the extreme south Atlantic coast, replacing the station at Fernandina, which was continued as a principal station in June, 1924.

It is a part of the program of the tide and current work for the fiscal year to continue the installation of standard staffs and backing pieces to replace the old 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 is being made as the different stations are visited, until all the principal stations are so equipped.

Provided the present appropriation for the year permits, a precise level party will visit the locations of discontinued tidal stations along a section of the Atlantic coast 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 bureau of maintaining five standard marks at all stations having a year of observations, and one additional for each additional year of observations to a maximum of 10 standard marks. This work is necessary in order to perpetuate long series of observations which are now preserved by few nonregulation bench marks, many of which have been destroyed and others in danger of being lost. It is the program of the general tidal work of the bureau to extend this work over a long period and bring it gradually up to date by doing a small amount of work each year which the appropriation will warrant.

During the year tidal bench marks at San Francisco will be checked by levels with the tidal series and sufficient new standard bench marks established to bring the number up to the requirements as set forth above. In order to carry on this essential bench-mark 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 on Nantucket Shoals, Diamond Shoals, and Overfalls Light Vessels. On the Pacific coast current observations will be continued for the full year at Blunts Reef Light Vessel.

Respectfully,

E. LESTER JONES, *Director.*

To Hon. HERBERT HOOVER,
Secretary of Commerce.

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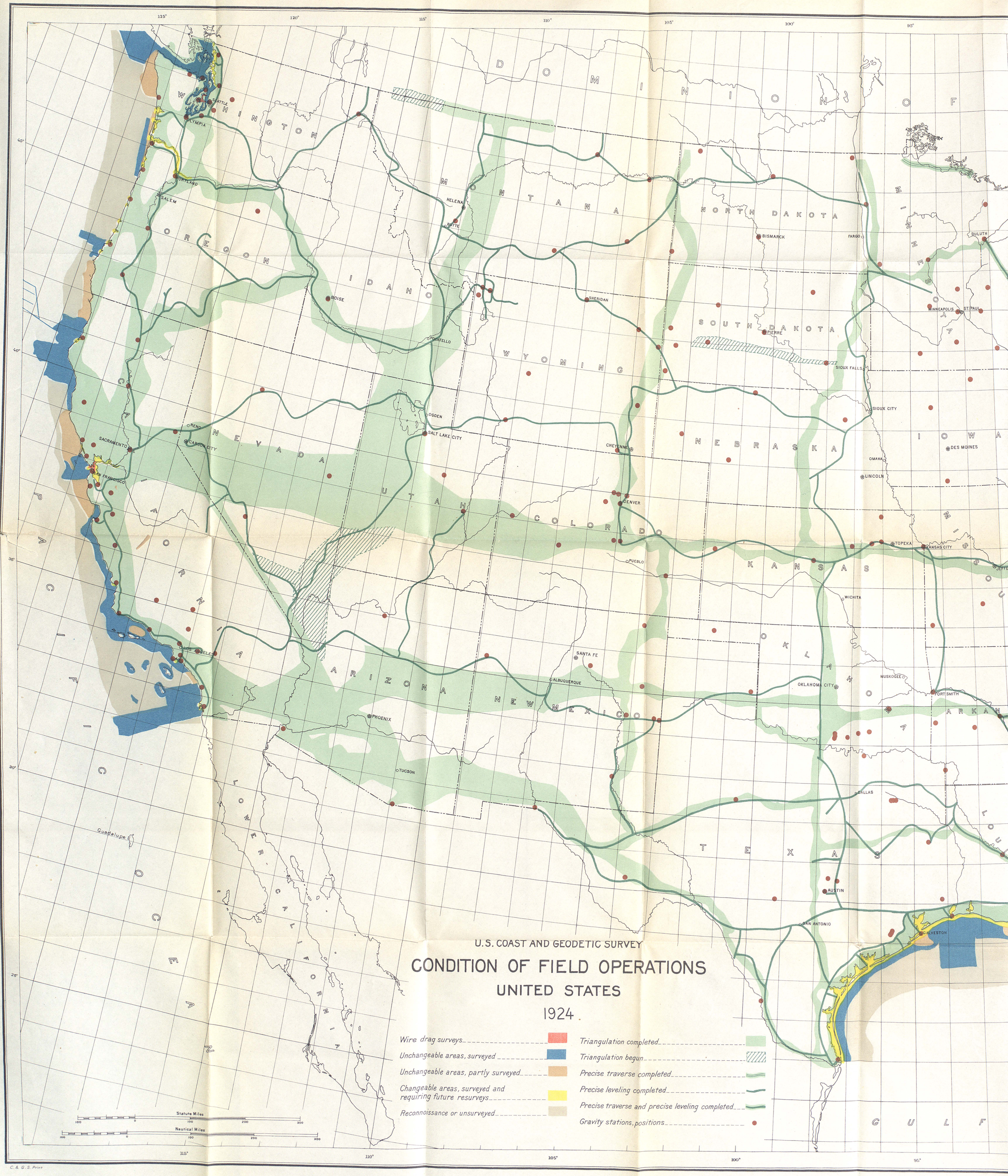
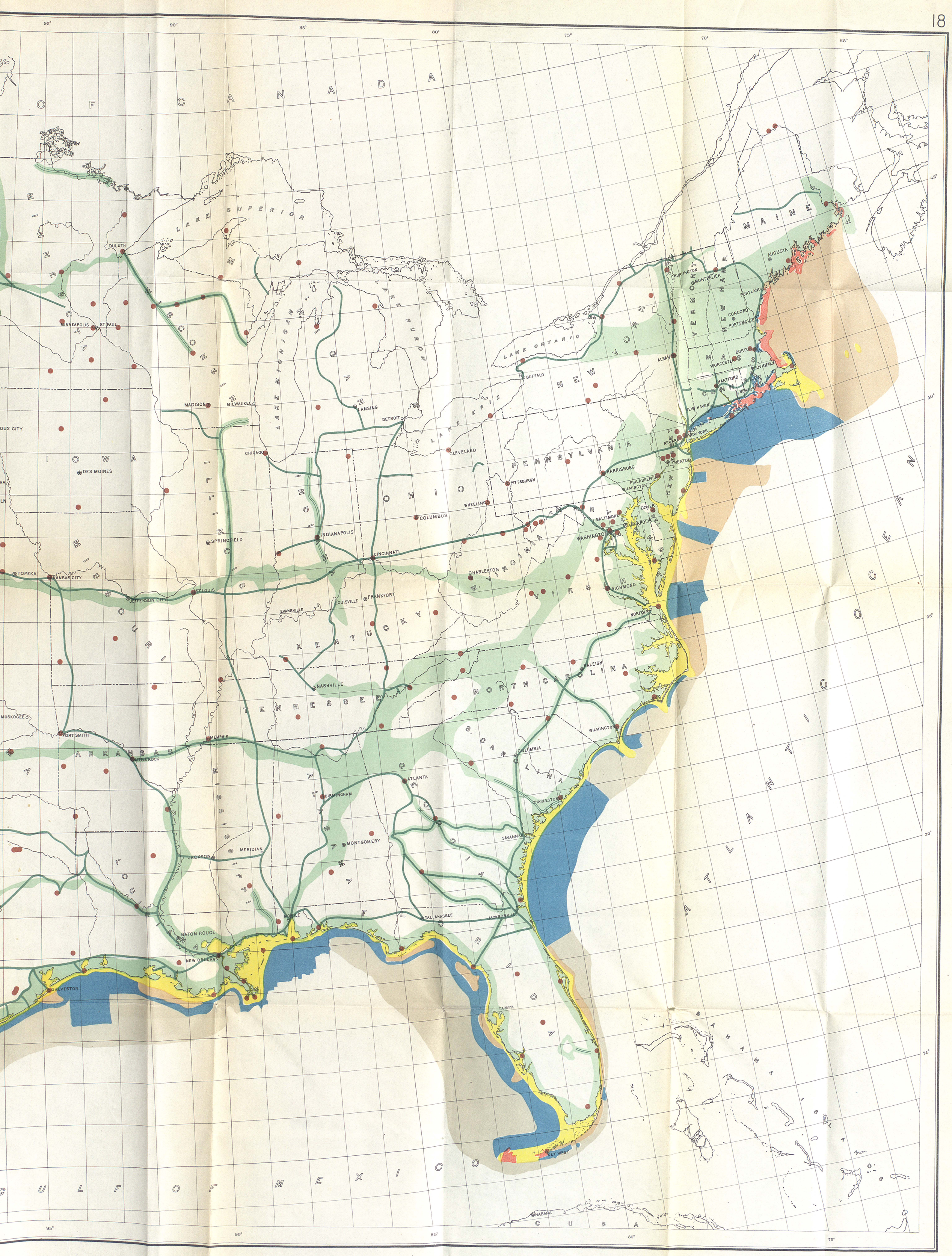
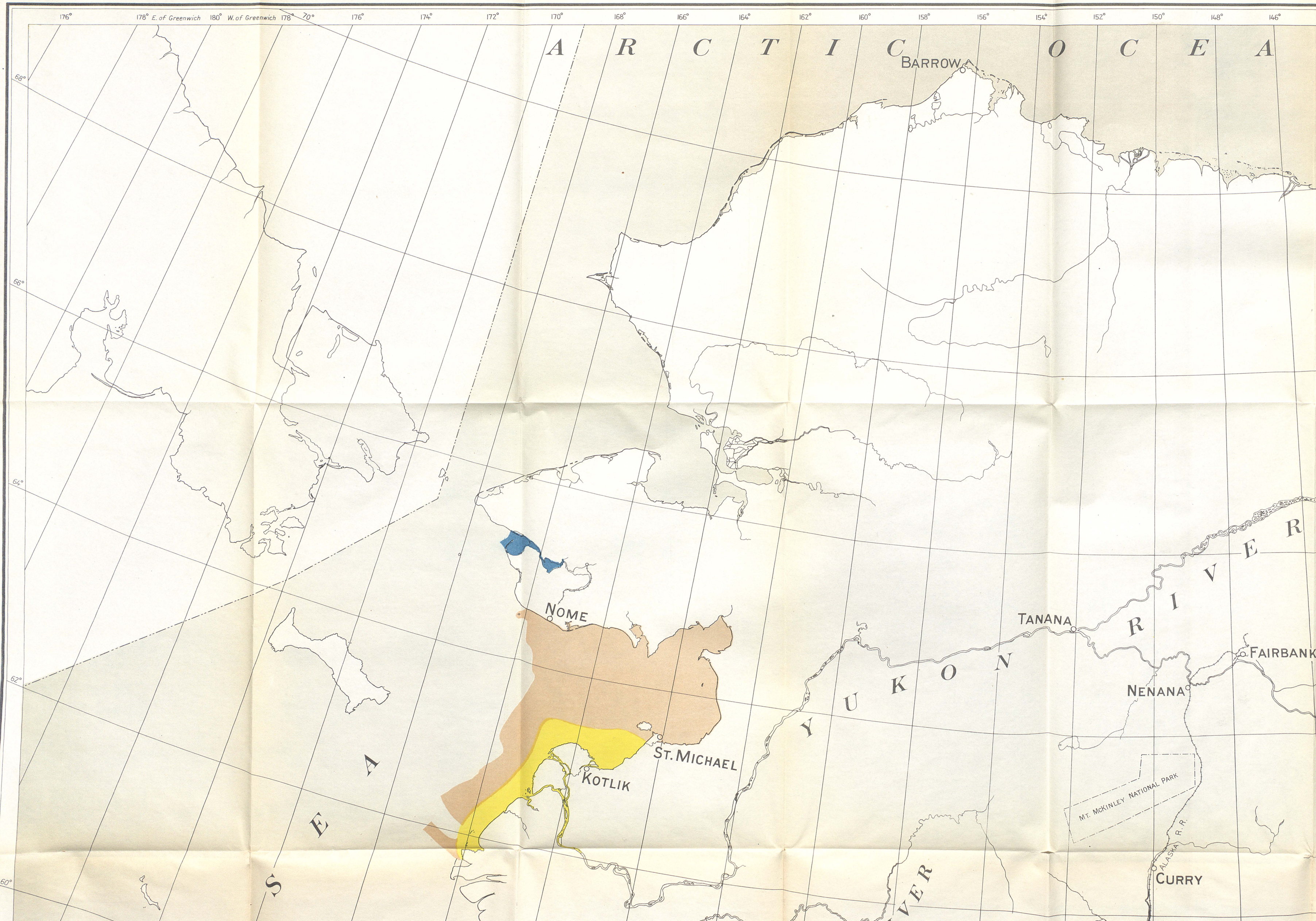
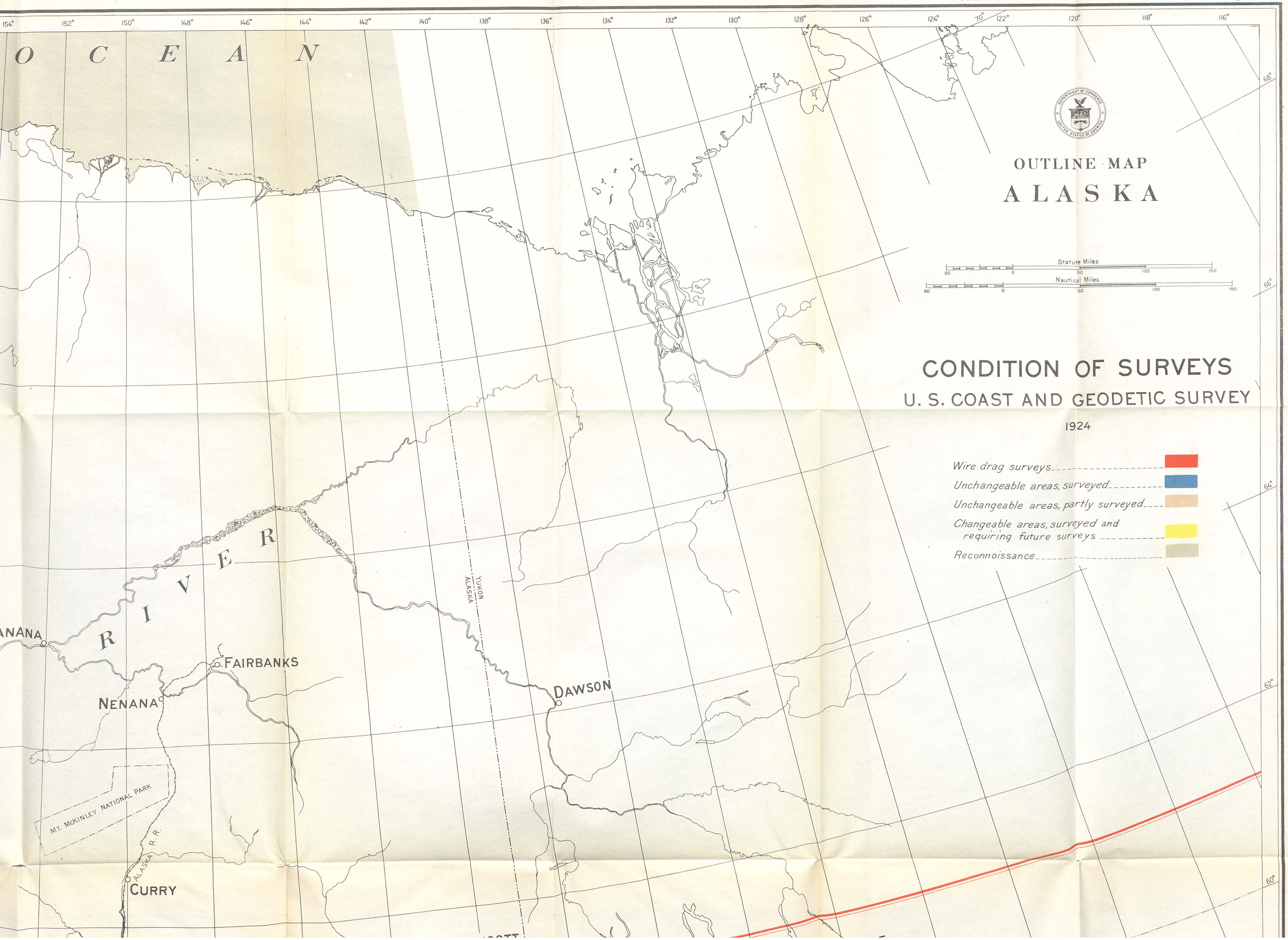

U.S. COAST AND GEODETIC SURVEY
CONDITION OF FIELD OPERATIONS
UNITED STATES
1924
Wire drag surveys
Unchangeable areas, surveyed
Unchangeable areas, partly surveyed
Changeable areas, surveyed and requiring future resurveys
Reconnoissance or unsurveyed
Triangulation completed
Triangulation begun
Precise traverse completed
Precise leveling completed
Precise traverse and precise leveling completed
Gravity stations, positions
Statute Miles
Nautical Miles
DOMINION OF CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
WYOMING
NORTH DAKOTA
SOUTH DAKOTA
MINNESOTA
NEBRASKA
IOWA
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
CALIFORNIA
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TEXAS
LOUISIANA
LOWER CALIFORNIA
PACIFIC OCEAN
GULF OF MEXICO
SEATTLE
OLYMPIA
PORTLAND
SALEM
HELENA
BUTTE
BISMARCK
FARGO
DULUTH
BOISE
POCATELLO
SHERIDAN
PIERRE
MINNEAPOLIS
ST. PAUL
SIOUX FALLS
SIOUX CITY
OGDEN
SALT LAKE CITY
RENO
CARSON CITY
SACRAMENTO
SAN FRANCISCO
CHEYENNE
DENVER
OMAHA
LINCOLN
DES MOINES
TOPEKA
KANSAS CITY
PUEBLO
WICHITA
LOS ANGELES
SANTA FE
ALBUQUERQUE
OKLAHOMA CITY
MUSKOGEE
FORT SMITH
PHOENIX
TUCSON
DALLAS
AUSTIN
SAN ANTONIO
GALVESTON
Guadalupe

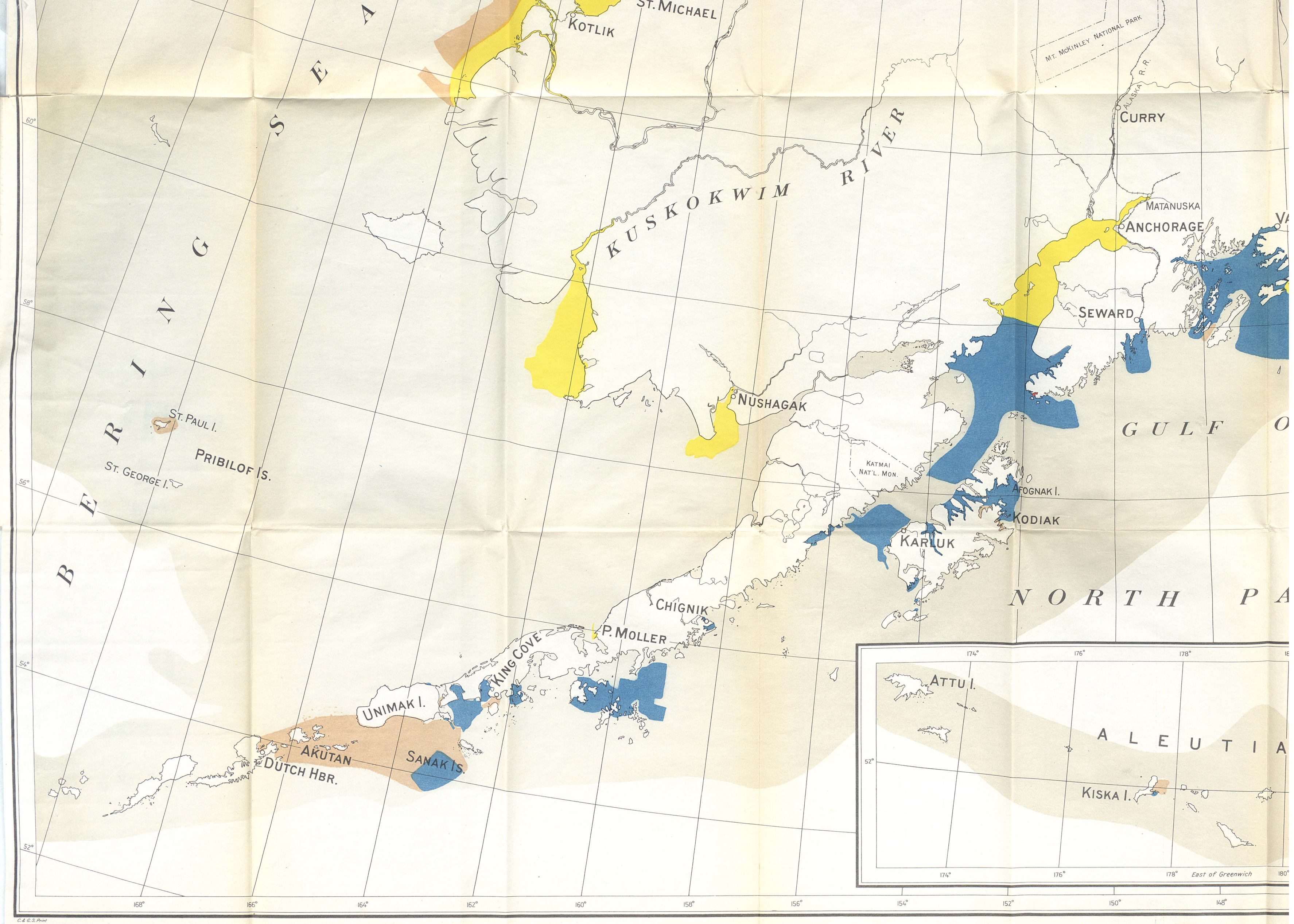
C. & G. S. Print


OF CANADA
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
MINNESOTA
WISCONSIN
MICHIGAN
IOWA
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA
NEW YORK
VERMONT
NEW HAMP.
MAINE
MASS.
CONN.
NEW JERSEY
DEL.
MARYLAND
VIRGINIA
W. VIRGINIA
KENTUCKY
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ALABAMA
FLORIDA
MISSISSIPPI
ARKANSAS
LOUISIANA
MISSOURI
KANSAS
NEBRASKA
S. DAKOTA
N. DAKOTA
ATLANTIC OCEAN
GULF OF MEXICO
BAHAMA ISLANDS
CUBA
DULUTH
MINNEAPOLIS
ST. PAUL
MADISON
MILWAUKEE
LANSING
DETROIT
CHICAGO
DES MOINES
BUFFALO
CLEVELAND
PITTSBURGH
WHEELING
COLUMBUS
INDIANAPOLIS
SPRINGFIELD
CINCINNATI
TOPEKA
KANSAS CITY
JEFFERSON CITY
ST. LOUIS
EVANSVILLE
LOUISVILLE
FRANKFORT
NASHVILLE
MEMPHIS
FORT SMITH
LITTLE ROCK
MUSKOGEE
JACKSON
MERIDIAN
MOBILE
BATON ROUGE
NEW ORLEANS
GALVESTON
BIRMINGHAM
MONTGOMERY
ATLANTA
TALLAHASSEE
JACKSONVILLE
TAMPA
KEY WEST
HABANA
CHARLESTON
COLUMBIA
WILMINGTON
RALEIGH
CHARLESTON
SAVANNAH
RICHMOND
NORFOLK
WASHINGTON D.C.
BALTIMORE
ANNAPOLIS
DOVER
WILMINGTON
PHILADELPHIA
HARRISBURG
TRENTON
NEWARK
NEW YORK
ALBANY
NEW HAVEN
HARTFORD
NEWPORT
PROVIDENCE
WORCESTER
BOSTON
PORTLAND
CONCORD
PORTSMOUTH
AUGUSTA
MONTPELIER
BURLINGTON
95°
90°
85°
80°
75°
70°
65°
45°
40°
35°
30°
25°

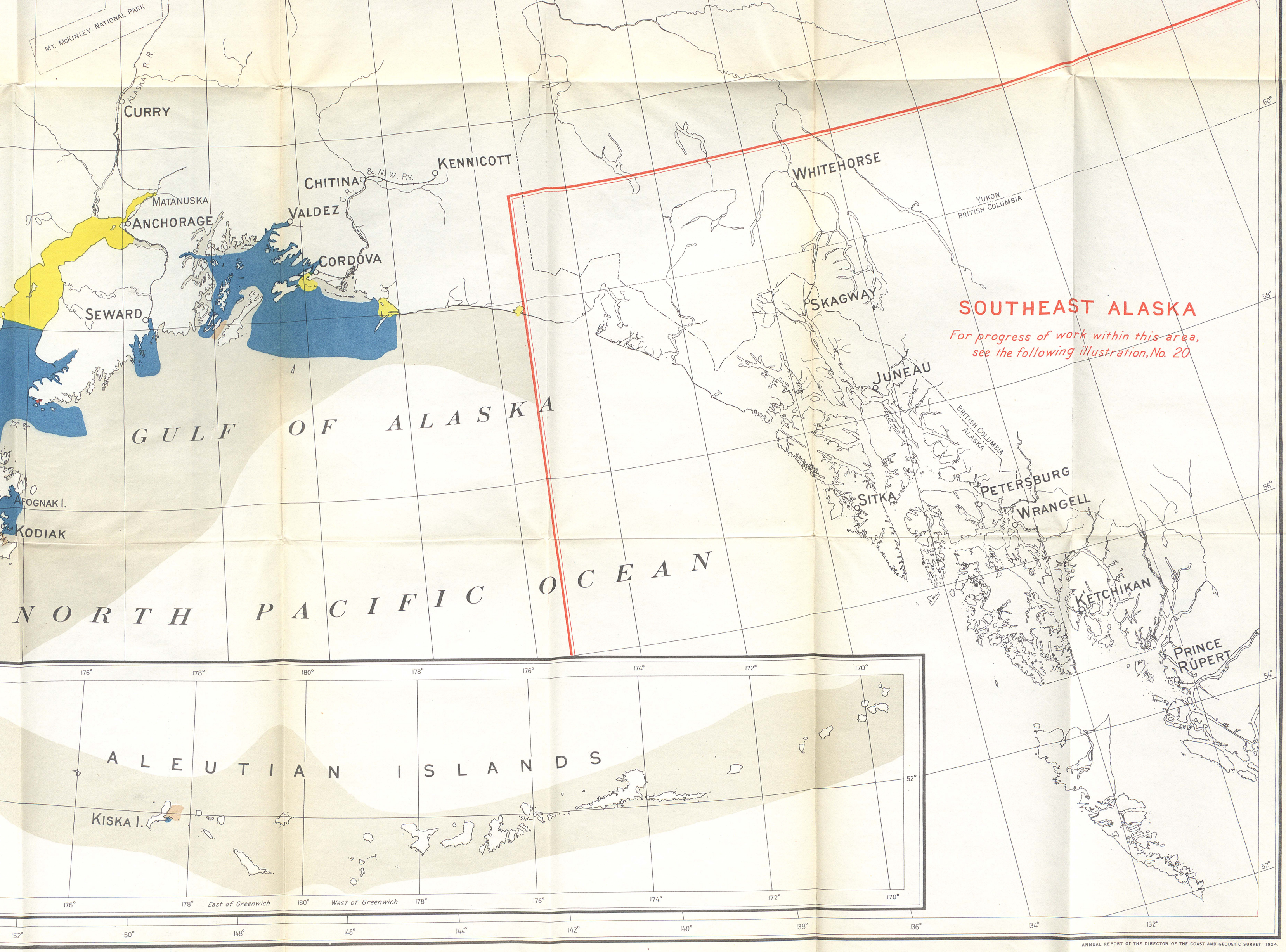

176°
178° E. of Greenwich
180° W. of Greenwich
178°
176°
174°
172°
170°
168°
166°
164°
162°
160°
158°
156°
154°
152°
150°
148°
146°
70°
68°
66°
64°
62°
60°
ARCTIC OCEAN
BARROW
NOME
ST. MICHAEL
KOTLIK
SEA
YUKON RIVER
TANANA
NENANA
FAIRBANK
MT. McKINLEY NATIONAL PARK
ALASKA R.R.
CURRY

Scale 2500000 Lambert Conformal Conic Projection




BERING SEA
KOTLIK
ST. MICHAEL
KUSKOKWIM RIVER
MT. McKINLEY NATIONAL PARK
ALASKA R.R.
CURRY
MATANUSKA
ANCHORAGE
SEWARD
NUSHAGAK
GULF O
ST. PAUL I.
PRIBILOF IS.
ST. GEORGE I.
KATMAI NAT'L. MON.
AFOGNAK I.
KODIAK
KARLUK
NORTH PA
CHIGNIK
P. MOLLER
KING COVE
UNIMAK I.
AKUTAN
DUTCH HBR.
SANAK IS.
ATTU I.
ALEUTIA
KISKA I.
East of Greenwich
60°
58°
56°
54°
52°
168°
166°
164°
162°
160°
158°
156°
154°
152°
150°
148°
174°
176°
178°
180°

C. & G. S. Print


MT. MCKINLEY NATIONAL PARK
ALASKA R.R.
CURRY
MATANUSKA
ANCHORAGE
SEWARD
VALDEZ
CHITINA
C.R. & N.W. RY.
KENNICOTT
CORDOVA
AFOGNAK I.
KODIAK
GULF OF ALASKA
NORTH PACIFIC OCEAN
WHITEHORSE
YUKON
BRITISH COLUMBIA
SKAGWAY
JUNEAU
BRITISH COLUMBIA
ALASKA
SITKA
PETERSBURG
WRANGELL
KETCHIKAN
PRINCE RUPERT
SOUTHEAST ALASKA
For progress of work within this area, see the following illustration, No. 20
ALEUTIAN ISLANDS
KISKA I.
East of Greenwich
West of Greenwich
60°
58°
56°
54°
52°
176°
178°
180°
178°
176°
174°
172°
170°
152°
150°
148°
146°
144°
142°
140°
138°
136°
134°
132°

141°
140°
139°
138°
137°
136°
135°
134°
60°
59°
58°
57°
56°
55°
54°
Mt. St. Elias 18,024
Mt. Augusta 13,947
Newton Gl.
Cascade Gl.
Agassiz Glacier
Marvine Gl.
Mt. Vancouver 15,676
Mt. Alverstone 14,493
Mt. Hubbard 14,950
Mt. Cook 13,755
Hubbard Gl.
10,092
Disenchantment Bay
Mt. Jette 8466
Malaspina Glacier
Russell Fiord
Nunatak Fiord
Mt. Aylesworth 9313
8776
Mt. Armour
7206
7990
6090
Mt. Herbert
YAKUTAT BAY
Yakutat
Situk R.
Ahrnklin R.
Dangerous R.
ALSEK RIVER
Alsek Glacier
DRY BAY
8837
10514
12495
Mt. Root 12938
Mt. Turner
8721
6867
Mt. Fairweather 15399
13561
Grand Plateau Gl.
Cape Fairweather
Lituya Bay
Icy Point
Dixon Hbr
Graves Hbr.
Cape Spencer
CROSS SOUND
Cape Bingham
Yakobi I
Cape Cross
Pt. Theodore
Pt. Urey
Cape Edward
Khaz B
SALISBURY SOUND
Shelikof B
KRUZOF I.
C Edgecumbe
SITKA SOUND
Mt. Foster 7122
7033
5926
Summit L.
White Pass 2904
6850
6700
Kelsall R.
6150
6325
Rose Cr.
6100
6580
5800
4525
Klehini River
Porcupine
Klukwan
Kalwatta
Chilkoot R.
Chilkat R.
Salmon R.
Taiya R.
Taiya Inlet
Skagway R.
Skagway
6695
6782
6379
7040
6927
6819
7148
Mt. Bagot
6576
Mt. Canning 6927
6819
7164
Mt. Poletica 7620
7847
7550
7446
Mt. Nesselrode 8105
7850
7406
Mt. Ogilvie 7700
7850
Devils Paw 8544
7424
5777
6196
6382
5863
6202
5704
5967
6461
8188
Carroll Gl.
Muir Glacier
Rendu Inlet
Queen Inlet
Berg L.
Reid Inlet
Muir Inlet
Tidal Inlet
Hugh Miller Inlet
GLACIER BAY
Geikie Inlet
Brady Glacier
Berg Bay
Bartlett Cove
Pt. Gustavus
Dundas Bay
Pt. Carolus
Taylor Bay
Icy Passage
Pleasant I.
Excursion Inlet
Lemesurier I
ICY STRAIT
Pt. Adolphus
Mud Bay
Idaho Inlet
Port Althorp
Port Frederick
Hoonah
Pt. Couverden
Chilkat Inlet
Chilkoot Inlet
LYNN CANAL
Comet
Berners Bay
St. James Bay
Amalga
Lincoln I.
Mansfield Peninsula
Funter
Hawk Inlet
Young B
STEPHENS PASSAGE
JUNEAU
Douglas
DOUGLAS I.
Gastineau Ch.
Oliver Inlet
TAKU INLET
Taku River
5867
6722
Speel River
Port Snettisham
Whiting R.
Taku
Snettisham
Pt. Augusta
Surge B.
Takanis B.
Lisianski Strait
Lisianski Inlet
Stag B.
Ilin Bay
CHICHAGOF ISLAND
Tenakee Inlet
Freshwater Bay
Tenakee
False B.
Gypsum
Deep B.
Portlock Hbr.
Patterson B.
Hoonah Sound
South Passage Pt.
Basket B.
Ushk B.
PERIL STRAIT
Rodman B.
Slocum Arm
Deep Bay
Suloia B.
Peril Str.
Fish Bay
Saook B.
Kelp Bay
Nakwasina Pas
Kasnyku B.
Takatz B.
Katlian B.
Salmer B.
Sukoi Inlet
Hayward Str.
Sitka
Baranof
Warm Spr. B.
Cascade B.
Silver Bay
Deep Inlet
Nelson B.
Redoubt Lake
Red Bluff B.
Crawfish Inlet
Hoggatt B.
Gut Bay
Necker Bay
Whale Bay
Small Arm
Great Arm
Rakovoi B.
Port Banks
Still Harbor
Patterson B.
Pt. Patterson
Close Bay
Sandy B
Snipe B
Port Herbert
Redfish B.
Big Branch B.
Little Br. B.
Port Lucy
Port Conclusion
Puffin B
Laren B
CAPE OMMANEY
BARANOF ISLAND
CHATHAM STRAIT
ADMIRALTY ISLAND
Windfall Hbr.
Seymour Canal
Glass Peninsula
Mole Hbr.
Kootznahoo Inlet
Killisnoo
Hood Bay
Gambier Bay
Chaik Bay
Pybus Bay
Whitewater Bay
Wilson Cove
Herring Bay
Eliza Hbr.
Pt. Gardner
Tyee
FREDERICK SOUND
HOLKHAM BAY
Sumdum 3110
Pt. Hugh
Tracy Arm
Cape Fanshaw
Cape Bendel
Kake
KUPREANOF ISLAND
Hamilton B
Keku Strait
Saginaw B.
Security B.
Washington B.
Pt. Kingsmill
Bay of Pillars
Threemile Arm
KUIU ISLAND
Tebenkof Bay
Gedney Hbr.
Reids B.
Port Malmesbury
Port Beauclerc
Affleck Canal
Bear Hbr.
Kell B
Port McArthur
Pt. Barrie
Strait I
SUMNER STRAIT
Pt. Baker
Port Protection
Labouchere B.
Calder P.
Shipley B.
Kosciusko Island
Holbrooks
Edna B
Davidson Inlet
Cape Decision
Hazy Islands
Coronation I
Sea Otter Sound
Heceta Island
Tonowek B.
Gulf of Esquibel
Portillo Ch.
Noyes I.
Lulu I.
Cape Addington
St. Nicholas Ch.
Baker I
Bucareli Bay
Cape Bartolome
Forrester I

C. & G. S. Print

U. S. COAST AND GEODETIC SURVEY
PROGRESS MAP
SOUTHEAST ALASKA
1924
Wire drag surveys
Unchangeable areas, surveyed
Unchangeable areas, partly surveyed
Changeable areas, surveyed and requiring future surveys
Reconnoissance
Areas tinted red show portions of the main steamer route made safe by the use of the wire drag.
DEPARTMENT OF COMMERCE
UNITED STATES OF AMERICA
135°
134°
133°
132°
131°
130°
129°
60°
59°
58°
57°
56°
55°
54°
Mt. Foster
Skagway
Mt. Bagot
Mt. Canning
Mt. Poletica
Mt. Nesselrode
Mt. Ogilvie
Devils Paw
Mt. Ogden
Taiya Inlet
Chilkat Inlet
Chilkoot Inlet
LYNN CANAL
Berners Bay
St. James Bay
JUNEAU
Douglas
DOUGLAS I.
STEPHENS PASSAGE
ADMIRALTY ISLAND
CHATHAM STRAIT
BARANOF ISLAND
Sitka
FREDERICK SOUND
KUPREANOF ISLAND
KUIU ISLAND
Mitkof I.
Wrangell
Zarembo I.
Wrangell I.
Etolin Island
SUMNER STRAIT
STIKINE RIVER
Kosciusko Island
PRINCE OF WALES ISLAND
CLARENCE STRAIT
CLEVELAND PENINSULA
REVILLAGIGEDO ISLAND
BEHM CANAL
Ketchikan
Annette I.
Duke I.
PORTLAND CANAL
PORTLAND INLET
Stewart
Pearse Island
DALL ISLAND
CAPE OMMANEY
Cape Decision
Cape Addington
Cape Bartolome
CAPE MUZON
Cape Chacon
Cape Fox
Dundas I.
Port Simpson
CHATHAM SOUND
Prince Rupert
SKEENA RIVER
Nass River
DIXON ENTRANCE
GRAHAM I.
Porcher I.