ANNUAL REPORT

OF THE

SUPERINTENDENT, UNITED STATES COAST AND GEODETIC SURVEY

TO THE

SECRETARY OF COMMERCE

FOR THE

FISCAL YEAR ENDED JUNE 30, 1916

Rarebook
QB
296
.U5
1916
LIBRARY
MAY 17 2001
National Oceanic &
Atmospheric Administration
U.S. Dept. of Commerce

WASHINGTON
GOVERNMENT PRINTING OFFICE
1916

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

ERRATA NOTICE

One or more conditions of the original document may affect the quality of the image, such as:

Discolored pages
Faded or light ink
Binding intrudes into the text

This has been a co-operative project between the NOAA Central Library, the Office of Coast Survey and the National Geodetic Survey. To view the original document please contact the NOAA Central Library in Silver Spring, MD at (301) 713-2607 x124 or www.reference@nodc.noaa.gov.

LASON
Imaging Contractor
12200 Kiln Court
Beltsville, MD 20704-1387
March 22, 2005

Persons on a regular mailing list of the Department of Commerce should give prompt notice to the "Division of Publications, Department of Commerce, Washington, D. C.," of any change of address, stating specifically the form of address in which the publication has previously been received, as well as the new address. The Department should also be advised promptly when a publication is no longer desired.

Persons receiving publications which are not desired, or for which they have only a temporary use, are requested to notify the Division of Publications, and franked mailing slips will be forwarded for their return.

CONTENTS.

Page.

Introduction 7

Part I.—ORGANIZATION, FUNCTIONS, AND NEEDS OF THE BUREAU.

Present organization of the Bureau 8
Office of assistant in charge 8
Division of hydrography and topography 9
Division of geodesy 10
Division of charts 11
Division of terrestrial magnetism 11
Division of accounts 11
Some benefits resulting from reorganization 12
Details required in preparing a nautical chart 13
Need of modern building 15
Essential improvements needed in present buildings 18
Freight elevator for printing office 18
Elevator for Butler Building 18
Individual motors for lathes in machine shop 19
Drafting tables and other furniture 19
Waterproofing vaults 20
Increase needed in numbers and salaries of computers, draftsmen, instrument makers, pattern makers and carpenters, and librarian 20
Office work and insufficient clerical help 22
Publicity officer and systematic distribution of publications 25
Printing office needs 26

Part II.—URGENT NEEDS IN THE FIELD AND NECESSARY EXPANSION OF THE WORK.

Need of 48 additional hydrographic and geodetic engineers 27
Increase in salaries for hydrographic and geodetic engineers 28
Greater necessity for wire-drag work 35
Two new vessels for Pacific coast and Alaska 35
Government-owned launches needed 36
Increase of pay of men on vessels 37
Geodetic work 39
Primary triangulation needed in Alaska 40
Precise leveling needed in Alaska 40
Improvements in precise-leveling methods and instruments 41
Value and need of magnetic observatories 42
Condition of hydrographic, geodetic, and other surveys in the United States and Alaska 43
New suboffices 44
Retirement 44
Purchase of Dutch Harbor, Alaska, as a Government base 44

Part III.—STATEMENT FOR PAST YEAR OF ACCOMPLISHED FIELD AND OFFICE WORK, ACCOMPANIED BY ILLUSTRATIONS AS REQUIRED BY STATUTE SHOWING PROGRESS MADE.

Division of hydrography and topography 45
Field work, Atlantic coast 45
Field work, Pacific coast 47
Field work, Philippine Islands 49
Assistance rendered 50
New vessels for the Survey 51
Section of field work 52
Section of field records 53
Section of vessels and equipment 53
Coast-pilot work 54
Tides and currents 55

	Page.
Division of geodesy	55
Field work	55
Office work	58
Division of terrestrial magnetism	59
Field work	59
Observatory work	61
Observatory buildings	61
Office work	62
Publications	63
Appropriations and disbursements	64
Surveys requested	65
Special duty	66
International Geodetic Association	66
Verification of speed-trial course for submarines in Cape Cod Bay	66
Current observations in Cape Cod Canal	66
Mississippi River Commission	66
Determination of latitude and longitude at Rochester, N. Y.	66
Determination of elevation of two points in District of Columbia	67
Determination of latitude on Kentucky-Tennessee boundary	67
Exhibit of Coast and Geodetic Survey at Panama-Pacific Exposition	67
Survey of military reservations at Orca Inlet, Alaska	67
Celebration of centennial of United States Coast and Geodetic Survey, and exhibit in connection therewith, held at United States National Museum	67
Exhibit of Coast and Geodetic Survey at meeting of United States Chamber of Commerce	67
Exhibit at National Motor Boat Show, New York	68
Exhibit of Coast and Geodetic Survey at fish fair at Eastport, Me.	68
Exhibit of Coast and Geodetic Survey at "safety-first" exposition	68
Details of field operations	68
Atlantic coast	68
Pacific coast	92
Interior States, geodetic work	94
Magnetic work	111
Alaska	115
Porto Rico	135
Hawaii	136
Philippine Islands	136
Special duty	148
INDEX	157

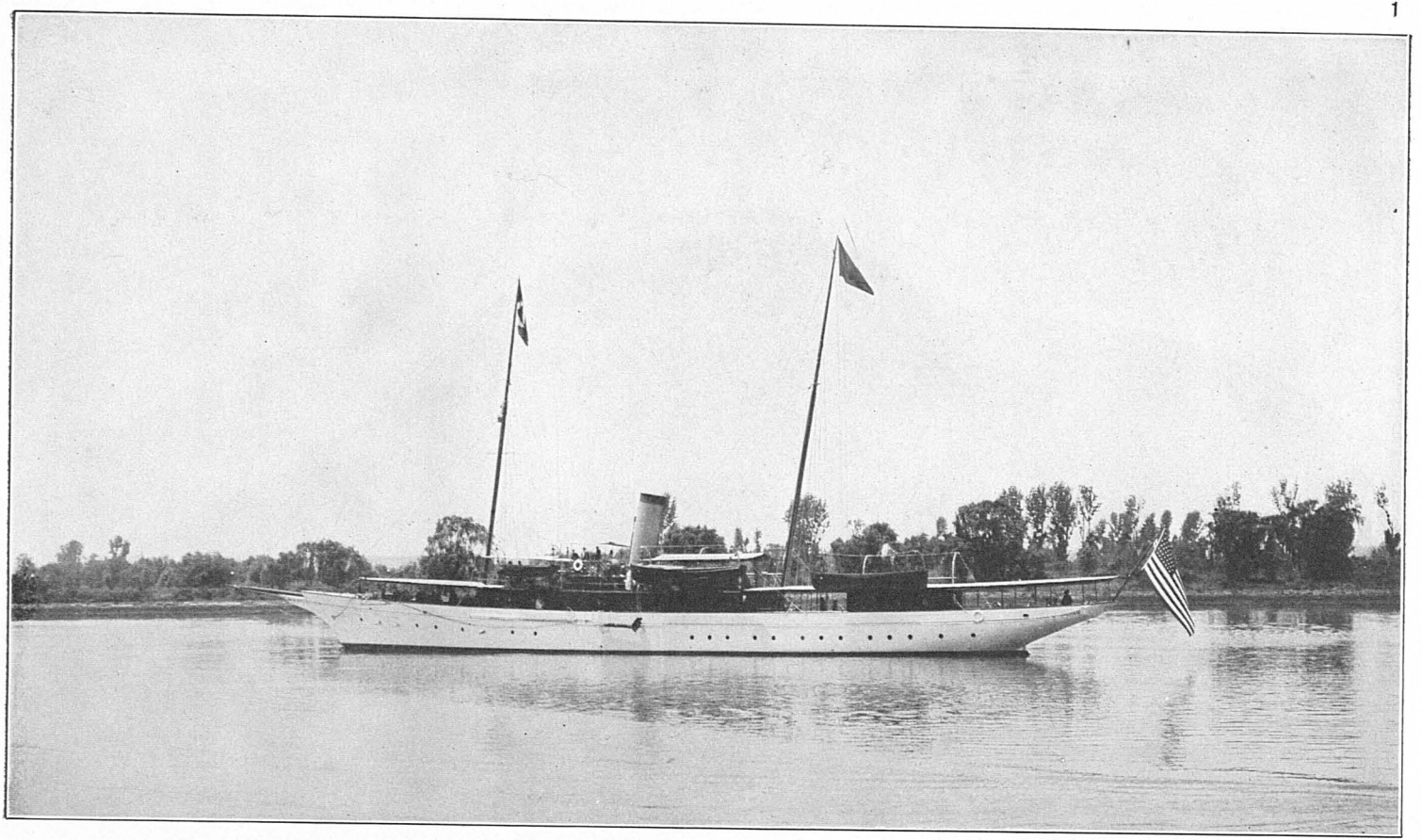
ILLUSTRATIONS.

	Facing page.
1. Survey steamer *Isis*	7
2. Organization diagram	11
3. Diagram showing output of nautical charts	12
4. Material necessary in construction of chart of Cook Inlet, Alaska	14
5. Filing original field sheets	16
6. Method of moving original sheets	16
7. Lower front view of office building	17
8. Method of carrying paper to presses	18
9. Carrying copper plates	19
10. Machine shop	19
11. New electric signal lamp	21
12. Diagram showing output of Coast Pilots	26
13. Comparative diagram of engineers' salaries	30
14. Important find by wire drag, Salem Harbor, Mass.	35
15. Improved form of wire drag	35
16. Some wire-drag discoveries in Alaska, 1916	35
17. Launching of Survey steamer *Surveyor*	36
18. Triangulation needed in Alaska	40
19. Precise leveling needed in Alaska	40
20. Motor velocipedes	41
21. New precise leveling rod, details of construction	42
22. New precise leveling rod, general view	42
23. 1916 hydrographic and topographic surveys, Maine to New Jersey	42

Facing page.

24. 1916 hydrographic and topographic surveys, New Jersey to North Carolina. 42
25. 1916 hydrographic and topographic surveys, North Carolina to east coast of Florida. 42
26. 1916 hydrographic surveys, Gulf of Mexico. 42
27. 1916 hydrographic and topographic surveys, southeastern Alaska. 42
28. 1916 hydrographic and topographic surveys, vicinity of Cordova, Prince William Sound, Alaska. 42
29. 1916 triangulation, gravity, and tide stations, United States. 42
30. 1916 precise leveling, magnetic stations, latitude, longitude, and azimuth stations, United States. 42
31. General progress map, United States, hydrography, triangulation, precise leveling, etc. 42
32. General progress map, Alaska, hydrography. 42
33. Steamer *Bache*. 45
34. Steamer *Hydrographer*. 47
35. Schooner *Matchless*. 49
36. Progress sketch, Alaska, triangulation. 114
37. Progress sketch, Alaska, topography. 114
38. Progress sketch, Alaska, gravity, latitude, longitude, azimuth, and tides. 114
39. Progress sketch, Alaska, magnetic observations. 114
40. Steamer *Patterson*. 117
41. Steamer *Explorer*. 119
42. Steamer *Gedney*. 121
43. Steamer *McArthur*. 123
44. Steamer *Taku*. 125
45. Steamer *Yukon*. 127
46. Progress sketch, Porto Rico. 134
47. Progress sketch, Hawaiian Islands. 134
48. Progress sketch, Philippine Islands. 134
49. Steamer *Pathfinder*. 137
50. Steamer *Fathomer*. 139
51. Steamer *Romblon*. 141
52. Steamer *Marinduque*. 143
53. Steamer *Research*. 145

Blank page retained for pagination



ISIS.

Steel steam vessel of 377 gross tons and 256 net tons; registered length 180.4 feet, breadth 24.8 feet, draft 11.7 feet; indicated horsepower 2,000; speed 15 knots; coal capacity 120 tons; complement 8 officers and 44 men. Purchased by the United States Coast and Geodetic Survey July 1, 1915. Present duty, offshore hydrography on the South Atlantic coast of the United States.

REPORT

OF THE

SUPERINTENDENT, U. S. COAST AND GEODETIC SURVEY.

DEPARTMENT OF COMMERCE,
COAST AND GEODETIC SURVEY,
Washington, October 5, 1916.

SIR: There is submitted herewith my annual report as Superintendent of the United States Coast and Geodetic Survey for the fiscal year ended June 30, 1916.

INTRODUCTION.

In my annual report for the year ended June 30, 1915, Part I dealt with the needs of the Bureau and Part II with the field and office work. The present report is divided into three parts as follows:

Part I outlines the functions of the Bureau, its reorganization, the branches into which it is divided, their functions, what has been accomplished in the office during the year just passed, and the needs of the office.

Part II deals with the urgent needs in the field and necessary expansion of the work.

Part III is a detailed statement for the past year of accomplished field and office work of the Bureau, accompanied by illustrations as required by statute, to show the progress made.

Part I.—ORGANIZATION, FUNCTIONS, AND NEEDS OF THE BUREAU.

The organic act establishing this Bureau was approved February 10, 1807 (2 Stat. L., 413), and is as follows:

AN ACT To provide for surveying the coasts of the United States.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the President of the United States shall be, and he is hereby authorized and requested, to cause a survey to be taken of the coasts of the United States, in which shall be designated the islands and shoals, with the roads or places of anchorage, within twenty leagues of any part of the shores of the United States; and also the respective courses and distances between the principal capes, or head lands, together with such other matters as he may deem proper for completing an accurate chart of every part of the coasts within the extent aforesaid.

SEC. 2. *And be it further enacted,* That it shall be lawful for the President of the United States to cause such examinations and observations to be made, with respect to St. George's bank, and any other bank or shoal and the soundings and currents beyond the distance aforesaid to the Gulf Stream, as in his opinion may be especially subservient to the commercial interests of the United States.

SEC. 3. *And be it further enacted,* That the President of the United States shall be, and he is hereby authorized and requested, for any of the purposes aforesaid, to cause proper and intelligent persons to be employed, and also such of the public vessels in actual service, as he may judge expedient, and to give such instructions for regulating their conduct as to him may appear proper, according to the tenor of this act.

SEC. 4. *And be it further enacted,* That for carrying this act into effect there shall be, and hereby is appropriated, a sum not exceeding fifty thousand dollars, to be paid out of any monies in the treasury, not otherwise appropriated.

The provisions of this act have been modified and added to from time to time until at present, broadly speaking, the functions of this Bureau are to make surveys of the coasts of the United States, Alaska, and our island possessions in order to procure data for accurate charts which will show the coast lines and such topography as is necessary for the needs of the navigator, the depths of water along these various coasts, with such accompanying coast pilots, sailing directions, and tide tables as are necessary to enable the mariner safely to traverse these waters.

It is also the duty of this Bureau to establish magnetic meridian lines and to furnish for surveyors, engineers, and others fundamental elevations and geographic positions in the interior of the United States and Alaska, and to make gravity observations.

PRESENT ORGANIZATION OF THE BUREAU.

For the accomplishment of these purposes, the Bureau has been organized since my last report into divisions and sections as follows:

OFFICE OF ASSISTANT IN CHARGE.

This division has charge of the upkeep and management of the buildings occupied by the Bureau, the purchase and distribution of

all instruments and miscellaneous supplies for the office. It receives and accounts for all moneys realized from the sale of publications, condemned property, and for work done for outside parties. It also has charge of the time records of the entire personnel of the Bureau and of the freight and express shipments made to and from the office at Washington.

Attached to the Office of the Assistant in Charge are the following sections, each under the direct supervision of a chief: (1) Section of instruments; (2) section of printing and sales; (3) section of library and archives; and (4) section of miscellaneous. The functions of these various sections are outlined below:

Section of instruments.—The chief of this section designs, makes drawings for, and supervises the construction of new instruments and parts thereof which are required in the operations of the Service. This section is charged with the responsibility, care, upkeep, issue, and accounting for all instruments and general property of the Service; also their packing, unpacking, shipping, and receipt.

Section of printing and sales.—This section attends to the printing of charts from the copper or aluminum plates on plate and lithographic printing presses and the sale and distribution of these charts and other nautical publications.

As a part of the office of the Assistant in Charge, and closely related to the printing and sales section, there is maintained a shop where electrotypes are made of the copper printing plates.

Section of library and archives.—This section has the keeping of the original records of field observations, the office computations and adjustments, and the technical library of books and periodicals maintained by the Bureau.

Section of miscellaneous.—This section is charged with the purchase of the supplies and equipment for the office work and certain supplies and equipment for the field parties. It maintains a store of stationery for the office and field forces, as well as the necessary blank books for field observations.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY.

Under this division are carried on the various hydrographic and topographic surveys and resurveys along the coasts of the United States, Alaska, and our insular possessions, principally Porto Rico, Hawaiian Islands, and the Philippines, and approaches to the Panama Canal. This division also has the supervision of the Bureau's four suboffices, located at New York, Galveston, San Francisco, and Seattle, and the office at Manila.

This division is subdivided into the following sections under separate chiefs and all under the general direction of the chief of the division: (1) Section of field work; (2) section of field records; (3) section of vessels and equipment; (4) section of coast pilot; and (5) section of tides and currents. The duties assigned to these various sections are as follows:

Section of field work.—The chief of this section prepares outlines of survey projects, formulates plans for their execution, advises the division on the conduct of all field operations, and has charge of the division in the absence of his chief.

Section of field records.—In this section the records of the field observations made under the direction of the division of hydrography and topography are reviewed, departures from approved methods are indicated for correction, and practices worthy of general adoption are noted for the use of the Service. In cooperation with the other sections of the division, especially the section of field work, the results of the examination of the field records are utilized in planning and directing the field work.

Section of vessels and equipment.—This section has charge of the purchase and maintenance of vessels and all equipment of hydrographic and topographic parties. It prepares plans and specifications, and supervises the repairs to the fleet and the construction of new vessels. Its duties include frequent inspection of the vessels, their equipment and personnel.

Section of coast pilot.—This section collects information for and compiles the Coast Pilots and Inside Route Pilots for the coasts of the United States, Alaska, and our insular possessions. The field work of the section enables its members to advise the chief of the division of the condition of the surveys and discrepancies in the published charts.

Section of tides and currents.—This section, from data obtained from observations made at the different tidal and current stations maintained by the Bureau, and from all other available sources, prepares the annual Tide Tables, and furnishes all tidal and current data for other nautical publications of the Survey and for the public.

DIVISION OF GEODESY.

This division is under the supervision of a chief and an assistant chief. The province of the division of geodesy is principally the extension of the network of precise leveling throughout the United States and Alaska for the control of levels run by other Government bureaus and by State and city officials, as well as by private individuals and corporations; the determination of geographic positions by triangulation or traverse for the control of Federal, State, and county boundaries, and other engineering work in all parts of the United States and Alaska; also the determination of field astronomic positions and the establishment of stations at which the intensity of gravity is determined.

The triangulation and traverse done in the interior of the United States and of Alaska are of a primary nature and are used as bases of control for the detailed triangulation and traverse by organizations which are making topographic or other surveys. Along the coasts the triangulation done by the Survey comes either directly or indirectly under the division of geodesy. It is of a detailed nature, intended for the control of topographic and hydrographic surveys made by the field parties of the Bureau in the construction of nautical charts.

These may be considered the field operations of the division.

In the office the observations made in the field are computed and adjusted and the results are prepared for publication, in order that they may be available for anyone who needs to use them.

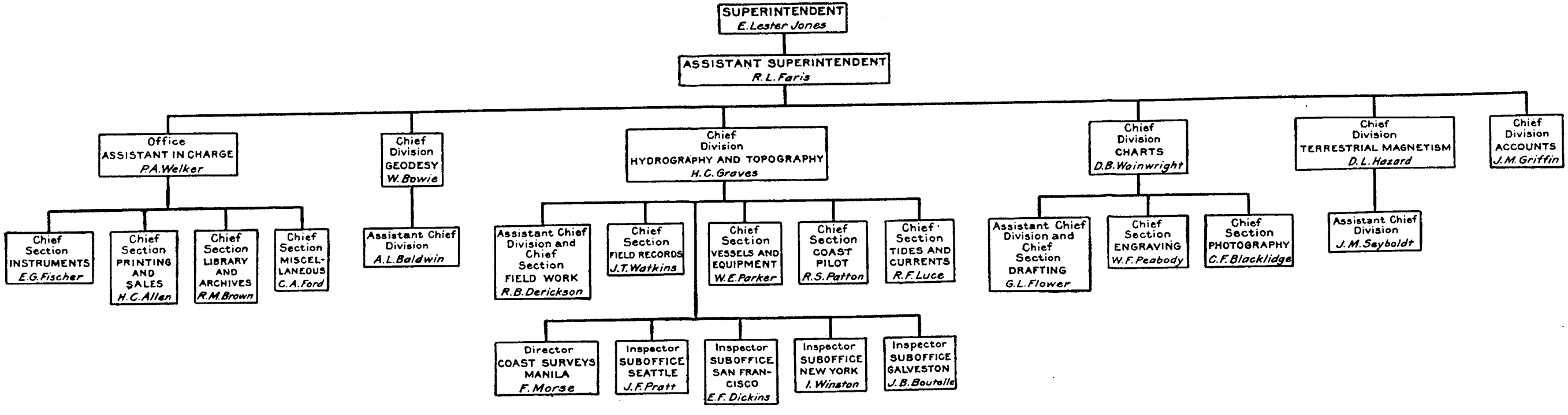
About 90 per cent of the work of the division is of a purely practical character and of immediate commercial or industrial value.

No. 2.

ORGANIZATION CHART.

Effective Oct. 15, 1915.
Revised to Oct. 1, 1916.

CHART SHOWING ORGANIZATION OF THE U.S.COAST AND GEODETIC SURVEY 1916



Equally important, however, is the other work done by the division, which consists of research into the scientific phases of geodetic work, such as the determination of the shape and size of the earth and of the variation of the densities in the outer portion of the earth.

DIVISION OF CHARTS.

Under the direct supervision of a chief and assistant chief this division prepares from the results of the field work new charts and keeps existing charts up to date by adding new data. It maintains complete indexes and diagrams of all surveys, reports of dangers, harbor improvements, and changes of lights and buoys. It engraves the copper plates from which the charts are printed and does all the photographic work for the Bureau.

The following sections, each under a chief, are under the supervision of the chief of the division: (1) Section of drafting; (2) section of engraving; and (3) section of photography.

Section of drafting.—In this section are compiled the results of surveys and all other information for new charts, new editions, and new prints. It furnishes the compilation drawings for the engravers and the finished drawings for the lithographers, verifies the proofs of all engraved work and the successive color prints for each lithographic chart, and does all the miscellaneous drafting for the Bureau. The chief of this section is also assistant chief of the division.

Section of engraving.—From the compilation drawings furnished by the drafting section, this section engraves the charts on copper printing plates and makes entirely new plates for new charts and corrects existing plates where changes have occurred, to bring them up to date.

Section of photography.—This section furnishes reproductions of hydrographic and topographic field sheets and record books, geodetic and tidal computations, and does all miscellaneous photographic work.

DIVISION OF TERRESTRIAL MAGNETISM.

This division is under the direct supervision of a chief and assistant chief. It is charged with the supervision of the magnetic observations in the field and at the magnetic observatories, with their computation in the office, the discussion of the results, and their preparation for publication in the form of tables and magnetic maps, as well as compass data for the charts.

DIVISION OF ACCOUNTS.

Under a chief this division examines and adjusts, preparatory for forwarding to the Auditor for the State and Other Departments, the accounts for every expenditure by the Bureau. It also disburses all the moneys appropriated for the Bureau.

The diagram on the inserted folder will give a clear conception of the units of divisions and sections that go to make up the organization of the Bureau. (See fig. 2.)

SOME BENEFITS RESULTING FROM REORGANIZATION.

Early in the fiscal year it became apparent that more and better results could be accomplished by changes in the organization. After consultations and careful consideration a reorganization of certain sections and divisions was effected on October 15, 1915. A further rearrangement was made in July, 1916. These provided more compactness and that closely allied work should be placed in a single division. The results have been most gratifying, as is shown by increased and better output.

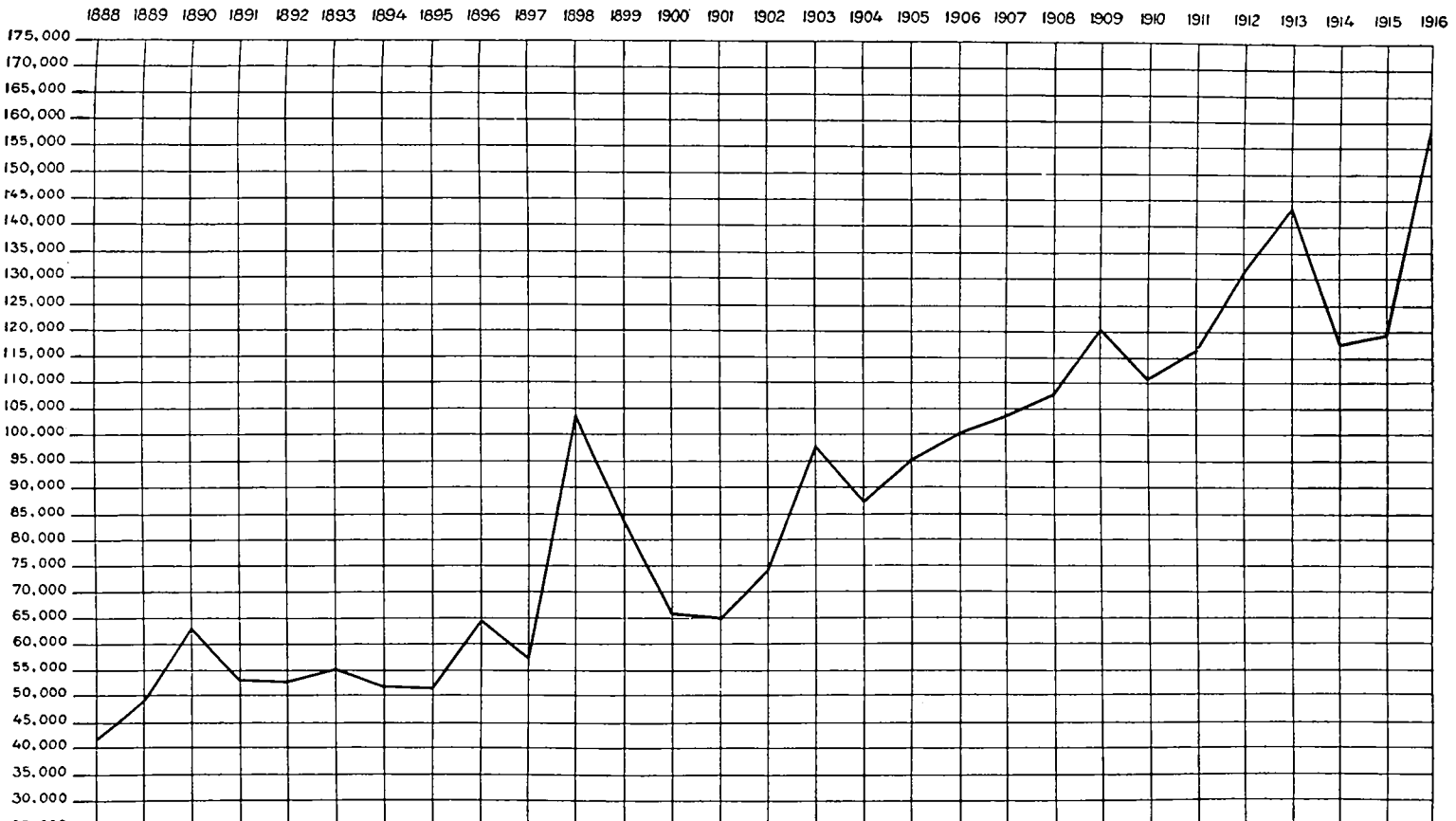
The present organization of the Survey with the duties of each unit, whether division or section, is shown in the preceding pages. Under the new arrangement the intricate details receive the attention of persons who have had experience in each of the particular branches. They are planning new hydrographic surveys, inspecting and caring for the field sheets on their arrival in the office, standardizing the equipment and expediting the repairs to the Bureau's vessels, compiling information for coast pilots, and preparing tidal and current tables. Prior to the reorganization nearly all of these subjects were managed by a chief of division and one assistant (and necessarily ineffectually). In the place of an unwieldy and unsatisfactory organization, where business was so congested that at no time could any piece of work or project be thoroughly studied, planned, and examined before its execution was attempted, there have developed more definitely laid plans for the execution of each project and the work is moving along in an orderly and efficient manner.

A fruitful result of the changes in the organization is the marked acceleration in the production of the Survey's printed charts. Due largely to an increased shipping business, the demand for the charts of the Bureau had taken such an upward trend that its facilities for their production were taxed as they had never before been taxed during the entire history of the Bureau. (See fig. 3.)

That the changes made were for the betterment of conditions is shown by the fact that at the time they were put into effect 200 different charts were out of print and there was an aggregate demand for 6,703 copies of charts that could not be supplied, and that within a comparatively short time after the changes had been made the number of charts out of print had been reduced to 25 and the number of copies of charts that could not be supplied to meet the current public demand had decreased to 904.

To show further the beneficial results of the changes, it may be said that the records show that very nearly as many charts were printed during the month of August, 1916, as were printed during the months of July, August, and September of the preceding year.

In connection with this subject, it may be well to advert briefly to the question of the inspection of the agencies through which these charts are sold to the public. The Bureau disposes of its charts through agents. This method has worked satisfactorily for a number of years, and is the best known means of getting the Bureau's nautical publications to distributing points most accessible to the maritime public. One point, however, that had been more or less overlooked previous to the past fiscal year is that but little attention was paid to the nature of the stock of charts, and other nautical pub-



ISSUE OF CHARTS FROM 1888 TO 1916.

lications, that these agents carried, except to hold them accountable financially for what they received.

During the year forms of reports were prepared on which each agent is required to make at stated intervals exact reports of the charts he has on hand and the date to which corrections on them have been made (each chart having noted on it the date to which it has been corrected). In this manner there were weeded out of the stocks of the Bureau's agents over 11,000 copies of charts on which the information was either obsolete or absolutely misleading to the mariner. These reports were supplemented by personal inspection by the Bureau's officers. This method of inspection will be carried on annually. Therefore, it may be safely said that the stocks of charts carried by the agents of the Bureau are now more nearly up to date than they have been at any previous time.

Another innovation in respect to the medium through which the Bureau's charts are disposed of to the public was put into effect during the year—that of making the Bureau's various suboffices distributing points for them. These suboffices were serving the purposes of lending every possible assistance in the way of distributing information to the maritime public at the points where they are located and of collecting nautical information for this Bureau in their various localities. It was proper, and to the public interest, to make these suboffices also distributers of the Bureau's publications. This has been done to the advantage of both the Bureau and the public.

DETAILS REQUIRED IN PREPARING A NAUTICAL CHART.

The surveys for and the publication of charts have been extended to cover one section of the coast after another until to-day charts are being printed of the coasts of the United States from the northern boundary of Maine to the southern boundary of Texas on the Atlantic and Gulf coasts, and from the southern boundary of California to the northern boundary of Washington on the Pacific coast, also of the coasts of Alaska, the Philippine Islands, Hawaii, and Porto Rico. There is a total of something over 103,000 miles of coast line now covered by 660 different charts.

The method of printing the charts from engraved copper plates has survived to the present day and was the only means employed in this office up to January, 1905, when a lithographic press was installed. Then we began printing charts from the lithographic stones. With the development of the process of making direct transfers from the prepared drawings to aluminum plates, the majority of charts are now printed on the lithographic press from those plates.

Prof. Hassler was the pioneer in the charting of the waters of the country under difficulties incident to his having nothing in the way of precedent for guidance as each step was taken by him. The scientific world looks with admiration on the work done by this master under difficulties that are little appreciated in this modern day with all the conveniences at hand in the way of transportation for carrying on the work and with surveying instruments that a century of experience has developed to a high degree of utility and precision. But even with these modern conveniences the general public is little aware of the enormous amount of detail in observations, soundings, and computations that go to make up one of our charts.

Take, for example, the chart of the northern part of Cook Inlet, Alaska. In the production of this single chart 12 hydrographic field sheets showing soundings were made, 16 topographic field sheets showing land features were drawn, 67 volumes were necessary for recording the soundings taken to show the depths of the waters, and 22 volumes contain the tidal observations. There were also 20 volumes of horizontal angle observations, 7 volumes of vertical angle observations, and magnetic observations. And, after these observations had been made, the office computations of the results had to be made, and from all these records and computations was compiled the drawing for the chart, and from this compiled drawing was made the finished drawing later transferred to the aluminum plate, from which is printed the chart.

The amount of detail required as to each particular chart covering a given section of our coasts is illustrated by figure 4.

It must not be assumed that after the different sections of our coasts have once been charted the work is done for all time and that nothing remains to be done, for on some parts of our coasts very few surveys by this Bureau have been made, and this is especially true of the coast of Alaska; and as both nature and man are continually changing the face of the earth so will resurveys always be necessary.

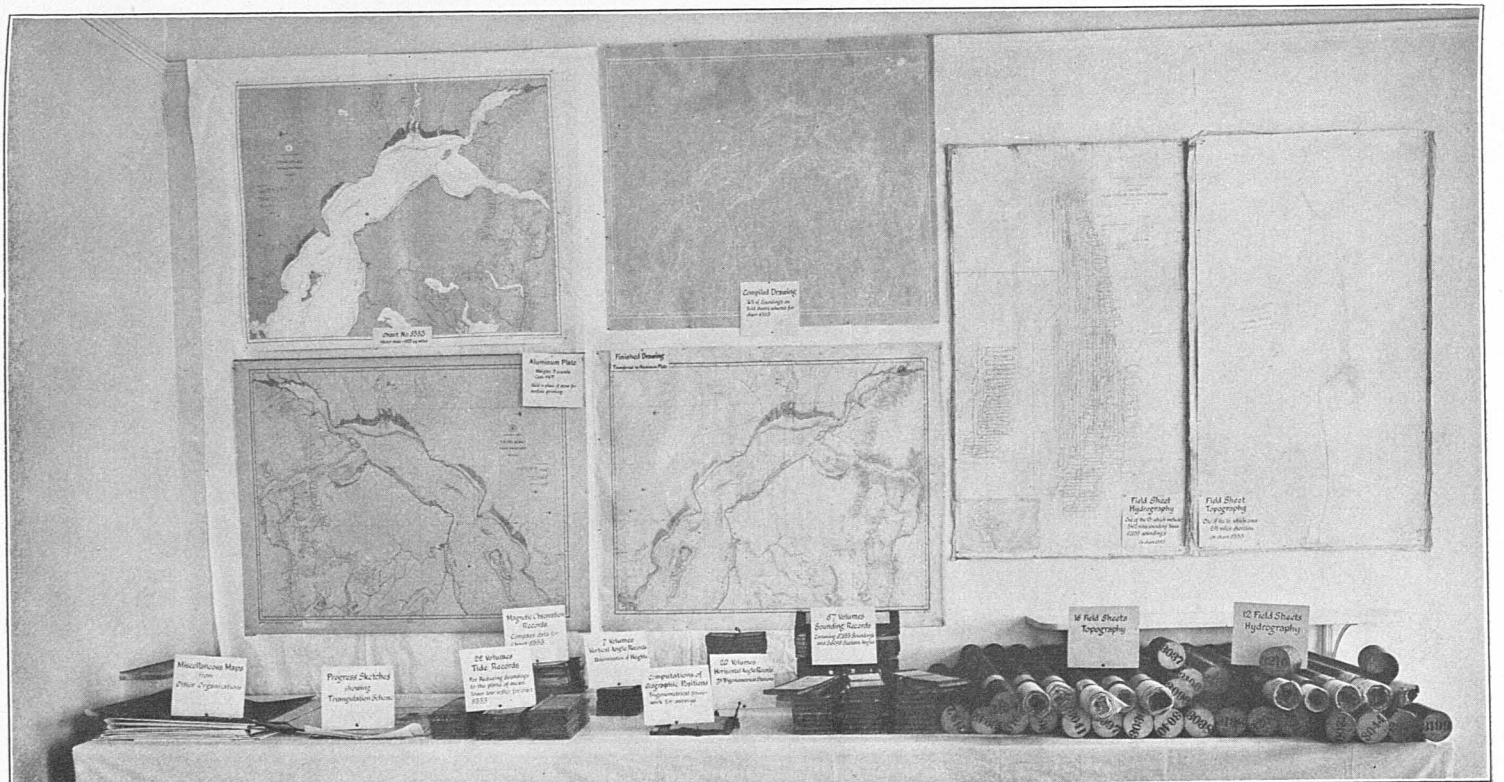
In order to give the public at the earliest possible date all the information at hand, charts of sections of this coast have been prepared from the information that in many instances has been compiled from very old surveys. Indeed, on the coast of Alaska some of the information is taken from the surveys made by Russia long before that territory was purchased by the United States.

While the charts in question have been issued with all available information at the time they are printed, yet they should be supplanted by charts made from the results of up-to-date surveys just as fast as the latter can possibly be made.

When we consider those sections of our coasts where civilization is older and the population is more dense, we find that while there may be no gaps in the surveys as originally made, yet the very presence of a dense population is responsible for changes in the shore line and the depths of water that must be shown on our charts.

In the harbors and approaches to most every city of any commercial importance on the Atlantic coast channels are continually being dredged and deepened, and the new depths are required to be shown; new canals are being opened, and the waters at their approaches must be resurveyed and more minutely examined. Buoys, lights, and other aids to navigation are continually being added to or shifted, and they must be shown on the charts in their new positions. Also, the prominent landmarks, such as chimneys, water towers, tall buildings, etc., which are shown on our charts as guides to the navigator, are continually being changed, necessitating changes on the charts.

Furthermore, during the course of the past decade a new method of surveying our waters has been developed, known as wire dragging, and by this method dangers to navigation are being found that escaped the most careful surveys with the lead line, and each new danger found means a revision of a chart.



COLLECTED MATERIAL USED IN COMPILING CHART OF COOK INLET.

The photograph illustrates the amount and variety of material used in compiling a single chart. The surveying vessels while sounding the area included by the chart steamed 5,412 nautical miles and recorded 67,855 casts of the lead.

NEED OF MODERN BUILDING.

It is of passing interest to many to see the former home of Gen. Benjamin Butler, but these are not told that part of that home and the adjoining brick building constitute the office of the United States Coast and Geodetic Survey.

Prior to 1871 this Bureau was housed in various small buildings near New Jersey Avenue and C Street SE. During that year Messrs. T. and A. T. Richards completed the building at what is now 205 New Jersey Avenue SE., with the understanding that it would be leased by the Government for a 10-year period for the use of the Coast and Geodetic Survey.

The builders must have anticipated the possibility of the Government not retaining the building after the 10-year period, in which event it would be used as a hotel, for the style of architecture is that of hotels that were built in those days. It is divided into a great number of small rooms, with half flights of stairs front and rear, and each floor level of the front building is a half flight above a floor level of the rear building.

In 1873 Gen. Butler built of Massachusetts granite what in those days was beyond question a magnificent home, with quarters for the servants in the basement and with stables in the rear. Until a few years ago the elegance of this home was plainly visible in the elaborate frescoing, the artistic chandeliers, and the commodious fireplaces. This building was occupied as a residence until 1891, when it was rented to the Government for the use of this Bureau, and in the same year both the home and stable were purchased for the same purpose.

As a result, this Bureau is now housed in part of one building that was erected for a dwelling and in another that was built for a hotel. Were this literally an "office" building and nothing else, no great hardship would be suffered from being housed in such unsuitable quarters, but since in addition to the administrative offices being located in them there are also operated a printing plant, a machine shop, a carpenter shop, a lithographic plant, etc., I shall undertake to set out in detail the difficulties that are met with.

As the depths of water are measured along our coasts, they are recorded on what is termed a "field hydrographic sheet" (which is usually a sheet of cloth-backed paper with approximate dimensions of 30 by 52 inches). As there is not room on this sheet for all the notes that are taken in regard to the survey, a record of various data is made in books. The field hydrographic sheet contains principally the figures showing the depths and drawings of the shore lines. The position of the boat or vessel when these soundings are taken is accurately determined from observations on objects ashore, and figures showing the various positions of the boat are also placed on the sheet.

As the work of surveying progresses, more and more figures showing soundings and the positions of the boat are added to this sheet, and by the time the survey of the area is made it usually contains thousands of figures. When it is considered that on this sheet is represented the work of many people for perhaps months or years, and often that of a surveying vessel, the importance of preserving it from injury is manifest. It is roughly estimated that each of the various sheets of this kind (and there are nearly 8,000 in the archives

of this Bureau) would require on an average $7,000 for its duplication and other records made with it, should it be destroyed. In round figures these cost originally about $56,000,000. (See fig. 5.)

Time and experience have shown that the best method of keeping these sheets from injury and from the ill effects of dust and dirt is to put them in tubes made of galvanized iron, each fitted with a cap at one end. For purposes of identification each is assigned a number corresponding to the numbered field sheet it contains.

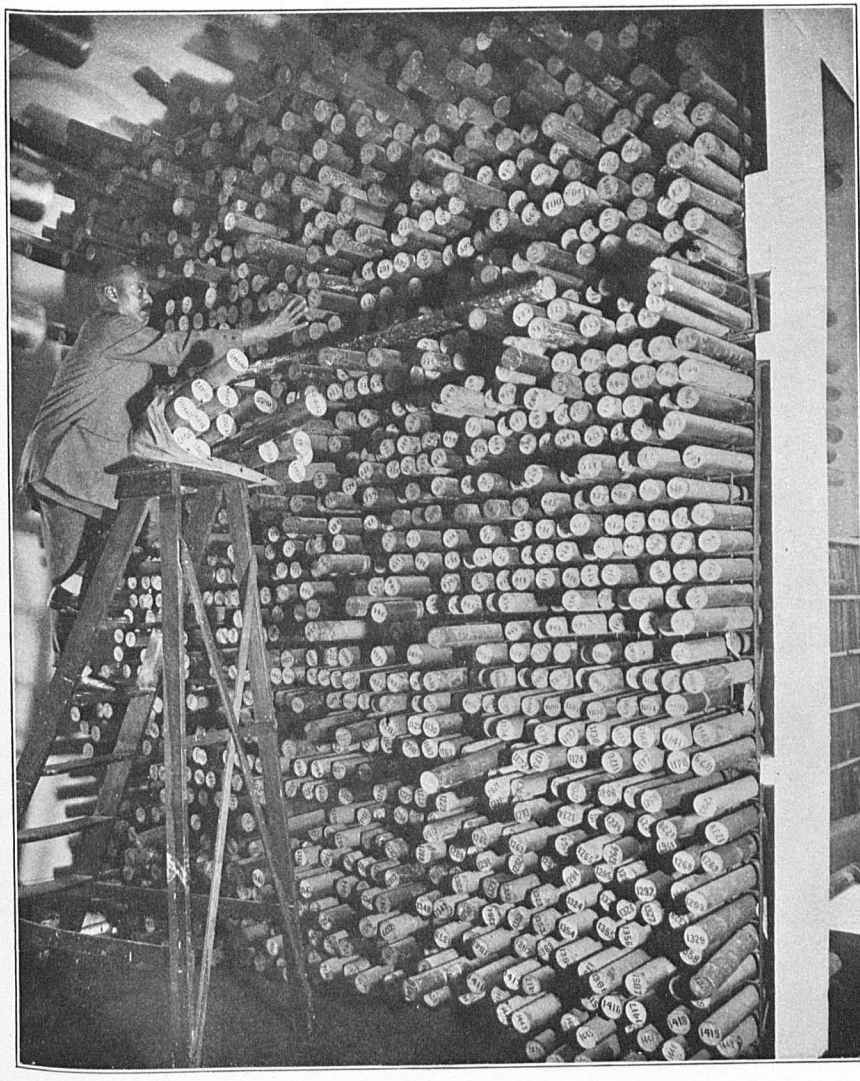
Now, it is perfectly clear that records of this value should be kept where they will be the least exposed to the danger of fire, and this is almost impossible in the present quarters. The nearest approach to a fireproof building is part of the old Butler residence. Here these tubes are kept in metal racks in two small rooms. These rooms are far from fireproof. The floors are of wood, as is the floor of the room above. The only facilities for fire protection are small hand extinguishers. There is no fire hose or fire water main in the building.

In addition to being exposed to the danger of destruction by fire, these tubes are most inaccessible. Because of the lack of space, the metal racks in which they are kept must extend from floor to ceiling, and the accompanying illustration (fig. 5) shows the great difficulty in getting them to and from the racks. But even this is not the greatest handicap that must be overcome. A large portion of these sheets is in daily use by the draftsmen in compiling drawings for charts. From the nature of the work, those engaged in drafting must have rooms that are well lighted. Such rooms are only available for these men in the old hotel building, at a considerable distance from where the sheets are stored.

To get these sheets from the storerooms to the draftsmen, they must be carried in sacks by messengers an average distance of 350 feet, and in this distance an average of four flights of stairs must be climbed. When one considers that the data represented on one of the finished charts are taken from perhaps 30 to 40 of these sheets, and that there are 24 draftsmen scattered in 15 rooms in the old hotel building on four different floors, the confusion that arises and the loss of time of these skilled men runs into alarming figures. And further, these sheets are used not only by the draftsmen, but in large numbers by various divisions and sections of the office, and the daily and constant question is, "Who has a needed sheet?" or, "Where can it be found?" The matter has received the most careful consideration, but with the present quarters there is no known remedy. (See fig. 6.)

The copper plates that are used in printing the charts are in many cases the most reliable and authentic as well as the permanent record of the completed work, and because of the time taken to engrave the thousands of figures and characters they contain, they represent a large expenditure of money and thus become exceedingly valuable. As in the case of the survey sheets, all possible precautions must be taken to secure them from danger of loss by fire, and for this reason they are kept in the basement of the Butler Building.

As is the case with the draftsmen, the engravers must have the best possible facilities in the way of natural light, and for this reason they are distributed so as best to secure these conditions in the old hotel building and in the Butler Building. Now, these copper plates are being constantly carried by messengers from the storage

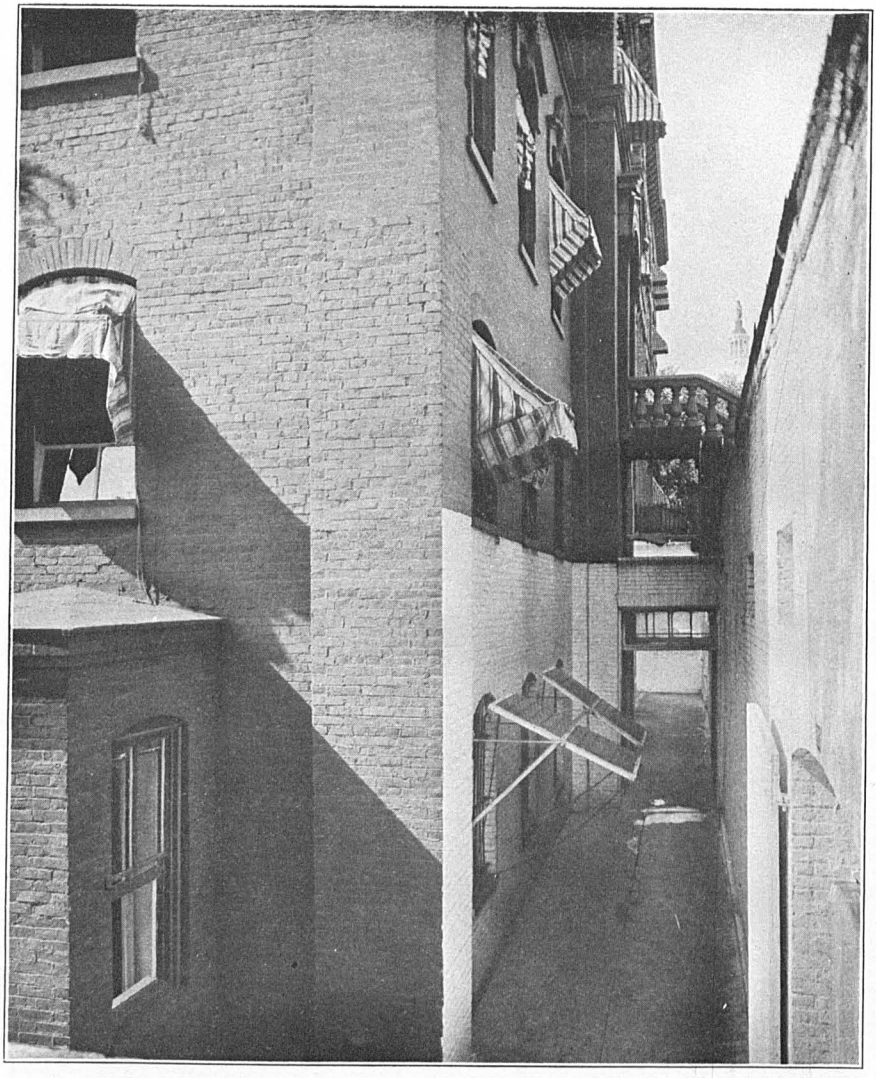


FILING ORIGINAL FIELD SHEETS.

Original field sheets filed in the archives in steel racks extending from floor to the ceiling. No water system for fire protection.

METHOD OF MOVING ORIGINAL SHEETS.

Several of these 70-pound sacks of original sheets are carried each day between the drafting rooms and the archives, a distance of 350 feet and over four flights of stairs.



LOWER FRONT VIEW OF OFFICE BUILDING.

Front of Richards Building, containing main offices of the Coast and Geodetic Survey. The top of the wall to the right is the street level of New Jersey Avenue. Lack of space necessitates use of rooms one and two stories, respectively, below street level for office rooms. Artificial light must be used throughout the day.

vault to the engravers for the addition of new information from surveys made in the field. As these 20 engravers are distributed in 15 rooms, an average of 300 feet away, and 7 flights of stairs must be traveled by messenger with each plate received, the same confusion and loss of time arises here as in the case of the draftsmen. The plates are heavy, weighing 42 pounds, and are cumbersome to handle, so that at most only one can be carried at a time.

Again, in the chart-printing establishment work is greatly hampered on account of cramped quarters and their poor structural arrangement. Because of the great weight of the presses that are used in printing charts (the sheets averaging 36 by 44 inches), these presses must be located on the ground floor. Also the lighting facilities must be good.

The nearest approach to these conditions is to be found in the small new building and the old Butler stable, where the printing establishment is located.

The inconvenience of these buildings can be better appreciated when it is known that in the course of the past year nearly 80,000 pounds of paper were carried to the presses, down flights of stairs and through different rooms. There is no room for the storage of the paper nearer the presses. (See fig. 8.)

To summarize, these buildings are wholly unsuited to our work. A fair proportion of the rooms are exceedingly poorly lighted on account of the construction of the buildings. Some of the rooms that, due to lack of space, must be used as offices are two stories below the street level, and in them light must always be supplied artificially. (See fig. 7.) Records that could not be reproduced short of an expenditure of many millions of dollars and years of effort are daily in danger of destruction by fire, although employees are continually admonished to be on the lookout for such danger, and frequent drills are given to bring about the highest efficiency in fighting a fire should one occur. We have had two startling examples of how fires start from no known cause—one in 1911, when the contents of one room were destroyed (happily a chart-mounting room where only equipment was involved), and another in 1914, when a part of the contents of one of the office rooms was destroyed. It is more or less a matter of good fortune that these two fires resulted no more seriously. In one case the fire was discovered by an officer of the Bureau who was detained at his desk until a late hour, and early enough to have it confined to one room. In the other instance the watchman had begun his rounds of inspection and discovered the fire in its incipiency.

Sanitation is exceedingly difficult with even the comparatively large force of employees that we have whose time is devoted to that work. The rooms are small, with numerous recesses for the accumulation of dirt; the windows are of the old-fashioned small-pane type, difficult to reach from the outside and hard to clean; all the floors are of wood, and worn, and it is safe to say that even with the large overhead charges (it costing $8,294.94 for the repairs and upkeep of these buildings during the fiscal year ended June 30, 1916) we are unable to approach the results that would be obtained in a modern building with a greatly decreased expenditure of money and a much smaller force of laborers. One of the greatest impediments to securing a normal efficiency is due to the awkward manner in which

most of the work has to be handled solely on account of the inadaptability of the buildings.

Viewing the whole situation from the standpoint of the inaccessibility of our records, the time lost by the skilled men in waiting for these records or searching for them themselves, and the unsuitable facilities for many of the Bureau's employees, I venture to say that for every dollar that is appropriated for the office of this Bureau but 75 cents in value is realized, and I make this statement with no intention of criticizing the legislative branch of our Government, or excusing in any way the shortcomings of this office, but to bring to you the facts as they exist.

The remedy is a modern building planned to meet the needs of this Bureau. Preferably this should be within the confines of the same building in which the Department of Commerce is to be housed. The present quarters are 2¼ miles from the building occupied by the Department, which results in difficulties and delays in administration. There is no reason why a building could not be planned to meet every need of this Bureau, which will allow to be realized the greatest efficiency and save the useless expenditure of time and effort to overcome obstacles that ought not to exist.

I have perhaps gone into details regarding the buildings that may seem in a measure trivial, yet it is these very things that stand in the way of realizing results that we hope to attain and which ought to be attained.

ESSENTIAL IMPROVEMENTS NEEDED IN PRESENT BUILDINGS.

From an administrative standpoint further expenditures on the present buildings would not be in the interest of economy, yet if they are to be occupied indefinitely there are certain essential matters that should be attended to. The following details of each of these important questions are given:

FREIGHT ELEVATOR FOR PRINTING OFFICE.

During the course of the past year we used nearly 80,000 pounds of chart paper in the printing of the charts issued by this Bureau. This paper was delivered at and stored on the street-level floor of the old Butler stables, in which a part of the printing office is located. This is the only space sufficiently free from dampness in the printing office that is available for storage purposes. To get the paper to the presses it must be carried down a narrow flight of stairs and into the room where the presses are located. (See fig. 8.)

Under present conditions the total distance that this paper must be carried by hand is 170 feet.

This defect in our old building can be overcome by providing a freight elevator, between the floor where this paper is stored and the floor on which the printing presses are located, and platform trucks so that the paper can be wheeled onto the elevator, lowered to the pressroom floor, and wheeled to the presses.

ELEVATOR FOR BUTLER BUILDING.

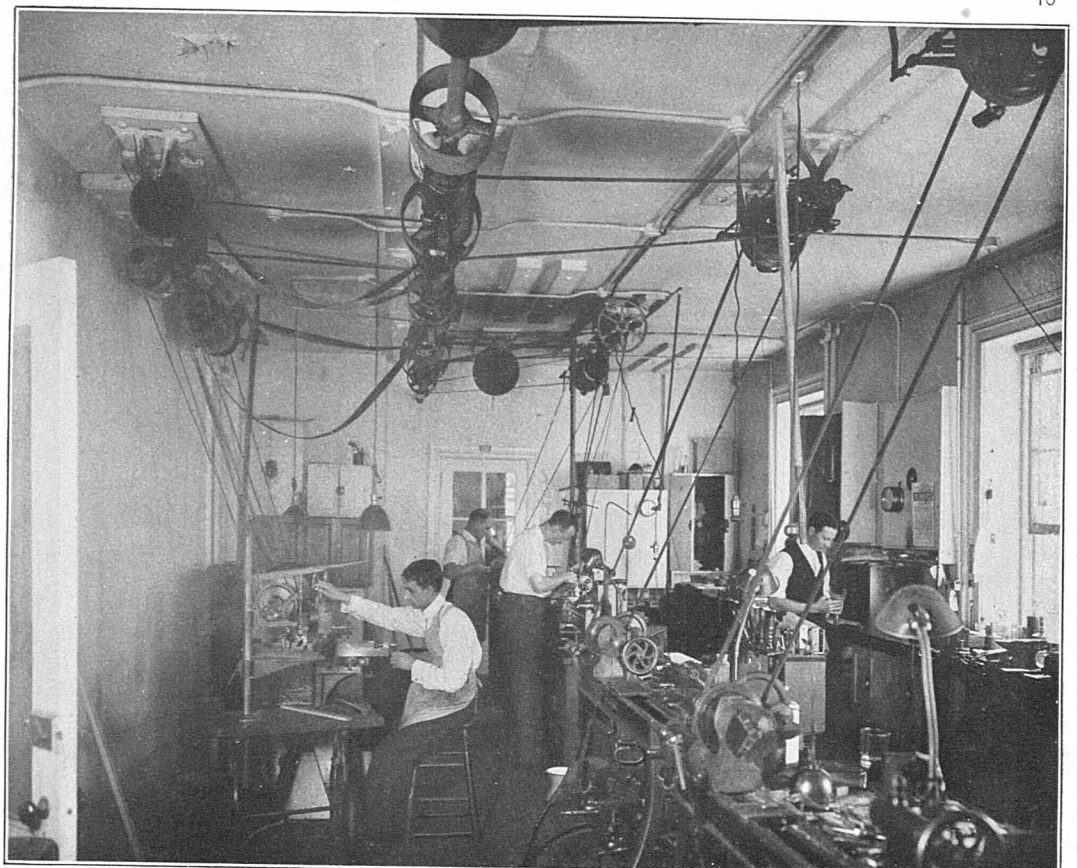
The Butler Building, including the basement, is five stories high. In the basement of this building are stored the copper plates from

METHOD OF CARRYING PAPER TO PRESSES.

Showing how nearly 80,000 pounds of chart paper must be carried annually from the stock room to the presses, an average distance of 170 feet and down one flight of stairs, owing to lack of an elevator.

CARRYING COPPER PLATES.

Transporting engraved plate from storeroom up one of seven flights of stairs and a distance of 300 feet to engraving room for correction. The plates average 42 pounds in weight. About 96 tons' weight is thus transported annually.



MACHINE SHOP.

Machine shop of the Coast and Geodetic Survey. Congestion within buildings necessitates assembly of machines in this small room. Result: Insufficient room for efficient operation, natural light obstructed by belting, shafting, etc., and depreciation of quantity of output.

which charts are printed. As stated earlier in this report, these plates must be carried from the storage vault to the engravers for corrections and additions of information, an average distance of 300 feet, and up seven flights of stairs. There are approximately 2,500 of these plates in the vault, and while an exact account of how many trips are made back and forth from the plate storage vault to the engravers in the course of a year has not been kept, yet it is probable that these trips number over 3,000. (See fig. 9.)

Beyond question, much of the loss of time on account of delays in delivering these copper plates to the engravers would be eliminated if an elevator were installed in the old Butler Building. Again, there are various offices on the different floors of this building, and an elevator would be a convenience to those occupying them, and further it would be a great convenience and save much of the time of our laborers in carrying books, records, ice, furniture, etc., to the various floors of the building.

INDIVIDUAL MOTORS FOR THE LATHES IN MACHINE SHOP.

While a long step in advance was taken during the past fiscal year by installing an electric motor for supplying power for the machine shop and discarding the gas engine, that was so expensive to operate, yet much that is desirable remains to be done.

The motive power for the line shaft in the machine shops is now supplied by a 7½-horsepower electric motor. The overhead cost of operating the machine shop has been greatly lessened by the installation of this motor, for the reason that it can be stopped and started at will; while the old gas-engine power and the power shaft, because of the great inconvenience in stopping and starting, were kept running throughout the working day. (See fig. 10.)

The motor in use at present is run only when there is need to use one of the lathes. Even this arrangement involves a great waste of power and consequently results in a high cost of operation, for the reason that to propel the line shaft with the greatest burden that may be placed upon it a 7½-horsepower motor must always be run. Now, it often happens that for a continuous period of time a machinist may require the use of a lathe that can be run by a half-horsepower motor.

A better arrangement, and one which should be put into effect, is to secure machines equipped with individual motors suited for the needs of the machine used. This will permit greater convenience in the shops, eliminate the light-obstructing and dirt-collecting belting and shaft, and allow even in our cramped quarters better means for carrying on our work.

DRAFTING TABLES AND OTHER FURNITURE.

There is no more important work than that done by the hydrographic and topographic draftsmen, yet these experts are handicapped by being compelled to use drafting tables nearly half a century old. Modern tables would greatly increase the expedition with which they turn out their work. There is much other antiquated furniture that should be replaced. A large portion of it has been condemned by the Public Health Service as being insanitary.

WATERPROOFING VAULTS.

The need of funds for providing waterproofed vaults in which to store valuable property should be again considered. So crowded are the present storerooms that it frequently happens that they have to be emptied in order to obtain a single article desired. This means hours of wasted labor.

INCREASE NEEDED IN NUMBERS AND SALARIES OF COMPUTERS, DRAFTSMEN, INSTRUMENT MAKERS, PATTERN MAKERS AND CARPENTERS, AND LIBRARIAN.

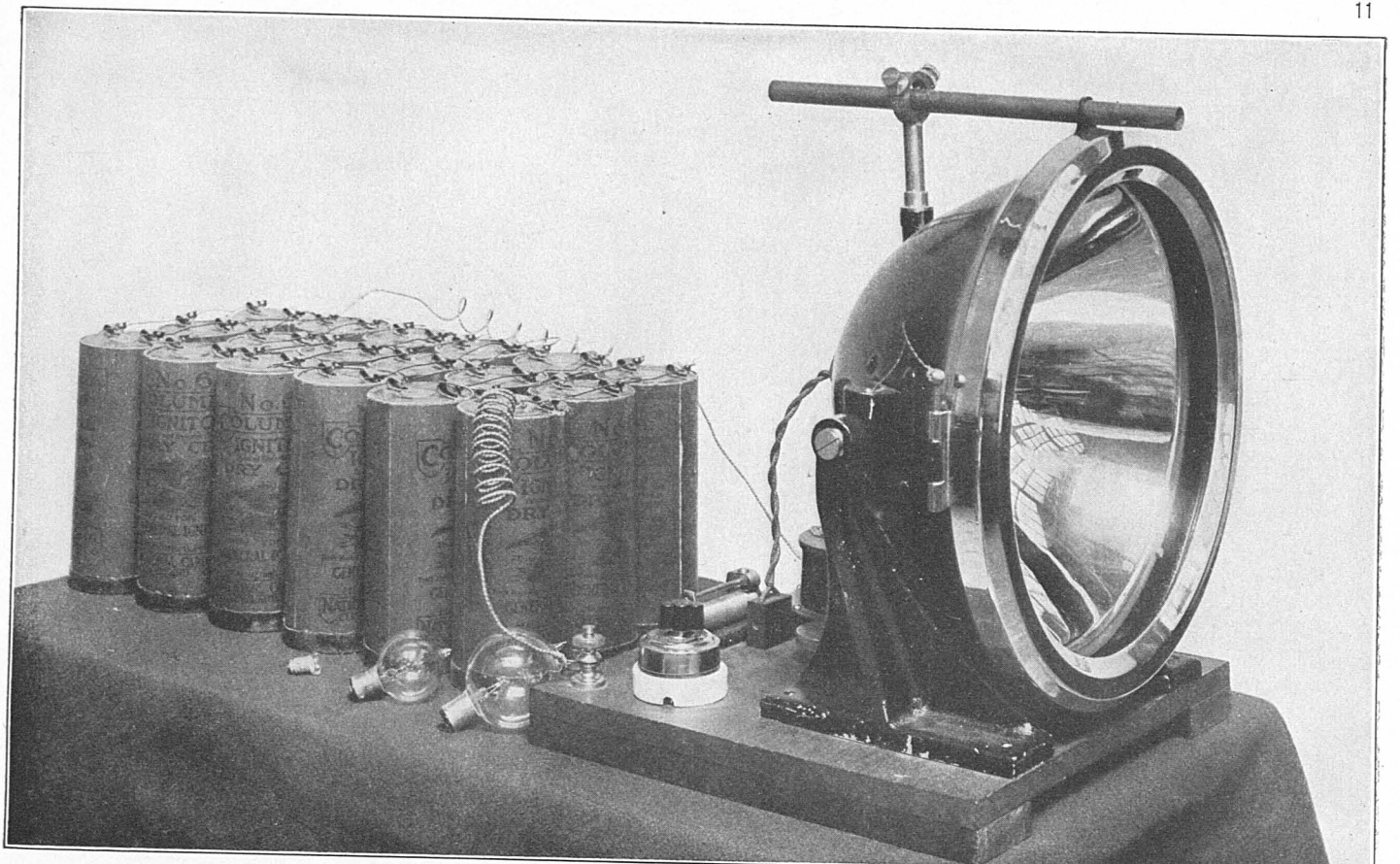
Congress provided for three additional computers in the 1917 estimates. This was a material help to partially keep up with current work, but not sufficient to meet the demands of the office. In the estimates for 1918, eight more computers are asked for to enable much geodetic, tidal, and current data to be made available, which otherwise must remain in the archives. Two of the computers should have higher salaries, commensurate with the duties they perform, and designated as computing engineers. One is *chief of the division of terrestrial magnetism* and the other *assistant chief of the division of geodesy.*

In order to provide for the preparation and publication of much available data that will be useful to navigators, engineers, and the public in general, these increases are essential. There are at present data in the archives ready to be computed for about 16,000 triangulation stations. These stations are located along the coasts and in the interior of the United States, Alaska, Porto Rico, and Hawaii. The published results would mean much toward rapid development of our country.

Much of the field geodetic work, especially along the coasts, is done to provide the control for the surveys made by our field parties and the construction of the charts by our office. In the field such computations as will make the results of the geodetic work immediately available are made, and in most cases the results are satisfactory for the small-scale charts of the Survey; in other cases they are not.

The policy of the Survey is to make at the office an adjustment of the field results which will make them harmonious with all previous geodetic surveys in the same area covered, and then to publish the results for the use of anyone in or out of the Federal Government who may wish to use them. This has not been possible except to a small extent, owing to lack of computers. The researches in geophysical problems can not be carried on to the extent that is desirable, owing to lack of computers. The conditions will be worse in the future than in the past, for the additional funds provided for field work both on the coasts and in the interior will make the new work to be computed much greater in amount.

Additional computers are needed for the purpose of furnishing the public promptly with information relative to tides and currents. With the increasing size and value of shipping, accurate knowledge concerning the time and height of the tides is essential. The Survey at present publishes tide tables giving tidal information for our coasts, but these should be augmented and improved by the observations now available and which can not be handled by the present force.



NEW ELECTRIC TRIANGULATION SIGNAL LAMP.

Yields at 100 feet 250,000 beam candlepower, with 9-volt, 2.5-ampere special bulb developed in the United States Coast and Geodetic Survey.

Definite information concerning currents along our coasts is of the greatest value in promoting the safety of navigation. For lack of this knowledge, vessels are frequently lost, especially in fog or in abnormal currents due to storms. There are at hand in the archives records of many continuous current observations which have been taken at lightships along our coast, together with a large amount of other current observations, and this is being augmented by important current surveys. The results of these observations will be of very great value to navigation, and should be made available at the earliest opportunity.

The need of additional draftsmen is more pronounced than ever before. In last year's estimates we asked for new positions which were not granted. The salary of $2,700 is for the present *assistant chief of the division of charts*, who is also the *chief of the section of drafting*. The designation of this new position should be "chief cartographer." The increase in force is absolutely necessary if the maritime public is to be furnished promptly with charts containing the results of the latest surveys by our field parties, by the United States Army Engineers, States, and cities. The field force of this Bureau is more generally engaged in hydrographic work than formerly, with the result that the increased field results can not be handled by the office without the increases asked for.

This work on the field sheets is so far in arrears that during the year some field officers were assigned to the work, and yet at the present time there are 57 unfinished field sheets, which would require about five years' work for a draftsman to complete.

A minimum salary of $1,200 for draftsmen is recommended, as it is found that the desirable men on the civil-service register will not accept a lower salary.

There is urgent need of changes in the instrument section. The change in designation of the chief of the section to "mechanical engineer," with an increase of salary from $2,400 to $3,000 is proper. The present incumbent is a physicist and mechanical engineer of exceptional ability. He designs new instruments, many of them most delicate and intricate. Among his noteworthy achievements has been the designing and construction of a tide-predicting machine that has been the admiration of the world. His latest achievement is the development of a new electric signal lamp for use in triangulation. This lamp has a beam candlepower of 250,000, a marked advance in efficiency over the lamp of 1,500 beam candlepower which has been in use. Government bureaus and private parties have adopted it, including the United States Navy, Forest Service, Coast Guard, and Aeronautic Service; also mine-rescue manufacturers. (See fig. 11.)

An increase in the present salaries is needed in order to reward long and underpaid services, and the addition of two instrument makers is desired to provide means for the development and construction of new instruments. As the field operations increase so will greater demands be made for instruments.

The following statistics give an illuminating picture of the volume as well as importance of the work done in the instrument section during the past year.

Total number of instruments, apparatus, tools, etc., repaired in the shops	2,356
Total number of instruments, apparatus, tools, etc., made in the shops	1,427
Total number of instruments, apparatus, tools, etc., purchased	497

Total number of instruments repaired outside of the shops	122
Instruments issued to the field	4,370
Instruments received from the field	3,290
Articles of general property issued to the field	4,168
Articles of general property received from the field	1,418

A part of the instrument section which has never had proper consideration is the pattern makers and carpenters. Under the present designation they are called carpenters, but these men are more than this. They are expert woodworkers. Their long years of experience have taught them how to make patterns for casting of parts of new instruments and repairs from drawings furnished by the chief of the section. The geodetic level rods used with the levels of precision are made and graduated by these men. In addition there are wooden parts of instruments, some of them in the experimental class, calling for an inventor's skill.

The entire force of this specific subsection have worked for more than 25 years at this work in this Bureau at $1,200 per annum each, and I recommend an advance to $1,400 per annum.

The increase in salary of the librarian is a renewal of my request made last year. The salary of the position has remained the same for 25 years, although the work and responsibilities have increased since 1891 almost 100 per cent. The number of books, pamphlets, records, original sheets, and other matter handled have increased from 69,000 to 137,400.

With the increase already indicated the need of an assistant librarian at $1,200 is also essential, as a $720 clerk does not make an efficient assistant.

OFFICE WORK AND INSUFFICIENT CLERICAL HELP.

I have already spoken of the reorganization of the office, by which greater efficiency has resulted, even with the limited personnel, but in order to place the Bureau in a position properly to execute its work it will be well to show briefly the need of a greater clerical force.

There are 40 employees in the Coast and Geodetic Survey rated as clerks. There is probably no basis for comparison to determine whether in the Government service a given bureau has an excess of clerks over another bureau, because the functions of one bureau may be such that the work is clerical while that of another bureau may be such that but little clerical work is done. Therefore, it might be thought that in a bureau of applied science such as the Coast and Geodetic Survey 40 clerks should be sufficient. Were the time of these 40 employees devoted to what is generally accepted as "clerical work," it is possible that such a number would be nearly sufficient, but experience only can give the final answer.

The Coast and Geodetic Survey is the oldest scientific bureau in the Government service. Its activities date back to 1816. In this Bureau custom and matters of expediency have had more to do with the shaping of its work and the assignment of duties to various employees than has a strict classification of duties, such as prevails among bureaus of more recent creation.

An impartial examination into the different classes of work that are being done by the 40 employees rated as clerks in the Coast and Geodetic Survey will disclose the fact that a large number of them

are engaged in what requires the broadest possible interpretation to come within the scope of clerical work, and which might well be classified under entirely different subjects. The assignment of these employees to such work has come about through force of necessity. The work of the Bureau is highly technical, and as a branch has developed there has been need for a person to take up and assist in its work. A clerk has more often been selected as a matter of expediency than by a definite classification of the duties to be performed, and probably because he was the most apt of those available for the work. The result is that of the 39 employees rated as clerks in the Coast and Geodetic Survey, but 25 of them are engaged on what is generally accepted as "clerical work," and in this technical Bureau the demands upon them are often very varied and require knowledge and training above the average.

This Bureau has no purchasing officer designated as such. As the number of different supplies for the Washington office increased, it became necessary to put some person in charge of their purchase. During the course of each year he manages the purchase of supplies of all kinds for the Bureau. It is obviously the work of a purchasing agent. The person who does this work is rated as a clerk.

For years in the section of tides and currents, the work has been in excess of what could be accomplished by the computing force. As it was necessary that our tide tables be printed in advance for each year (and their printing admitted no delay), the clerical force was called upon to do the computing work which had to be done in order to get these tables printed. In this section four employees, in addition to the force of computers, are engaged in making these computations. They are rated as clerks.

In the printing and sales section, as its work has developed, it frequently happens that after a supply of charts has been printed new information is received necessitating minor changes on the printed chart. It would be wasteful to throw away these printed charts and print others merely because of these small changes and they are made by pen corrections on the printed chart. This method of making the corrections has come to be known as "hand correcting." These corrections are liable to be necessary on any of our 660 different charts, and it soon became a matter of such importance with regard to accuracy that one person was put in charge of the work and he has therefore acquired an intimate knowledge of all our charts. This person should be designated as a chart corrector. He is carried on the rolls as a clerk.

On account of the difficulties in the way of registration caused by the expansion and shrinkage of paper, it has been found more practicable to indicate by hand the colors of the buoys shown on some of our charts rather than to do it mechanically by the printing press. There is at present one person rated as a clerk employed in doing this work. All persons engaged in such work should be designated as buoy colorists.

When the reorganization was put into effect so that the management of the printing of our charts and of their sale and distribution was put under one section chief, it was realized that the best results would be obtained by a man who had had a wide experience in office

work and could therefore readily grasp the many details involved. Such a man was selected to be chief of the printing and sales section. This man is rated as a clerk.

It thus follows that the clerical force of this Bureau is wholly insufficient to meet its needs. Although overtime work is constantly required, the demands on the clerical force are so heavy that clerks are shifted from division to division, and from section to section, to catch up work that falls behind. It therefore necessarily follows that these employees are constantly engaged on duties that are not wholly familiar to them, and the work is sometimes poorly executed. This is particularly true with respect to our files. A careful study has been made of the matter, and it is believed that the filing systems adopted are the best for the character of the correspondence in this Bureau, but no system will overcome lack of accuracy in following the method adopted, and it is a constant source of annoyance, because either this or that clerk has not had time to get his correspondence in the files, or in the haste of placing it in the files it was misplaced. The difficulties with our files are only typical of many other matters that suffer from the clerks' lack of time to finish, in a workmanlike manner, the various duties assigned to them.

Another feature tending to lower the standard of our clerical force is the low entrance salary, which is only $720 per annum.

It is quite true that in many of our cities, in response to an advertisement placed in the papers, a fairly efficient clerk may be selected for $15 per week. However, the vacancies in our office must be filled from lists of eligibles furnished from the registers of the Civil Service Commission.

Now, the most desirable qualifications of a clerk in this office, and in many cases the most necessary qualifications, are that he be a stenographer and typewriter. The demand for stenographers and typewriters by the Government is so great that those eligibles who pass both tests—that is, the test for stenographer and the test for typewriter—almost invariably state that the lowest entrance salary that they are willing to accept is $900 per annum. Therefore, the register at $720 per annum contains those eligibles who have passed the typewriter examination but failed to pass the test in stenography. As a consequence, in nearly every instance the employee we secure at $720 per annum is one who has barely passed the examination as a typewriter and has an indifferent knowledge of stenography.

Furthermore, those clerks who come to us under the above circumstance, who are ambitious, qualify themselves to pass the examination as a stenographer, go on the $900 register, and shortly leave for another place where the entrance salary is $900 per annum.

To remedy this matter the entrance salary of clerks in this Bureau should be raised from $720 to $900 per annum.

While all that is possible by reorganization and by cooperation has been done to meet the demands of the Bureau, yet these demands are constantly growing and the office personnel is taxed to the utmost.

As an index of what is meant when we say that the demands on the Bureau are constantly growing, there is cited the fact that for the fiscal year ended June 30, 1916, 32½ per cent more charts were sold and

distributed than during the fiscal year ended June 30, 1915. If we analyze the meaning of such a statement, we are soon brought to the realization that an accomplishment of this kind means an immense increase in the office activities of the Bureau in the way of compiling information, drafting and engraving, printing, correspondence in connection with the sale of these additional charts, and the keeping of accounts.

There is no question but that there has been an increase in maritime activities within the past fiscal year, which has created greater demands for every one of the Bureau's nautical publications. The result is that the office force of the Bureau has been unable to do anything but the most pressing current work in the way of preparing and supplying these publications, and much work that is desirable to be done has gone into arrears. The time has come when the matter of assignment of duties in this office that has been brought about by half a century of following custom and expediency must be abandoned; and new positions must be provided in the Bureau giving proper designations to each of its different classes of office employees more in keeping with the classes of work performed. This means that there must be new places provided under various designations, such as buoy colorists, computers, bookkeepers, and various other classes to meet the present needs.

To make a *well-balanced organization* both in office and field, the increases in the salaries and number of positions asked for in my 1918 estimates are necessary.

PUBLICITY OFFICER AND SYSTEMATIC DISTRIBUTION OF PUBLICATIONS.

Another need of this Bureau that is growing more and more apparent daily is what might be termed a "publicity officer." Without in the least so intending, and undoubtedly without being conscious of it, we have for years been collecting, compiling, and digesting information without properly calling it to the attention of persons, municipalities, and public-service organizations to which this information is most vital.

During the past year we have undertaken, with the facilities at hand, to remedy this condition. Letters were addressed to the secretaries of the chambers of commerce of all our important coastal cities, asking that we be supplied with the names of the steamship companies operating from those cities, the important steamship wharves located in them, and a list of the yacht clubs at or near them.

Now, when the Bureau issues a new coast pilot, or chart, or other publication of a certain locality, an announcement is sent to these shipping companies, and posters are placed on the wharves and at other places giving information as to the scope of the publication and its price.

Cooperation by everyone concerned has been surprisingly responsive, and by this means we are bringing to the attention of those most deeply concerned the very information that is of the greatest benefit to them.

This is only one step, however. It is a matter that requires much time and thought both as to the means of reaching the persons interested and the manner of presenting the facts to them. So much does

this appeal to me that I believe it would be a wise expenditure of money to secure the services of a person qualified as an editor whose time shall be devoted to the study of how most economically to bring to the attention of the public the existence of the results of the work of this Bureau, and to assist in preparing for the printer the many publications issued by the Survey.

As an illustration of what can and ought to be accomplished: Heretofore it has been the custom to make the necessary surveys, compile information, publish a chart, and supply the demands for it as they came in, leaving the public to learn of the existence of the chart as best it could. Recently we published the usual edition of a new chart of Long Island Sound above New York City. Simultaneously with its publication prepared notices were sent to the newspapers in the locality of the waters covered by the chart, calling attention to this new chart, and giving the particulars regarding it. The demand for this chart was so great that the usual edition was soon exhausted. This chart was first issued April 29, 1916; within four months we had received orders for nearly 1,700 copies of it. There is no question but that this demand is far above the normal and has resulted largely from the gratuitous newspaper announcements concerning it. (It must be borne in mind that all the charts are sold for a stated price.)

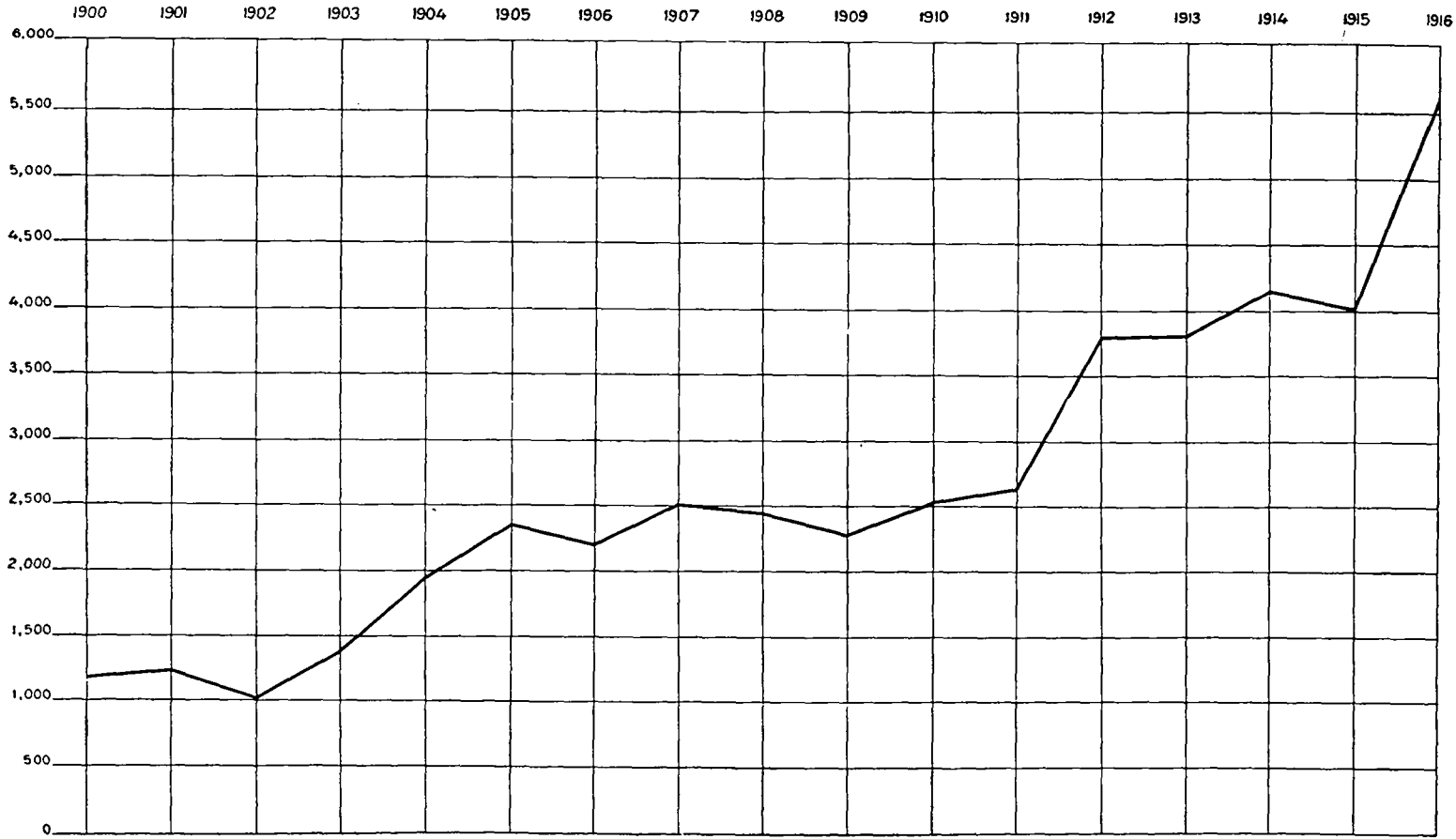
There are numerous instances of this kind where with proper public announcements the information that is necessary to shipping interests, and which has cost so much to secure, could be in the hands of those to whom it would be of real benefit, rather than uselessly stored here in Washington. How best to do this without an extravagant distribution of more or less expensive publications to persons ordering them through curiosity alone is being given earnest consideration. (See fig. 12.)

PRINTING OFFICE NEEDS.

For the printing office, now combined with the former sales section, the request is renewed for a new printing press, a transfer press, and a modern cutting machine. These would greatly increase the efficiency of that office.

The printing force has been under a heavy strain, and it should be rewarded by increases in salary for efficiency shown. Besides, increases in salaries are needed in order to place its employees on a par with employees in similar lines of occupation in other Government bureaus and in private concerns.

A continuance of the overtime work that has been necessary to meet (without increased pay) the demands for the Coast and Geodetic Survey's charts must result in the loss of the services of the employees in the printing office through their obtaining employment in branches of the Government service where overtime is not required and in private plants, and in decreased efficiency in those who remain here.



ANNUAL DISTRIBUTION OF COAST PILOTS.

Part II.—URGENT NEEDS IN THE FIELD AND NECESSARY EXPANSION OF THE WORK.

THE NEED OF 48 ADDITIONAL HYDROGRAPHIC AND GEODETIC ENGINEERS.

In the 1918 estimates request has been made to change the present title of "assistant," as applied to the Bureau's engineers, to "hydrographic and geodetic engineer." The universal feeling is that the suggested designation is far more appropriate than a title intended for a few men a century ago.

The accompanying table shows the need of additional engineers to officer properly and efficiently the various parties of the Survey. Congress wisely provided some additional funds with which to pay the party expenses, and this year additional increases in party expenses are asked for and it is hoped will be received from the Congress at the coming session.

That there should be increased activity of the Survey in charting the waters of the country and in providing geodetic control in the interior of the country admits of no doubt. If increased funds are provided for general expenses of the ships and shore parties, there must be provided increased funds for more hydrographic and geodetic engineers under whose immediate direction this work must be done.

The appropriations must bear a logical relation to each other for efficient expenditure or for minimum unit costs.

A board of directors of an industrial plant would not, without financial disaster, provide money in ample amount for supplies, raw materials, and labor, and only provide funds for 75 per cent of the number of necessary supervising officials and foremen.

In our case the engineers are not only the chiefs of party but they also make the observations with sextant, theodolite, plane table, and level. The men, or nontechnical force, are there to assist the engineer by rowing the boat, running the launch, heaving the lead, etc.; they absolutely can not do the instrumental work. Without the engineers the Survey is in the same condition as a merchant vessel which has not the requisite number of officers for its proper navigation. The result of such a condition is evident. The officers are overworked, lose their ambition to do things in the most efficient manner, and at the end of the season look for other and more inviting fields of engineering. Or, they may accept the conditions imposed and drift along thinking they (the officers) would be exerting futile efforts if those higher in authority are not sufficiently impressed with the importance of providing means for securing a well-balanced party which can secure results at a minimum unit cost. We can not blame them.

There will be needed 22 additional officers in the spring of 1917 to carry on the work for which party expenses have been appropriated as follows: On the *Surveyor*, 11; *Yukon*, 3; *Isis*, 4; *Matchless*, 2; and the Pacific coast triangulation, 2.

There are 48 additional officers asked for in my estimates for 1918. This will provide for the 22 now needed and mentioned above and for 26 more who will be needed if the increases in the party expenses appropriations are allowed. The following table shows how all these officers will be distributed:

PERSONNEL OF PARTIES, FIELD OFFICERS, COAST AND GEODETIC SURVEY.

Assignment.	Summer of 1916.						Summer of 1917.	
	Assistants.	Aids.	Mates.	Deck officers.	Total.		Parties.	Officers.
					Parties.	Officers.		
Office	15				10	15	10	15
Suboffices	5	1			4	6	4	5
Bache	2		2	4	1	8	1	7
Isis	3				1	3	1	7
Hydrographer	1	1		2	1	4	1	4
Matchless	1		1	2	1	4	1	6
Patterson	3	4	2	1	1	10	1	9
Explorer and Cosmos	3	2	1	1	1	7	1	7
Taku	1	2			1	3	1	3
Surveyor [a]							1	11
Yukon [a]							1	3
Wire drag:								
No. 1	2	2	1	3	1	8	1	7
No. 2	1	3	1	2	1	7	1	7
No. 3	2	3		3	1	8	1	7
No. 4	3	1	1	2	1	7	1	7
No. 5							1	7
No. 6							1	7
Pacific revision	3				2	3	3	6
Atlantic revision	3		1	1	3	5	4	6
Philippines	10	10	4		6	24	6	24
Inspecting new vessels	1				1	1	1	1
Coast pilot	4				4	4	4	4
Tides and currents	1				1	1	2	2
Triangulation	2				2	2	9	13
Levels	4				4	4	7	7
Gravity	2				2	2	2	2
Astronomical	3				3	3	3	3
Total	75	29	14	21	53	139	70	187

[a] Not in commission in the summer of 1916.

INCREASE IN SALARIES FOR HYDROGRAPHIC AND GEODETIC ENGINEERS.

The old theory about the civilian appointments in the Government was that any man was very fortunate who retained his job for more than four years, however insignificant the position and however small the pay. This was in the days before it was found necessary to enact the civil-service laws and put them into effect. Now the Government considers itself very fortunate if it can retain experts in its service for more than four years at salaries much smaller than those ruling in similar work in private life.

The Government is the largest single employer of skilled labor (for the sake of argument, calling all who work for salaries or wages laborers) in the country. It is also the most inefficient employer. It sees 15 or a larger per cent of the skilled employees leave each year. These are, as a general rule, the most able and most efficient ones. The least able employees remain, and on account of long and faithful, but many times not notably efficient, service they reach the highest salaries. Then we have too much dead wood at the top. How often do we hear that remark about a Government organiza-

tion, especially an old one. We sometimes try to remedy this condition by having a surgical operation when a much milder treatment given at the right time would have prevented the trouble.

What is the condition to-day in the field force (hydrographic and geodetic engineers) of the Survey?

There are 104 engineers in statutory and 14 in nonstatutory positions. Of the total of 118, there are 62, about 53 per cent, who have had less than 6½ years of service. There are 43, or about 36 per cent, who have had less than 3¼ years of service. Aside from the inefficiency in costs involved in having inexperienced officers, are we not menacing vessels carrying millions of dollars worth of cargo, besides their own value, and thousands of the crews and passengers who run the gravest risks from having a number of inexperienced engineers and surveyors making the surveys upon which the sailing charts are based? We are; and this condition should be remedied. We can not make some of the work easy, nor can we always make the conditions pleasant under which the men have to live in the field, but we should make our engineers feel that we (that is the Government) are fair.

What is necessary to make for greater efficiency in the force is to have salaries more nearly like those paid for similar or less exacting duties in other Government services and also in private engineering fields. The following tables show the salaries of the officers of the Survey in contrast with those of some other organizations, the relative increase of field officers and appropriations, and separations for six years:

COMPARISON OF PAY OF HYDROGRAPHIC AND GEODETIC ENGINEERS WITH ANALOGOUS ENGINEERING AND GOVERNMENT ORGANIZATIONS.

Service.	Average pay.	Reference.
American Society of Civil Engineers	$4,224	Report of committee of society, December, 1914.
41 civil engineers, United States Navy	3,429	1916 Estimates, p. 1078.
226 engineers, United States Army	3,008	1916 Estimates, p. 202.
62 Coast Guard officers (retired list)	2,921	1916 Estimates, p. 1120.
249 Coast Guard officers (active list)	2,670	1916 Estimates, p. 1120.
Geologists, Geological Survey (73 annual employees)	2,130	1916 Estimates, pp. 791-798.
Topographers, Geological Survey (57 annual employees).	2,164	1916 Estimates, p. 792.
Bureau of Mines (34 annual employees)	2,662	1916 Estimates, p. 806.
Patent Office (396 annual employees)	2,019	1916 Estimates, p. 95.
Hydrographic and geodetic engineers, Coast and Geodetic Survey (104 annual employees).	1,720	1917 sundry civil act.
Hydrographic and geodetic engineers, if granted increase requested (152 annual employees).	1,900	1918 Estimates.

RELATIVE INCREASE OF FIELD OFFICERS AND APPROPRIATIONS, COAST AND GEODETIC SURVEY.

Fiscal year.	Field officers.	Deck officers.	Total officers.	Percentage of increase over previous year.	Appropriation party expenses.	Percentage of increase over previous year.
1915	125	5	130	0	308,000	0
1916	123	13	136	5	343,000	11
1917	118	21	139	2	422,320	23
1918a	166	21	187	35	589,838	40

a Estimated.

SEPARATIONS DURING THE SIX YEARS SINCE NOVEMBER, 1909.

Class.	Positions in class.	Resignations in about 6 years.	Per cent.
$3,000 and above	8	2	25
Below $3,000 and above $2,000	20	1	5
$2,000	8	3	37
$1,800	8	6	75
$1,600	8	1	12
$1,400	8	8	100
$1,200	10	11	111
$1,100	6	9	150
$1,000	18	14	78
$900	5	11	220

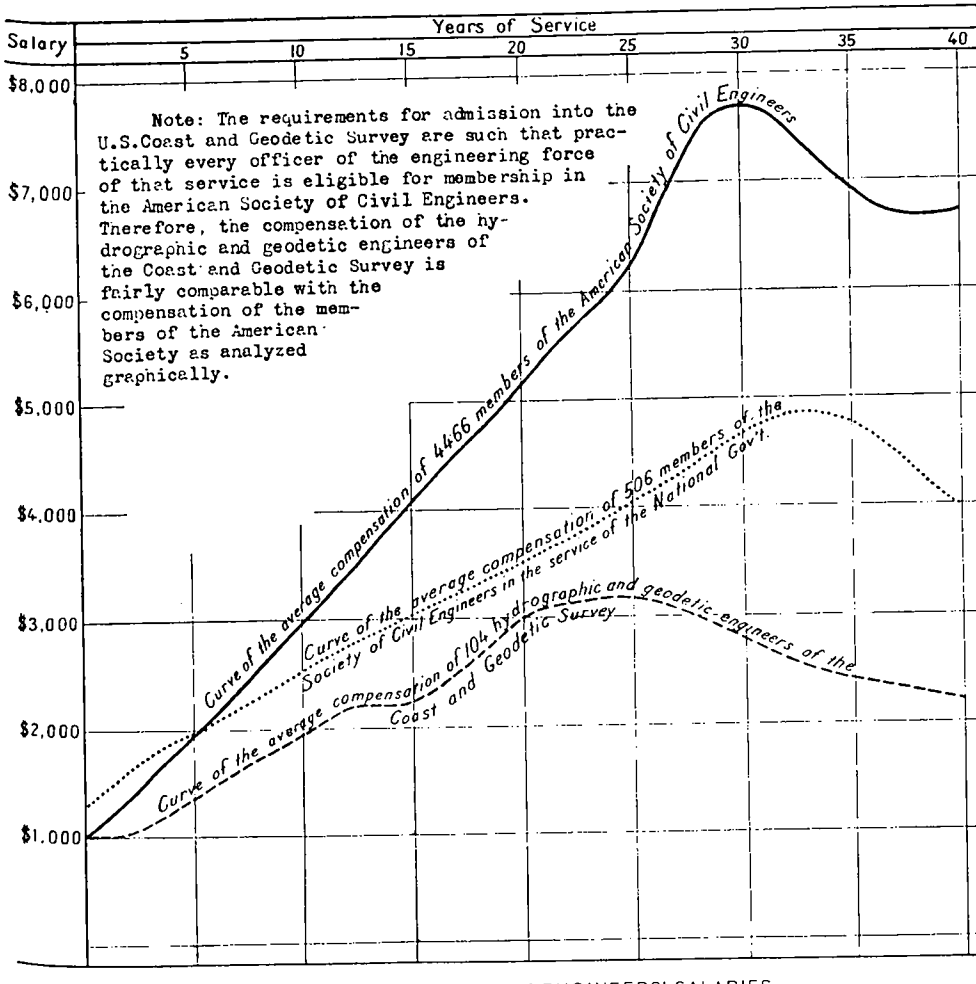
NOTE.—Wherever information is available in regard to those who resigned from the field force, in general, the salary received in the new position is higher than that received in the Coast and Geodetic Survey.

This table shows that, during the six years since November, 1909, 66 members of a total of 99 field officers of the Coast and Geodetic Survey resigned their positions. The list does not include any removals on account of death. Nearly all in the list resigned to take up work paying higher salaries or with prospects of an increased income or because of hardships incident to the life of a field man in the Survey.

The increases in the number of positions called for in the 1918 estimates are distributed in such a way as to make the salary list more attractive to those now in the service and to the graduates of our engineering schools.

During the past seven years and until July 1, 1916, every man whose name was placed on the aid register by the Civil Service Commission was offered a position in the Survey. This is an unhealthy condition of affairs. We should have so many names on the register that the appointing officer may always have a choice of at least three eligibles for each position to be filled. Any other condition is contrary to the best public policy.

The salary list is designed to provide for lowest unit costs and maximum safety; in other words, the greatest efficiency. (See fig. 13.)



COMPARATIVE DIAGRAM OF ENGINEERS' SALARIES.

Coast and Geodetic Survey Appropriations for Salaries, 1899–1917, Compared with Estimates for 1918.

Designation.	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918[a]
Superintendent	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$5,000
Assistants:																				
$4,500																				[b] 1
$4,000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	[b] 2
$3,500																				[b] 2
$3,200	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	[b] 4
$3,000	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	[b] 5
$2,800																				[b] 5
$2,600																				[b] 6
$2,400	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
$2,200			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	7	8	[b] 14
$2,000	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	9	[b] 16
$1,800	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	[b] 16
$1,600	3	3	3	3	3	3	4	4	4	8	8	8	8	8	8	8	8	8	9	[c] 16
$1,400	3	4	4	4	4	4	4	4	4	8	8	8	8	8	8	8	8	8	9	[c] 14
$1,200	3	3	3	3	3	3	4	4	4	8	8	8	8	8	8	8	8	8	9	[c] 12
	6	8	8	8	8	8	10	10	10	10	10	10	10	10	10	10	10	10	10	[c] 13
Total	40	47	48	48	48	48	52	52	52	64	64	64	64	64	64	64	64	70	[d] 75	126
Aids:																				
$1,100									6	6	6	6	6	6	6	6	6	6	10	13
$1,000													13	18	18	18	18	18	19	13
$900	4	6	6	6	6	6	6	6	13	13	13	13	10	5	5	5	5	5		
$720	4	8	8	23	23	23	23	23	10	10	10	10								
Total	8	14	14	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	26
Disbursing agent	$2,200	$2,200	$2,200	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500
Librarian	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800	$2,000
Clerks:																				
$2,000																				[e] 2
$1,800				2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	[f] 4	4
$1,650	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	5
$1,400	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	6
$1,200	6	6	6	6	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8	10
$1,000	3	3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	5	10
$900											6	6	6	10	10	10	10	10	10	10
$800											1	1	1							
$720											7	7	7	6	6	6	6	6	6	
$600											1	1	1							

[a] Estimates.
[b] Hydrographic and geodetic engineers.
[c] Junior engineers.
[d] Includes 5 nautical experts.
[e] One chief of printing and sales section and 1 bookkeeper.
[f] Includes 1 clerk to the superintendent.

COAST AND GEODETIC SURVEY APPROPRIATIONS FOR SALARIES, 1899–1917, ETC.—Continued.

Designation.	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918
Chart correctors, writers, etc.: [a]																				
$1,200	2	2	2	2	2	2	2	2	2	2										
$900	3	3	3	3	3	3	3	3	3	6										
$800	1	1	1	1	1	1	1	1	1	1										
$720	7	7	7	7	9	9	9	9	9	7										
$600	1	1	1	1	1	1	1	1	1	1										
Total	29	29	29	31	33	33	33	34	34	35	35	35	35	38	38	38	39	39	40	47
Draftsmen:																				
$2,700																				b 1
$2,400	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3
$2,200	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3
$2,000	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	4
$1,800	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4
$1,600			2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	5
$1,400	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	5
$1,200	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3	3	3	5
$1,000	3	3	3	3	3	3	3	3	3	3	3	3	3	5	5	2	2	2	c 3	c 2
$900	2	2	2	2	2	2	2	2	2	2	2	2	2							
$700	1	1	1	1	1	1	1	1	1											
Total	16	16	18	18	18	18	19	19	19	22	22	22	22	22	22	22	22	22	23	32
Computers:																				
$2,700																				d 2
$2,500													1	1	1	1	1	1	1	1
$2,400	1	1																		
$2,200													1	1	1	1	1	1	2	3
$2,100													2	2	2	2	2	2	2	
$2,000	2	2	2	2	2	2	2	2	2	2	2	2							2	4
$1,800	1	1	1	1	1	1	1	1	1	2	2	2	3	3	3	3	3	3	3	5
$1,600	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	5
$1,400	1	1	1	1	1	1	1	1	1	1	1	1	4	4	4	4	4	4	4	5
$1,200	1	1	1	1	1	1	1	1	1	1	1	1	5	5	5	5	5	5	5	5
$1,000	3	3	3	3	8	8	8	9	9	9	9	9								
Total	12	12	12	12	17	17	17	18	18	19	19	19	19	19	19	19	19	19	22	30
Engravers:																				
$2,400														1	1	1	1	1	1	1
$2,200														2	2	2	2	2	2	2
$2,000	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
$1,800	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
$1,600	2	2	2	2	2	2	3	3	3	3	3	3	3	2	2	2	2	2	2	2

$1,400	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2
$1,200	2	2	2	2	2	2	2	2	2	3	3	3	3	2	2	2	[c]1	1	1	1
$1,000	2	2	2	2	2	2	2	2	2	3	3	3	3	2	2	2	2	2	2	2
$900	4	4	4	4	4	4	4	4	4	4	4	4								
$700	1	1	1	1	1	1	1	1	1											
Lump sum													$3,600	$3,600	$3,600	$3,600	$3,600	$3,600	$3,600	$3,600
Total	17	17	17	17	17	17	19	19	19	21	21	21	17	17	17	17	16	16	16	16
Instrument makers:																				
$3,000																				[f]1
$2,400																	1	1	1	
$1,800																				1
$1,600																	1	1	1	2
$1,400																	2	2	2	3
$1,200																	1	1	1	3
$1,000																	3	3	3	
Total																	8	8	8	10
Carpenters and painters:																				
$1,400																				[g]3
$1,200																	3	3	3	
$900																	1	1	1	2
Total																	4	4	4	5
Electrotypers, photographers, etc.: [h]																				
$2,200																				[f]1
$2,000																	1	1	1	2
$1,800																	[f]1	1	1	2
$1,700																	[f]1	1	1	
$1,600																	1	1	1	7
$1,400																	1	1	1	2
$1,200																	[h]8	8	8	4
$1,000																	2	2	2	3
$900																	2	2	2	2
$700																	5	5	5	2
Total																	22	22	22	25

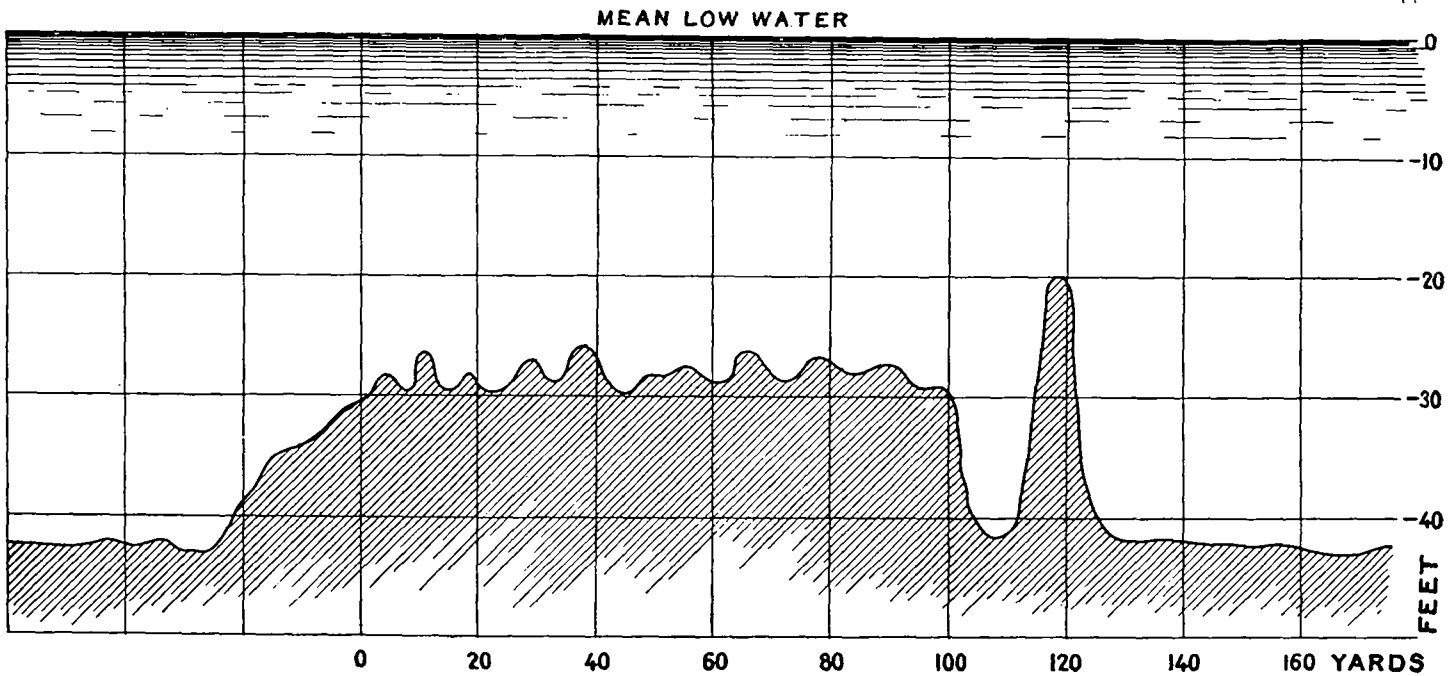
[a] Classified as clerks after 1908.
[b] Chief cartographer.
[c] Copyist draftsmen.
[d] Computing engineers.
[e] Classified as lithographer in 1915.
[f] Mechanical engineer.
[g] Pattern makers and carpenters.
[h] Classified as electrotypers, photographers, printers, instrument makers, etc., prior to 1915.
[i] Chief printer.
[j] Formerly paid from lump-sum appropriation for lithographers.
[k] Were formerly engravers; designation changed to lithographers.

COAST AND GEODETIC SURVEY APPROPRIATIONS FOR SALARIES, 1899–1917, ETC.—Continued.

Designation.	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918
Electrotypers, photographers, printers, instrument makers, etc.: [a]																				
$2,400														1	1	1				
$2,000										1	1	1	1	1	1	1				
$1,800	2	2	2	2	2	2	2	2	2	1	1	1	1							
$1,600	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2				
$1,400																2				
$1,200	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3				
$1,000	9	9	9	9	10	10	10	11	11	12	12	12	11	11	11	11				
$900	2	2	5	5	5	5	5	5	5	5	5	5	5	5	5	5				
$700	5	5	1	1	2	2	2	2	2	3	3	3	3	3	3	3				
$600			6	6	6	6	6	6	6	7	7	7	7	7	7	5				
															1					
Total	21	21	24	24	26	26	26	27	27	30	30	30	30	30	31	31	34	34	34	
Watchmen, messengers, etc.:																				
$900																				[b] 1
$880	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
$840																				5
$820	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
$720					2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	4
$700	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4	4	4	4
$640	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$630	4	4	4	4	4	4	4	4	4	2	2	2	2	3	3	3	3	3	3	3
$550	2	2	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4
$365	2	2	2	2	2	2	2	2	2	2	2	2	2							
Total	19	19	20	20	22	22	22	22	22	23	23	23	23	23	23	23	23	23	23	26

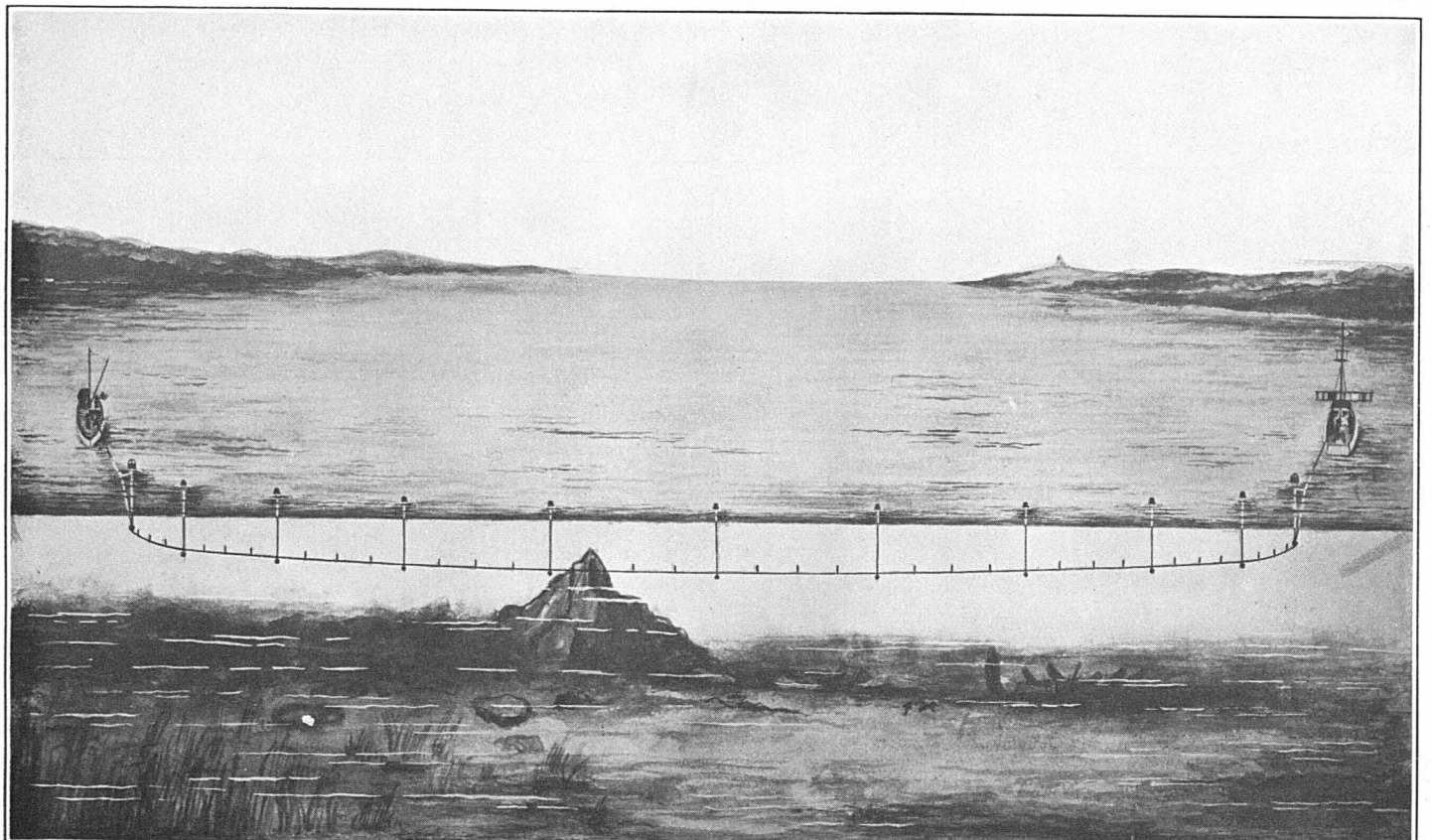
[a] After 1914 classified as electrotypers, photographers, etc.

[b] Foreman.

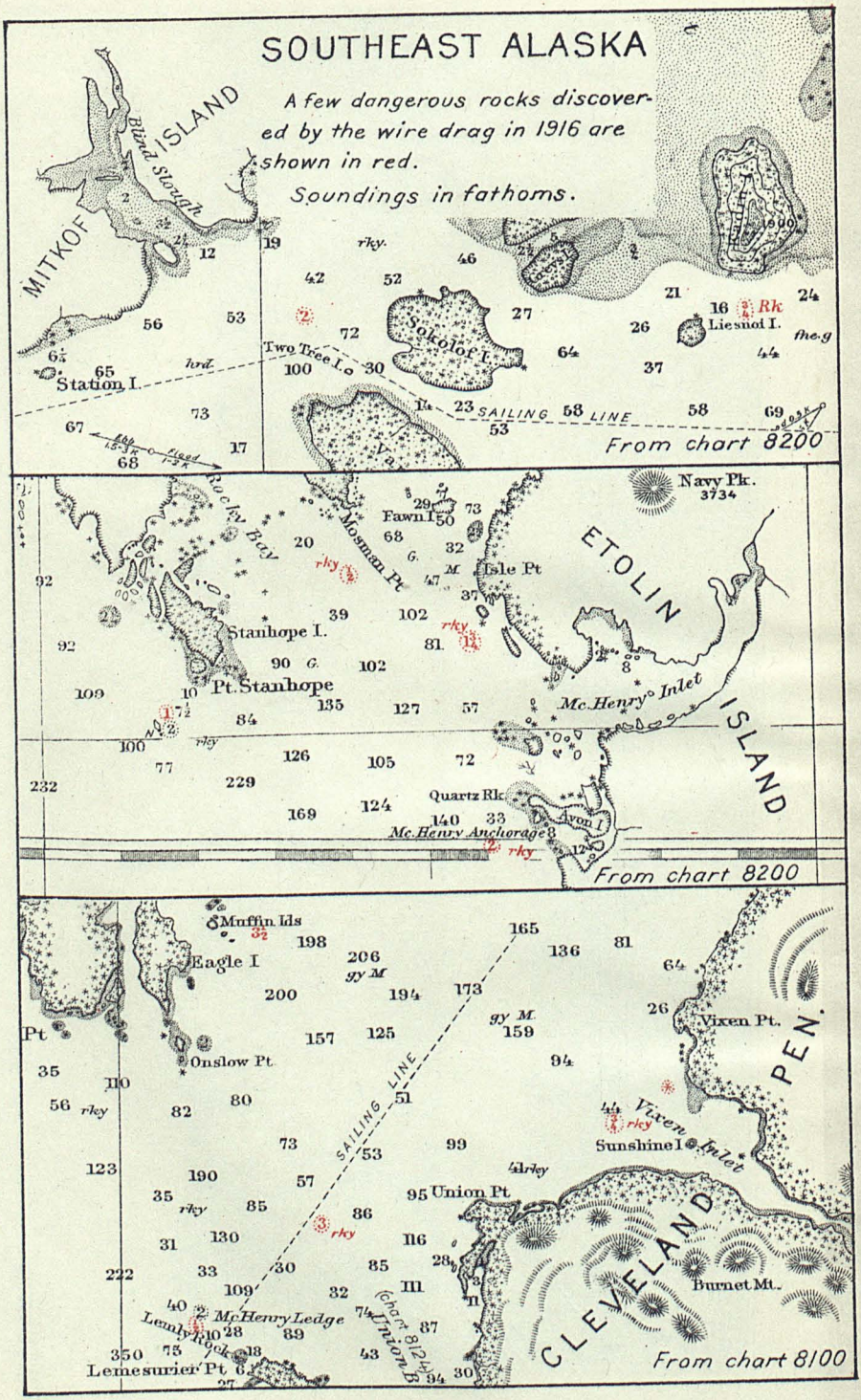


IMPORTANT FIND BY WIRE DRAG, SALEM HARBOR, MASS., 1916.

This pinnacle rock recently found at the approch to Salem Harbor, Mass., is no less dangerous than submerged pinnacles abounding in Alaskan waters.



IMPROVED FORM OF WIRE DRAG.


SOUTHEAST ALASKA
A few dangerous rocks discovered by the wire drag in 1916 are shown in red.
Soundings in fathoms.
MITKOF ISLAND
Blind Slough
Station I.
Two Tree I.
Sokolof I.
Liesnoi I.
SAILING LINE
From chart 8200
Rocky Bay
Mosman Pt.
Fawn I.
Isle Pt.
Navy Pk.
3734
ETOLIN ISLAND
Stanhope I.
Pt. Stanhope
Mc. Henry Inlet
Quartz Rk.
Mc. Henry Anchorage
Avon I.
From chart 8200
Muffin Ids
Eagle I.
Onslow Pt.
SAILING LINE
Vixen Pt.
Vixen Inlet
Sunshine I.
CLEVELAND PEN.
Union Pt.
Burnet Mt.
Mc. Henry Ledge
Lemesurier Pt.
(chart 8124)
Union B.
From chart 8100

GREATER NECESSITY FOR WIRE-DRAG WORK.

Bowlders, ledges, and other forms of pinnacle rocks have, as usual, been found by the surveys this year. Perhaps the most striking illustration during the year proving the value of the wire-drag work was the development of the main ship channel leading to Salem Harbor, Mass. (See fig. 14). Numerous rocks were found in this channel, which very considerably restricted its width for deep-draft vessels, and this work was fortunately done prior to the visit of one of our battleships there the summer of 1916. At the request of the commanding officer of the battleship, one of the wire-drag parties buoyed the channel and an anchorage for the use of the ship.

The correspondence upon the subject drew the attention of the Navy Department to the matter, and as a result a request was received from the Secretary of the Navy that the areas covered by wire-drag surveys be indicated on special editions of the charts for the use of naval vessels. Arrangements have been made for complying with this request.

The general board of the Navy has also given consideration to the use of wire-drag surveys as a part of the national defense, and the Bureau has cooperated with them in planning this work to meet their most urgent needs. A careful study of the subject has been made, and the estimates submitted to Congress for the fiscal year 1918 have been prepared to carry funds for surveys of two localities requested by the Navy, and which it would not be possible for us to do with only our usual appropriations. (See fig. 15.)

A striking development in hydrographic methods this year was the use of a drag 15,000 feet in length in open areas. It is hoped that this length may be increased for ordinary use in open areas as soon as larger reels to hold the necessary length of wire are available. The delivery of the reels has been delayed owing to circumstances over which we have no control.

The numerous submerged pinnacles found in Alaskan waters and on the New England coast during 1916 clearly demonstrate again the urgent need of expediting this important work in these vast areas known to be dangerous to human life and commerce. There is also wire-drag work urgently needed in Puget Sound and San Francisco Harbors and among the coral reefs of southern Florida, which is only waiting for the necessary funds when their safety can be assured. (See fig. 16.)

TWO NEW VESSELS FOR THE PACIFIC COAST AND ALASKA.

Since my last report to you I recommended, and you approved, the sale of the *McArthur* and *Gedney* of the Pacific coast fleet, both of which had reached the stage where their existence jeopardized the lives of officers and men.

In last year's estimates two new vessels were asked for to take the place of the *Gedney* and the *Patterson*. The *Patterson* is still in the service, but old, weak, and unfit for exposed work that should be expected of her in protecting the waters on the Pacific coast.

Congress felt that the replacing of these vessels should be deferred for the present. This request for these two new vessels for the Pacific coast and Alaska is renewed, with the earnest hope that the

increasing need of surveys on that coast will be recognized. It may be well to add here that both the *Patterson* and the *Explorer* will necessarily require repairs this year. In view of the age of these vessels and their condition, it is inadvisable to make extensive repairs to them. It has never been more evident that extraordinary efforts should be made to keep up with the rapid progress of the Pacific coast and Alaska, and to safeguard the waters which are really the main method of transportation. Alaska, up to 1913, had been in a more or less dormant state. Within three years the Territory has developed wonderfully; the new railroad is being built to tap the interior, and its exports and imports have increased from $61,000,000 to about $100,000,000; and the work of making surveys, which was backward before this increased trade activity, has not kept pace with the development of this vast and valuable Territory.

It is very essential that these new vessels asked for be allowed in order to survey without further delay the great water area of central and western Alaska.

It is gratifying to be able to say that the *Surveyor*, the most suitable vessel of her kind ever built for this Service, will be ready for the Alaska work next spring. Her keel was laid in the winter of 1915 and she was launched in July of this year. She is intended to replace the *McArthur*. (See fig. 17.)

In addition to the present work in Alaskan waters, the coasts of Washington, Oregon, and California are in urgent need of completed surveys and the protection which complete and accurate charts afford. It has been impossible heretofore to give these coasts the attention they have needed and their commerce demands.

It is a fact that should bear some weight in further argument for these new vessels that their construction in accord with the Navy's views makes them auxiliaries for our country's protection in time of war.

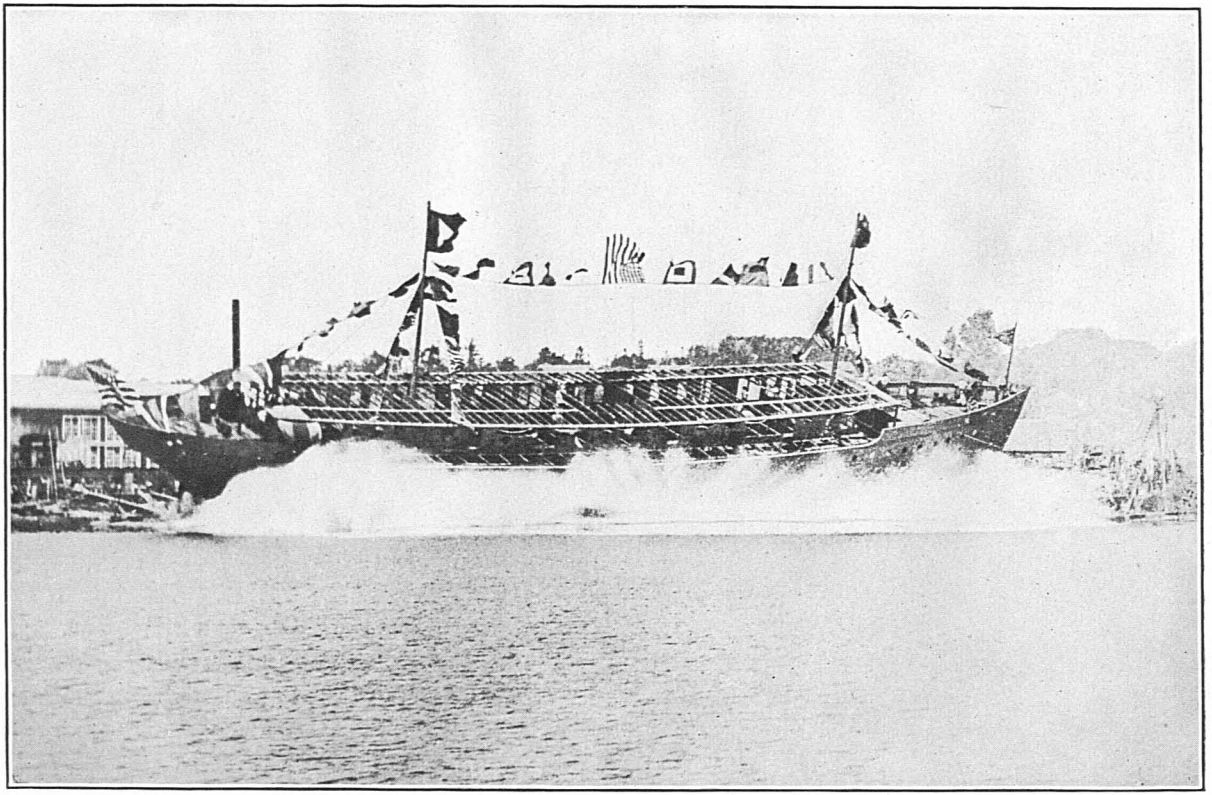
On the Atlantic coast the new vessel *Isis* has done admirable work during the past season. She, the *Bache*, and the *Hydrographer* are all in good working condition and suited for the work they are called upon to do. The *Matchless*, an old sailing vessel, nearly 60 years old, is used as a houseboat for surveying parties in some of the inland waters. Extensive repairs on her are useless as she will probably last only a few years longer.

It is earnestly hoped that sufficient funds will be appropriated to keep these vessels in service during the whole year, as their services are needed on survey work continuously. Annual repairs do not prevent continuous work by officers and crews.

One of the pressing needs for new vessels and appropriations to keep all of our vessels in service throughout the entire year is the close relation of surveys to our national defense, inasmuch as the Navy is dependent upon these surveys for the safe navigation of its ships.

GOVERNMENT-OWNED LAUNCHES NEEDED.

An appropriation for the purchase of launches for wire-drag surveys and inshore work on the Atlantic and Pacific coasts is again urged. The wire-drag parties cost, on an average, $3,173 per month each, a large part of which is for the hire of launches. Launches



LAUNCHING OF SURVEY STEAMER "SURVEYOR."

suitable for these operations are scarce, and all that are available must be modified to meet the needs of the work. The launches most suitable are the highest priced. For example, the largest boat in each of the Alaska parties cost nearly $1,000 each per month. A great deal of time is lost each year and annoyance incurred in selecting and remodeling the boats for this particular service. The superstructure has to be removed and put back in the shape it was found at the end of the season, and the Government has to pay for it. If, on account of bad weather, the launches have to be laid up, the cost of their hire still goes on, and while the officers and men are not idle the launches are making no returns.

If the appropriation is made for Government built and owned launches, they can be built not only in the way best adapted for the work, but they can be used for wire-drag work as well as revision and inshore work. Considered from the standpoint of economy, it is certain that as much as 20 per cent would be saved annually on the investment.

The same argument applies in building these launches as with the vessels—that their construction is subject to consultation with the Navy Department and they would be invaluable in time of war.

INCREASE OF PAY OF MEN ON VESSELS.

One of the most serious matters that the Bureau has had to contend with is the general increase in the pay of the men employed on the vessels of the Coast and Geodetic Survey. While more or less evident in previous years, this has been brought to the point the past season where drastic action was necessary. On July 1, 1916, you approved recommendations for increases in pay of $8 per month for seamen and quartermasters and $5 a month for other petty officers in Alaska in order to insure the retention of these employees. This matter is made clear by the following extracts from communications from the commanding officer of the steamer *Explorer*, and I believe the statements are conservative:

U. S. S. "EXPLORER,"

Port Bazan, W. Coast Dall Island, Alaska, June 7, 1916.

During the last month two sailors have deserted. William Sellick, who had previously been in the service, deserted to take a position on a pile driver at $65 per month and board, overtime at 50 cents per hour; Sondersen, to go on the schooner *Kuskokwim River* at the coasting wage for seamen of $55 per month and 50 cents an hour overtime, and no uniform to purchase.

We have a very good crew, a number of old men in the service, who by their work have become very valuable to it, but can one blame them from being dissatisfied when they see other Government services, as well as merchant service, paying a much greater wage than they are receiving?

I hope, sir, to be able to get through the season without any serious trouble with the crew. I am quite sure none will be caused by the treatment the men receive, but only by lack of enough wage, poor accommodations, and the uncertainty as to their employment during the winter.

U. S. S. "EXPLORER,"

Ketchikan, Alaska, June 18, 1916.

Owing to the great demand for labor and the scarcity of good men the wages on the coast have been raised in all work connected with steamships. The captains, mates, and engineers have already received an increase of at least $15 per month on the Alaska boats; the sailors' and longshoremen's unions have

both conducted a successful strike; and the latest development is a reported strike of the crew of the *Kukui* of the Lighthouse Service, which pays much more than this service. These facts have caused a just spirit of unrest among the crew of this vessel. They realize that they could get a great deal more outside the Coast Survey. This led me to send you today the following wire:

"Would strongly recommend increase in wage of all enlisted men. Impossible on coast to get men for wages now paid. Labor scarce and wages high. Understand crew lighthouse tender *Kukui* struck at Seward. Have good crew. All can get more money on outside. Please wire me Ketchikan."

To avoid the possibility of delaying the work I felt it my duty to send you this wire recommending a raise for all enlisted men.

In the estimates for 1918 for the Alaska vessels a further increase of $3 per month per man is included for the lower paid employees.

On the Atlantic coast increases in pay are urgently needed, but the present appropriation will not permit it. In the estimates for 1918 increases of $5 to $10 per month are included. The following communications and extracts from communications from the commanding officers of the steamers *Bache* and *Isis* explain conditions:

STEAMER "BACHE,"
Norfolk, Va., July 6, 1916.

I desire to call your attention, although I am aware that you are conversant with the condition, to the scale of wages paid our enlisted force on board the vessels of this service.

At present it is with extreme difficulty that we can keep our crew, when all other services are paying higher wages, especially the merchant service. Every day my men want their discharges to accept better paying jobs elsewhere on board ships. Only a few of my men seem contented. To fill the places of those that leave, I can only get men of the class that nobody else has use for. Alongside of us is the Fisheries steamer *Roosevelt* paying $40 per month for seamen and the lighthouse tender *Orchid* $35 per month, with the other ratings high in proportion.

STEAMER "ISIS,"
Norfolk, Va., June 28, 1916.

Owing to the high rate of wages being paid in the merchant service at the present time it is very difficult to hold good men on the complement of this vessel, when some receive less here as petty officers than they would receive in the merchant marine as ordinary seamen. Heretofore it has been very difficult to hold good men here on account of the low pay. Of course, the petty officers are the backbone of an efficient organization and unless it can be arranged to pay these men more money, we will certainly lose some of them.

The facts are emphasized by the following statement of seamen's pay:

Service.	East coast.		West coast.	
	Pay per month.	Rations per day.	Pay per month.	Rations per day.
Coast and Geodetic Survey	$30.00	$0.45	$48.00	$0.45
Lighthouse Service	30.00–45.00	.45	55.00–60.00	.45–.60
Coast Guard	36.00	[a] .30	44.40	[a] .30
Merchant marine	45.00	[b]	55.00	[b]
Bureau of Fisheries	50.00	.25		

[a] Commuted subsistence fixed by law at 30 cents and used only when a mess can not be conducted. Actual cost of living when food is purchased by the Government and issued to the men varies from 47 cents to 55 cents each per day. At some stations food has cost 60 cents per man per day during this year.

[b] From 50 cents to $1, depending upon class of vessel and line. Crews are furnished meals by the vessel's owners.

This brings out the fact that there is no service in the Government where trained seamen are so absolutely essential to the welfare of the work. An officer in this Service is a trained specialist, and the same term can be used in reference to a seaman who has had a term of service in this Bureau. The demands on him are much more exacting than under the regular routine on passenger steamers, and his duties are more varied and require more thoughtfulness and skill. It can be readily understood that a man who has been trained by an officer of the Government until he reaches a high degree of efficiency should be retained from year to year. Conditions should be such that an employee who proves satisfactory can be given assurance that promotion will follow efficient effort on his part. Under the present conditions an inexperienced man is hired in the spring, receives a partial training during the summer, and is dismissed in the fall because the funds are insufficient to continue his employment from year to year. Were the funds sufficient it is perfectly feasible to keep these men busy continuously from year to year on work that is necessary to be done.

GEODETIC WORK.

In my report for 1915 it was shown that the national Government should do the geodetic work of the United States, which furnishes the fundamental control in elevation and geographic position for the surveying and mapping and the various engineering operations of the country.

This work largely consists in the precise leveling, which, starting at the coasts, extends inland along the principal lines of communication and forms a network of lines of bench marks of a permanent nature which may be used as bases from which leveling of equal or lower accuracy may at any time in the future be extended for the detailed surveying and engineering work; and in primary triangulation which will cover the country with connecting arcs of stations all substantially monumented. The standard or final latitude and longitude of each station are determined and published for the control in horizontal positions of maps, surveys, and engineering works.

This country has an area of about 3,000,000 square miles and the extension of the fundamental control has been necessarily slow on account of the cost involved; but to-day this work is done for less than one-half what it cost 20 years ago and with more accuracy, and as the demands for the results are far greater than they were previously it appears to be good management, on account of the necessity for the results and the economy with which it is done, to push to a rapid completion that part of the work which is essential now in the proper development of the country.

The plan that should be carried out during the next few years is to have such an amount of primary control that no place in the United States will be more than approximately 100 miles from a precise-leveling bench mark and a primary triangulation station.

The appeal to Congress during the past session for funds to extend the geodetic work of the Survey was met by an increase of 70 per cent. This is a good start, but considering the fact that the previous appropriation was only $31,000, it will be seen that further increases should be made, as the estimated cost of completing the

work which is badly needed *now* is more than $1,000,000. If no further increase is made, this work will require from 15 to 20 years. It should be done in one-half that time.

What has been said as to the need for geodetic control in the United States applies equally to the interior of Alaska. There is no control, except along the Alaska and Canada boundary and along a portion of the coast, for an area of over one-half million square miles of territory, which is becoming more and more necessary for the operations of several Federal organizations as well as for private individuals and corporations. The country can not be properly developed without maps and surveys, which in the interior are being made by the United States Geological Survey, the General Land Office, the Forest Service, and the Alaskan Engineering Commission. Requests for geodetic data in the interior of Alaska have been made upon the Coast and Geodetic Survey by officials of those organizations, and I strongly recommend that funds be provided for starting this important work.

The precise leveling and primary triangulation which should be done in the interior of Alaska to enable these requests to be met are indicated on the accompanying diagrams and in the following statement:

PRIMARY TRIANGULATION NEEDED IN ALASKA. (SEE FIG. 18.)

	Miles.
Norton Sound to Eagle via Yukon River	750
Yukon River to Kuskokwim Bay	850
Upper part of Kuskokwim River	250
Across Alaskan Peninsula, Cook Inlet to Bristol Bay	120
Susitna River, Cook Inlet to Fairbanks	300
Cordova to Tanana, along Copper and Tanana Rivers	700
From Copper River to one hundred and forty-first meridian	100
Total	2,570

PRECISE LEVELING NEEDED IN ALASKA. (SEE FIG. 19.)

	Miles.
Norton Sound to Eagle via Yukon River	800
Yukon River to Kuskokwim Bay	400
Upper part of Kuskokwim River	300
Susitna River, Cook Inlet to Fairbanks	325
Cordova to Tanana, along the Copper and Tanana Rivers	750
Copper River to one hundred and forty-first meridian	110
Total	2,685

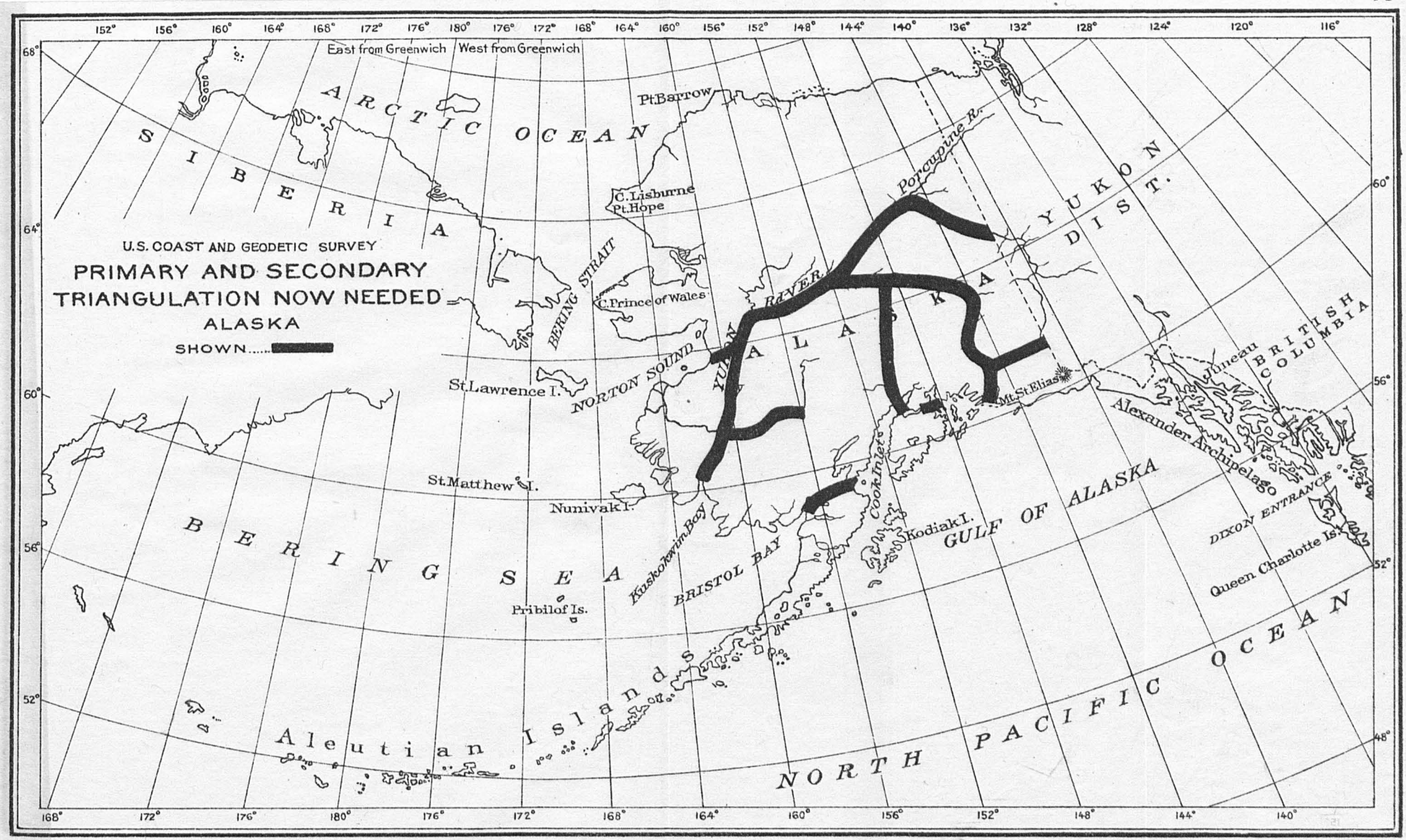
In my report for the previous year, there was shown the importance of having certain primary triangulation on the Pacific coast of the United States and Alaska and supplementary triangulation on the Atlantic and Gulf coasts. The increased funds provided by Congress made it possible to do something on these lines of work.

The Survey has continued the establishment of gravity stations and astronomic observations for the purpose of collecting data to be used in making researches in isostasy. From the results of these researches our knowledge will be increased regarding the shape and size of the earth and the variations from the normal densities in the outer portion (commonly called the crust) of the earth.

I can not leave this subject of geodetic work before calling attention to the assistance needed at the office to make the results of the

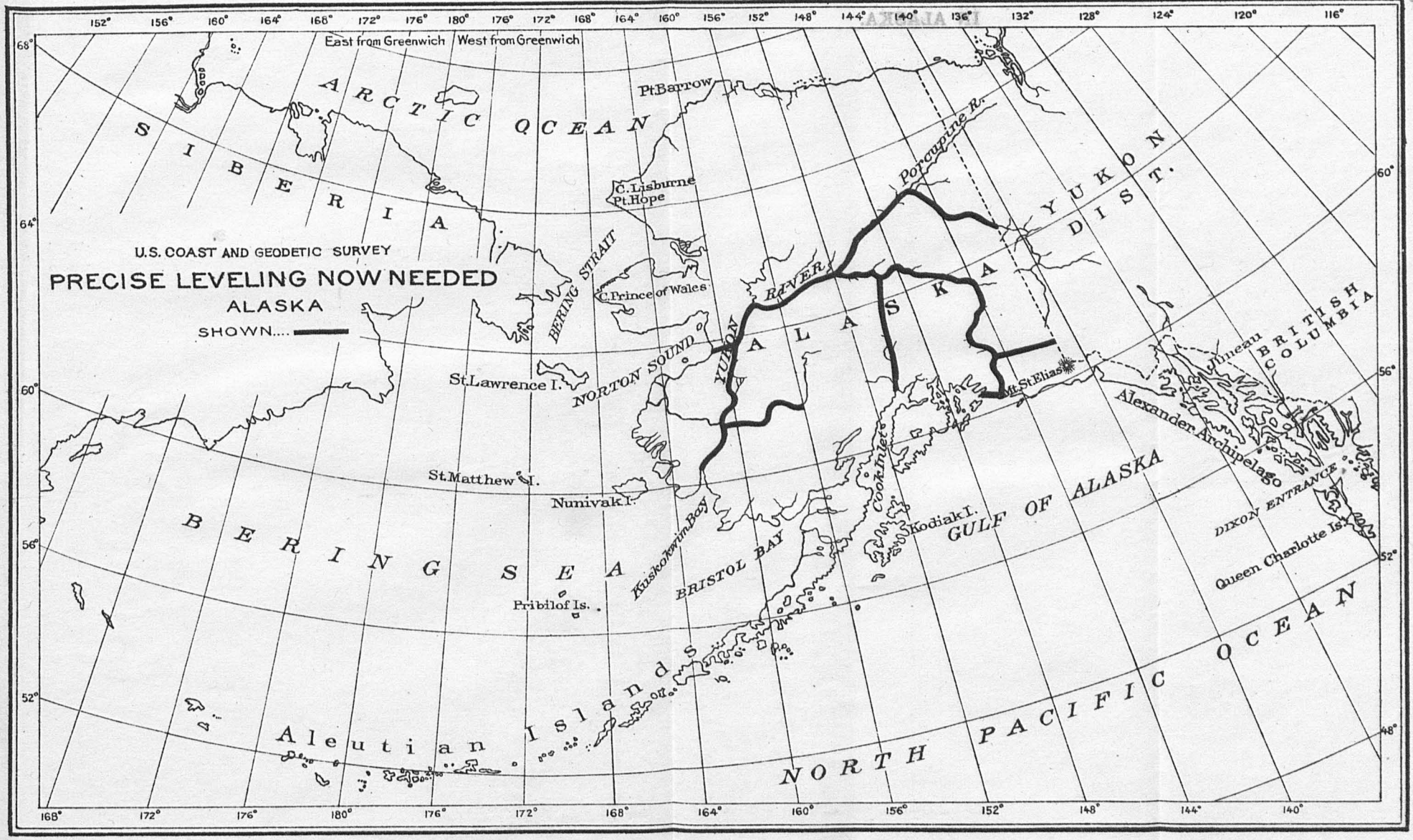
No. 18.

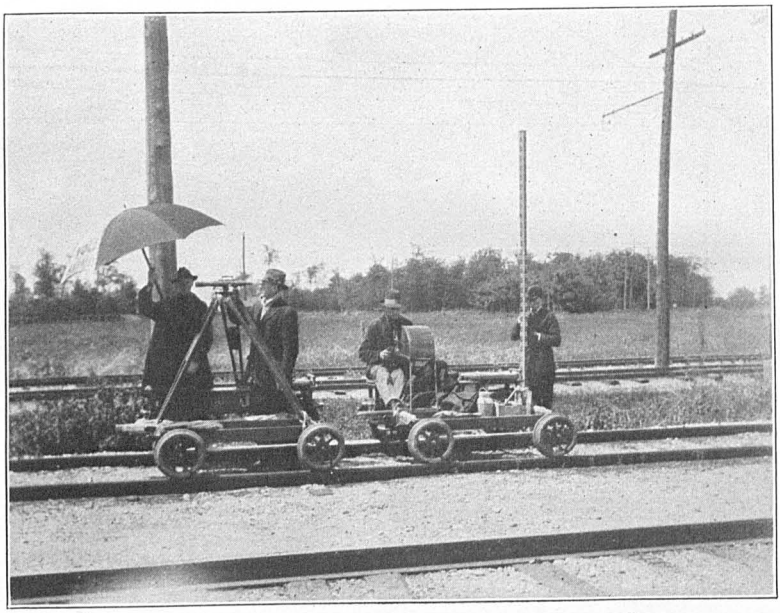
TRIANGULATION NEEDED IN ALASKA.


U.S. COAST AND GEODETIC SURVEY
PRIMARY AND SECONDARY TRIANGULATION NOW NEEDED
ALASKA
SHOWN.....
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.
ALASKA
YUKON RIVER
NORTON SOUND
St.Lawrence I.
St.Matthew I.
Nunivak I.
BERING SEA
Kuskokwim Bay
BRISTOL BAY
Pribilof Is.
Aleutian Islands
Mt.St.Elias
Juneau
BRITISH COLUMBIA
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
Cook Inlet
Kodiak I.
GULF OF ALASKA
NORTH PACIFIC OCEAN

No. 19.

PRECISE LEVELING NEEDED IN ALASKA.


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



MOTOR VELOCIPEDES USED IN PRECISE LEVELING.

field work available for the Government and for the public; in the language of the day, the ultimate consumers.

For many years the primary triangulation in the interior and the tertiary triangulation on the coast existed as a number of detached schemes each based upon a separate astronomic determination (datum) for the latitudes and longitudes of the stations. Eventually (in 1901) the systems were sufficiently connected to justify the adoption of a single datum for the whole country. This was necessary for the proper utilization of the results. The adoption of the single datum for the whole country has been highly commended by geodesists of Europe where, in general, each country has its own datum, with consequent confusion in the maps along the frontiers.

The adoption of the single datum, however, involved the Survey in much office work, for practically all of the triangulation done previously needed recomputing. But new geodetic work has been turned in, in increasing amounts, by the vessels and land parties, due to larger appropriations for field work, so that at present there have accumulated thousands of triangulation stations for which the standard or final positions are not available in the proper form for use. There has not been a proportionate increase in the computing force, which is now just about able to compute and have published each year data for as many stations as are established in a year. It is not able to handle in addition the older but very valuable work. Without an increase in the force of computers much geodetic data must remain in the archives and be practically unavailable for use.

The establishment of a triangulation station in the field costs, on an average, about $60, while the cost of computing the observations and preparing the results for printing is only about $7 per station. It will be good business to make this additional expenditure, in the form of increased appropriation for additional geodetic computers. Not to do so would be as inefficient as officials of a factory not providing sufficient force for the packing and sale of its products.

IMPROVEMENTS IN PRECISE-LEVELING METHODS AND INSTRUMENTS.

Several marked improvements were made in precise leveling during the year. One was the change in the manner of setting up the tripod on which the level is mounted. Formerly, the tripod was set upon the ballast of the railroad track, while now it is set rigidly upon a motor velocipede car. The level is placed upon the tripod at the beginning of a day's work and remains there until the day's work is completed. The observing is not now such a strain upon the observer and greater progress can be made. Another innovation was the use of a listing adding machine on which to record the rod readings. The use of this machine insures greater accuracy and smaller costs in the computations of the results. Figure 20 shows the two motor velocipedes on which are mounted the tripod for supporting the instrument and the adding machine on which are recorded the rod readings.

A third improvement was in changing from the top of the railroad rails to the railroad spikes as the supports for the rods during the leveling. This has resulted in greater accuracy in the results and a slight decrease in the costs.

The fourth improvement was the substitution of metal for wooden rods. The metal used is the alloy known as gamma steel, which has a very small change in length as compared with other metals for any given change in temperature. The new rods had been in use only a short time before this report was written, so it is not known how well they fulfill the expectations of this office. It is practically certain that their use will result in increased accuracy and reduced costs. A section of the rod is shown in figures 21 and 22. This brings out its peculiar design and the special foot made necessary by the substitution of the spike as the rod support in place of the top of the rail. It will be observed that the wooden staff is merely a support for the rod, which is a thin strip of metal. The wood also serves to carry the numbers of the distances in meters and decimeters above the foot of the rod.

VALUE AND NEED OF MAGNETIC OBSERVATORIES.

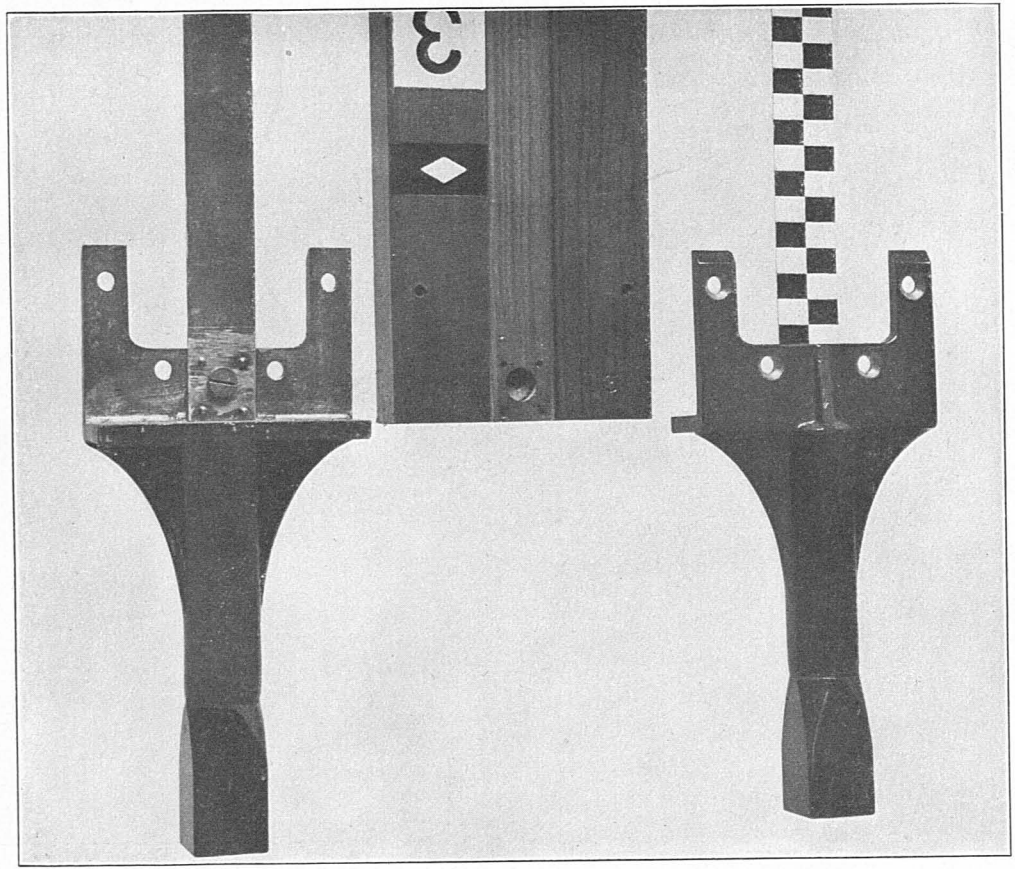
Most of the leading nations of the world are cooperating in a study of the earth's magnetism in an effort to determine its origin, the causes of its many fluctuations, and the laws which govern them. In view of the dependence of navigators and land surveyors upon the compass needle, of which the directive force is the earth's magnetism, the practical importance of this study can not be questioned.

In order that accurate data may be available for these investigations, many magnetic observatories are in operation, at which continuous records are made of the changes in direction and intensity of the earth's magnetic force. As the changes are found to be different in different parts of the earth, it is important to have the observatories as widely distributed as possible. The United States, by reason of its large extent of territory, is called upon to take a large share of this work, and magnetic observatories are now being operated by the Coast and Geodetic Survey at Cheltenham, Md., Tucson, Ariz., Vieques, P. R., Honolulu, Hawaii, and Sitka, Alaska.

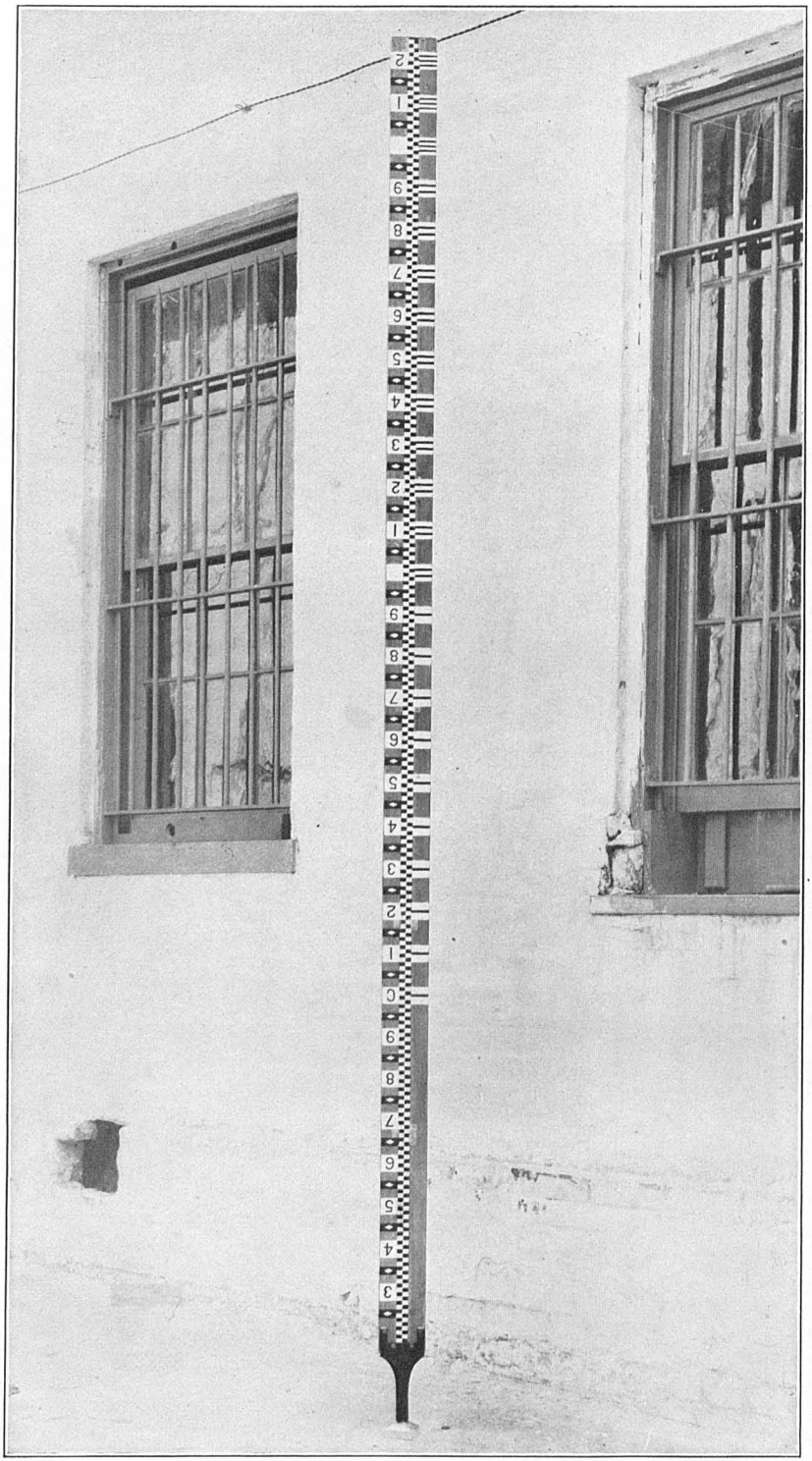
In his address at the celebration of the Centennial of the Coast and Geodetic Survey, held in April, 1916, Dr. L. A. Bauer, director of the department of terrestrial magnetism of the Carnegie Institution of Washington, urged the establishment by the Coast and Geodetic Survey of magnetic observatories in the Canal Zone and at Guam. The desirability of a magnetic observatory in the Canal Zone had already been recognized by the Coast and Geodetic Survey, and in view of the proposed rehabilitation of the Jesuit observatory near Manila under the auspices of the above department, it is felt that there is greater need for one in the Canal Zone than at Guam. It is proposed, therefore, as soon as conditions are favorable and the necessary funds can be secured, to establish a magnetic observatory in the Canal Zone.

To insure freedom from the disturbing effect of electric car lines and similar causes it is necessary to place a magnetic observatory at least 10 or 15 miles from such installations. From this it follows that it is usually necessary to provide quarters for the observer and means of transportation for supplies from the nearest supply point.

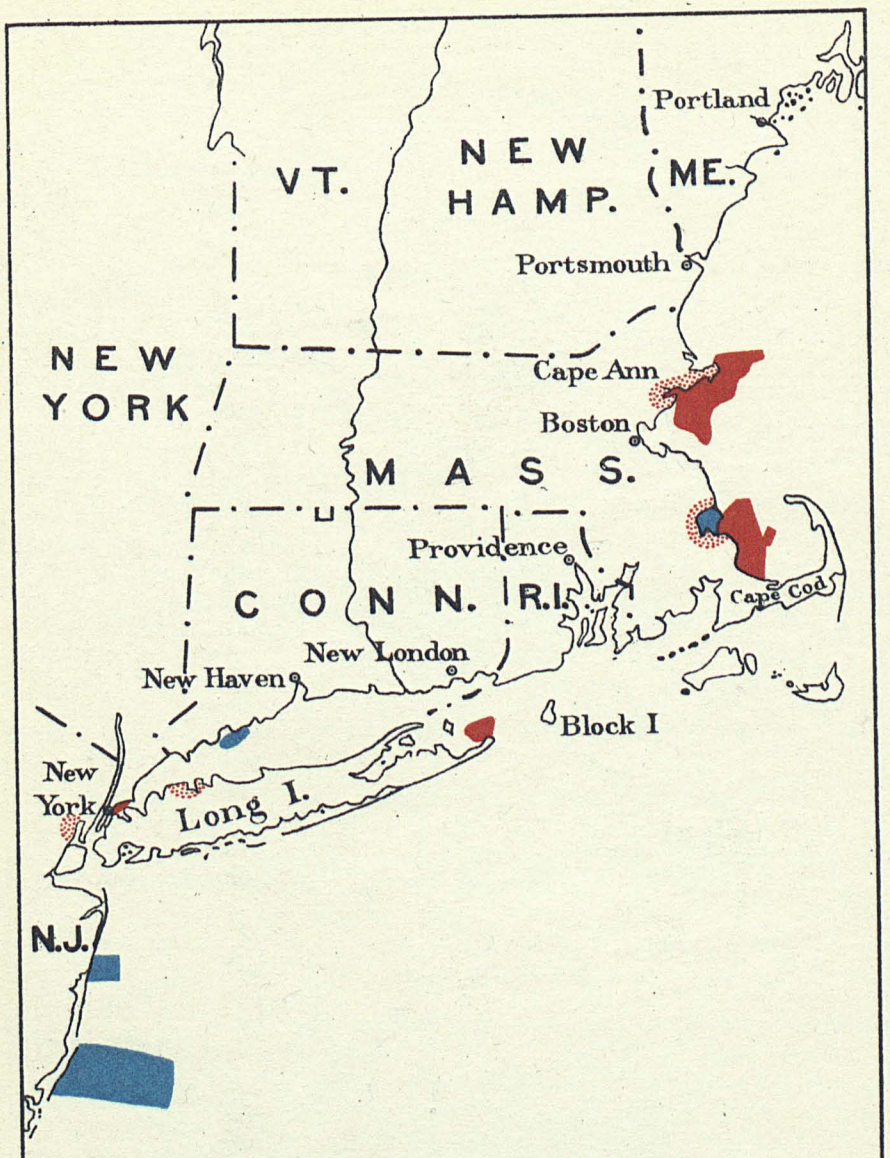
When the building now in process of construction at the Sitka observatory is completed there will be observer's quarters at each of the five observatories except Cheltenham. Up to the present time it has been possible for the observer in charge of that observatory to rent



NEW PRECISE LEVELING ROD, DETAILS OF CONSTRUCTION.

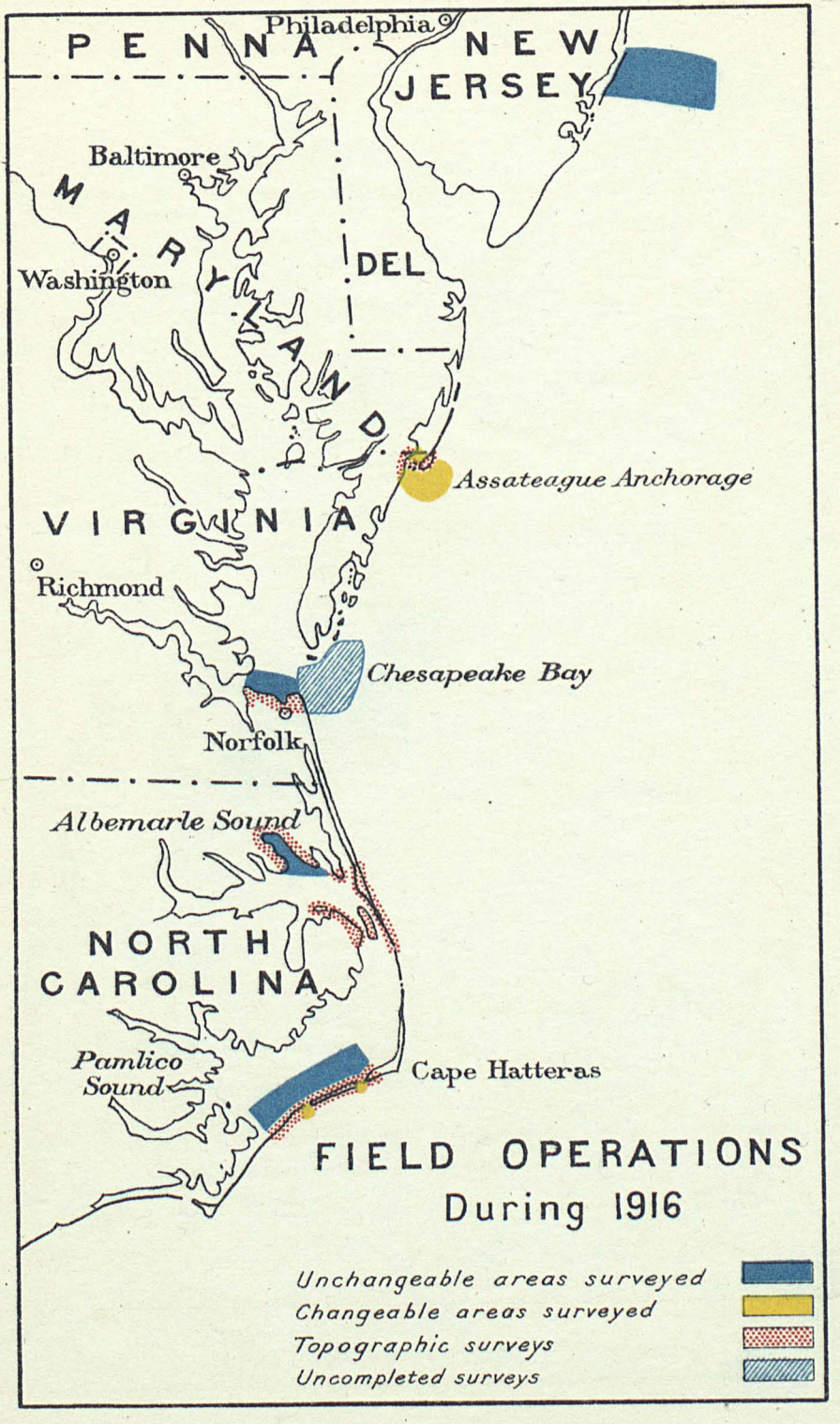


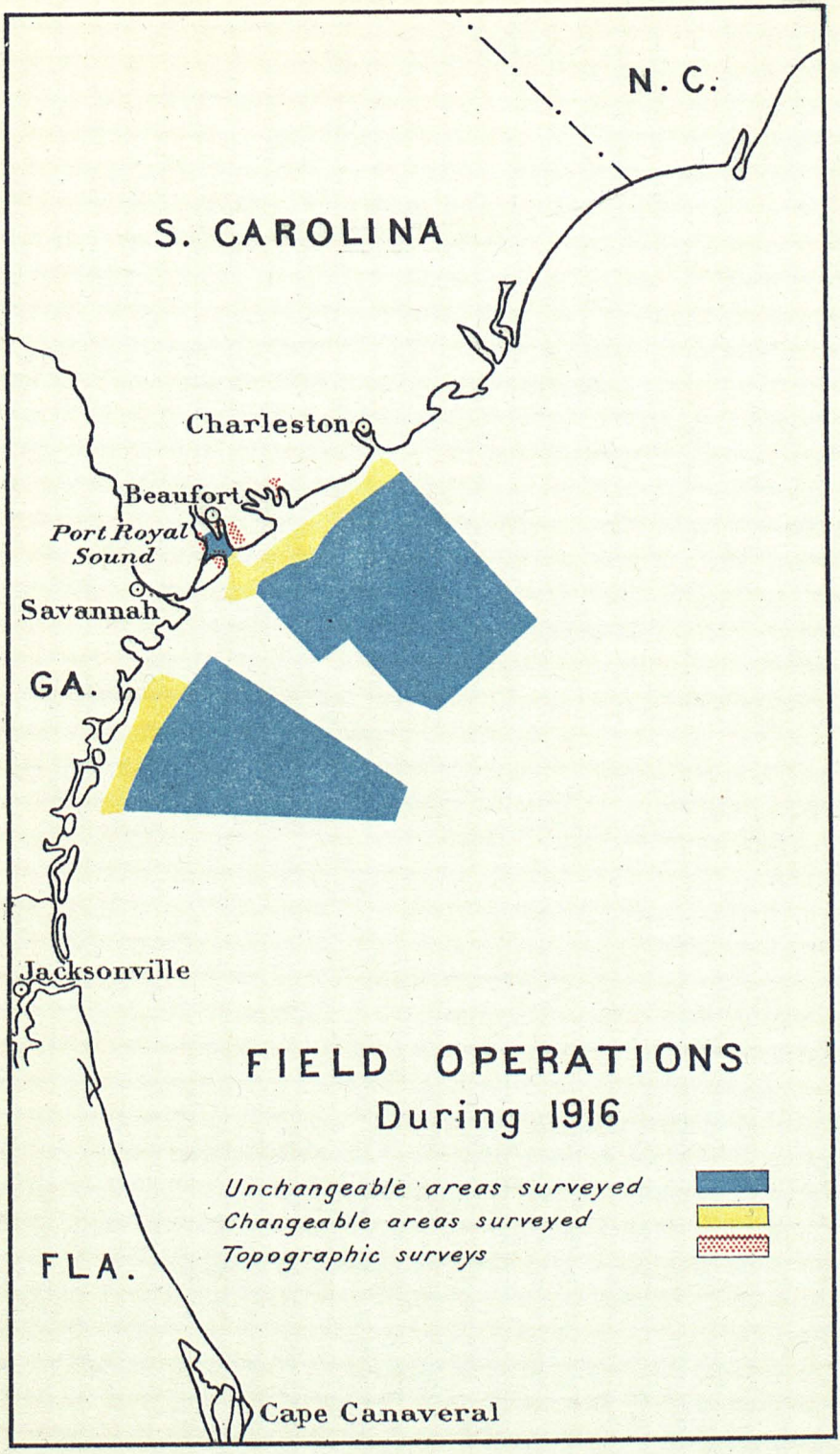
NEW PRECISE LEVELING ROD, GENERAL VIEW.



FIELD OPERATIONS
During 1916

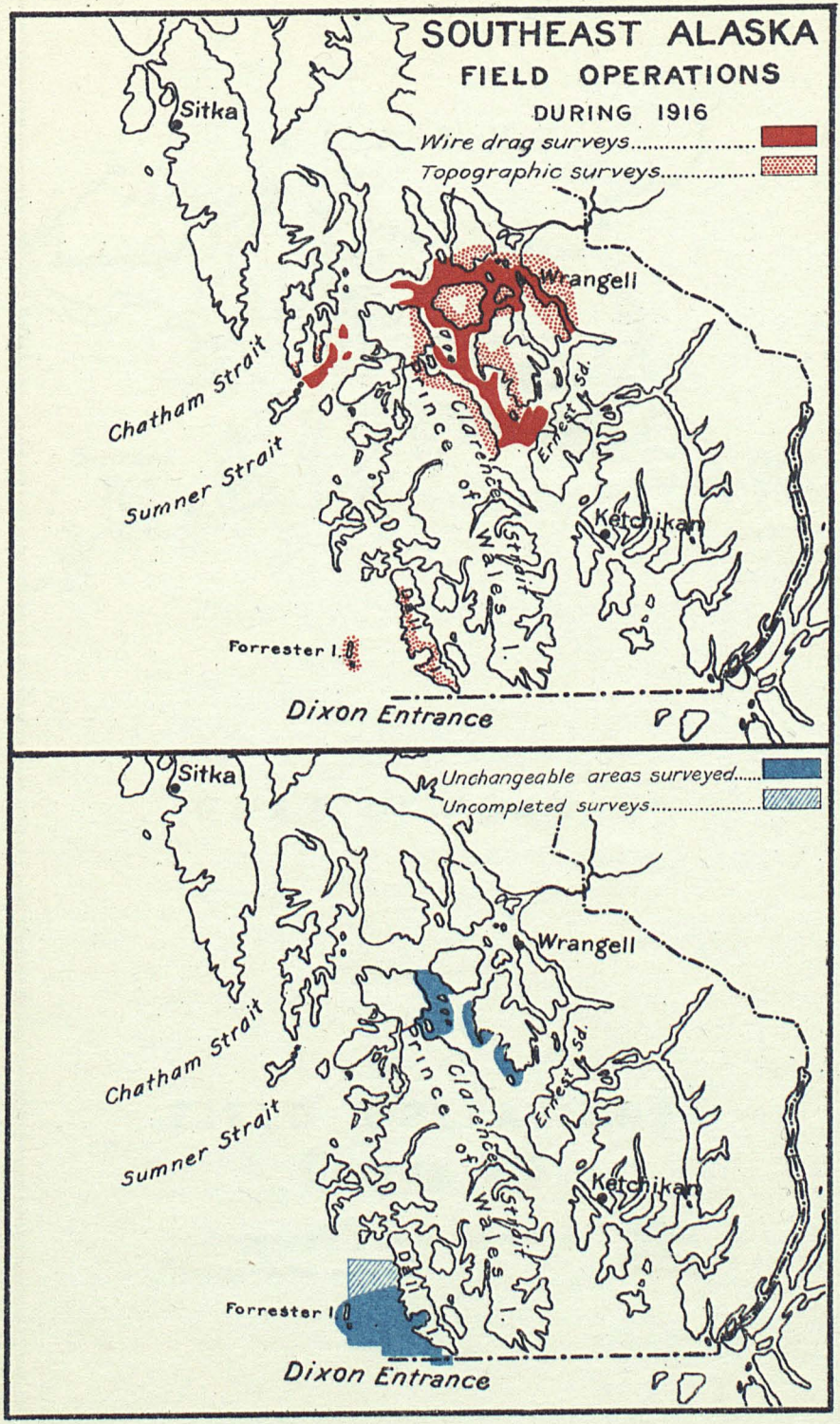
Wire drag surveys
Unchangeable areas surveyed
Topographic surveys

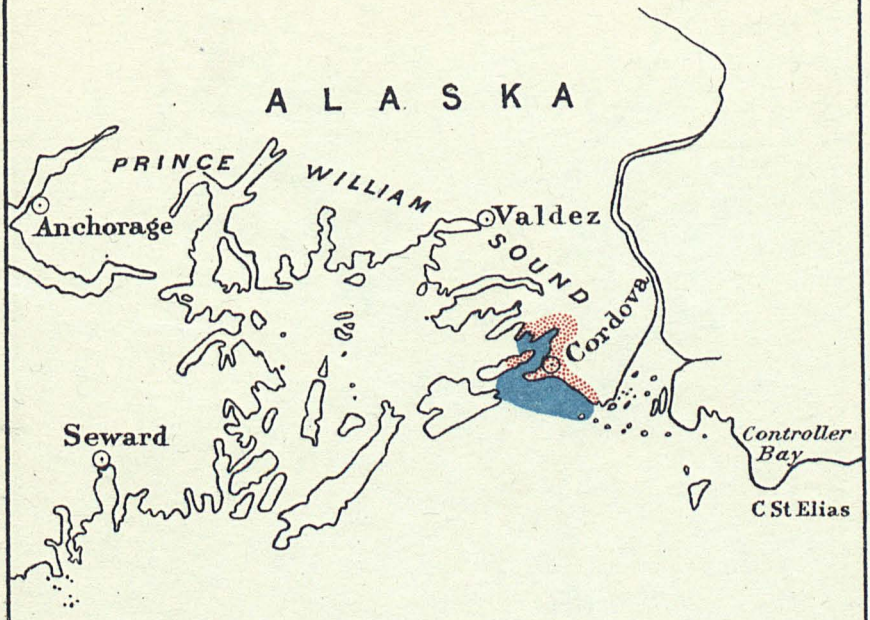

PENNA.
Philadelphia
NEW JERSEY
Baltimore
MARYLAND
Washington
DEL.
Assateague Anchorage
VIRGINIA
Richmond
Chesapeake Bay
Norfolk
Albemarle Sound
NORTH CAROLINA
Pamlico Sound
Cape Hatteras
FIELD OPERATIONS
During 1916
Unchangeable areas surveyed
Changeable areas surveyed
Topographic surveys
Uncompleted surveys


N. C.
S. CAROLINA
Charleston
Beaufort
Port Royal Sound
Savannah
GA.
Jacksonville
FLA.
Cape Canaveral
FIELD OPERATIONS
During 1916
Unchangeable areas surveyed
Changeable areas surveyed
Topographic surveys

FIELD OPERATIONS
During 1916

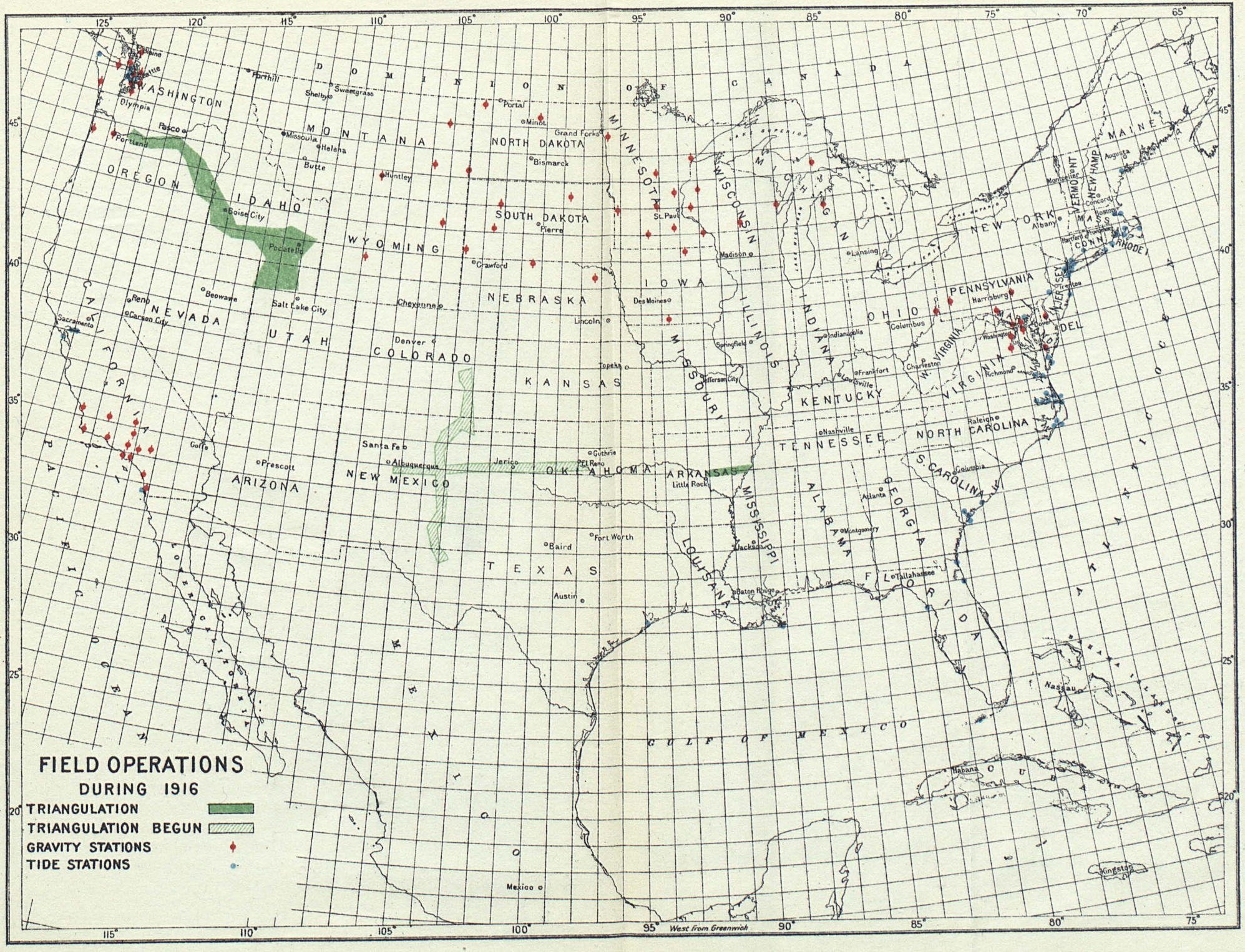
Changeable areas surveyed

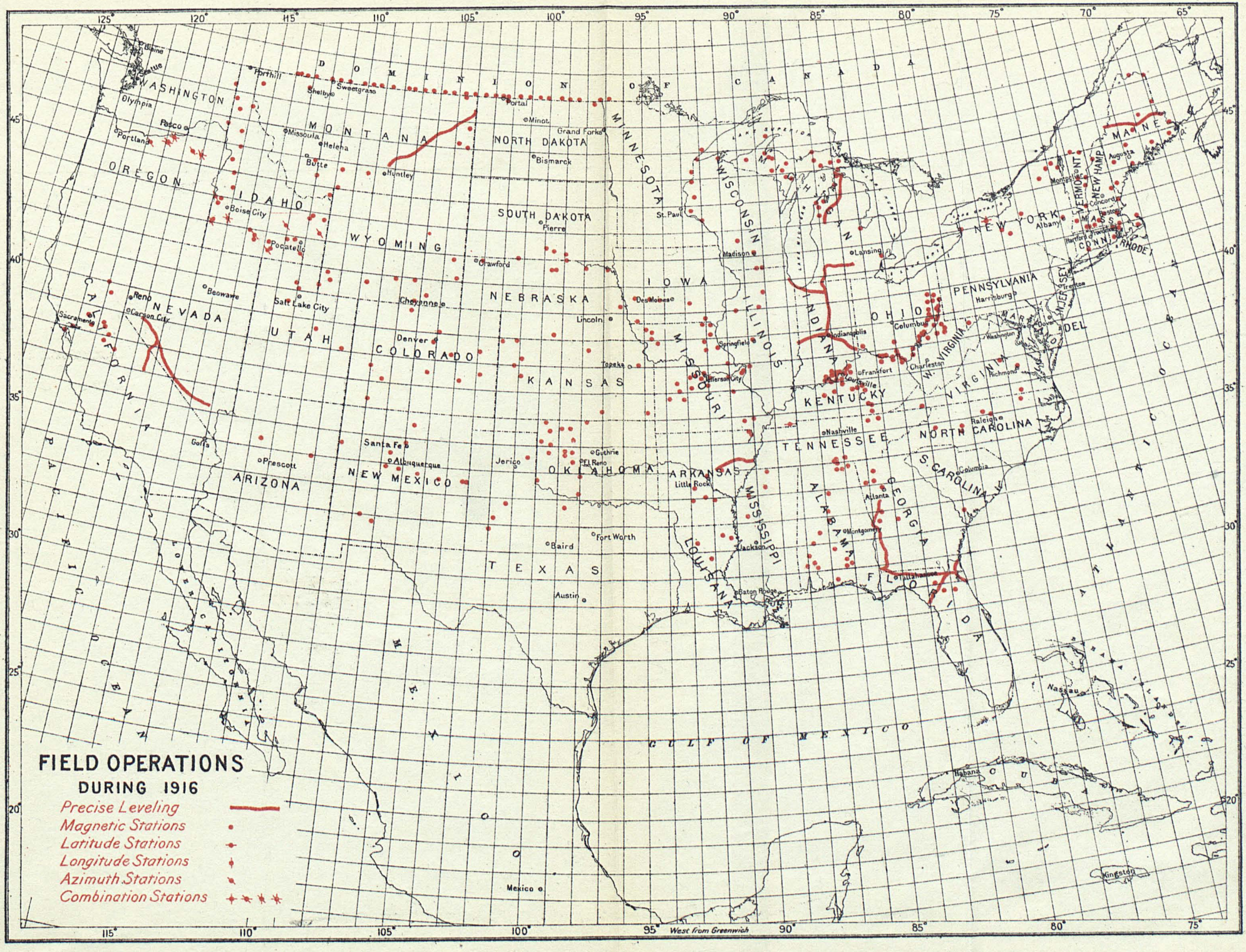

SOUTHEAST ALASKA
FIELD OPERATIONS
DURING 1916
Wire drag surveys
Topographic surveys
Sitka
Wrangell
Chatham Strait
Sumner Strait
Prince of Wales I.
Clarence Str.
Ernest Sd.
Ketchikan
Dall I.
Forrester I.
Dixon Entrance
Unchangeable areas surveyed
Uncompleted surveys
Sitka
Wrangell
Chatham Strait
Sumner Strait
Prince of Wales I.
Clarence Str.
Ernest Sd.
Ketchikan
Dall I.
Forrester I.
Dixon Entrance



FIELD OPERATIONS
During 1916

Unchangeable areas surveyed
Topographic surveys


FIELD OPERATIONS
DURING 1916
TRIANGULATION
TRIANGULATION BEGUN
GRAVITY STATIONS
TIDE STATIONS
DOMINION OF CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
WYOMING
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
COLORADO
UTAH
NEVADA
CALIFORNIA
ARIZONA
NEW MEXICO
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
VERMONT
NEW HAMP.
MASS.
CONN.
RHODE I.
NEW JERSEY
DEL.
MARYLAND
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
MEXICO
CUBA
Olympia
Pasco
Portland
Boise City
Pocatello
Reno
Carson City
Sacramento
Beowawe
Salt Lake City
Goffs
Prescott
Santa Fe
Albuquerque
Jerico
Denver
Cheyenne
Crawford
Huntley
Missoula
Helena
Butte
Shelby
Sweetgrass
Portal
Minot
Grand Forks
Bismarck
Pierre
St. Paul
Madison
Lansing
Des Moines
Lincoln
Topeka
Jefferson City
Springfield
Indianapolis
Columbus
Frankfort
Louisville
Charleston
Richmond
Harrisburg
Washington
Albany
Montpelier
Concord
Boston
Augusta
Hartford
Trenton
Raleigh
Columbia
Nashville
Atlanta
Montgomery
Tallahassee
Jackson
Baton Rouge
Little Rock
Guthrie
El Reno
Fort Worth
Baird
Austin
Mexico
Nassau
Habana
Kingston
West from Greenwich


FIELD OPERATIONS
DURING 1916
Precise Leveling
Magnetic Stations
Latitude Stations
Longitude Stations
Azimuth Stations
Combination 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
VERMONT
NEW HAMP.
MASS.
CONN.
RHODE I.
NEW JERSEY
DEL.
MARYLAND
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
LOWER CALIFORNIA
MEXICO
CUBA
BAHAMA ISLANDS
Seattle
Olympia
Portland
Pasco
Blaine
Forthill
Shelby
Sweetgrass
Portal
Minot
Grand Forks
Bismarck
Missoula
Helena
Butte
Huntley
Boise City
Pocatello
Pierre
Crawford
Beowawe
Salt Lake City
Cheyenne
Denver
Reno
Carson City
Sacramento
Goffs
Prescott
Santa Fe
Albuquerque
Jerico
Guthrie
El Reno
Lincoln
Topeka
Des Moines
St. Paul
Madison
Springfield
Jefferson City
Little Rock
Jackson
Baton Rouge
Fort Worth
Baird
Austin
Mexico
Lansing
Indianapolis
Columbus
Frankfort
Louisville
Nashville
Atlanta
Montgomery
Tallahassee
Charleston
Richmond
Raleigh
Columbia
Washington
Dover
Harrisburg
Trenton
Albany
Montpelier
Concord
Boston
Hartford
Augusta
Nassau
Habana
Kingston
West from Greenwich

No. 31.

CONDITION OF FIELD OPERATIONS, UNITED STATES, 1916.

125°
120°
115°
110°
105°
100°
95°
45°
40°
35°

WASHINGTON
Olympia
Portland
OREGON
CALIFORNIA
Sacramento
Carson City
NEVADA
IDAHO
Boise City
Salt Lake City
MONTANA
Helena
WYOMING
Cheyenne
UTAH
Denver
COLORADO
Santa Fe
NEW MEXICO
Prescott
ARIZONA
DOMINION OF
NORTH DAKOTA
Bismarck
SOUTH DAKOTA
Pierre
MINNESOTA
St.Paul
NEBRASKA
Lincoln
IOWA
Des Moines
KANSAS
Topeka
Guthrie
OKLAHOMA
PACIFIC

CONDITION OF FIELD OPERATIONS
UNITED STATES
1916

Wire drag surveys completed
Wire drag surveys required
Unchangeable areas, no present work required
Unchangeable areas, additional work required
Changeable areas, recent surveys
Changeable areas, old surveys

Reconnoissance work or unsurveyed
Triangulation completed
Triangulation begun
Precise Leveling completed
Gravity Stations, positions

NEVADA
UTAH
COLORADO
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
ARIZONA
NEW MEXICO
LOWER CALIFORNIA
PACIFIC OCEAN
GULF

Salt Lake City
Carson City
Sacramento
Cheyenne
Denver
Lincoln
Des Moines
Topeka
Santa Fe
Prescott
Guthrie
Austin

35°
30°
25°
115°
110°
105°
100°
95°

ATLANTIC OCEAN

MAINE
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
R.I.
CONN.
NEW YORK
NEW JERSEY
PENNSYLVANIA
DELAWARE
MARYLAND
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
OHIO
WEST VIRGINIA
KENTUCKY
TENNESSEE
INDIANA
ILLINOIS
MICHIGAN
WISCONSIN
MINNESOTA
IOWA
MISSOURI
ARKANSAS
OKLAHOMA
LAKE ONTARIO
LAKE ERIE
LAKE HURON
LAKE MICHIGAN
LAKE SUPERIOR

Augusta
Boston
Montpelier
Concord
Providence
Hartford
Albany
Trenton
Dover
Annapolis
Washington
Harrisburg
Richmond
Raleigh
Charleston
Columbia
Columbus
Lansing
Indianapolis
Frankfort
Nashville
Atlanta
Madison
St. Paul
Springfield
Jefferson City
Des Moines
Lincoln
Topeka
Little Rock
Guthrie

45°
40°
35°
65°
70°
75°
80°
85°
90°
95°

IOWA
Des Moines
Lincoln
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA
Harrisburg
Trenton
NEW JERSEY
MARYLAND
Dover
Annapolis
Washington
Columbus
Indianapolis
Springfield
Topeka
Jefferson City
MISSOURI
Charleston
WEST VIRGINIA
VIRGINIA
Richmond
Frankfort
KENTUCKY
Raleigh
NORTH CAROLINA
Nashville
TENNESSEE
Guthrie
OKLAHOMA
ARKANSAS
Little Rock
Columbia
S. CAROLINA
Atlanta
GEORGIA
MISSISSIPPI
ALABAMA
Montgomery
Jackson
LOUISIANA
Tallahassee
FLORIDA
Baton Rouge
ATLANTIC OCEAN
BAHAMA ISLANDS
Nassau
GULF OF MEXICO
35°
30°
25°
95°
90°
85°
80°
75°

No. 32.

CONDITION OF HYDROGRAPHY, ALASKA, 1916.

160° 170° 180° 170° 160° 150°

ARCTIC OCEAN

SIBERIA

Pt. Barrow

Icy Cape

Pt. Hope

BERING STR

Nome

St. Michael

YUKON RIVER

KUSKOKWIM RIVER

St. Lawrence I.

St Matthew I

Nunivak I.

Nush

60°

Pribilof Is

BRISTOL BAY

BERING SEA

ALASKA

Unimak I.

Unalaska I

Attu I

ALEUTIANS

Kiska I

Tanaga I

Atka I

East from Greenwich.

180° 170°

CONDITION OF HYDROGRAPHY

ALASKA

1916

Wire drag surveys completed	shown
Unchangeable areas, no present work required	shown
Unchangeable areas, additional work required	shown
Changeable areas, recent surveys	shown
Changeable areas, old surveys	shown
Reconnoissance work or unsurveyed	shown

WIRE DRAG WORK

Approximately 50 per cent of the water areas, with depths less than 50 fathoms, of the inside passages and harbors of Southeast Alaska, Prince William Sound, Cook Inlet, and coast of Alaska Peninsula and Aleutian Islands require wire drag surveys.

150° 140° 130° 120° 60° 50° 160° 150° 140°

West from Greenwich

ALASKA
BRITISH COLUMBIA
YUKON TERR.
GULF OF ALASKA
PACIFIC OCEAN
DIXON ENTRANCE
Gross Sound
SOUTHEAST ALASKA
PRINCE WILLIAM SD.
COOK INLET
KENAI PENIN.
ALASKA PENIN.
ALEUTIAN IS
Controller B.
Mt.St.Elias
C St Elias
Shumagin Is
Kodiak I.
Iliamna L
TANANA RIVER
YUKON RIVER

Dawson
Fairbanks
Anchorage
Valdez
Cordova
Seward
Yakutat
Nushagak
Skagway
Juneau
Sitka
Wrangell
Petersburg
Ketchikan

suitable quarters. The character of the observatory work is such that it is important to have the observer in charge live so near that he can readily make an inspection of the buildings and instruments at any time of the day or night. At the present time there are only two rented houses at Cheltenham, and they are about a mile from the observatory. Conditions might easily arise which would compel the observer to go still farther away for suitable quarters. The present combination of an office and observatory in one building is also unsatisfactory because of the danger that necessary articles of office equipment may have a disturbing effect on the instruments. Provision has therefore been made in the estimates for 1918 for a building for office and quarters at Cheltenham.

A material reduction in the cost of operation of the Tucson and Honolulu observatories is expected from the substitution of motor-driven for horse-drawn vehicles. A small truck has been purchased for Tucson, and while the first cost was about $250 greater than for a horse and wagon, it is estimated that there will be a saving of about $75 a year in the cost of operation (including depreciation) and there will also be a material saving of time on the road and in eliminating the care of the horse. A similar change is being made at Honolulu. The needs of the observatory will thus be better served.

CONDITION OF HYDROGRAPHIC, GEODETIC, AND OTHER SURVEYS IN THE UNITED STATES AND ALASKA.

The hydrographic surveys of our coastal waters constitute the most important element of the charts and are the prime factors in promoting the safety of navigation.

The primary triangulation and precise leveling are extended over the interior of the country to furnish the fundamental horizontal and vertical control for surveys, maps, and engineer works.

The gravity stations furnish the data for studying the variations from normal in the densities of the materials forming the outer portions of the earth. These data are also used in determining the shape of the earth. These are geophysical problems of much interest in the scientific world.

The magnetic observatories must be in continuous operation in order to furnish data regarding the numerous changes in the direction and force of the earth's magnetism for the purpose of discovering the laws governing such changes.

The astronomic stations are used in the adjustment of the great arcs of primary triangulation and for the purpose of determining the deflection of the vertical by means of which the shape and size of the earth are determined.

Of the following figures, numbers 23, 24, 25, 26, 27, and 28 show the hydrographic work done in the United States and Alaska by lead line and wire drag during the past year; figures Nos. 29 and 30 show primary triangulation, precise levels, magnetic, gravity, tidal, and astronomical work done the past year; and figures Nos. 31 and 32 show the conditions of hydrography, geodesy, etc., in the United States and Alaska to date.

NEW SUBOFFICES.

Funds with which to provide for suboffices in each of the cities, Boston, Norfolk, and Juneau, and to maintain the Galveston suboffice are necessary. The last-named office is in quarters furnished by local public organizations. At a small cost it would be possible to place in each office a local inspector, who, by coming in contact with local conditions and nautical people, would greatly increase the value of the Bureau to the public, and materially increase the information it could gather in the course of each year regarding local nautical conditions.

RETIREMENT.

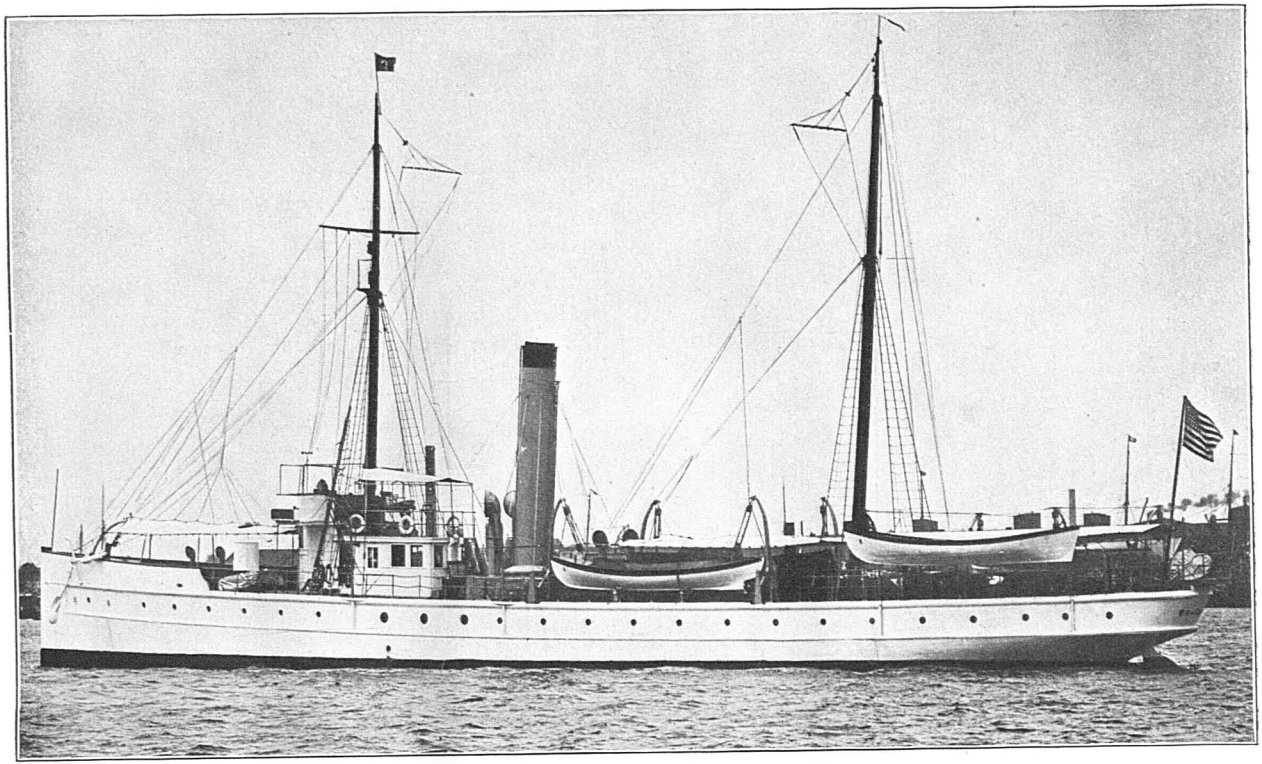
The serious question of retirement for civil-service employees, while probably affecting more or less all the bureaus of the Government, is so specially evident in the Coast and Geodetic Survey that some specific retirement provision should be made for its hydrographic and geodetic engineers. The Bureau is somewhat handicapped to-day because of the fact that a number of these highly trained men who have served the country faithfully for nearly 50 years and have had largely the same education as the graduates of Annapolis or West Point have now reached the age where the duties they once performed are too irksome for their advanced years. It necessarily results in a hardship for them to undertake such arduous tasks.

The small salaries these hydrographic and geodetic engineers, who are also navigators, have received during their tenure of office have not been adequate for them to save any considerable amount of money. The result is that in their advancing years they are forced to attempt to continue at their duties when at the age of 64 they should be allowed to retire at a substantial retired pay, the same as an Army, Navy, Public Health Service, or Coast Guard officer. It is not justice to ask that these men retire from the service. At the same time, speaking frankly, the service is handicapped, inasmuch as their places should naturally be filled by younger men who are better able to meet the hardships.

To-day there are fifteen or more men who have passed the retirement age, and they should be properly cared for by the Government to which they have devoted their lives. No one except those in touch with the situation can realize what their services have meant to this part of the Government work. While I have dwelt particularly on the question of retirement for hydrographic and geodetic engineers here, other aged employees of the Bureau are deserving of recognition under retirement legislation but along different lines.

PURCHASE OF DUTCH HARBOR, ALASKA, AS A GOVERNMENT BASE.

Further attention is called to the desirability of the purchase of Dutch Harbor, Aleutian Islands, Alaska, as a Federal Government base. It is a matter that has been advocated by the heads of other services in the Government, and the value to the Government of this location in far western Alaska can not be overestimated at this time. Further, it can be said that it would be a better investment to the Government than it was a year ago on account of the increased activities in Alaska and its waters and the greater need of a permanent coal, oil, and supply base on the Bering Sea.



BACHE.

Composite steam vessel of 472 tons displacement, 370 gross tons, and 252 net tons; registered length 153.2 feet, breadth 26.2 feet, draft 10 feet; indicated horsepower 400; speed 10.5 knots; coal capacity 96 tons; complement 9 officers and 42 men. Built at Shooters Island, N. Y., in the year 1901. Present duty, offshore hydrography on the South Atlantic coast of the United States.

Part III.—STATEMENT FOR THE PAST YEAR OF ACCOMPLISHED FIELD AND OFFICE WORK, ACCOMPANIED BY ILLUSTRATIONS AS REQUIRED BY STATUTE, SHOWING THE PROGRESS MADE.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY.

The division of hydrography and topography has supervision of the hydrographic and topographic work on the coasts of the United States and insular possessions; the vessels of the Survey, including their construction, maintenance, repair, equipment, personnel, and office records; the suboffices, including the office of the Director of Coast Surveys at Manila; the completion in the office of the field records of the surveys; the compilation of the Coast Pilot in the field and office; and the tide and current work of the Survey, including the compilation of the tide tables.

Orders and instructions for the personnel and parties engaged in the above-named work, and the necessary correspondence, are prepared in the division of hydrography and topography. The division includes five sections, namely, field work, field records, vessels and equipment, coast pilot, and tides and currents.

Following is a general statement of progress of the field and office work. Detailed statements of the work are given in the reports of the chiefs of sections and parties.

FIELD WORK, ATLANTIC COAST.

The steamer *Bache* was employed during the greater part of the year on hydrography extending out to the 100-fathom curve on a part of the coast of New Jersey; off the entrance of Chesapeake Bay, Va.; and on the coast of Georgia from Brunswick to a point 8 miles southward of Savannah entrance. Repairs were made to the vessel during parts of July, August, December, and January; and work was interrupted during parts of September and October for necessary repairs to the boiler. While the repairs were in progress during July and August, 1915, revision work was done by the party in Norfolk Harbor and Hampton Roads. While the vessel was laid up at Norfolk during June, 1916, because of a shortage in funds for party expenses, the party was engaged in a resurvey of the approach to Hampton Roads inside of Cape Henry, in the office work on the records of the work on the coast of Georgia, and in preparing for repairs.

The steamer *Hydrographer* was employed in hydrography in New York entrance in the vicinity of Sandy Hook; current observations in the Race at the easterly end of Long Island Sound; hydrography around the northerly half of Block Island and including Great Salt Pond, R. I.; the examination by means of an improvised wire drag of a reported shoal in Gardiners Bay, N. Y.; a topographic and hydrographic resurvey of Assateague Anchorage and the near-by

outlying shoals; and a topographic and hydrographic resurvey, including the channels out to the bar, of Port Royal Sound, S. C. Four tall signals to be used by the *Isis* for the offshore hydrography were erected by the party on the *Hydrographer*. Repairs to the *Hydrographer* were made during November, 1915, and during parts of May and June, 1916.

The steamer *Isis* was purchased on July 1, 1915, and was employed during the greater part of the year on hydrography, extending out to the 100-fathom curve on a part of the coast of New Jersey; off the entrance of Chesapeake Bay, Va., and the coast of South Carolina from Charleston to a point 18 miles northward of Savannah River entrance. Repairs were made to the vessel during parts of July, August, and October. The vessel was laid up at Norfolk during June, 1916, because of a shortage in funds for party expenses, and several of the officers were ordered to the steamer *Bache* to assist in the survey of the approach to Hampton Roads.

The schooner *Matchless* completed the resurvey of Roanoke and Croatan Sounds, Pasquotank River from Albemarle Sound to a point 2 miles above Elizabeth City, and the easterly side of Pamlico Sound from the north end of Core Sound to Ocracoke Inlet, N. C. Repairs were made during parts of December and January, while the survey of Pasquotank River was in progress.

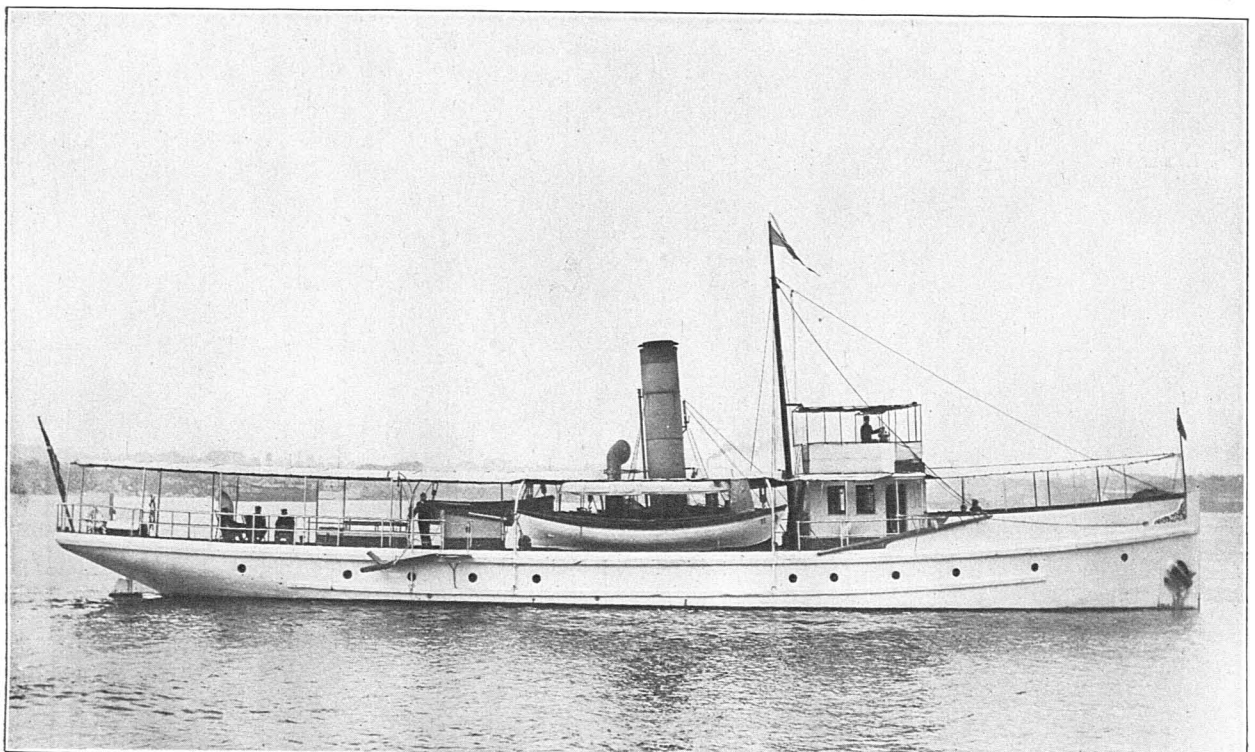
Wire-drag party No. 1 continued the survey of the approach to Boston Harbor, Mass., which was completed from Minots Ledge to Nahant; Quicks Hole and a near-by part of Buzzard's Bay, Mass.; the eastern passage of Narragansett Bay in the vicinity of Newport, R. I.; and the coast of Massachusetts in the approaches to Salem. Chart revision was done by this party in Narragansett Bay. Field work was done from July 1 to November 15, 1915, and from May 15 to June 30, 1916. An earlier start in the spring of 1916 was prevented by a shortage in party expense funds.

Wire-drag party No. 2 continued the survey of the coast of Massachusetts between Boston and Cape Cod Canal, and completed the stretch from Minots Ledge to Plymouth; and began a survey of East River, N. Y., the most difficult part of the main channel of which was completed from Lawrence Point to College Point. Wire-drag field work was done from July 1 to November 2, 1915, and May 15 to June 30, 1916. An earlier start in the spring of 1916 was prevented by a shortage in party expense funds. Chart revision was done in East River and Newark Bay, and hydrographic examinations were made in the vicinity of Bergen Point, N. J., and in Pollock Rip Slue, Mass. This work was done principally after the close of the wire-drag work in the fall and prior to the organization of the main party in the spring.

A large number of uncharted rocks were found by the wire-drag parties in the regions examined. These were reported promptly, and wide publicity was given them through the Notice to Mariners and the press.

On June 17, 1916, a subparty of wire-drag party No. 2 began a topographic and hydrographic resurvey of Plymouth Harbor, Mass.

A revision survey of Arthur Kill, lying between Staten Island and New Jersey, begun the previous fiscal year, was completed, and a resurvey of Oyster Bay was begun. Early in February the party disbanded, owing to a shortage of funds.



HYDROGRAPHER.

Wooden steam vessel of 146 tons displacement, 116 gross tons, and 79 net tons; registered length 101 feet, breadth 19.5 feet, draft 6.8 feet; indicated horse-power 250; speed 10 knots; coal capacity 22 tons; complement 5 officers and 18 men. Built at Port Jefferson, N. Y., in the year 1901. Present duty, hydrographic survey of approaches to the Mississippi River.

Revision surveys for the location of prominent natural objects and building and locating tall hydrographic signals were made on the coast of New Jersey in the vicinity of Beach Haven, at the entrance of Chesapeake Bay, and on the coast of South Carolina and Georgia between Charleston and Brunswick. This work was done by shore parties for the use of the *Isis* and *Bache* in the offshore hydrographic work.

Prior to sending the volume to the printer, a field verification was made during a part of November, 1915, of Coast Pilot information from Sandy Hook to Cape Henry, including Delaware and Chesapeake Bays. During May and June, 1916, field work was in progress for a new edition of Inside Route Pilot, New York to Key West.

Suboffices of the Survey, each in charge of a field officer of the Bureau, were maintained at New York and Galveston. A stock of charts and other publications of the Survey has been kept on hand for consultation by the public and for sale. In addition to collecting and giving information, the officer at Galveston has made an examination of many seamen for certification in compliance with the seamen's act. Due to the lack of an additional officer, or a clerk, at each suboffice, the inspector in charge has little opportunity to make important field inspections of the state of the charts and surveys in his district.

At the request of the Navy Department, an officer of the Survey verified and renewed the beacons of the torpedo-boat trial course at Provincetown, Mass.

FIELD WORK, PACIFIC COAST.

The steamer *Explorer*, during the summer of 1915, was employed on combined surveys at the entrance of Cook Inlet, where large unsurveyed areas with reported dangers existed in the track of vessels bound to and from the Government railroad terminal at Anchorage, Knik Arm. During the latter part of October a resurvey was made in Port Gamble, Wash. The vessel was laid up with reduced crew, and repairs were made at Seattle during the winter. On April 4, 1916, the vessel left Seattle for the field of work, to take up surveys on the unsurveyed coast of Dall, Baker, Suemez, and other islands, northward from Cape Muzon, southeast Alaska, and extending out to the 1,000-fathom curve. The launches *Cosmos* and *117* were assigned to this party. Field work was begun on April 20 and is in progress.

The steamer *Gedney* made a complete survey of Bucareli Bay, Port Real Marina, and Portillo Channel from the limits of previous surveys to the seaward entrance between Capes Bartolome and Felix, southeast Alaska. Forrester Island, Wolf Rock, Cape Lookout, and prominent peaks on Dall Island were located by triangulation. A wire drag was passed over the more doubtful areas in the main channels and harbors. The vessel returned to Seattle on October 26. The crew was immediately reduced and the vessel was condemned and sold.

The steamer *McArthur*, during the summer of 1915, was engaged on combined surveys of Sealed Passage, Felice Strait, and the northerly part of Revillagigedo Channel. During a large part of the season four working parties were employed in the field. Upon the

return of the vessel to Seattle on October 26 the crew was immediately reduced and the vessel was condemned and sold.

The steamer *Patterson*, during the summer of 1915, was employed on general surveys in the Shumagin Islands, Alaska Peninsula. In the latter part of August and the first half of September the vessel proceeded to Goodnews Bay, Kuskokwim entrance, and with the launch *Alpha* on deck convoyed the steamer *Yukon* to Isanotski Strait. A large camp party, employed on combined operations, was maintained during the entire season. The work was unusually difficult owing to the precipitous coast, exposure to the ocean swell, and the danger in making landings.

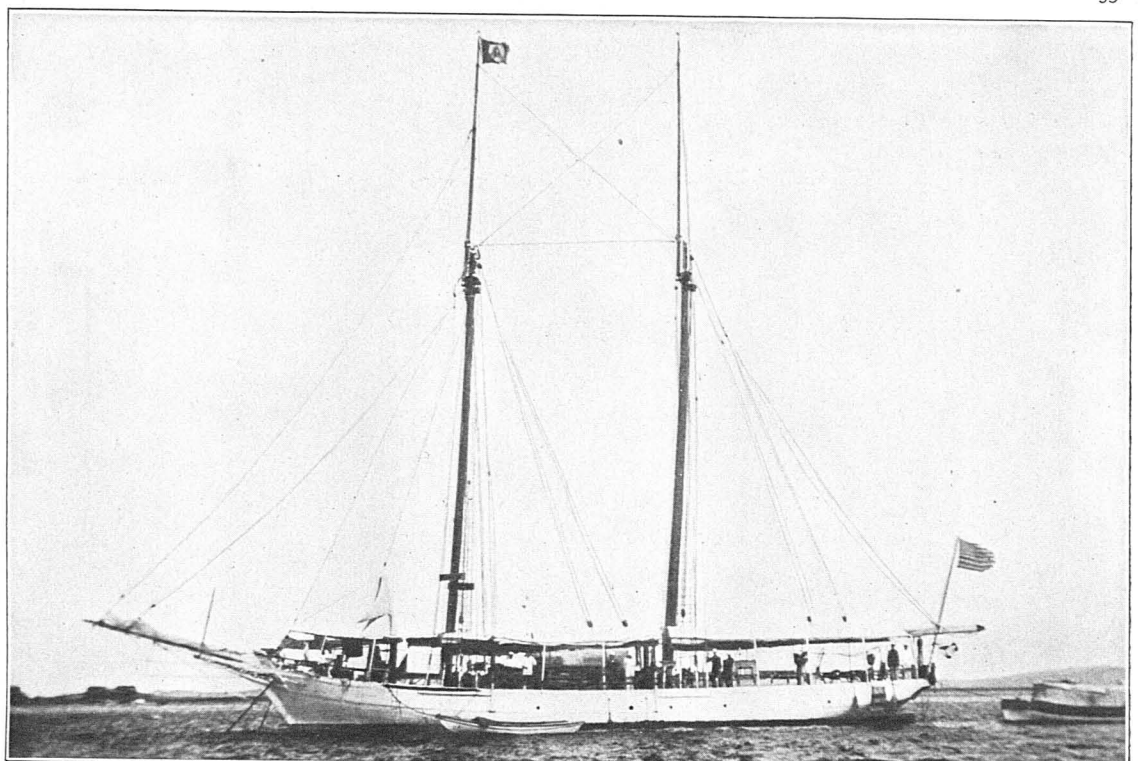
Parts of Nagai and Big Koniuji Islands and all of Peninsula, Spectacle, Bendel, and Turner Islands were surveyed. Ship hydrography was executed between the islands, and launch hydrography was extended along all the coasts surveyed except Turner Island. Several anchorages were developed, of which Mist Harbor is the best protected. While at Unalaska for coal, the area about Tuscarora Rock was developed, and at the end of the season, on the passage to Kodiak, the reported extension of the spit at Harvester Island was developed.

The *Patterson* arrived at Seattle on November 8, was laid up, and her crew reduced. Repairs were made during the winter. On April 5, 1916, the vessel left Seattle for the field of work, which embraces the passages in southeast Alaska leading southward from Sumner Strait between Kashevarof Passage and Eastern Passage and including Ernest Sound and Bradfield Canal. Field work was begun on April 20 and is in progress.

The steamer *Taku* continued and completed the combined surveys of Port Gravina, the coast from Knowles Head to Red Head, and Fidalgo Bay, Prince William Sound. Field work was closed on September 29, 1915, and the party returned to Seattle. The party left Seattle on April 23, 1916, arrived at Cordova on April 29, and on May 25 took up the survey of Orca Inlet and the delta from Point Whitshed to Point Martin. A shore party began the survey of the military reservation at Orca Inlet on May 10.

The steamer *Yukon* continued combined surveys of the Kuskokwim River during the summer of 1915. A large beacon was erected on Carter Spit as an aid to navigation. An officer from this party piloted the commercial steamer *Alliance* through Kuskokwim Bay and into the river, and then made a running survey of the river above Bethel on a river steamer. Work was closed on August 29, and the *Yukon* was convoyed to Isanotski Strait by the *Patterson*. The *Yukon* and launch *Alpha* were then hauled out at Kings Cove, and were not put in commission in the spring of 1916 owing to a shortage of officers and party expense funds.

Wire-drag party No. 3 completed the dragging of channel areas with depths less than 50 fathoms in Revillagigedo Channel from Twin Islands southward to the Canadian boundary, and the topography from the entrance of Boca de Quadra to Foggy Point, including Very Inlet. In Clarence Strait the main channel was dragged from Caamano Point to Lemesurier Point. Triangulation was carried from Vallenar Point to Zarembo Island. Field work closed October 9 and the party returned to Seattle on October 22.



MATCHLESS.

Wooden two-masted schooner of 118 gross tons and 94 net tons; registered length 91 feet, breadth 25 feet, draft 8 feet; complement 6 officers and 16 men. Built at Key West, Fla., in the year 1859. Present duty, used as a houseboat in surveys of North Carolina sounds.

On April 2, 1916, the party arrived at Ketchikan and drag work was begun April 21. The field of work includes the passages between Clarence Strait and Eastern Passage, extending southward from Sumner Strait to and including Ernest Sound.

Wire-drag party No. 4 completed the dragging of the main channel of Sumner Strait from Shakan Bay around Point Baker to Zarembo Island. The work was rendered unusually difficult in the vicinity of Point Baker by reason of strong tidal currents and swirls. Field work closed on October 9 and the party returned to Seattle on the 20th.

On April 2, 1916, the party arrived at Wrangell and drag work was begun on April 22. The field of work comprises the completion of the entire channel of Sumner Strait from Wrangell to the sea, including the entrance northward of Coronation Island, and the passages extending southward from Sumner Strait to a junction with the work of wire-drag party No. 3.

A considerable number of uncharted rocks were found by the wire-drag parties in the regions examined. These were reported promptly and wide publicity was given them through the Notice to Mariners, special notices in Alaska and Seattle, and the press. A publication was prepared descriptive of the wire-drag work in Alaska.

A revision party made a hydrographic examination at the end of September, 1915, of the bar between Middle and Stake Points, Suisun Bay, San Francisco Bay, Cal.

In June, 1916, a supplemental hydrographic examination was made in the vicinity of Cape Flattery, which located a reported breaker 1½ miles southwest of Tatoosh Island, and developed Neah Bay and the broken ground near Duncan Rock. This party then took up the field revision of the coast pilot of California, Oregon, and Washington.

On May 31, 1916, an officer arrived at Ketchikan and began a field revision of the coast pilot of southeast Alaska. Advantage was taken of the low run of tides in June to locate several uncharted rocks.

Suboffices of the Survey, each in charge of a field officer of the Bureau, were maintained at Seattle and San Francisco. A stock of charts and other publications of the Survey has been kept on hand for consultation by the public and for sale. In addition to collecting and giving information, the office and the officers on vessels (while laid up at Seattle) have made an examination of many seamen for certification in compliance with the seamen's act.

FIELD WORK, PHILIPPINE ISLANDS.

The work of the Survey in the Philippine Islands is executed under the direction of the Director of Coast Surveys, an officer of the Coast and Geodetic Survey, who, acting under authority of the Superintendent, makes plans for the work, issues detailed instructions to the field parties, and also has charge of the suboffice at Manila. The expenses of the work are met partly from the appropriation for the Coast and Geodetic Survey and partly from funds provided by the Philippine Government, which also furnishes four vessels for surveying purposes. One steamer, the *Pathfinder*, is furnished by the Coast and Geodetic Survey.

The five vessels of the Survey have been kept at work in the field as continuously as possible, being absent from the field only for the purpose of renewing coal and other supplies and having the necessary repairs made, except that the *Fathomer* was laid up owing to lack of funds during October, November, and December. Until February 1, 1916, there were available but little over one-half of the surveying officers required for the vessels, and at the close of the fiscal year there was a shortage of 3 officers in the 24 required.

In the item of party expenses the increased cost of coal is adding very materially to the cost of the work. This is true, in general, for all of the vessels, as their field of work is now distant from the more frequented routes of travel and commerce, in consequence of which the price of coal at ports in such regions is much higher than in the principal commercial ports of the Archipelago.

The steamer *Pathfinder* was employed on hydrographic surveys in the easterly approach to San Bernardino Strait and combined surveys at the entrance of Manila Bay. Lines of hydrography across the Sulu Sea were run to develop a safe route for vessels through Balabac Strait, northward of Borneo. Combined surveys were begun at the south end of Palawan. A base site was selected and a base measured on Mantagule Island, which involved a large amount of heavy cutting and the erection of five scaffold signals, the highest 235 feet, constructed from the timber cut on the ground. Repairs were made during a part of July, October, and November.

The steamer *Fathomer* was employed on hydrographic surveys in the north end of the Sulu Sea in the vicinity of the Cuyo Group. The vessel was laid up from October 6 to December 31 for want of Philippine funds. Combined surveys were then done in Green Island Bay, east coast of Palawan. Afterwards the triangulation of the south coast of Mindanao was taken up.

The steamer *Romblon* was employed on combined surveys in the vicinity of the north end of Palawan and the Cabulaun Islands during the entire year, when field work was in progress. The vessel was laid up during December for want of funds and was repaired during January, when the Philippine appropriations became available.

The steamer *Marinduque* was employed on combined surveys on the east coast of Coron and Busuanga and the western approaches to Coron Bay. Repairs were made during January and February. Combined work was then continued on the east coast of Palawan from a junction with the work previously done in Green Island Bay.

The steamer *Research* was employed on combined surveys on the east coast of Masbate Island, on the south coast of Luzon from Canrusan Point to Port Putiao, and Sorsogon Bay. During April the triangulation was extended from near Sorsogon to Lagonoy Bay, in cooperation with a shore party.

A shore party established a triangulation station on Mayon Volcano, southern Luzon, and connected it with the scheme of triangulation, connecting Sorsogon to Lagonoy Bay.

ASSISTANCE RENDERED.

At 10.30 on the night of June 23, 1916, the Spanish Royal Mail Line steamer *Fernando Poo* stranded on a reef near Black Rock Light in the Sulu Sea, Philippine Islands. Urgent distress calls were immediately sent out by radio and were picked up by the

Coast and Geodetic Survey steamer *Pathfinder* at 11.30 p. m., then at anchor among the maze of coral reefs off the southwest end of Palawan Island. Steam was immediately raised on the *Pathfinder*, boats were sent out with lights to mark the channel through the reefs, and the vessel immediately proceeded to the relief of the *Fernando Poo*, a distance of 180 miles, where she arrived at midnight on June 24. At daylight on the morning of June 25, the work of taking off 50 passengers, 9 members of the crew, mail, baggage, and necessary provisions was begun. Several attempts were made by the *Pathfinder* to tow the *Fernando Poo* off the reef, but without success. Upon the arrival of the Coast Guard cutter *Mindanao*, the *Pathfinder* with the passengers and mail left for Iloilo, where she arrived at 1.15 p. m. on June 26. The rescued passengers of the *Fernando Poo* greatly appreciated the assistance rendered by the officers of the *Pathfinder*, who in order to accommodate them gave up their own cabins to the shipwrecked people and in every way possible contributed to their comfort and safety.

Several vessels were rendered minor assistance by the *Isis* while employed on offshore work in southern waters. The four-masted schooner *Augustus Welt*, 75 days out from Buenos Aires and bound for Stamford, Conn., spoke this vessel off Port Royal Sound on February 11 and requested that she be reported to her owners, which was done.

On January 13, during very thick weather, the United States Engineers' dredge *Barnard* spoke the *Isis* off the entrance to Charleston and requested course and distance to Charleston Light Vessel, which was given them.

On April 28 the gasoline launch *North Star*, in Charleston Harbor, was about to swamp, due to overloading and a light choppy sea, and was towed in by the *Isis*.

Several vessels were rendered minor assistance by the steamer *Bache* while employed on offshore work in southern waters.

On February 23, 1916, assistance was rendered to the barkentine *Argo*, of Nostral, Denmark, 42 days from the Mediterranean. She was sighted about a mile off in thick haze, and, although making no sign of wishing to speak, the *Bache* changed course to her. When spoken, the captain said he had been lost for three days in thick fog and haze and was making for Satilla River, Ga. His position and course were given him.

Later a radiogram from the steamship *Rio Grande* was received asking for the distance and the course from survey buoy "A" of the *Bache* to St. Simons Gas Buoy. His position and course were furnished by radiogram.

On March 2, 1916, the *Bache* spoke the Finnish bark *Vega* bound for Sapelo River from Europe. At his request a radiogram was sent for a tug to meet him off Sapelo Bar.

On April 13, 1916, the *Bache* spoke the topsail schooner *Jarstein* of Syndesnas, Norway, and gave the master his position and sent a wireless to Brunswick requesting a tug to meet him at Sapelo Bar.

NEW VESSELS FOR THE SURVEY.

An appropriation of $289,000 was made available July 1, 1915, for two new vessels for the Survey to replace others worn out in the service and not worth further repairs.

As mentioned in the last annual report of the Superintendent, the *Isis* was purchased on July 1, 1915, for service on the Atlantic coast.

Plans were prepared for a new vessel, the *Surveyor*. Invitations for bids were sent to all ship-building concerns on the Atlantic and Pacific coasts of the United States and the Great Lakes. The lowest bid was made by the Manitowoc Shipbuilding & Dry Dock Co., Manitowoc, Wis., to which firm the contract was awarded on October 2, 1915, and calls for the delivery at Manitowoc, Wis., on or before October 4, 1916.

The *Surveyor* is a steel steam vessel of 1,000 tons displacement. Her dimensions are: Length over all, 186 feet; length on load water line, 160 feet; beam, 34 feet; depth of hold, 21½ feet; loaded draft, 12 feet. She will be driven by one triple-expansion engine of 1,000 indicated horsepower, and is expected to make 12 knots under this power.

The vessel will carry a complement of 13 officers and 56 enlisted men. She will burn fuel oil exclusively, and will have a tank capacity of 230 tons. She will carry 20,000 gallons of fresh water for boilers and for general ship use, and will have sufficient capacity for mess and ship's stores for about six months. The main engine is of the vertical, inverted, three-cylinder, triple-expansion, surface-condensing type, with cylinders 18, 29, and 47 inches in diameter and 30-inch stroke. The working steam pressure at the high-pressure cylinder will be 185 pounds, driving the engine at 110 revolutions per minute. The propeller is of cast steel of the built-up type with four blades. The diameter is 10 feet 6 inches, and the pitch is 13 feet 4½ inches.

Steam is furnished by two Scotch-type boilers, 11 feet 9 inches in diameter by 11 feet 11 inches long over all, each fitted with two Morrison corrugated furnaces of 42 inches inside diameter. The boilers are in a compartment just forward of the engine compartment and are placed one forward of the other with the firing space between. The boilers are fitted to burn fuel oil, which is carried in tanks on each side and forward of the boiler space.

The *Surveyor* will carry the usual equipment of a surveying vessel, including machines for sounding at all depths down to the greatest ocean depths. The lighter machines will be electrically driven, while the deep-sea sounding machine will be operated by a steam engine. The radio equipment, which will be the new type of apparatus designed by the United States Bureau of Standards for Government vessels, will be tested and installed by the radio experts of that Bureau.

SECTION OF FIELD WORK.

The section of field work was created October 15, 1915, as a part of the newly organized division of hydrography and topography.

This section has direct supervision over the hydrographic and topographic work of the Survey. The methods used and the results obtained in the field are carefully reviewed with a view to developing uniform and improved methods and means for field work.

The investigation of surveys with respect to differences of existing surveys, the character of the locality, the nature of the bottom, and the required closeness of the work pertaining to areas where new surveys or revision work are contemplated, is carried on, and data

prepared for instructions to the officer to be assigned as chief of party.

In supervising field operations, inspection was made of the party engaged upon revision work in the vicinity of Oyster Bay, N. Y., and of the party upon the survey of Port Royal Sound, S. C.

The work of the section was performed by the chief of the section. Many miscellaneous duties have been, of necessity, performed by the chief of the section, and the time for the work of critically inspecting the field sheets with a view to recommending them for approval has been limited. The lack of facilities for filing charts upon which data has been prepared, together with the lack of clerical assistance, handicapped the work for which the section was created.

The very important work of analyzing the cost of the work of field parties, in order that attention can be called to all causes which increase the cost of the work, has not been done owing to other duties that required immediate action.

The section has made estimates of cost and time required for work in localities when surveys have been requested and of work to be done in connection with surveys of the United States Engineer Corps.

Field officers upon arrival at the office have been temporarily assigned to this section to complete their field notes and data under the supervision of the chief of the section as the responsible head.

SECTION OF FIELD RECORDS.

The section of field records was created October 15, 1915, as part of the newly organized division of hydrography and topography.

One draftsman was detailed to the section to assist the chief of this section.

The work assigned to the section was, briefly, the critical review and verification of the results of the field work and the preparation of such data for publication.

Between November, 1915, and May, 1916, field officers, averaging 13 to the month, were detailed to this section for the completion of the field work of the past season. The field parties were disbanded sooner after the close of work in the field than had been done in former years, due to the assignment of officers to the Philippines and elsewhere. As a result the field data were received in the office in a more unfinished condition than ever before.

Notwithstanding this fact, the field officers were able, during the winter and spring, to practically complete the plotting of the field sheets preparatory to the office verification and inking. This was due to the fact that the work of the field officers could be more efficiently directed when under the control of a responsible head than if assigned to the office at large. The resulting benefit, both to the officers and to the work, from this method of handling the field force during the periods between field work, is so considerable that it will be continued in the future.

SECTION OF VESSELS AND EQUIPMENT.

The section of vessels and equipment was created on October 15, 1915, for the purpose of keeping better supervision over the vessels and other equipment of the parties employed on hydrographic and topographic surveys and to standardize as far as possible this equipment.

This section is charged with the construction, maintenance, and improvement of the vessels and their equipment; with the preparation of plans and specifications for new vessels, boats, and equipment; with the standardization of outfits for vessels and shore parties; and with the supervision of the personnel on the vessels to the extent that discipline shall be maintained, that the vessels shall be properly cared for, and that the regulations shall be observed.

All of the vessels on the Atlantic coast have been inspected twice since October 15, 1915, and all defects have been corrected, to the extent of the funds available for that purpose. On account of an insufficient appropriation for "Repairs to vessels," some necessary repairs and alterations to the steamers *Isis*, *Bache*, and *Hydrographer* were deferred until the appropriation for 1917 became available, but these matters will be attended to this season. It was impossible to inspect the vessels of the Pacific coast before the beginning of this field season, and accordingly the inspection and repairs to them were made by the inspector in charge of the Seattle suboffice.

All plans and specifications for repairs, for new construction, and for the purchase of equipment have been prepared in this section or have been examined and passed or revised in the section. All contracts for these repairs and purchases and leases for launches have been examined in this section before acceptance.

A large part of the work of the section has been the examination of estimates for supplies and operating expenses of hydrographic and topographic parties as well as the estimates for repairs to vessels. The examination of the monthly and inspection reports and statements of field parties and records of the enlisted personnel of the vessels, together with correspondence regarding vessels, equipment, and personnel, has required much of the time of the section.

COAST-PILOT WORK.

The coast-pilot section has been engaged both in field and office work. The field work is mentioned under "Field work, Atlantic coast."

The office work includes the preparation of Coast Pilot, Alaska, Part II; Coast Pilot, Section C; and Coast Pilot, Section E; supplements for eight Coast Pilots; and correction sheets for insertion in Coast Pilots. Alaska, Part II, and Sections C and E have been received from the printer.

Much valuable work has been done by the coast-pilot section in the examination of original sheets and furnishing data as to the condition of the surveys and also in answering inquiries and compiling information on various subjects.

A plan for obtaining, with the cooperation of the Steamboat-Inspection Service, information relating to wrecks and casualties to vessels was carried into effect.

An analysis was made of the cost of printing coast pilots and supplements which showed that changes in the form and typing made about 1912 has cut in half the cost of both coast pilots and supplements. Further simplification of the type in the volumes at present in press is expected to still further reduce the cost.

TIDES AND CURRENTS.

Tidal observations were made in connection with all hydrographic surveys in the United States, Alaska, and the Philippines, and at 7 regular stations on the Atlantic coast, 3 in the Gulf of Mexico, and 3 on the Pacific coast.

Tidal indicators, exhibiting automatically the stage and height of the tide, were maintained at Fort Hamilton and New York City, N. Y., and at Reedy Island, Delaware River.

With the cooperation of the Bureau of Lighthouses, observations of currents were made at 5 light vessels on the Atlantic coast, 2 in the Gulf of Mexico, and 5 on the Pacific coast. Current observations were made also by a number of field parties in connection with their hydrographic work.

Slack-water observations were made at the Race, Long Island Sound, and current observations made in the Race and in the Cape Cod Canal.

In order to make immediately available for the benefit of navigation the new current information obtained, two special publications were prepared and distributed, Tidal Currents, Pacific Coast, 1916, and Tidal Currents, Atlantic Coast, 1916.

These publications give the predicted times of slack water at two Pacific coast and five Atlantic coast points for the year 1916, with differences giving slack water at numerous places along each coast. Information concerning coastal currents was also given in detail.

The Tide Tables for 1917 were prepared and sent to the printer. Beginning with the tables for 1917, considerable additional information along tidal and current lines has been added, the tables have been greatly enlarged and simplified, and all the information has been put in a form specially adapted for the use of mariners and others using the tables.

Special tide tables for the Kuskokwim Bay and River, Alaska, for 1916, were prepared and distributed. This information will in the future be included in the regular Tide Tables.

An effort has been made to greatly improve the tidal bench marks of the service, and to this end a circular on tidal bench marks was prepared.

A special effort was made to have newspapers in all the principal cities publish official tidal and other data, giving credit for the same to the Survey, and a large number of newspapers responded.

Considerable new current information was prepared for coast pilots of Alaska, west of Yakutat Bay; Atlantic coast, Sandy Hook to Cape Henry; and of the Gulf of Mexico.

DIVISION OF GEODESY.

On October 15, 1915, the office of inspector of geodetic work and the computing division were consolidated under the title of division of geodesy.

FIELD WORK.

The reconnoissance for primary triangulation from southern Idaho westward along the Oregon Short Line Railway through Oregon was completed and a connection made with triangulation stations of the California-Washington arc in the vicinity of Portland, Oreg. During the progress of this work stations were prepared for the

use of the observing party. An automobile truck was used successfully as a means of transportation.

In the months from January to April the angles were measured at the turning points of the primary traverse which extends from Memphis, Tenn., to Little Rock, Ark.

Observations at primary triangulation stations in northern Utah which were begun during the previous fiscal year were continued. The work follows the Oregon Short Line Railway to its crossing of the Columbia River in northeastern Oregon. The arc then runs westward down the river to a junction with the California-Washington arc of primary triangulation in the vicinity of Portland, Oreg. Work was suspended in November, 1915, and resumed in the spring of 1916, with the measurement of a primary base line at Stanfield, Oreg. At the end of the fiscal year observations were in progress at triangulation stations in the vicinity of and to the eastward of Portland, Oreg.

Astronomic azimuths were observed at many of the triangulation stations. Two three-fourth-ton automobile trucks were used for transporting the party in 1916.

A primary traverse line between Memphis, Tenn., and Little Rock, Ark., was measured with base tapes, with the tape supported on the rails throughout its length. Near the end of the fiscal year a primary base line was measured in the vicinity of Argenta, Ark. The angles on the turning point of the traverse had been observed previously by a separate party.

From August to October, 1915, a reconnoissance for primary triangulation was begun and was extended from the vicinity of Pecos, Tex., northward through New Mexico and into Colorado. The work began at stations of the Texas-California arc and ended at stations of the transcontinental arc. Provision was made for connections with monuments of State boundaries crossed and with triangulation stations of the United States Geological Survey.

A portion of an old traverse line was rerun which had been extended from Point Isabel to Brownsville, Tex.

During the winter of 1915–16 a secondary triangulation was executed along a portion of the Patapsco River and in Baltimore Harbor and the vicinity of Baltimore, in compliance with a request from the district engineer officer of Baltimore. In spite of very unfavorable weather this work was carried through to completion with a very satisfactory degree of accuracy and at a small cost. This triangulation has been computed at this office, and the resulting geographic positions have been furnished to the district engineer officer as well as to the Baltimore city engineer and harbor board.

During the winter of 1915–16, in cooperation with the Chief of the Geodetic Survey of Mexico, a connection was made across the Rio Grande of the triangulation systems of the United States and of Mexico. This connection is a matter of very great moment in the field of geodesy and geography.

Two parties were engaged at different times during the fiscal year in determining by triangulation the positions of a number of objects on the Pacific coast for use by the Lighthouse Service in locating buoys and other aids to navigation. One of these parties worked to the northward and the other to the southward of San Francisco.

The line of precise levels between Reno and Las Vegas, Nev., which had been begun in the latter part of the previous fiscal year, was completed. This line was run primarily at the request of the United States Geological Survey. It was needed to coordinate a number of lines of levels of that Bureau which had been extended into the southern part of Nevada. A spur line was run into southern California to the town of Laws. Connection was also made with bench marks established by railroads and other organizations.

This leveling party worked under very trying conditions as to temperature, since it was operating in a desert country and the heat was excessive.

When the line had been carried to Las Vegas and the office computation made, it was found that the new value obtained for a bench mark at Las Vegas agreed with the elevation of this same bench mark, as determined by previous precise leveling, within a very few millimeters. While this must be considered as largely accidental, at the same time it was anticipated that the connection would give an elevation for Las Vegas bench mark which would agree within several inches of the previous elevation.

Early in March, 1916, leveling was begun on a line across Florida connecting the permanent tide gauges at Cedar Keys, St. Augustine, and Fernandina. The primary object of this leveling was to determine whether or not the mean sea level of the Atlantic and that of the Gulf of Mexico are in the same equipotential surface. This work was completed before the end of the year. The preliminary results indicate that the Gulf level is slightly higher than the Atlantic, but the final computations have not yet been made.

At the close of the fiscal year a line of levels was being extended from Baldwin, Fla., to Atlanta, Ga. This new line, which it is expected will be continued westward from Atlanta to Birmingham, will then be carried southward through Mobile to Biloxi. At the last-mentioned place mean sea level has been determined by a long series of observations.

In the early part of the fiscal year a line of precise levels was run from the vicinity of Huntley, Mont., northeastward through Glendive to Snowden, a point on the Great Northern Railway, where a connection was made with the precise leveling line which had been carried along that railroad in a previous year.

The usual connections were made with bench marks of the Geological Survey and those established by the railroad and other organizations.

The statistics of the leveling parties show that the rate of progress was more than 100 miles per month. Previous to the use of motor cars the monthly progress was about 67 miles. When the motor cars came into use in 1911 the rate of progress per month was increased to slightly more than 80 miles. The increase to more than 100 miles per month is due in large part to better organization and management of the parties.

In April, 1916, work was begun on lines of precise leveling in the States of Indiana and Michigan which had been asked for by the United States Geological Survey. At the end of the fiscal year the levels had been completed between Terre Haute and Lawrenceburg, Ind. A second line had been extended for a considerable distance

north of Indianapolis, and progress had been made on a line to the eastward of Chicago.

In June, 1916, work was begun in Maine on a line of precise leveling which will extend across the State from Boundary to Vanceboro. This line is being run primarily to connect that part of the precise leveling net of Canada which is in New Brunswick to the eastward of Maine with the part in Quebec to the westward of Maine. This line of levels across the State of Maine will greatly strengthen the eastern portion of the network of precise leveling in Canada, which supplements and strengthens the leveling net of the United States near the boundary.

During the first half of the fiscal year gravity stations were established by two parties in the States of Michigan, Minnesota, North and South Dakota, Montana, Wyoming, Nebraska, Virginia, Delaware, Maryland, and Pennsylvania. The observations were made with the Mendenhall half-second pendulums, which have been in use in all of the recent work of the Coast and Geodetic Survey. The stations were selected with the view of furnishing data for use in investigations of the variations in density of the materials in the outer portions of the earth.

In July and August, 1916, determinations were made of the differences of longitude between Omaha, Nebr., and Minneapolis, Minn., and between the latter place and Warroad, Minn.

In the autumn of 1915 a determination was made of the difference in longitude between the observatory at the office of the Coast and Geodetic Survey in Washington and the observatory of the Bausch & Lomb Optical Co. in Rochester, N. Y. The exchange of signals was made over the wires of the Western Union Telegraph Co., which were placed at the disposal of the observers. The instruments used in the work were equipped with the transit micrometer and no exchange of observers was necessary. An astronomic latitude was afterwards determined at Rochester. The field expenses of this work were paid for by the Bausch & Lomb Optical Co., the Survey furnishing the observers and instruments, as the results are of value to the public.

In March and April, 1916, the astronomic latitudes of two monuments on the Tennessee-Kentucky boundary between the towns of Hickman, Ky., and Union City, Tenn., were determined. These determinations of latitude were made in compliance with a request of the local authorities in order to settle the question of the location of the boundary between those States.

OFFICE WORK.

The office work of the division of geodesy includes the computation and reduction of observations made by the parties in the field engaged in triangulation, leveling, astronomic and gravity work; the discussion and preparation for publication of the results obtained for the benefit of the Government and the public; the preparation of plans and instructions for the geodetic work; and other incidental duties growing out of these principal ones.

Among the important pieces of work which were in progress during the fiscal year were the computation and adjustment of the

triangulation on the arc between Memphis, Tenn., and Huntsville, Ala.; the triangulation which controls the surveys of the Maryland Shell Fish Commission; the triangulation along the coast of Maine; on Core and Bogue Sounds, N. C.; along the coast of Louisiana; in vicinity of Lake Washington and Seattle, Wash.; between Troy, N. Y., and Lake Champlain; along the Patapsco River, and in Baltimore, Md.; also the computation and adjustment of lines of precise leveling for the lines from Huntley to Snowden, Mont.; from Blaine to Seattle, Wash.; and from Reno to Las Vegas, Nev., including a spur line from Tonopah Junction, Nev., to Laws, Cal.

Other work in progress during the year was the computation and adjustment of latitude and gravity observations at stations in the United States, the computation of the effect of topography and isostatic compensation at a number of gravity stations, the preparation for publication of the results of the investigation of the effect of topography and isostatic compensation on the intensity of gravity, and the preparation for publication of the results of leveling from Reno to Las Vegas, Nev.

The following publications relating to geodetic work were received from the printer during the year: Application of the Theory of Least Squares to the Adjustment of Triangulation (Special Publication No. 28); Triangulation in West Virginia, Ohio, Kentucky, Indiana, Illinois, and Missouri (Special Publication No. 30); Triangulation Along the Columbia River and the Coasts of Oregon and Northern California (Special Publication No. 31); and Determination of the Difference in Longitude Between Each Two of the Stations Washington, Cambridge, and Far Rockaway (Special Publication No. 35).

DIVISION OF TERRESTRIAL MAGNETISM.

FIELD WORK.

Until October 15, 1915, the field work of terrestrial magnetism was under the direction of the inspector of magnetic work and the office work under the direction of the chief of the division of terrestrial magnetism, both positions being held by the same person. After that date the position of inspector of magnetic work was abolished and both field and office work were placed under the direction of the chief of the division of terrestrial magnetism.

Except for two visits of inspection to the Cheltenham magnetic observatory, the duties of the chief of division have been performed at Washington. They include the preparation of plans, estimates, and instructions for the field work; the inspection of the records as they are received; recommendations regarding the purchase, construction, and repair of instruments and the construction and alteration of observatory buildings; supervision of the office computations and preparation of results for publication; and discussion of results.

The following table shows the localities at which observations were made:

DISTRIBUTION OF STATIONS.

State.	New stations.		Repeat stations.	New station in old locality.	Total.
	Primary.	Auxiliary.			
Alabama	17	3	1		21
Arizona			3		3
Arkansas	2	5	2		9
Colorado	8		1	1	10
Connecticut			1	1	2
Florida	3		1		4
Georgia	6		1		7
Illinois	6	1	1		8
Indiana	4	4	1		9
Iowa	5		1		6
Kansas	5		1	3	9
Kentucky	26	12	2	4	44
Louisiana	2		2	1	5
Maine	4	8	2		14
Maryland			1		1
Massachusetts	7	5	3	3	18
Michigan	19	15	5	1	40
Minnesota	2	1	1	1	5
Mississippi	3		1		4
Missouri	11	3	1		15
Montana	14				14
Nebraska	6	3	2	1	12
New Hampshire		4	1		5
New Mexico	11			1	12
New York			3		3
North Carolina		1	3	3	7
North Dakota	15		2		17
Ohio	11	14	2	2	29
Oklahoma	15			1	16
Rhode Island			2		2
South Dakota	3		1		4
Tennessee	3	3	1		7
Texas	5				5
Utah	4		1		5
Virginia		5	5	3	13
West Virginia	18		1	4	23
Wisconsin	7		1		8
Wyoming	8		2	1	11
Total	250	87	59	31	427

In the continuation of the magnetic survey of the United States, observations for the determination of the three magnetic elements were made at 427 stations, of which 250 were new primary stations, 87 were auxiliary stations for the investigation of regions of local disturbance, 59 were repeat stations for the determination of the secular change, and 31 were new stations in old localities. At the request of the local authorities meridian lines were established at 20 places in connection with the magnetic work. The magnetic survey of the forty-ninth parallel, Canadian boundary, which was suspended in July, 1915, because of an accident to the observer, was resumed in May, 1916, and had been nearly completed at the end of the fiscal year. The three magnetic elements have now been determined at intervals of about 30 miles from the Lake of the Woods to the Pacific, the part west of the Rocky Mountains having been done in 1905. Last year it was reported that observations had been made at all but 331 of the county seats in the United States. During the past year this number has been reduced to 240.

Observations were also made (declination only, in most cases) at a number of places in Alaska and the Philippine Islands in connection with other branches of the work of the Survey.

The observations at sea were, for various reasons, confined to those needed for the determination of the deviations of the ships' compasses.

OBSERVATORY WORK.

The magnetic observatories at Cheltenham, Md., Vieques, P. R., Tucson, Ariz., Sitka, Alaska, and near Honolulu, Hawaii, were in operation throughout the year. Continuous records were secured of the variations in declination, horizontal intensity, and vertical intensity by means of magnetographs recording photographically. Absolute observations were made at least once a week and scale value determinations once a month. Daily meteorological observations were made, and the results of those at Tucson were transmitted to the Weather Bureau office at Phoenix and of those at the Honolulu observatory to the Weather Bureau office at Honolulu. A seismograph was kept in continuous operation at each observatory, and about the usual number of earthquakes were recorded.

All of the magnetic instruments used in the field work were standardized at Cheltenham. Two sets of these instruments were compared also at Tucson. Magnetometers were standardized at Cheltenham for the United States Navy and for the University of Texas.

OBSERVATORY BUILDINGS.

At Cheltenham a considerable portion of the sills and posts of the buildings required renewal because of decay. Cement was substituted for wood wherever possible. At Vieques the insulation of the variation building was increased by the addition of a 4-inch thickness of sawdust, which is expected to reduce materially the daily range of temperature inside.

At Sitka the condition of the rented building used as office and quarters for the observer had become so bad that some change became imperative. A small Government reservation known as the Tea House Lot was secured by transfer from the Treasury Department, and arrangements were made for the erection of an office building on the lot in accordance with the plans secured in the previous year. The foundation was laid and much of the building material was purchased near the end of the fiscal year, in order to divide the expense of the building between two fiscal years.

With the completion of this building there will be a building for office and quarters for the observer at each of the observatories except Cheltenham. The erection of such a building at Cheltenham is recommended. The present combination of office and absolute observatory in one building is unsatisfactory because of the necessity of guarding against the effect upon the absolute instruments of magnetic material in the office. The character of the observatory work is such that it is important to have the observer live so near that he can readily make an inspection of the buildings and instruments at any time of the day or night. At the present time there are only two rented houses in Cheltenham, and they are about a mile from the observatory. Conditions might easily arise which would compel the observer to go still farther away for suitable accommodations, probably to some village farther down the railroad.

The decision to begin the erection of an office building at Sitka made it necessary to curtail the field work somewhat during the year, and in consequence the assignments of magnetic observers to office duty were for longer periods than usual, amounting in the aggregate

to about 15 months for one man. With this assistance from the magnetic observers it was possible, in addition to keeping the reduction and publication of field and observatory work up to date, to undertake the special investigation of "magnetic activity" for 1915, as requested by the International Commission for Terrestrial Magnetism.

OFFICE WORK.

Office revision was made of the observations at the field stations and of the standardization observations at Cheltenham, Tucson, and Honolulu.

The reduction of the observations made at the five magnetic observatories during 1913 and 1914 was completed and the results were prepared for publication.

The reduction of the observations made at Cheltenham in 1913 was begun.

The results of the special observations made at the magnetic observatories at the time of the solar eclipse of August 21 were prepared for publication in the Journal of Terrestrial Magnetism.

The following were prepared for publication and the proof was read:

Serial No. 18. Distribution of the Magnetic Declination in the United States for January 1, 1915, with isogonic chart and secular change tables. (Special Publication No. 33.)

Serial No. 19. Results of Observations Made at the Cheltenham Magnetic Observatory in 1913 and 1914.

Serial No. 21. Results of Observations Made at the Honolulu Magnetic Observatory in 1913 and 1914.

Serial No. 23. Results of Observations Made at the Tucson Magnetic Observatory in 1913 and 1914.

Serial No. 27. Results of Observations Made at the Sitka Magnetic Observatory in 1913 and 1914.

Serial No. 33. Results of Observations Made at the Porto Rico Magnetic Observatory in 1913 and 1914.

Serial No. 36. Results of Magnetic Observations Made by the U. S. Coast and Geodetic Survey in 1915. (Special Publication No. 36.)

Good progress was made in the preparation of a publication to be entitled "Magnetic tables and magnetic charts for 1915," the tables to contain the latest values of declination, dip, and horizontal intensity for all places in the United States and adjacent foreign countries at which magnetic observations have been made up to the end of 1915, together with corresponding reduced values for January 1, 1915, and the charts to show the distribution of the declination, dip, horizontal intensity, vertical intensity, and total intensity for that epoch. The values have all been reduced to 1915, and the lines showing the distribution and annual change of declination, dip, and horizontal intensity have been drawn. A new discussion has been made of the secular change of dip and horizontal intensity between 1870 and 1915, tables have been prepared for reducing the observations to the common epoch, and the secular change data have been prepared for publication.

The earthquakes recorded by the seismographs at the five magnetic observatories have been tabulated promptly, and the results have been submitted for publication in the Monthly Weather Review and transmitted to the International Seismological Association and others engaged in a comparative study of earthquake data.

At the request of the International Commission for Terrestrial Magnetism a computation was made to determine the magnetic activity of each day of 1915 from the records of the Cheltenham magnetic observatory, using the method proposed by the late Dr. Bidlingmaier.

Data for specified days in 1913 and 1914 were prepared for Dr. L. A. Bauer for use in his investigation of a possible connection between terrestrial magnetism and solar activity.

A table giving the values of the magnetic declination at numerous places in the United States was prepared for insertion in the World Almanac.

A card system has been adopted for filing the results of observations at field stations. Results obtained since January, 1916, are being entered directly on the cards, and the system will be extended to the older observations as soon as there is opportunity. The magnetic stations, heretofore shown on the maps of a Cram atlas, have been marked on a set of backed post-route maps, so that one may see at a glance the progress of the magnetic survey in any particular locality. It is expected that the card-filing system, in conjunction with these maps, will add materially to the efficiency of the division.

Magnetic information was supplied for 104 charts.

PUBLICATIONS.

The following publications were received from the printer during the fiscal year 1916:

Serial 6. General Instructions for Field Work of U. S. Coast and Geodetic Survey, 1915. (Special Publication 26.) 176 p., 27 il. 12mo.

Serial 7. Latitude Observations with Photographic-Zenith Tube at Gaithersburg, Md.; by Frank E. Ross, Ph. D. (Special Publication 27.) 127 p., 18 il. 4to.

Serial 9. Application of Theory of Least Squares to Adjustment of Primary Triangulation; by Oscar S. Adams. (Special Publication 28.) 220 p., 9 fig. 8vo.

Serial 12. Supplement to Third Edition of U. S. Coast Pilot, Atlantic Coast: Part VIII, Gulf of Mexico from Key West to Rio Grande. June 12, 1915. 18 l. 8vo.

Serial 13. Wire-drag Work on Atlantic Coast; by N. H. Heck and Jean H. Hawley. (Special Publication 29.) 24 p., 8 il. 4to.

Serial 14. Triangulation in West Virginia, Ohio, Kentucky, Indiana, Illinois, and Missouri; by A. L. Baldwin. (Special Publication 30.) 67 p., 12 il. 4to.

Serial 15. Triangulation Along Columbia River and Coasts of Oregon and Northern California; by C. A. Mourhess. (Special Publication 31.) 149 p., 45 il. 4to.

Serial 16. Description of U. S. Coast and Geodetic Survey Tide-Predicting Machine No. 2. (Special Publication 32.) 35 p., 15 pl. 8vo.

Serial 17. Supplement to Fourth Edition of U. S. Coast Pilot, Atlantic Coast: Part VI, Chesapeake Bay and Tributaries. 13 l. 8vo.

Serial 18. Distribution of Magnetic Declination in United States for Jan. 1, 1915; by Daniel L. Hazard. (Special Publication 33.) 16 p., 1 map. 8vo.

Serial 19. Results of Observations Made at U. S. Coast and Geodetic Survey Magnetic Observatory at Cheltenham, Md., 1913 and 1914; by Daniel L. Hazard. 98 p., 16 fig. 4to.

Serial 20. Supplement to U. S. Coast Pilot, Atlantic Coast: Parts I–II, Section D, Cape Henry to Key West. Sept. 25, 1915. 13 l. 8vo.

Serial 21. Results of Observations Made at U. S. Coast and Geodetic Survey Magnetic Observatory at Honolulu, Hawaii, 1913 and 1914; by Daniel L. Hazard. 105 p., 8 pl. 4to.

Serial 22. Lengths, in Statute Miles, of General Coast Line and Tidal Shore Line of United States and Outlying Territories. November, 1915. 3 p. 8vo.

Serial 23. Results of Observations Made at U. S. Coast and Geodetic Survey Magnetic Observatory Near Tucson, Ariz., 1913 and 1914. 102 p., 16 fig. 4to.

Serial 24. Wire-Drag Work in Alaska; by L. O. Colbert and John A. Daniels. (Special Publication 34.) 31 p., 2 maps, 15 text fig. 8vo.

Serial 25. Supplement to U. S. Coast Pilot, Atlantic Coast: Parts I–II, New York to Chesapeake Bay Entrance. Jan. 7, 1916. 18 l. 8vo.

Serial 26. Supplement to Third Edition of U. S. Coast Pilot, Atlantic Coast: Part VIII, Gulf of Mexico from Key West to Rio Grande. Jan. 15, 1916. 18 l. 8vo.

Serial 27. Results of Observations Made at U. S. Coast and Geodetic Survey Magnetic Observatory at Sitka, Alaska, 1913 and 1914. 100 p., 17 fig. 4to.

Serial 28. Explanation of Dates on U. S. Coast and Geodetic Survey Charts. Jan. 21, 1916. 2 p. 8vo.

Serial 29. Determination of Difference in Longitude Between Each Two of Stations Washington, Cambridge, and Far Rockaway; by O. B. French and Fremont Morse. (Special Publication 35.) 40 p., 8 fig. 8vo.

Serial 30. Tide Tables for Kuskokwim Bay and River, Alaska. 2 p. 8vo.

Serial 31. Supplement to Coast Pilot, Pacific Coast: California, Oregon, and Washington. 18 l. 8vo.

Serial 34. U. S. Coast Pilot, Alaska: Part II, Yakutat Bay to Arctic Ocean. 1st ed. 303 p. 8vo.

Serial 35. Supplement to U. S. Coast Pilot, Atlantic Coast: Part III, from Cape Ann to Point Judith. Mar. 31, 1916. 13 l. 8vo.

Serial 37. Military and Naval Service of U. S. Coast Survey, 1861–1865. (Special Publication 37.) 72 p. 8vo.

Serial 38. Supplement to U. S. Coast Pilot, Atlantic Coast: Parts I–II, St. Croix River to Cape Ann. Mar. 17, 1916. 13 l. 8vo.

Serial 39. Tidal Currents, Pacific Coast, for Year 1916. 11 p. 8vo.

Serial 40. Tidal Currents, Atlantic Coast for Year 1916. 28 p. 8vo.

Serial 41. Supplement to Fifth Edition of U. S. Coast Pilot, Pacific Coast, Alaska: Part I, from Dixon Entrance to Yakutat Bay. Apr. 28, 1916. 34 l. 8vo.

Serial 46. Supplement to U. S. Coast and Geodetic Survey Catalogue of Charts, Coast Pilots, and Tide Tables, 1916. May 9, 1916. 5 p. 4to.

Plane Table Manual. [Reprint with corrections of Appendix 7, Annual Report for 1905]. 54 p., 37 il. 4to.

Atlantic Coast Pilot: Part V, New York to Chesapeake Bay Entrance. [Reprint.] 169 p., 9 il. 8vo.

Atlantic Coast Pilot: Part VI, Chesapeake Bay and Tributaries. [Reprint.] 162 p., 7 il. 8vo.

Catalogue of Charts, Coast Pilots, and Tide Tables, 1916. 231 p., 88 il. 4to.

Catalogue of Charts, Sailing Directions, and Tide Tables of Philippine Islands. [Reprinted from General Catalogue.] 53 p., 23 il. 4to.

Annual Report of Superintendent, U. S. Coast and Geodetic Survey, 1915. 156 p., 26 maps, 3 pl. 8vo.

APPROPRIATIONS AND DISBURSEMENTS.

The appropriation made by Congress in the sundry civil act for the United States Coast and Geodetic Survey for the fiscal year ended June 30, 1916, was $1,365,520, divided as follows:

Field expenses	$355,400
Repairs and maintenance of vessels	40,000
Officers and men, vessels	252,200
Pay of field officers	174,600
Pay of office force	204,420
Two new vessels	289,000
Office expenses	50,000
Total	1,365,620

For the fiscal year ending June 30, 1917, the total amount appropriated is $1,227,140 and the items of appropriation are as follows:

Field expenses	$425,320
Repairs and maintenance of vessels	56,000
Officers and men, vessels	285,000
Pay of field officers	184,900
Pay of office force	213,420
Office expenses	62,500
Total	1,227,140

The statement of disbursements required by law to be made annually to Congress and published as a separate document gives an account of the names and number of employees of different classes, the amount of their salary or compensation, the length of time employed, to whom payments were made under the different items of appropriation and on what account, and the balances remaining of the amounts appropriated for the fiscal year.

SURVEYS REQUESTED.

The following requests for surveys were received during the year and most of them have been completed or are in progress:

Massachusetts: Wire-drag work in vicinity of Plymouth requested by Charles C. Doten, harbor engineer of Plymouth; verification and marking of trial course for submarines in Cape Cod Bay, requested by Navy Department.

New York: Resurvey of Hudson River, requested by United States Engineer Office at New York; determination of longitude of observatory of Bausch & Lomb Optical Co., at Rochester, requested by Bausch & Lomb Optical Co.

New Jersey: Line of levels from Cape May to Sandy Hook and from Delaware Bay to Camden, Trenton, etc., requested by governor of New Jersey.

Maryland: Determination of triangulation points on Baltimore Harbor, requested by United States Engineer Office and by the Topographic Survey Commission of the City of Baltimore.

North Carolina: Revision of survey of eastern shore of Pamlico Sound in vicinity of Ocracoke Inlet, requested by Bureau of Lighthouses.

South Carolina: Resurvey of channel on the bar at entrance to Port Royal, requested by the Hydrographic Office, Navy Department.

California: Resurvey of San Diego Bay, requested by mayor of San Diego and the Cabrillo Commercial Club; survey of Monterey Harbor, requested by Chamber of Commerce of Monterey.

Oregon: Determination by triangulation and marking of points for identification, requested by Forest Service.

Oregon and Nevada: Extension of triangulation in these States requested by Pacific Power & Light Co.

Washington: Survey of Port Gamble, requested by United States Engineer Office.

New Hampshire: Determination of meridian line at Spofford, requested by Fred. E. Kilburn.

Kentucky and Tennessee: Determination of latitude of points on boundary between Kentucky and Tennessee, requested by Hon. Ollie M. James, United States Senator, and others.

Indiana: Precise levels requested by city engineer of Indianapolis.
Indiana and Michigan: Extension of line of precise levels in those States, requested by United States Geological Survey.
Alaska: Survey of area southward of the entrance to Cross Sound, requested by the manager of the Deep Sea Salmon Co.; survey of channel into Whale Bay, requested by A. K. Foss, Ketchikan; survey of Port Moller, requested by Pacific American Fisheries Co.

SPECIAL DUTY.

INTERNATIONAL GEODETIC ASSOCIATION.

The Superintendent has continued to supervise the operations of the observatory maintained by the International Geodetic Association at Ukiah, Cal.

The urgent deficiency act for 1916 appropriated $2,500 for continuing work at the Ukiah station if lack of funds for the association during the European war should threaten a break in the series of observations. This act also provided $3,000 with which to pay the subscription of the United States to the International Geodetic Association for the years 1915 and 1916. The consular and diplomatic act for 1917 contained an item of $1,500 for the same purpose for the fiscal year 1917 and a proviso reading as follows:

> The duly appointed representative of the United States on the Permanent Commission of the International Geodetic Association is hereby granted authority to vote with the representatives on the permanent commission from other nations on all matters coming before the association, including the extension of its existence, subject to the approval of Congress.

The representative of the United States on the Permanent Commission of the International Geodetic Association is William Bowie, chief of the division of geodesy of the United States Coast and Geodetic Survey.

VERIFICATION OF SPEED TRIAL COURSE FOR SUBMARINES IN CAPE COD BAY.

In August, 1915, at the request of the Navy Department, an officer of the Survey verified and marked a speed trial course for submarines in Cape Cod Bay, Mass.

CURRENT OBSERVATIONS IN CAPE COD CANAL.

In December, 1915, at the request of the chief engineer of the Cape Cod Construction Co. and with the cooperation of that company a series of current observations were made by an officer of the Survey in the Cape Cod Canal.

MISSISSIPPI RIVER COMMISSION.

An officer of the Survey in addition to other duties has continued to serve as a member of the Mississippi River Commission.

DETERMINATION OF LATITUDE AND LONGITUDE AT ROCHESTER, N. Y.

In November, 1915, at the request of the Bausch & Lomb Optical Co., Rochester, N. Y., a determination was made by officers of the

Survey of the longitude of the observatory of that company at Rochester, N. Y. In June, 1916, the latitude of that observatory was determined.

DETERMINATION OF THE ELEVATION OF TWO POINTS IN THE DISTRICT OF COLUMBIA.

In June, 1916, at the request of the Navy Department, the elevations of two points at the Navy Yard, Washington, D. C., were determined by leveling.

DETERMINATION OF LATITUDE ON THE KENTUCKY-TENNESSEE BOUNDARY.

In March and April, 1916, at the request of the State authorities, a determination was made of the latitude of two points on the boundary between Kentucky and Tennessee by an officer of the Survey.

EXHIBIT OF THE COAST AND GEODETIC SURVEY AT THE PANAMA-PACIFIC EXPOSITION.

An officer of the Coast and Geodetic Survey was in charge of the exhibit illustrating the work of the Survey at the Panama-Pacific International Exposition held at San Francisco, Cal.

SURVEY OF MILITARY RESERVATIONS AT ORCA INLET, ALASKA.

At the request of the War Department, a topographic survey of the military reservations at the head of Orca Inlet, Alaska, was begun by an officer of the Survey in June, 1916.

CELEBRATION OF THE CENTENNIAL OF THE UNITED STATES COAST AND GEODETIC SURVEY, AND EXHIBIT IN CONNECTION THEREWITH, HELD AT THE UNITED STATES NATIONAL MUSEUM.

Exercises in commemoration of the centennial anniversary of the United States Coast and Geodetic Survey were held in the auditorium of the United States National Museum on the afternoon of April 5 and from 10 a. m. to 6 p. m., April 6, when the work of the Survey during the past 100 years was discussed by distinguished persons not connected with the Bureau. From April 5 to April 10, 1916, an exhibit illustrative of the history and progress of the work of the United States Coast and Geodetic Survey was made at the United States National Museum in connection with the celebration.

EXHIBIT OF THE COAST AND GEODETIC SURVEY AT MEETING OF THE UNITED STATES CHAMBER OF COMMERCE.

In February, 1916, the Coast and Geodetic Survey took part in an exhibit showing the activities of the bureaus of the Department of Commerce in relation to commerce and industry, which was open during the meeting in Washington, D. C., of the Chamber of Commerce of the United States.

EXHIBIT AT THE NATIONAL MOTOR BOAT SHOW, NEW YORK.

An exhibit was made of the charts and publications of the Survey at the National Motor Boat Show held at the Grand Central Palace, New York City, from January 29 to February 5, 1916.

EXHIBIT OF THE COAST AND GEODETIC SURVEY AT THE FISH FAIR AT EASTPORT, ME.

An exhibit of the charts, coast pilots, and other publications of the Coast and Geodetic Survey and of publications of other bureaus of the Department of Commerce was made at the Fish Fair held at Eastport, Me., on December 22, 1915.

EXHIBIT OF THE COAST AND GEODETIC SURVEY AT THE "SAFETY-FIRST" EXPOSITION.

An exhibit illustrating the work of the Coast and Geodetic Survey with especial reference to the construction of nautical charts was made in connection with the "Safety-First" Exposition held in the United States National Museum, Washington, D. C., during the week beginning February 21, 1916.

DETAILS OF FIELD OPERATIONS.

ATLANTIC COAST.

MASSACHUSETTS AND RHODE ISLAND.

[N. H. HECK.]

SUMMARY OF RESULTS.—Triangulation: 20.5 square miles of area covered, 11 stations in supplemental scheme occupied for horizontal measures, 27 geographic positions determined. Topography: 21 miles of general coast line run (chart revision). Hydrography: 124.5 square miles of area dragged, 365 miles run while dragging, 24,366 angles measured, 774 soundings made, 4 tide stations occupied, 2 hydrographic sheets finished and 3 partly finished, scales 1:25,000, 1:20,000, and 1:10,000.

Wire-drag work in Boston Bay was in progress at the beginning of the fiscal year. The greater part of the open area included in this work had then been completed, and from July 1 to October 1, the date on which the operations in the field in this locality were concluded, the work was in shoal water, and uncharted shoals or depths less than charted were found on practically every working day.

The weather and atmospheric conditions during the season were unusually favorable.

The nature of the bottom in the area dragged was such as to make progress comparatively slow. Eighty per cent of the area covered either was of less than the maximum depth to be verified (48 feet at mean low water) or else of such a character that a portion of the drag had to be set at less than the maximum depth. Over much of the area the depths were moderate and the bottom was flat but rocky with small projections extending only slightly above the general bottom. The remainder of the area was covered with fairly deep water with pinnacles or ridges.

The number of retained soundings indicating rocks or shoals found was high, averaging for several months five to six per square mile, with an average of three per square mile for the entire season.

Currents were generally found to be moderate so that favorable conditions for the drag work could usually be selected. In the vicinity of Boston Light Vessel and off Minots Ledge Light the directions were frequently opposite to what was expected.

The range of tide, averaging 9 feet and at the extreme 13 feet, made it necessary to use constant care to keep the drag depth correct. The observed tides were found to agree closely with the predictions. The rolls of the automatic tide gauge maintained by the Metropolitan Water and Sewerage Board were used, and these were found to agree closely with those obtained at Scituate and Plymouth.

The working grounds were exposed to sea and swell, especially from the eastward. The area is very little broken up by islands, projecting ledges, or buoys. The principal obstruction was due to lobster pots. The usual notices to men engaged in the lobster industry were posted in a number of places. Dragging was done only as announced, and as a result there was comparatively little interference with the work.

Little time is lost in buoying sections to be dragged. The buoys used are long bamboo poles with flag. A can is attached to the pole, which is moored with a light rope attached to a small rock.

In the equipment and apparatus an important change was the adoption of stranded in place of solid wire. The wire now used is only one-eighth inch in diameter, and has a breaking strain of 2,000 pounds. It is flexible and its weight is so small that it is used in 100-foot sections with floats one-half the size of those formerly used every 50 feet.

Improvements were also made in the small and large buoys.

In a region such as the approaches to Boston, noninterference with navigation is of vital importance as the drag often extends across the approach to the principal channels. During the season a total of 131 vessels of all classes, besides numerous power boats, crossed the wire, and in only two cases did a passing vessel catch on the drag.

One day was spent in work with a 24,000-foot drag with four launches of the two wire-drag parties cooperating. This resulted in covering 20 square miles in a single day, with a long run to and from the working ground.

A 4,000-foot drag was used for shoal-water work whenever conditions would permit.

In the latter part of August a subparty was organized to drag the remaining area in Buzzards Bay and Quicks Hole. The party began work from Cuttyhunk on September 7 and was continued through that month. The work to be done in Quicks Hole was the more important. This is an important channel in constant use, especially by barges, up to 23 feet draft. The current has a maximum of $3\frac{1}{2}$ to $4\frac{1}{2}$ knots at strength in the middle of the hole and slack lasts only a short while. This made the work extremely difficult.

A 19-foot and a 20-foot shoal were found on the eastern edge of the channel and a greater depth than previously found was taken between them and the 16-foot shoal in the center of the channel found during the preceding year, giving a clear distance of about 700 feet. Several days' work was done to the north of Quicks Hole

and a good start was made toward finishing the bay. Work was suspended at the end of September on account of bad weather.

A reported shoal in Cuttyhunk Harbor was found and developed.

On October 1 the party left Hull, Mass., for Newport, R. I., arriving late that night.

Work was begun October 6 in dragging the Eastern Passage of Narragansett Bay and continued without interruption until November 12.

The conditions in Narragansett Bay were favorable for work, the chief interference with the work being from trawl fishermen and from the operations of the Navy in testing torpedoes. In a few cases buoys marking oyster beds gave trouble.

The tidal currents in the bay are strong but regular. The bottom conditions are unusually favorable, the bottom being either flat and muddy or rocky and irregular.

In addition to covering all of the sheet, the north approach to the Bradford coal depot was dragged. The unfinished part of the area covered during the previous year was completed, and a large number of shoals were found in proportion to the small area involved.

A considerable amount of triangulation was done to locate prominent objects and extensive chart revision was undertaken. New wharves were located on the chart and the shore line was examined for outlying rocks.

Two existing trial-course ranges were verified and permanently marked.

The important results of the season's work may be summarized as follows:

In the approaches to Boston an area of over 50 square miles was proved clear from obstructions.

This included the main approach from sea to all the channels except the Narrows and Nantasket Roads.

Several rocks were found near the sailing line from the Cape Cod Canal to Boston, with less water over them than the depth of the canal. As determined by the drag survey, vessels approaching Boston from Provincetown or other points on Cape Cod Bay will have to use care in navigating an extensive area between Minots Ledge Light and Boston Light.

In Buzzards Bay only a small portion of the general unfinished area was completed, but Quicks Hole, the important locality, was finished. Not only were two dangerous rocks found that affect the depth of the channel seriously and narrow it to a width difficult for tows with barges to navigate, but the deepest part of the channel, only 700 feet in width, was dragged so as to insure the safety of vessels keeping within it.

In Narragansett Bay the Eastern Passage up to the lower end of Prudence Island was proved free from obstruction in so far as the ordinary demands of navigation are concerned and also for the anchorage of the largest vessels of the Navy. A large number of shoals were found, but these were chiefly in the vicinity of previously charted shoals or the extension of charted ridges. In the north approach to Newport, the area partially dragged during the previous year, a large number of rocks were found, some being dangerous to vessels of small draft.

A much needed chart revision was made of this locality.

Motion pictures showing all of the wire-drag operations were made by expert photographers from the office when the work at Newport was in progress.

On May 4 preparations were begun for resuming wire-drag work along the coast of Massachusetts.

The work of dragging the doubtful area along the coast between Nahant and Cape Ann and of the approaches to Salem, Beverly, and Marblehead Harbors was prosecuted continuously from May 19 to the end of the fiscal year.

Every class of area was encountered from conditions requiring a 600-foot drag to those where a 12,000-foot drag was used and where even a larger drag might have been used had the equipment been available.

The results indicate the successful use of the long drag, a total of 60 square miles having been covered at the end of the fiscal year, of which but 20 per cent, or 12 square miles, was shoal water or short-drag work.

A number of important shoals were found. The appearance of the inshore area with its numerous ledges and islands indicates the existence of shoals, and the results of the wire-drag work fully bear out the indications. An important 17-foot shoal was found in the south approach to Salem Harbor, and 20 feet were found in several places where greater depths were charted. A 24-foot shoal was found in the approach from outside toward the Main Ship Channel where 7½ fathoms were charted, and the Main Ship Channel was found to be much narrower than charted with an effective width of not more than 400 feet for deep-draft vessels. Twenty feet instead of 7 fathoms were found on the north side of the channel outside the buoy.

Two wrecks were discovered in the deep outside area. The least depth over them was not found, but the finding illustrates the effectiveness of the long drag and the need for dragging these areas, especially for the use of submarines.

An important feature of the work of the season was the practical elimination of drag failure as a cause of lost time. The new wire, fittings, and swivels, all having a strength of about 4,000 pounds, have such a margin of safety that the parting of the drag which was formerly a daily occurrence has occurred only twice this season, once on a sharp rock and once on a wreck. The former time loss from this cause represented a very considerable sum—much more than the new equipment has cost in excess of the old.

At the request of the harbor master of Salem, flags were set to mark a safe anchorage and safe entrance channel for the battleship *Vermont* to enter Salem Harbor on July 4. These were placed on June 30.

MASSACHUSETTS, NEW YORK, AND NEW JERSEY.

[JEAN H. HAWLEY.]

SUMMARY OF RESULTS.—Triangulation: 10 square miles of area covered, 1 signal pole erected, 5 stations in main scheme occupied for horizontal measures, 23 geographic positions determined. Topography: 37 square miles of area surveyed, 44 miles of general coast line surveyed, 10 miles of roads surveyed, 1 topographic sheet finished, scale of topographic sheets 1:10,000 and 1:20,000.

Hydrography: One-half square mile of area covered, 19 miles run while sounding, 1,187 angles measured, 1,409 soundings made, 1 hydrographic sheet finished, scale of hydrographic sheets 1:10,000 and 1:30,000. Wire-drag work: 163.2 square miles of area covered; 376.95 miles run while dragging; 191 retained soundings, 2 hydrographic sheets finished, scales of hydrographic sheets 1:30,000, 1:25,000, and 1:10,000.

On July 1, wire-drag party No. 2 was located at Scituate, Mass., and operations were being carried on from that base. It was necessary to devote all of the time available to inshore work and to complete as much of this as possible before the lobster season opened about the middle of the month.

Weather conditions were unfavorable during the first part of August and no field work could be done until the 10th. The work was extended as far to the southward as was practicable from Scituate until the 21st, when the party was transferred to Plymouth, Mass. From this place the work was carried on until September 24. One day's work was done on the adjoining sheet to the north, when wire-drag parties Nos. 1 and 2 working in cooperation successfully used a drag 24,000 feet in length.

Numerous shoals were discovered and reported in practically every case; these consisted of single bowlders or piles of bowlders in sand or hard mud.

With few exceptions all dangerous obstructions were found inside a 3-mile limit from shore. The remainder of the area from this limit out to the 20-fathom curve was proved to be safe for navigation to a depth of 48 feet.

The general directions of the currents were noted. The currents were found to increase in velocity southward and to be strongest in the vicinity of the shoals near Brant Rock.

Work was prevented by bad weather on 41 days.

On September 30 the party was transferred to College Point, N. Y., to make a wire-drag examination of East River.

The locations of objects suitable for controlling the work were not available and it was necessary to determine them by triangulation. Five stations of the Greater New York triangulation scheme were recovered and occupied. Large-scale charts of the vicinity were used for boat sheets, and to avoid delays necessary for triangulation computations all signals were located on these sheets by plotting intersecting lines.

Dragging was begun on October 8 and continued until October 30. An area of 1.7 square statute miles covering the main channel from Lawrence Point to Whitestone Point was investigated; in this area over 20 separate shoals were discovered and reported. In addition to this, numerous instances were found where the mud banks along the sides of the river had encroached into the main channel. Several wrecks were found, and, while their exact nature was not ascertained, their locations and distances beneath the surface were determined. The most important obstructions were found in the main channel between Barretts Point and Rikers Island. Three pinnacle rocks, with depths of 20, 21, and 22½ feet, respectively, were found near mid channel here, and their presence practically closes the channel for safe navigation to drafts over 20 feet. The channel has been used by vessels with drafts as great as 24 feet, and a 25-foot channel is now (December, 1915) being dredged between North and South Brother Islands to relieve traffic congestion.

In addition to the wire-drag work, several rocks off City Island were located and the topography in the vicinity of the work was revised.

In November a subparty made a hydrographic examination in the vicinity of Bergen Point, Newark Bay, and afterwards a topographic revision was made of the west shore of Newark Bay. This work includes the location of the new terminal dock at Newark, reclamation projects of the Mosquito Elimination Commission of New Jersey, and changes in shore line due to corrected location of triangulation stations.

The work at College Point was closed November 9, and that on Newark Bay on December 6.

Preparations for resuming wire-drag work in Cape Cod Bay were begun at Plymouth, May 8, 1916. Signals were built and objects located by plane table traverse for the control of the work.

While these preliminary operations were going on a subparty was engaged in making a hydrographic examination in the vicinity of the shoal marked by buoy 3A in Pollock Rip Slough. A tide staff was erected at Monomoy Point and connected by leveling with bench marks previously established. Soundings were made on May 13 in the vicinity of buoy No. 3A. Further work in this locality was prevented by unfavorable weather.

Dragging operations in Cape Cod Bay were begun May 19 and continued until the close of the fiscal year.

The work was carried southward from a junction with the work of the previous season. Numerous changes in charted depths were discovered and reported, but no shoals especially dangerous to navigation were found.

Drags from 2,400 to 4,000 feet in length were used in shoal water. The maximum length of drag used was 14,400 feet.

On June 17 a subparty began a topographic and hydrographic survey of Plymouth Harbor and vicinity. This work was in progress at the end of the fiscal year.

Tidal data for the wire-drag work were obtained from a gauge at Nut Island in Boston Bay.

The design of the power reel was improved by attaching the brake wheel directly to the drum instead of through the shaft.

A design was also completed for a new reel in which the power is transmitted by gears instead of by sprocket chains from a jack-shaft.

NEW YORK AND NEW JERSEY.

[STEHMAN FORNEY AND E. E. REESE.]

SUMMARY OF RESULTS.—Reconnoissance: 30 square miles of area covered. Triangulation (tertiary): 30 square miles of area covered, 5 signal poles erected, 5 stations in main scheme occupied for horizontal measures, 44 old stations recovered. Topography: 37.75 square miles of area surveyed, 81.10 miles of shore line of rivers surveyed, 25 miles of shore line of creeks surveyed, 1.58 miles of shore line of ponds surveyed, 48.75 miles of roads surveyed, 2 topographic sheets finished, scale 1:10,000.

At the beginning of the fiscal year the resurvey of Arthur Kill was in progress. This work was completed on October 7, and the party was transferred to Oyster Bay, Long Island, N. Y., to revise the topography of that vicinity.

On October 19 the chief of party investigated the cause of sinking of the steamer *Isabel* in the vicinity of the gas buoy off Cows Reef, on the Connecticut shore.

On November 8 triangulation was begun on the Connecticut shore, two well-determined stations being occupied, and the work was carried across Long Island Sound to Sands Point, connecting with the tertiary triangulation in that vicinity.

Many of the old triangulation stations and of those recovered in recent years were again recovered, and these were re-marked when necessary. Upon this triangulation was based the shore-line topography.

The charge of this work was transferred on February 3 to E. E. Reese, who closed field operations on February 8.

NEW JERSEY.

[E. B. LATHAM.]

The work of determining the positions of natural and artificial objects on the coast of New Jersey between Tucker Beach Light and Ocean Beach begun in June was in progress at the beginning of the fiscal year.

Poles 2 by 4 inches in diameter and 16 feet long were erected between Little Egg Inlet and Barnegat City. An azimuth and distances by telemeter-rod readings were carried between these points, using topographic sheets Nos. 2456 and 2459 from surveys in 1899, with the points thereon for control.

The positions of the poles referred to and of all prominent objects were determined, as well as their heights.

The shore at the inlets and at various other points was redetermined and appears on the sheets. Streets and roads were determined when it could be done without loss of time. Fifty-two miles of shore line were revised between June 18 and July 10, of which 23 miles were covered between July 1 and 10 and 29 miles prior to that date. One hundred and eighty objects, including signal poles, were determined in position.

NEW YORK, RHODE ISLAND, AND VIRGINIA.

[F. G. ENGLE, Commanding Steamer *Hydrographer*.]

SUMMARY OF RESULTS.—Magnetic work: 1 sea station at which ship was completely swung. Topography: 19 miles of general coast line surveyed. Hydrography: 60 square miles of area covered, 1,045 miles run while sounding, 5,694 angles measured, 34,163 soundings made, 2 tide stations established, 5 current stations occupied, 5 hydrographic sheets partly revised.

Hydrographic work in the vicinity of Sandy Hook, N. J., which was in progress at the close of the last fiscal year was continued until July 30. The work was extended on the south side of Romer Shoal and in the old main channel eastward to the 5-fathom curve and southward as far as Navesink Light.

Besides the hydrography in the vicinity of Sandy Hook a portion of the shore line was resurveyed by plane table where changes had occurred.

On July 30 the work called for by instructions was completed, and on August 30 the vessel proceeded to New London.

On August 5 the *Hydrographer* was anchored about one-half mile southwest of Valiant Rock in the Race, at the eastern end of Long Island Sound, and current observations with weighted pole and line were made every half hour, day and night, until noon on August 7. A secondary station was established and simultaneous observations were made over two slack waters from a launch, at a point one-half mile northeast of Valiant Rock. On August 9 three lighthouses in the vicinity of the Race, from which slack waters were being noted, were visited to check their time and the vessel then proceeded to Block Island, R. I., to take up hydrographic and topographic work.

Work in this locality was begun August 10 and continued until September 1.

The limits of the hydrographic work were as follows: Inshore of the 10-fathom curve from a point 2 miles south of the entrance to Great Salt Pond on the west side of the island, northward around Sandy Point covering the North Bar Reef, and on the east side from Sandy Point to within 2 miles of the old harbor, together with an examination of a shoal on the north side of this harbor and additional lines in Great Salt Pond to supplement the previous survey. The lines were run by the launch and were spaced 100 meters apart. Several shoal indications were developed.

Signals were located by plane table traverse between triangulation stations and the adjacent shore line was located.

Current observations were taken over two slack waters at a station near the North Reef gas buoy in about 10 fathoms, and also in the dredged channel leading into Great Salt Pond.

The ship was swung off North Reef for deviation of compass.

After the completion of this work an examination was made in Gardiners Bay of a reported shoal between red spar buoy No. 4 and Cedar Island Light, approach to Sag Harbor. This shoal had been struck by the steam yacht *Kanawha*, drawing 10 feet, and was reported as being 150 yards south of the spar buoy No. 4.

A 1,000-foot wire drag was swept over the position drawing 11½ feet and grounded on the 11-foot spot shown 150 yards westward of the reported position. Here a sounding of 13 feet was obtained. It is probable that this was the shoal struck by the *Kanawha*.

The vessel proceeded to New York on September 2, and thence on the 7th for Assateague Anchorage, Va., arriving on the following morning.

A tide staff was erected and connected by leveling with bench marks already established. A hydrographic signal "Smith" was erected about 5½ miles north of Assateague Island and sounding was begun. Excellent progress was made and the work was completed on September 29.

The work at Assateague Island included a resurvey of the anchorage and of Chincoteague Inlet Bar, and the hydrography out to the 6-fathom curve as far north as to include Chincoteague shoals, Turners Lump, and Blackfish Bank. The main system of lines was run by the ship and the lines were spaced one-fourth mile apart with additional splits and development lines on shoal and channels. Aids to navigation within this area were located; Winter Quarter Shoal buoy and gas buoy were also located. The shore line of Fishing Point, Assateague Point, and Gunboat Point was rerun to locate

changes which had occurred since the previous survey. The most important change in depth was noted at the junction of Turners Lump and Chincoteague Shoal.

NEW YORK, NEW JERSEY, PENNSYLVANIA, AND MARYLAND.

[F. B. T. SIEMS.]

In the latter part of June an inspection was made of the tide gauges at Baltimore, Md.; Philadelphia, Pa.; Atlantic City, N. J.; and Fort Hamilton, N. Y.

Levels were run connecting the tide gauges with bench marks, and the proper adjustment was made to each tide gauge.

NEW JERSEY, PENNSYLVANIA, DELAWARE, MARYLAND, VIRGINIA, NORTH CAROLINA, SOUTH CAROLINA, GEORGIA, AND FLORIDA.

[L. A. POTTER.]

Between November 2 and November 20, 1915, a field revision was made of Coast Pilot, Section C, from Sandy Hook to Cape Henry.

The principal cities within the limits of the volume were visited and the United States Engineer offices, lighthouse inspectors, and local maritime interests were consulted with reference to necessary changes or corrections.

On May 10 a revision was begun of the Inside Route Pilot from New York to Key West, and by June 30 the inside route from Norfolk, Va., to St. Augustine, Fla., had been examined.

The waterway was covered on local passenger steamers, hired launches, and from Charleston to Savannah on a lighthouse tender. The United States Engineer offices and lighthouse district offices were visited for the purpose of obtaining information as to works of construction and improvement and changes in aids to navigation.

The work was in progress at the close of the fiscal year.

NEW JERSEY AND VIRGINIA.

[W. M. STEIRNAGLE, Commanding Steamer *Bache*.]

SUMMARY OF RESULTS.—Hydrography: 34.9 square miles of area covered, 97.8 miles run while sounding, 478 angles measured, 2,004 soundings made, 1 tide station established, 2 current stations occupied, 1 hydrographic sheet partly finished, scales 1:20,000 (subplan 1:10,000) and 1:50,000.

On completion of extensive repairs at Norfolk, Va., the steamer *Bache* sailed August 24 for the coast of New Jersey to continue the offshore hydrography. A reconnoissance was made on the way beginning at Atlantic City and continuing northward.

On the arrival of the vessel at Tompkinsville on August 27 work was begun at once on the preparation of the buoys to be used for offshore signals. These buoys, six in number, were loaned by the lighthouse depot at Tompkinsville and were afterwards placed in position by a lighthouse tender.

The buoys were ready for sea on September 3, but unfavorable weather prevented the tender from setting them until September 9; September 10 and 11 were spent by the *Bache* in cutting inshore

objects northward from Ocean Grove to locate them on the charts and for use as shore signals. Objects to be used as signals had previously been determined by E. B. Latham from Ocean Grove southward to Barnegat Inlet. One signal about 7 miles north of Barnegat was erected by the same officer later in the season.

Owing to delay caused by bad weather and necessary repairs to the ship's boiler the positions of the buoys could not be determined until September 23. These buoys were about 11 miles offshore and clear weather was needed in observing on them. On October 1 the command of the vessel was transferred to Paul C. Whitney.

While the *Bache* was at Norfolk, a party with a launch made three detached local surveys in the vicinity of Newport News.

By October 1 some inshore hydrography had been done on the coast of New Jersey and the buoys had been located for use in offshore work.

NEW JERSEY, VIRGINIA, AND SOUTH CAROLINA.

[R. F. LUCE, Commanding Steamer *Isis*.]

SUMMARY OF RESULTS.—Magnetic work: Ship swung for compass deviation at 1 station. Hydrography: 560 square miles of area covered, 642 miles run while sounding, 1,487 angles measured, 8,287 soundings made, 29 stations occupied by ship to locate shore and offshore signals, 133 sextant cuts made to locate shore and offshore signals, 1 shore object located by angles from ship, 11 offshore buoys and objects located by angles from ship, 1 tide station established, 26 current stations occupied.

During the period from August 16 to November 30, 1915, the steamer *Isis* was employed in hydrographic surveys off the entrance to Chesapeake Bay, Va.; off the coast of New Jersey near Barnegat Lighthouse; and off the South Carolina coast near Charleston.

On August 16 the *Isis* was at Norfolk undergoing necessary repairs. In the meanwhile some work had been done in preparing survey buoys and superstructures for the buoys for offshore work, and on the completion of the repairs to the vessel this work was continued and brought to completion.

On August 20 the *Isis* left Norfolk for the working ground and began hydrographic work off the entrance to Chesapeake Bay, which was continued during the remainder of that month.

Information having been received from the commandant of the Norfolk Navy Yard that the naval fleet was to engage in target practice during September in the area in which the *Isis* was engaged in hydrography, and it being considered unsafe to continue that work while target practice was going on, the *Isis* was ordered to take up work off Barnegat, N. J., in conjunction with the steamer *Bache*.

The *Isis* sailed for New York on September 4, arriving at Tompkinsville, Staten Island, on the 5th, and from that time until September 12 was engaged in rigging up a trolley sounding apparatus and other apparatus required for offshore work off Barnegat.

Arrangements were made to have the survey buoys which had been prepared at Norfolk, Va., brought up and placed by the lighthouse tender of the Baltimore district, and these buoys were dropped on September 13, 1915.

The *Isis* left port on that date and began the hydrography, which was continued until October 11.

During this time the patent logs were tested, the ship swung for deviation, and the survey buoys were located in conjunction with the hydrography.

On October 11 it was necessary to suspend operations in order to make needed repairs to the boiler, and on the 12th the vessel left the working ground for Norfolk, arriving on the 13th.

The repair work was completed November 1 and on the same date the vessel sailed for Charleston, arriving on November 3.

Between November 6 and 11, during the session of the Atlantic Deeper Waterways Convention, the *Isis* was at Savannah. During this time the vessel was at the dock at the foot of the principal street, together with the U. S. S. *Dolphin*, the Coast Guard cutter *Yamacraw*, and the lighthouse tender *Cypress*, and was visited by a large number of persons to whom the work of the ship was explained.

On November 12 the *Isis* sailed from Savannah, arriving at Charleston on the same day. Between November 13 and 22 the ship was engaged in preparing survey buoys and other work in preparation for offshore work. On November 23 the survey buoys were dropped by a lighthouse tender. The buoys were located by sextant cuts, and hydrographic work was begun and was in progress when the command was transferred on November 30, 1915.

The first survey work performed by the *Isis* after its purchase by the Government began August 20 off the entrance to Chesapeake Bay, and consisted of inshore hydrography off Cape Charles, in the area between Ship Shoal Inlet and the south end of Nautilus Shoal (between latitudes 37° 12′ and 37° 02′ N.) and extending from the 3-fathom curve out to about 9 miles offshore. All of this work was located by sextant positions on shore objects, and comes entirely under the classification of inshore work. The shore objects used were three signals which had been erected by E. B. Latham and natural objects such as lighthouses and water tanks which had already been located. Cape Charles Lightship was located by sextant angles and was used occasionally on the outer ends of the lines. All soundings were taken from the ship with the hand lead as the depth of water was less than 14 fathoms in this entire area. Lines were spaced one-half mile apart and were run in an east and west direction. Special care was taken to develop all areas where shoal or uneven depths were found. Soundings were taken from 50 to 100 meters apart, depending on the depth of water.

As the ship was forced to discontinue this work September 1, all of the area could not be completed.

The work off Barnegat, N. J., included offshore work for which the *Isis* had not been equipped, and therefore upon arrival at New York work was begun of rigging up a trolley sounding apparatus and preparing all necessary equipment for offshore hydrography. Through the courtesy of the lighthouse inspector at Tompkinsville, a portable trolley lead stand and sounding boom embodying several new features were constructed at the lighthouse depot and completed in a very short time.

The shore signals in this work consisted entirely of natural objects which had been previously located by E. B. Latham.

As the coast in this section is flat and low and as shoal water extends farther from shore than it would be possible to see shore sig-

nals, four survey buoys placed in a line parallel to the coast and about 11 miles offshore were used for offshore signals. These were loaned by the lighthouse inspector at Baltimore and placed in position by a lighthouse tender.

The hydrography was begun September 13. The work done was of two classes, inshore and offshore, the former being entirely within sight of shore or offshore signals and the latter dead-reckoning work.

The hydrography done covers the area between latitudes 39° 48′ N. and 39° 36′ N., and extends from the 3-fathom curve out to about 23 miles offshore.

The lines were run generally in an east and west direction and spaced about one-half mile apart from the shore to the 10-fathom curve and about 1 mile apart to the outer limit of the work. Areas where shoal or uneven depths were found were developed with special care. Soundings were taken from the ship, with the hand lead to depths of 14 fathoms and by means of a hand-operated trolley sounding apparatus at greater depths. Soundings were taken from 30 to 200 meters apart according to the depth.

The inshore work was located by sextant positions on shore objects or signal buoys. The offshore work in the area outside the limit of visibility of shore or offshore signals was done by dead reckoning of the accurate class recently developed in the Atlantic coast work. Great care was exercised in this dead-reckoning work to make it as accurate as possible. Compass deviation was carefully determined. The lines were run only in the best of weather, and the amount of leeway was determined as closely as practicable. The ship was anchored at the beginning and end of each line and at two-hour intervals on the line, and current observations were taken at each one of such anchorages.

This work was discontinued on October 11.

Preparations for work off the South Carolina coast were begun November 12.

Six first-class bell and whistle buoys loaned by the lighthouse inspector at Charleston were fitted with superstructures and otherwise adapted for use as survey buoys. These buoys were dropped by a lighthouse tender of the Charleston district on November 23 and hydrographic work was begun by the *Isis* on that date.

The shore signals used had been erected and located by O. B. French prior to the beginning of the work.

The hydrographic work done by the *Isis* before the transfer of the command, in addition to rigging up survey buoys, consisted in locating five of the six survey buoys and one day's sounding work.

In connection with the hydrography, current observations were made at the beginning and end of each dead-reckoning sounding line and every two hours on the line, from the ship at anchor, in order to correct the dead reckoning. In addition current observations were taken every half hour day and night whenever the ship was at anchor on the working grounds and the sea was not too rough to make good observations possible.

In connection with the surveys off Chesapeake Bay a tide staff with three permanent bench marks cut into stone foundations of various buildings was established at the entrance to Lynnhaven Bay, Va.

RHODE ISLAND, CONNECTICUT, NEW YORK, AND NEW JERSEY.

[E. F. DICKINS, January 18 to April 21; H. P. RITTER, June 19 to June 24; ISAAC WINSTON, July 1 to January 17, April 22 to June 18, and June 25 to June 30.]

Inspection duty for the region included between Narragansett and Delaware Bays was continued by an officer who is in charge of the suboffice of the Survey in the Customhouse Building, New York City.

The duties of the inspector are to obtain information for the correction of charts, Coast Pilots, and Notices to Mariners concerning dangers to navigation or changes affecting the charts; to furnish information to the public concerning charts, Coast Pilots, Tide Tables, and other publications of the Survey; to supervise the construction and shipment of material needed for the repair or outfit of vessels and boats of the Survey; and to receive and forward instruments or material for the field parties and vessels.

Every effort has been made to bring the Survey in close touch with the maritime public, to ascertain their needs and to meet them as promptly as conditions will permit.

The suboffice keeps a file of charts and nautical publications of the Survey for the convenience of persons wishing to consult them, and is also supplied with a stock of charts, Coast Pilots, and Tide Tables for sale.

The agencies in New York for the sale of the charts and publications of the Survey were inspected and obsolete charts and publications condemned.

Attention was called to the necessity for a revision of the surveys in vicinity of Port Newark Terminal, and request was made for the revision of the western shore line of Newark Bay.

Information was compiled and furnished to the public concerning the tides and the time of sunrise and sunset.

Matter of interest to the mariner was furnished for publication in newspapers publishing marine news.

VIRGINIA.

[PAUL C. WHITNEY, Commanding Steamer *Bache*.]

SUMMARY OF RESULTS.—Hydrography: 165 square miles of area covered, 627.3 miles run while sounding, 2,138 angles measured, 10,991 soundings made, 1 tide station established, 6 current stations occupied, 1 hydrographic sheet partly finished, scale 1:40,000.

During the period from October 1, when the command was transferred, until October 17 the steamer *Bache* was undergoing repairs at Brooklyn, N. Y.

Upon the completion of these repairs, the vessel sailed for Norfolk, Va., on October 18, 12.45 a. m., stopping en route to hunt for a 24-foot spot off Barnegat Inlet. An unsuccessful search was made, and the ship arrived at Norfolk at 5.50 p. m. October 19.

On October 22 the vessel was inspected by the chief of the section of vessels and equipment preparatory to making further necessary repairs.

On October 26 the survey of Chesapeake Bay Entrance, which had been begun by the *Isis* during August, was taken up. This work was carried forward as rapidly as the weather would permit.

The sheet extends off the entrance 30 miles, but owing to the lateness of the season, work was confined to the inshore section of the sheet, the lines running out to the limit of visibility of shore signals, which was about 14 miles offshore.

The signals used were the lighthouses at Capes Henry and Charles, the buoys already established for navigating purposes in the entrance and which were located by this party, a high water tank at Virginia Beach, and three tall hydrographic signals erected by Assistant E. B. Latham.

In accordance with instructions this work was closed on November 30, 1915, when proposals for general repairs were prepared and sent out to bidders in Baltimore, Norfolk, Newport News, and Charleston. The bids were opened on December 13 and the contract awarded to the Norfolk Marine Railway Co. (Inc.). They began the work on the 16th.

[R. F. LUCE, Commanding Steamer *Bache*.]

SUMMARY OF RESULTS.—Triangulation: 3½ miles of area covered, 3 stations occupied for horizontal measures, 2 geographic positions determined. Topography: 1 square mile of area covered, 2 miles of shore line surveyed. Hydrography: 2 square miles of area covered, 16 miles run while sounding, 686 soundings made, 107 angles measured, 1 tide station established.

Between July 1 and 8 the steamer *Bache* was at Baltimore, Md., being examined by prospective bidders for repairs. On July 8 bids for repairs were opened and on July 9 the *Bache* sailed for Norfolk, Va., arriving on the afternoon of July 10. From that date until August 16, the end of the period covered by this report, the vessel was at Norfolk undergoing repairs.

On August 10 a party detailed from the *Bache* began chart revision work in Norfolk Harbor and Hampton Roads, which work was in progress when the command of the vessel was transferred on August 16.

The field work performed consisted principally of chart-revision work in two sections, the channel to Norfolk, Va., and the small-boat harbor at Newport News, Va.

In the vicinity of Norfolk and Hampton Roads the local navy yard had been using a number of local objects for ranges in piloting their larger vessels up the deep-water channel to the Norfolk Navy Yard and desired that they should be plotted on the charts. Upon request the master of tugs of the Norfolk Navy Yard, who acts as pilot for battleships entering Norfolk, took an officer of the *Bache* down the channel in a Navy tug and pointed out the local marks used as ranges. These objects, together with all other prominent objects in the vicinity, were located by triangulation or by plane table cuts.

At Newport News, near the shipyard, a dredged, small-boat harbor was reported as not shown on the charts. This boat harbor was mapped by plane table survey based on signals located by triangulation, and a close system of soundings was carried out over the area of the harbor to the deep-water channel outside. While work was in progress readings of a tide staff located near by were taken at half hourly intervals to reduce the soundings obtained.

VIRGINIA, SOUTH CAROLINA, AND GEORGIA.

[G. T. RUDE, Commanding Steamer *Isis*.]

SUMMARY OF RESULTS.—Triangulation: 35 square miles of area covered, 6 signal poles erected, 10 stations occupied for horizontal measures, 33 geographic positions determined. Magnetic work: Ship swung for compass deviation at 4 stations. Topography: 2.1 square miles of area surveyed, 7.5 miles of general coast line surveyed, 1.3 miles of shore line of creeks surveyed, 9.8 miles of roads and railroads surveyed, 3½ topographic sheets finished, scales 1:10,000 and 1:20,000. Hydrography: 3,145 square miles of area covered, 2,701 miles run while sounding, 5,266 angles measured, 40,203 soundings made, 77 stations occupied by ship to locate shore and offshore signals, 340 angles observed (sextant cuts) to locate shore and offshore signals, 3 shore objects located by angles from ship, 26 offshore buoys and objects located by angles from ship, 54 surface temperatures taken, 50 bottom temperatures taken, 8 bottom specimens taken, 2 log tests made, 3 tide stations established, 181 current stations occupied, 4 hydrographic sheets finished, scales 1:10,000, 1:20,000, 1:80,000, and 1:180,000.

Hydrographic work off the coast of South Carolina begun by the party on the steamer *Isis* was continued after the transfer of the command of the vessel on November 30, 1915, until May 26, 1916, when the vessel sailed for Norfolk to undergo necessary repairs and alterations.

Charleston, S. C., was used as headquarters for the vessel for the greater portion of the season.

Shore signals for the work had already been erected for use in this work by special signal-building parties.

In addition to these signals other artificial objects on shore previously located by triangulation were used for the control of the survey.

Six first-class whistle and bell buoys, with iron pipe superstructures carrying black flags 6 feet long, were used for offshore signals. These buoys were planted and shifted by the lighthouse tenders of the sixth district. The lighthouse inspector for this district did everything in his power to facilitate the work of the *Isis* in shifting the line of buoys when required and arranging for the transfer of supplies from the lighthouse depot to the *Isis*.

The positions of the buoys were determined by sextant cuts taken from the *Isis* when located inshore of the lines of buoys by sextant angles to shore stations.

Owing to extended periods of hazy weather during the winter and early spring months it was found necessary to place these buoys not more than 11 miles offshore and from 3 to 3½ miles apart.

The field work extended along the coast between Charleston Light Vessel and Martins Industry Light Vessel, a distance of 50 miles, and from the 3-fathom curve offshore to the 100-fathom curve, a distance of approximately 60 miles.

When the vessel was in Charleston Harbor at intervals during the winter, chart-revision work was done extending from the toll bridge on the Ashley River around the water front of Charleston and up Town Creek to and including the Southern Railway dock. The radio masts, flagpole, and chimneys at the navy yard were also located.

In connection with the chart-revision work launch hydrography was done in the vicinity of the Southern Railway Co.'s dock and on the bar south of the Battery in Charleston Harbor.

Triangulation in Norfolk Harbor for the location of landmarks was undertaken June 21 at the request of the Navy Department and was in progress at the close of the fiscal year. This work extends from Old Point up the Elizabeth River to the railroad bridge from Norfolk to Berkley.

The hydrography executed by the steamer *Isis* off the coast of South Carolina was of two classes, the ordinary inshore or fixed position work in which the vessel is located at frequent intervals by sextant angles to shore signals and offshore buoys, and the offshore or dead-reckoning work on which the vessel makes a departure from an accurately located buoy from 10 to 12 miles offshore or from a position outside the line of buoys located by sextant angles to three buoys.

The position of the vessel in the dead-reckoning work is determined in a manner somewhat similar to that employed in ordinary navigation except that greater refinement is observed.

The flow of the currents is determined by frequent observations and each course is corrected for leeway.

Sounding was done with the trolley, using either a 25 or a 40 pound lead from the line of offshore buoys to the 25-fathom anchorage. From this to the 100-fathom anchorage stranded sounding wire with registering dial was used and the engines were reversed until all headway was off the ship and a vertical cast could be obtained. When using the dial and stopping the ship for each cast the soundings were spaced from 0.5 to 0.6 mile apart; when using the trolley they were spaced, at a speed of 4½ knots, every one, one and a half, and two minutes, depending upon the depth.

From the line of offshore buoys out to the generalized 10-fathom curve the lines were spaced about a mile apart; from the 10-fathom curve to the outer edge of the inshore sheet 2 miles apart; and from the edge of the inshore sheet to the 100-fathom curve 4 miles apart. In order to remain in the Gulf Stream as short a time as possible the lines at the 100-fathom anchorage were brought to a point and only one sounding taken at the 100-fathom curve, so the soundings at the curve are spaced about 8 miles apart.

Practically all the dead-reckoning work on the inshore sheet was done at night; that on the offshore sheet was done both during night and day, since from 24 to 30 hours were necessary to complete one of these long lines.

In order to increase the accuracy of these lines and also shorten the time on the long lines on account of the uncertainty of the weather conditions and not being equipped with radio, after the first two lines a departure was made from an offshore buoy and a full-speed run made to an anchorage at the outer edge of the inshore sheet, the line was then run at slow speed to the 100-fathom curve and return to an anchorage at the edge of the inshore sheet, from which a full-speed run was again made to a connection with an offshore buoy.

Astronomical observations were made at every opportunity on the offshore lines; but very little weight was attached to them as it was considered that the adjusted dead-reckoning line was never in error more than half a mile, while the positions by astronomical observations are probably not correct within 1 to 3 miles, while in the Gulf Stream they may be even 5 or more miles in error due to the uncertainty in the refraction.

The inshore hydrography was done on a scale of 1:80,000 and consists of the ordinary position work except that navigation sextants were used instead of the ordinary hydrographic sextants. This was necessary on account of the very poor seeing and the distances which it was necessary to "carry" the signals and buoys. The vessel was located by fixes on the shore stations as long as possible when running offshore, and after the shore stations were shut out fixes were taken on the offshore buoys. The line of buoys was passed and locations obtained as far as possible outside the buoys. During clear weather in May strong positions were obtained as far as 6 miles outside the buoys.

The preliminary lines on the inshore work were spaced 1 mile apart, and extended from the 3-fathom curve offshore to conjunction with the dead-reckoning work. Off entrances to harbors and over broken areas these lines were split; and where ground appeared very broken, an additional system of lines spaced about a quarter mile apart were run at an angle of about 45° with the main system.

Practically the whole area inside the line of buoys and extending from Charleston Harbor entrance to Hunting Island Lighthouse was more or less broken and irregular, so that a great part of the season was spent on this development work. As this was to be considered a finished and final survey it was thought that this broken area should have all the attention given it. The one shoal spot, 27 feet, found only 1 mile inside the sailing line from Charleston Light Vessel to Martins Industry Light Vessel, would appear to justify all the other development made.

The hand line, with 10-pound lead, was used on this inshore work from the 3-fathom curve to the 10-fathom curve; outside this curve the trolley, with 25-pound lead, was used. The ship was run at a speed varying from 4½ to 5 knots and soundings spaced from 15 seconds to 1 minute, depending on the depth. At this speed good vertical casts were easily obtained and the soundings spaced sufficiently close.

At all current anchorages at and inside the 25-fathom curve the steamer was anchored with her regular ground tackle; at the 100-fathom curve a simple apparatus, devised on board the vessel at the beginning of the past season, was used for anchoring a buoy from which the current observations were taken.

When the weather was good and the sea moderate a small boat was lowered from the steamer and the current observations made from it with the ordinary current pole and line. The set of the current was obtained by means of a small boat compass or the steamer was maneuvered to bring the pole and small boat on range and the bearing taken from the bridge of the vessel with standard compass.

The observations were made from the *Isis* when the sea was too rough for lowering a small boat.

The current observations at all anchorages at and inside the 25-fathom curve were taken from the vessel, obtaining the drift by means of the ordinary current pole and line and the set with pelorus which was referred to the quarter-deck compass. At each station three observations were made or continued until a sufficient number were checked to make sure of the correct current.

During the season, while at anchor, when conditions were unfavorable for sounding, current observations were taken from the *Isis* every half hour day and night. Observations were also made on the light vessels by their crews during the winter.

A plain tide staff of the Army Engineers at the customhouse dock at Charleston was used for the sounding at the Southern Railroad Co.'s dock and for that south of the Battery.

For the work down the coast a plain tide staff at Fort Sumter was connected with the bench marks of the Army Engineers. Two new bench marks were established and connected with the staff at the end of the season. For the reduction of soundings taken at night the tide rolls from the Fort Sumter automatic tide gauge have been obtained from the Engineer officer in charge of the Charleston office.

The triangulation executed in Charleston and vicinity was done only for the location of the wireless masts at the navy yard for the purpose of adjusting to the chart revision projection the topography from a blue print of a Navy survey furnished by the commandant of the yard.

St. Michaels Church steeple was occupied twice in an attempt to get cuts to signal "Ponds" but without success.

The triangulation in Norfolk and vicinity was done for the location of leading marks for the Navy Department. It extends from Old Point to the railroad bridge across the river from Norfolk to Berkley.

The only topography executed by the party on the *Isis* during the past season was that in Charleston Harbor for chart revision.

The most important changes in the harbor were charted. Considerable changes were found along the Charleston water front and the immediate vicinity, the most important of which is the Southern Railroad Co.'s new dock.

On the projection several chimneys, flagpole, and radio masts were located at the Charleston Navy Yard and a blue print was obtained from the commandant so that the survey may be reduced at the office and adjusted to the points located on our sheet, as the blue print and our sheet have a number of points in common.

While engaged on the lines to the 100-fathom curve, observations were made at fixed intervals with whirling psychrometer, and surface and bottom temperatures were obtained.

Barometer observations were recorded in ship's log every hour and 215 comparisons, reduced to sea level, between this vessel's barometer and the Charleston weather bureau were obtained, all readings made when vessel was in Charleston Harbor.

Bottom specimens were obtained at intervals on the lines to the 100-fathom curve whenever bottom was such that they could be taken. Coquina was brought up at one place.

Tests were made over a 2-mile course twice during the season to standardize the logs used on the dead-reckoning work.

The ship was swung for deviation four times during the season to secure accurate corrections for the courses steered on the dead-reckoning lines.

Inclination tests were made on June 2 and 3 at Norfolk to determine the stability of this vessel preparatory to making alterations to the bridge.

While employed on offshore work in southern waters during the past season several vessels were rendered minor assistance by the *Isis*.

The four-mast schooner *Augustus Welt*, 75 days out from Buenos Aires and bound for Stamford, Conn., spoke the vessel off Port Royal Sound on February 11 and requested that she be reported to her owners, which was done.

On January 13 during very thick weather the United States Engineer dredge *Barnard* spoke the *Isis* off the entrance to Charleston and requested to be furnished with course and distance to Charleston Light Vessel, which was given them.

On April 28 the gasoline launch *North Star* was rendered minor assistance in Charleston Harbor. The *Isis* was getting under way from an anchorage off the yacht club wharf to go to the coal dock for coal, when it was noticed that this launch was about to swamp, due to overloading and light choppy sea. The launches of the *Isis* had already been sent to the dock to take the lines, so the *North Star* was towed in by the *Isis*.

On January 31 it was reported at Charleston that a United States submarine was in distress off Cape Romain. The *Isis* and crew were immediately placed at the disposal of the commandant of the Charleston Navy Yard to be used in searching for and assisting her. Soon afterwards it was learned that the submarine had been located and was proceeding to Key West under her own power.

NORTH CAROLINA.

[O. W. FERGUSON, Commanding Schooner *Matchless*.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 110 miles, 390 square miles of area covered, 252 lines of intervisibility determined, 96 points selected for scheme. Triangulation: 330 square miles of area covered, 33 signal poles erected, 6 observing tripods and scaffolds built, average height 25 feet, 61 stations in main scheme occupied for horizontal measures, 10 stations in supplemental schemes occupied for horizontal measures, 33 geographic positions determined. Leveling: 6 miles of levels run, 13 permanent bench marks established. Topography: 60.1 square miles of area surveyed, 231.8 miles of general coast line surveyed, 27.4 miles of shore line of creeks surveyed, 47.2 miles of roads surveyed, 4 topographic sheets finished, scales 1:40,000, 1:20,000, and 1:10,000. Hydrography: 283.3 square miles of area covered, 1,721.3 miles run while sounding, 7,852 angles measured, 60,550 soundings made, 5 tide stations established, 3 hydrographic sheets finished, scales 1:20,000 and 1:10,000.

During the half year ended December 31, 1915, the schooner *Matchless* was engaged upon surveys of Croatan and Roanoke Sounds and adjacent waters in the vicinity of Roanoke Island and upon the triangulation of the Pasquotank River, N. C.

The surveys in Croatan and Roanoke Sounds were begun in May of the previous fiscal year and were in progress on July 1.

The area included extends from Oregon Inlet to Powells Point, N. C., embracing Roanoke Island and all of the shores and waters in that region.

The waters are wide and shallow, averaging 10 miles across in the lower portion and 7 to 8 in the upper portion with depths ranging from 6 to 14 feet.

The triangulation of this region had been done in 1909, but by the washing away of the shore many of the station marks had been destroyed and it was necessary to determine a number of new points.

The old stations recovered were re-marked where necessary for their preservation. The new points were marked with standard brass disks set in cement.

The topography executed on the scale of 1:40,000 extends from below Oregon Inlet to Powells Point on the east side, and from a point on the west shore directly west from the starting point below Oregon Inlet north and west to Alligator River. The ocean shore line was run for the whole distance.

The hydrography of Croatan and Roanoke Sounds was closely developed, and the channels in Croatan Sound were gone over a second time in order that no shoal spots should be overlooked. The channels were finally gone over with an improvised drag by means of which several shoal spots were found.

Tide observations were made at Burnside Wharf on Croatan Sound; at Croatan Lighthouse; at the north end of Croatan Sound; and at Naghead, Roanoke Sound.

After repairing the *Matchless* at Elizabeth City, N. C., the reconnoissance and triangulation of the Pasquotank River were begun and the greater portion of this work was completed by December 31.

The survey of the Pasquotank River was completed April 4, 1916, and the survey of the eastern part of Pamlico Sound was begun.

[PAUL M. TRUEBLOOD, Commanding Schooner *Matchless*.]

SUMMARY OF RESULTS.—Triangulation: 2 signal poles erected, 6 stations in main scheme occupied for horizontal measures, 8 geographic positions determined. Leveling: one-half mile of levels run, 3 permanent bench marks established. Topography: 12 square miles of area surveyed, 43 miles of general coast line surveyed, 1 topographic sheet finished, scale 1:40,000. Hydrography: 79 square miles of area covered, 645 miles run while sounding, 3,506 angles measured, 29,180 soundings made, 4 tide stations established, 3 current stations established, 1 hydrographic sheet finished, scale 1:20,000.

The survey of the eastern part of Pamlico Sound, which had been begun early in April, 1916, was continued after the transfer of the command of the schooner *Matchless* on May 10, and was in progress at the close of the fiscal year.

At that time the *Matchless* was anchored in Sheep Island Slough, 2.3 miles west of Portsmouth. Portsmouth was used as a base of supplies and post office. Most of the signal building had been finished, a number of triangulation stations occupied, and some of the area sounded over.

The work was continued from the same base, the best sheltered anchorage in the area to be surveyed and the only place where it was practicable to get water and supplies from shore.

The work having been completed in this vicinity the anchorage was shifted on June 24 to a point off Brant Island Shoal Lighthouse.

After completing a small area for which water signals were necessary, the anchorage was shifted to a point 4 miles northwest of Ocracoke, just off the edge of Nine Foot Shoal.

Practically all the triangulation in this area was completed some eight years ago, but it was necessary to reoccupy some of the old stations to determine intersection points. In accordance with supplemental instructions, dated May 10, three points in Pamlico Sound were connected with Harbor Island Bar Lighthouse in the Core Sound triangulation by a single figure, all points being observed. One other Core Sound station, Long Point 2, was occupied to de-

termine new points. Eight new geographic positions were determined. All stations capable of being permanently marked were marked with cement blocks.

The topography included all of Portsmouth Island southward to a point east of East Drum Shoal Light; part of the islands at the entrance to Core Sound which came on the sheet; the small islands in Ocracoke Inlet; and the lower point of Ocracoke Island. Most of this work was done by plane table traverse, though the intersection and resection methods were used on the small islands. The whole country is practically featureless so there is very little detail except the intricate maze of sloughs and islets on the inner shore of the main island.

The hydrography includes all the area on the smooth sheet southwest of Ocracoke Inlet and also certain areas in the Inlet and on and adjacent to Royal Shoal. The work was executed in accordance with the instructions of April 15, which are very complete. In general, the bottom is as flat, uniform, and featureless as the land. The slopes at the edges of the sloughs are in some cases steep. There is a wide expanse of flats all along the outer island which is broken in places by comparatively deep sloughs. All these sloughs were investigated and most of them were found to have sufficient depth for light-cruising motor boats.

In order to complete the western corner of the sheet it was necessary to anchor the ship off Brant Island Shoal Lighthouse and to use the foremast as a signal. The only other signals which showed up from the launch were Northwest Point Royal Shoal Lighthouse ("Old") and "Hog", a 75-foot hydrographic signal on Hog Island. A smaller signal was made by putting up a sail in a small boat and anchoring it in a convenient place. The day being practically dead calm and with practically no current, no difficulty was experienced with these signals at comparatively short range.

Lines were run across the inshore flats with the light-draft launch and a flat-bottom skiff, the two being used independently. In some cases it was necessary to leave the boat and wade across carrying sextant, book, watch, and sounding pole.

No attempt was made to locate intermediate soundings in such cases as there was no change in depth. The ends of such lines were determined and a range was followed in between.

An automatic tide gauge was established and maintained at Portsmouth and was still in operation on June 30. Tide staffs were also located on Sheep Island Slough Beacon, Harbor Island Bar Lighthouse, and Nine Foot Shoal Beacon and connected with the automatic gauge by suitable comparisons. There is an appreciable difference in range between the automatic gauge and the staff in the Sound.

Currents were observed for 24 hours at each of the following stations: Anchorage in Sheep Island Slough, anchorage off Brant Island Shoal Lighthouse, and Harbor Island Bar Lighthouse. The tidal current is small in any case. The wind currents are greater, especially after a decided change in the direction if the new breeze continues for a day or more. Northerly winds have most influence on the depth of water and amount of current.

One tall hydrographic signal was necessary for the offshore work. This was "Hog" on Hog Island, a wooden tower 75 feet high. It was built of rough lumber with a somewhat larger base than is usual for triangulation signals.

It was impossible to cross the flats with the launches already on hand, and permission was therefore obtained to purchase a new flat-bottom boat for this work. This boat is 25 feet long, 6½ feet beam, has a 4-horsepower engine and draws only about 15 inches when under way with a working party. The hull is cypress and juniper. The speed can be varied by advancing or retarding the spark, by either the timer or throttle.

SOUTH CAROLINA.

[F. G. ENGLE, Commanding Steamer *Hydrographer.*]

SUMMARY OF RESULTS.—Triangulation: 35 square miles of area covered, 7 signal poles erected, 7 stations in main scheme occupied for horizontal measures, 6 stations in supplemental schemes occupied for horizontal measures, 8 geographic positions determined. Topography: 4 square miles of area surveyed, 20 miles of general coast line surveyed, 10 miles of shore line of rivers surveyed, 8 miles of shore line of creeks surveyed, 1 topographic sheet finished, scale 1:20,000. Hydrography: 109 square miles of area covered, 928 miles run while sounding, 4,515 angles measured, 30,712 soundings made, 5 tide stations established, 6 current stations occupied, 2 hydrographic sheets finished, scales 1:20,000 and 1:40,000.

After the completion of repairs at Norfolk, Va., on November 30 the steamer *Hydrographer* proceeded to Beaufort, S. C., and on December 8 began the erection of signals at stations Hilton and Sand at the entrance to Port Royal Sound. These signals were afterwards destroyed by a storm on December 18 and had to be rebuilt.

On December 30 work was begun on signal Deer, 1 mile southwest of Hilton Head Front Range Light, and on January 4 work was begun on an automatic tide gauge structure at Station Creek; both signal and gauge were completed on January 7. On January 10 a tide staff was erected at the marine barracks wharf, and connected with bench marks formerly established.

Sounding by ship was begun January 11 outside the entrance to Port Royal Sound and carried on when the weather conditions permitted. The revision of the shore line in the sound and up Broad and Beaufort Rivers and the hydrographic resurvey of the sound and rivers as far up as the marine barracks were prosecuted when the weather was unfavorable for ship hydrography in the vicinity of Port Royal Bar.

On January 25 a party was sent from the ship at Bay Point to build signal Surf on the southwest end of Tripps Island. This work was completed February 2.

In order to obtain positions for topography and hydrography and for the recovery of old stations in Port Royal Sound and Broad River, it was necessary to carry new triangulation from the line Point-Parry. Seven new stations were built; two old stations, Parry and Dick, were recovered; two signals were cut in from old stations and several old stations were re-marked with regulation disk marks. Reference and witness marks were established where necessary and new descriptions made.

The shore line from Hilton Head Range lights to the southwest end of Capers Island was rerun together with the shore line of Port Royal Sound and Broad and Beaufort Rivers as far as the naval station and Paris Island.

An automatic tide gauge was operated at the site of an old gauge in Station Creek from January 7 to May 8. The bench mark here was not recovered, so a simultaneous series was observed at the naval station gauge which was connected with old bench marks.

On April 5 a 4-inch pipe was pumped down on Port Royal Bar (northeast breaker shoal), and simultaneous observations made upon it with automatic gauge. Two attempts were made to pump the gauge down, the first on March 21 being unsuccessful due to a defective coupling. In all, three sea gauges were erected, one on Martins Industry Shoal, one on the northeast breaker shoal, and a third one-half mile south of Fishing Rip.

Series of current observations were made at five stations between the naval station and the bell buoy on the bar whenever practicable, selecting such times when weather was unfavorable for other work.

All aids to navigation in the vicinity of the work were located and sextant angles between five triangulation stations on shore were obtained from the masthead of Martins Industry Light Vessel.

[PAUL C. WHITNEY, Commanding Steamer *Bache*.]

SUMMARY OF RESULTS.—Triangulation: 15 signal poles erected, 2 stations in main scheme occupied for horizontal measures. Magnetic work: 1 sea station occupied for magnetic declination, ship completely swung at 1 station. Hydrography: 2,226 square miles of area covered, 1,571 miles run while sounding, 2,394 angles measured, 20,664 soundings made, 1 tide station established, 334 specimens of bottom preserved, 130 current stations occupied, 2 hydrographic sheets partly finished, scales 1:80,000 and 1:200,000.

Having completed repairs at Norfolk, the *Bache* left that place on January 20 for Charleston, arriving February 1.

Shore signals for the hydrography had already been erected by a party charged with that work. They were located in suitable positions at about 5 miles apart and averaged about 100 feet in height.

Buoys upon which a superstructure was built were used as in previous seasons for offshore signals. An improved design was adapted for the superstructure which proved satisfactory.

The offshore signals were planted about 11 miles off the coast, a little beyond the limit of visibility of the shore signals and about 4 miles apart. They were located by sextant angles taken from the ship at anchor in positions from which three of the shore signals would be seen.

The buoys were placed by one of the tenders of the Lighthouse Service.

The hydrography executed embraces the area between St. Simons Lighthouse and Ossabaw Sound and its southern limit overlaps the work of the steamer *Bache* done during the previous year.

In the inshore work, usually inside the line of buoys and within sight of shore signals or buoys, lines were run at a distance of 1 mile apart or closer where irregularities of the bottom were indicated. While sounding the ship was run at an average speed of 5 miles an hour and soundings were taken with the hand lead from 30 seconds to 1 minute apart up to a depth of 15 fathoms. This speed insured vertical casts with the lead. Bottom specimens were obtained at frequent intervals. In most cases the bottom consisted of gray sand, broken shells, and black specks.

In the offshore hydrography outside the line of buoys and extending outward to the eastern limit of the work, sounding lines were located by dead reckoning. Lines were spaced 1 mile or less apart to the 10-fathom curve, 2 miles apart to the edge of the inshore sheet, and 4 miles apart to the outer edge of the work. Every precaution was taken for the accurate determination of the positions of the various dead-reckoning lines. The logs used were carefully tested. The ship was swung for compass deviation at frequent intervals. Allowance was made for leeway caused by winds and currents, and observations were made of velocity of winds and currents. In the Gulf Stream currents were observed as in former years with a buoy anchored by 300 fathoms of braided wire.

When anchoring the vessel in deep water, a 300-pound kedge anchor with a 3½-inch manila rope was used, and a saving in the standard tackle was thereby effected.

In water up to 15 fathoms the hand lead was used, between 15 and 30 fathoms a trolley apparatus was used, with a special device for reeling in by steam which had been used during the previous season. From 30 to 100 fathoms the Sigsbee machine was used, stopping the vessel for each sounding and the interval between soundings being run at full speed.

Surface temperatures were obtained every hour while sounding to 30 fathoms and at every sounding to the 100-fathom curve. Bottom temperatures were obtained at every current station and at every sounding outside the 30-fathom curve.

Psychrometer observations were made every hour while sounding. Bottom specimens were taken every half hour to the 30-fathom curve and then at every sounding.

Tides were read at the tide staff near St. Simons Lighthouse and the results used for the reduction of soundings.

Field work was closed May 18 and the vessel proceeded to Norfolk, Va., for repairs.

While the repairs were in progress a topographic and hydrographic survey was begun of Lynnhaven Roads and adjacent waters at the entrance to Chesapeake Bay.

On February 23 minor assistance was rendered to the barkentine *Argo*, of Nostral, Denmark, bound for Satilla River, Ga., which had been lost for three days in thick fog and haze. A position and course was furnished the vessel. A position was given by radiogram to the steamship *Rio Grande*. On March 2 the Finnish bark *Vega*, bound for the Sapelo River, was spoken, and a radiogram was sent directing a tug to meet the vessel off Sapelo Bar. On April 13 the topsail schooner *Jarstein*, of Syndesnas, Norway, was furnished with position and a wireless was sent directing a tug to meet the vessel at Sapelo Bar.

TEXAS.

[J. B. BOUTELLE.]

Inspection duty for the coast of the Gulf of Mexico has been continued by an officer of the Survey who is in charge of the suboffice of the Survey in the Cotton Exhange Building at Galveston, Tex.

The suboffice had been established June 1, 1915, in the rooms of the Galveston Commercial Association, and was removed to the Cotton

Exchange Building on July 15 and to its present quarters in room No. 19 of that building on September 22.

Information in regard to chart corrections, reported dangers, changes in aids to navigation, changes in shore line or depths, river and harbor improvements, tides, currents, and other matters affecting the charts and publications of the Survey has been obtained by the inspector and forwarded to the Washington office.

He has supplied information in regard to the charts and publications of the Survey to persons interested, has furnished tidal information for publication in the newspapers, and has maintained a stock of the latest charts and publications for sale to the public.

In cooperation with the Steamboat-Inspection Service, applicants have been examined for certificates as able seamen and for efficiency as lifeboat men.

INSPECTION OF CHART AGENCIES ON ATLANTIC COAST.

[E. B. LATHAM.]

Between October 23 and November 27, 1915, an inspection was made of the chart agencies on the Atlantic coast between Eastport, Me., and Baltimore, Md.

On December 16 an inspection was begun of the chart agencies on the Atlantic coast southward of Baltimore and on the Gulf coast to New Orleans. This duty was completed January 7, 1916.

In all, 59 agencies were visited, the stock of charts examined, inventories checked, and obsolete charts destroyed.

During this inspection of chart agencies information was gathered in regard to changes or improvements in progress along the coast affecting the shore line, depth of channels, etc., and lists were prepared of prominent objects desirable to be placed on the charts as land marks.

PACIFIC COAST.

CALIFORNIA.

[FREMONT MORSE.]

SUMMARY OF RESULTS.—Triangulation: 5 signal poles erected, 6 stations in main scheme occupied for horizontal measures, 3 geographic positions determined. Hydrography: 1 square mile of area covered, 12.5 miles run while sounding, 164 angles measured, 840 soundings made, 2 tide stations established, 1 hydrographic sheet finished.

Between September 23 and October 1 a hydrographic survey was made of the bar between Middle and State Points, Suisun Bay, Cal.

A tide staff was erected at the arsenal dock at Benicia and another on the dock of the Smith Lumber Co. at Bay Point, and simultaneous observations of tides were made beginning with the first daylight tide of September 27 and ending on the forenoon of the following day. The tide observations for the two stations were compared and the reading of the plane of reference on the staff at Bay Point was computed on September 28.

Soundings were begun on the twenty-ninth and completed October 1. Work was closed on the following day.

As a result of this survey it was found that there has been practically no change of depth in the main channel.

An improvement is noted in the fact that in this channel the bar is not so wide as is shown in the survey of 1914.

South of the main channel the bar has also improved and shows a tendency to develop a second channel with the same depth as the main one. On this crossing the bar is, however, considerably wider than in the main channel.

Since the former survey in 1914 was made in the winter during high-water conditions from the rainy-season outflow of the Sacramento and San Joaquin Rivers, and the present one during the dry season, it is considered probable that the changes noted are seasonal. That is, during flood conditions of the rivers discharging into the bay the bars increase in width and the depths on them decrease, and during the following dry season the ebb currents gradually improve the bars.

A tracing of the hydrography was furnished to the inspector of the eighteenth lighthouse district for use in placing aids to navigation.

Between October 11 and 22 the geographic positions of a number of points on the coast of California between Point Dume and Punta Gorda were determined for the use of the Lighthouse Service in placing buoys.

Points were determined in the vicinity of Punta Gorda, Albion, Stewarts Point, Timber Gulch, and Russian Gulch. Field work was closed October 21.

[F. WESTDAHL, July 1, 1915, to April 30, 1916; E. F. DICKINS, May 1 to June 30, 1916.]

An officer of the Survey has continued on duty as inspector for the coast of California and in charge of the suboffice of the Survey at San Francisco.

The inspector has obtained information for the revision of the Pacific Coast Pilot, and has furnished information in regard to charts, tide tables, and sailing directions.

He has supervised the tidal observations at the Presidio station; attended to the sale and distribution of charts, tide tables, and other publications; furnished transportation to officers of the Survey; and attended to the shipment of instruments and supplies to the suboffice of the Survey at Manila, P. I.

During part of the time the inspector was in charge of the exhibit of the Survey at the Panama-Pacific International Exposition.

CALIFORNIA, OREGON, AND WASHINGTON.

[R. S. PATTON.]

On May 25, 1916, an officer of the Survey left Washington to make a field revision of coast pilot of California, Oregon, and Washington.

Before beginning the coast-pilot work he was instructed to make a search for a breaker reported to exist about 1½ miles outside Tatoosh Island. For this purpose a party was organized at Seattle, a launch was chartered, and on June 5 the party left Seattle for Neah Bay.

Between June 5 and June 18 the breaker was located, including sufficient dragging to insure finding the least water over the shoal.

An area of about 4 square miles having the breaker in its center was sounded as was also the passage between Tatoosh Island and Duncan Rocks and a detailed hydrographic survey was made of Neah Bay.

After the completion of this work the coast-pilot revision work was taken up and this was in progress at the close of the fiscal year.

WASHINGTON.

[R. S. PATTON, Commanding Steamer *Explorer*.]

On October 18, at the request of the United States Army Engineers, the party on the *Explorer* undertook a detailed revision of the survey of Port Gamble, Wash., to ascertain what changes, if any, had taken place in the entrance. The actual hydrographic work was completed in two days, but through lack of the triangulation stations necessary for connecting the work with the original surveys, it became necessary to measure a base and an azimuth, and observe a scheme of triangulation consisting of two figures, reaching the one station which it had been possible to recover.

WASHINGTON AND OREGON.

[J. F. PRATT.]

An officer of the Survey has acted as inspector for the coasts of Washington and Oregon, and has charge of the suboffice of the Survey at Seattle, Wash.

The work of the inspector includes the collection of data relating to the charts of Washington, Oregon, and Alaska, making reconnoissance in regard to future surveys, and furnishing information to the public concerning the work of the Survey and special notices to mariners concerning newly discovered dangers.

A stock of charts and nautical publications is maintained at the suboffice for the convenience of the public.

The inspector also supervised the repairs of the vessels of the Survey at Seattle; the work of the tide station at Seattle; the current observations at three light vessels at Columbia River, Umatilla Reef, and Swiftsure Bank; and attended to numerous other details.

INTERIOR STATES GEODETIC WORK.

MAINE.

[J. D. POWELL.]

A party was organized and equipped in June to run a line of precise levels from Boundary to Vanceboro, Me.

It set bench marks pending the arrival of instruments and material and began the actual work of leveling at the beginning of the fiscal year 1917.

NEW JERSEY.

[E. B. LATHAM.]

In the latter part of September work was begun on the erection of a tall hydrographic signal on the coast of New Jersey about 4 miles north of Barnegat Inlet. Work on the signal was completed on October 7. Unfavorable weather delayed the work.

The construction of the signal being completed with the exception of the work of putting in place some additional braces and guy wires, which was arranged for, the officer in charge returned to Washington on October 8.

MARYLAND.

[E. W. EICKELBERG.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 28 miles, 73 square miles of area covered, 114 lines of intervisibility determined, 52 points selected for scheme. Triangulation: 34 signal poles erected, 21 observing tripods built, 16 stations in main scheme occupied for horizontal measures, 25 stations in supplemental scheme occupied for horizontal measures, 70 geographic positions determined.

At the request of the United States Engineers' office at Baltimore there was executed a supplemental secondary and tertiary triangulation of the Patapsco River and Baltimore Harbor.

The Baltimore Harbor Board and the Baltimore Topographical Survey Commission were consulted in order that such points might be determined as would best aid in the control of their work.

The United States Engineers' office, the Harbor Board, and the Topographical Survey Commission cooperated by furnishing transportation, heliotropes, and office and storeroom, and in marking stations, erecting signals, and by the personal assistance of their engineers. Actual field work was begun December 1.

With the exception of two lighthouses and a station established at Rock Point in 1907, practically all points on the river had been lost, the loss having been caused in most cases by a change in the shore line. With two old lines available the party started working up the river toward Baltimore.

The Baltimore Harbor Board has located monuments at most of the prominent points on the shore line, and wherever possible these monuments were used either for triangulation stations or they were tied into the triangulation net by observations from the triangulation stations.

The line between the old stations Monument and Bay View was tied into the new work. This line was the base from which the previous triangulation of Baltimore started.

The new work was also connected with the base line at the head of Spring Gardens measured by the United States Engineers.

VIRGINIA.

[E. B. LATHAM.]

SUMMARY OF RESULTS.—Signal building: 5 signals built 20, 25, 40, 79, and 88 feet in height, 9 geographic positions of signals and natural objects determined.

In July five hydrographic signals were built on the coast of Virginia at Cape Charles for use in offshore hydrographic work by the steamer *Isis*. One signal 79 feet in height was erected about 95 feet above high water at triangulation station Ship Shoal 3. A tall signal was erected in the vicinity of Smiths Island triangulation station. Two small signals were built, one on the south side of Little Inlet and one at the extreme southern end of Smiths Island. The last signal was located between Cape Henry and Virginia Beach. The positions of the signals were determined by sextant angles.

SOUTH CAROLINA.

[O. B. FRENCH.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 10 miles, 40 square miles of area covered, 2 hydrographic signals built, heights 84 and 88 feet, 3 stations in main scheme occupied for horizontal measures, 2 geographic positions determined.

The work of building signals on the coast of South Carolina for the hydrographic parties on the steamers *Bache* and *Isis* was begun at Folly Island on November 6. About a week had been occupied in making preliminary arrangements, hiring a motor boat for the transportation of the party, and purchasing necessary material.

The first signal, Folly, was completed November 16 and the party proceeded to the site of the next signal the same day. The erection of the second signal was somewhat delayed by rain and strong winds, but the signal was completed on the 21st. The party then proceeded to Charleston to procure necessary material.

In order to locate the positions of the two signals, horizontal angles were observed at each and also at St. Michael's Church spire at Charleston, so that the line St. Michael's Church spire–Charleston Lighthouse could be used as a base, and additional observations were made upon St. Philip's Church spire to verify the recovery of the old stations.

At Folly the total height of the signal erected was 88 feet above ground or about 92 feet above high tide. At Bass a signal 84 feet in height was erected, and being on a hill about 20 feet in height its top is more than 100 feet above high tide.

SOUTH CAROLINA AND GEORGIA.

[A. JOACHIMS.]

SUMMARY OF RESULTS.—Triangulation: 10 signal poles erected, 12 signal towers erected 90 to 100 feet in height, 18 stations in supplemental schemes occupied for horizontal measures.

The work of building tall signals on the coast of South Carolina and Georgia, which had been begun by O. B. French November 6, was continued from November 26 by A. Joachims.

The coast for the entire stretch consists of a chain of low islands made up of marsh, sand dunes, and heavily timbered hammocks. The only practicable means of approach is by landing on the inshore side of the islands, for which purpose, owing to the shallowness of the waters, a light-draft boat is necessary.

In addition to the two signals already built, four more were erected to cover the first 30 miles south of Charleston.

The first was erected about midway along the coast of Kiawah Island. A 90-foot signal was erected here with a 45-foot target, the lower half painted white and the upper half black. The black target was high enough to have a sky background when observing it from out at sea. Also a 22 by 6 foot black side wing was erected so as to help the visibility of the signal when observing it at an angle with the main target. The dimensions of the latter were 45 by 22 feet.

The next signal was erected on Seabrook Point. The construction of this signal was the same as that on Kiawah Island both as to height and size of target.

A similar signal was erected on Frampton Inlet at the south end of Botany Bay Island. A fourth signal 86 feet in height and with the same size of target as the other three was erected over the old triangulation station Bay Point.

After completing the erection of signals for 30 miles south of Charleston the party moved to Brunswick, Ga., to begin the erection of signals from that place northward.

The site for the first signal on the coast of Georgia was chosen on the north end of the Island of Palms, locally known as Long Island. A 90-foot signal was erected here with a 50 by 12 foot curved target.

During the early part of the season it was noticed that the straight target with side wings on the signal was not altogether satisfactory. A curved target was then designed and used on the last eight signals built.

The curved target was found to possess great advantages over the straight target on account of its greater visibility, as during the greater part of the day some portion of the curved target will reflect the sunlight.

A similar signal was erected on the north end of Little St. Simons Island at the entrance to Altamaha Sound.

The next site chosen was at the south end of Blackbeard Island, where a 100-foot signal with a 50 by 22 foot curved target was erected. Three more signals of the same size were erected on St. Catherine Island, one at each end and one midway on the island.

The last two signals were erected on Ossabaw Island, one along the beach about 3 miles from the south end and the other at the north end, each 90 feet in height with a 50 by 22 foot curved target.

The signals were all except one located by triangulation. A great number of the old triangulation stations along the coast were recovered and occupied. In most cases the signal tower itself had to be occupied.

Work was closed for the season on February 24.

FLORIDA.

[GEORGE D. COWIE.]

SUMMARY OF RESULTS.—Leveling: 157 permanent bench marks established, 396 miles of levels run.

On November 25, 1915, instructions were issued for running a line of precise levels between the tide gauges at Fernandina and St. Augustine, Fla., and another line from Fernandina to Cedar Keys, connecting with the tide gauge at the latter place.

Preliminary work of setting out bench marks, etc., was begun March 4, and the actual leveling was begun at Cedar Keys, Fla., on March 18 and continued until May 12, when the line was completed to St. Augustine.

The line from Cedar Keys to Gainesville follows the old Coast and Geodetic Survey leveling route along the Seaboard Airline Railroad, but only a few of the old bench marks could be found. These were redetermined as were also the bench marks of the United States Geological Survey and of the United States Army Engineers.

From Gainesville the line ran to Jacksonville by way of Baldwin and thence to Fernandina by way of Yulee.

The remainder of the line follows the Florida East Coast Railway, and runs from Jacksonville to St. Augustine.

Connections were made with the Coast and Geodetic Survey tide stations at Cedar Keys, Fernandina, and St. Augustine, the field computations giving the following results: Mean sea level of the Atlantic Ocean at Fernandina 2¾ inches lower and at St. Augustine 4 inches lower than the mean Gulf level at Cedar Keys, Fla. Further tidal observations and the final computations may change these values somewhat.

After the completion of the line to St. Augustine a spur line, about 1 mile long, was run from the courthouse to the campus of the University of Florida at Gainesville.

The leveling was completed in 1.8 months at the rate of 113.5 miles per month.

About 82 permanent bench marks were established at an average of 2.5 miles apart. Besides this about 35 tidal bench marks were redetermined, and about 35 concrete mileposts along the Florida East Coast Railway were used as semipermanent bench marks.

The new bench marks are concrete posts 6 inches square in cross section and 4 feet long, into which are set standard bronze disks.

During the season frequent requests from local surveyors and engineers for data regarding the bench marks were complied with.

A method, used for the first time in precise leveling, was adopted during the season and found to give good results. This was the use of the spikes which hold the rails to the crossties as turning points for the rods. This change increased the accuracy of leveling.

Mr. Cowie also used a listing adding machine for recording the rod readings. This method of entering notes was inaugurated by Mr. Peters one day earlier than by Mr. Cowie.

Later in the season the party mounted the tripod and level on a motor velocipede car, as had been done previously by J. H. Peters.

The party commenced work on the line from Baldwin, Fla., to River Junction, Fla., on May 18 and completed same on June 30. The line ends on two United States Engineers' bench marks Nos. 83 and 84, on the west bank of the Apalachicola River, 2 miles west of River Junction.

The line follows the Seaboard Air Line Railway through gently rolling country ranging from 65 feet to 290 feet above sea level. The total length of line is 192 miles and the leveling time is 1.45 months. This gives the rate of progress 132½ miles per month. The total number of bench marks established is 75, at an average of 2½ miles apart. They consist of concrete posts and standard bronze disks set in substantial buildings.

TEXAS.

[C. V. HODGSON.]

SUMMARY OF RESULTS.—Triangulation: 2 observing tripods and scaffolds built, height of each tripod 65 feet, scaffold 85 feet.

In March instructions were issued for making a connection between the triangulation of Mexico and that of the United States on the Rio Grande, near the ninety-eighth meridian.

The officer assigned to this duty proceeded to Brownsville, Tex., and conferred with Mr. Silverio Aleman, who had charge of the work

on the Mexican side of the river in regard to the details of this work. Mr. Aleman is the chief of the section of geodesy of the Bureau of Geographical and Climatological Studies of Mexico.

Building operations were begun by the American party about March 24 and a tower at Donna, Tex., was completed on the morning of the 30th. The party moved to Progreso on the afternoon of the 30th and completed the tower at that place on April 4. The towers built by the American party at Donna and Rio were 60 feet in height to the tripod head and 85 feet to the light stand.

Observations at Rio were finished on April 8 and the party moved to Donna on the following day. Here it was found that the lines from Donna to both Tenicitas and Colombres on the Mexican side were obstructed, and it was arranged to test the lines once more and then have a conference of the observers at Brownsville.

On the final testing it was found necessary that the tower at Tenicitas should have a height to the tripod head of 60 feet and that at Colombres 65 feet, while the light stands should be about 75 and 80 feet in height, respectively.

Owing to the delay incident to increasing the heights of the towers and the approach of the time for beginning work on the Utah-Oregon arc of primary triangulation, the chief of party left the field and proceeded to Washington to make preliminary plans for his new work. The observations on the United States side of the Rio Grande were continued and completed by Assistant E. H. Pagenhart.

[E. H. PAGENHART.]

SUMMARY OF RESULTS.—Triangulation: 1 station in main scheme occupied for horizontal measures, 1 station occupied for vertical measures, 2 geographic positions determined, 1 elevation determined trigonometrically.

On April 26, 1916, instructions were issued for the completion of the work necessary to connect the triangulation of the United States with that of Mexico.

The observer arrived at Brownsville on April 30 and there conferred with the Mexican engineer, Mr. Silverio Aleman.

The observing towers on the Mexican side had at that time been sufficiently elevated to permit the completion of the work begun by C. V. Hodgson, of the Coast and Geodetic Survey, in the early part of April.

Lights were shown from stations Rio and Donna, and horizontal observations were made at Donna. On May 6 notice was received of the completion of observations at the Mexican stations Colombres and Tenicitas. On the 8th the two observers met in Brownsville and exchanged results which proved satisfactory.

Instructions were issued November 8, 1915, for the remeasure of the traverse between that point and triangulation station Arista, a distance of about 19.5 kilometers, for the purpose of developing an error existing in the previous measurement.

Field work was begun January 3, 1916. Stations at western end of the Arista-Brownsville traverse of 1884 were recovered (triangulation stations Brownsville and Garrison in Fort Brown). At the eastern end of the traverse triangulation station Arista was recovered. Starting at Arista and using the old directions and distances a preliminary traverse was run to aid in the search for old stations.

None was recovered until triangulation station Tank was reached. Here the foundation of the old water tank was found, and as the distance indicated a point at the middle of the tank, a point just south of the rail was taken as old triangulation station Tank.

From Tank westward the old distances were laid off, and at each point a search for the old station was made. The distance laid down for Forto put it in the mesquite beyond the field in which the description stated the station was located. At 84 meters less than the distance called for by the notes a preliminary position of Forto was marked.

Then starting from the recovered station Garrison, a traverse was measured, between the old station Garrison and the new station Forto.

Forto, as determined from Garrison, was about 1½ meters to the eastward of the tentative point, as determined from Arista. After correcting the latter by 84 meters, search failed to recover Forto.

Again, starting from triangulation station Tank, a second running between triangulation stations Tank and Garrison was made, in which the azimuth of the lines was carried along. A discrepancy of 86.35 meters, in azimuth about 230°, was developed between the old and the new position of Garrison; and, as the section of line closest to 230° was the section Egan-Valls, it was assumed that a tape length was added on this section when the original traverse was run. A compromise value of 85.17 meters (mean between length of old tape, 84 meters, and the discrepancy developed in check traverse, 86.35 meters) was used because of lack of precise methods in the check work. Field work was completed January 12.

CALIFORNIA.

[E. B. LATHAM.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 25 miles, 82 square miles of area covered. Triangulation: 82 square miles of area covered, 22 signal poles erected, 25 stations in main scheme occupied for horizontal measures, 72 geographic positions determined.

In accordance with the request of the inspector of the eighteenth lighthouse district at San Francisco, made through the Bureau of Lighthouses, an officer of the Survey was directed to determine by tertiary triangulation or otherwise the positions of a sufficient number of objects in the vicinity of the following buoys on the coast of California to permit their being correctly located by the officers of the Lighthouse Service: Point Dume whistling buoy, Point Buchon whistling buoy, Half Moon Bay buoys, and Duxbury Reef whistling buoy. Subsequently Mouse Rock bell buoy, Cayucos Landing buoys Nos. 2 and 3, and Constantine Rock buoy were added to this list. Direction was also given for a hydrographic survey of the immediate approach to Cayucos Landing Wharf and a revision of the chart of the southern part of San Diego Bay for the purpose of making it possible to fix the positions of a number of buoys established on that part of the coast.

Work was begun at Half Moon Bay, Cal., on April 26 and was in progress on June 30. At that date all of the work requested had been completed except some additional hydrography at Cayucos and the location of points to determine the position of Duxbury Reef buoy.

NEVADA AND CALIFORNIA.

[GEORGE D. COWIE.]

SUMMARY OF RESULTS.—Leveling: 427 miles of precise levels run, 107 permanent bench marks established.

Precise leveling on the line from Reno to Las Vegas, Nev., which had been begun in May of the previous fiscal year, was in progress on July 1.

The line followed the Virginia & Truckee Railway from Reno to Mound House via Carson City and thence along the Southern Pacific tracks via Churchill to Tonopah Junction. Here a spur line branched off and followed a narrow-gauge railroad of the Southern Pacific over a pass of the Sierra Nevada Mountains (elevation of about 7,500 feet) near Mount Montgomery to Laws, Cal., where connection was made with several bench marks of the United States Geological Survey. From Tonopah Junction the main line of levels runs along the Tonopah & Goldfield Railroad tracks to Columbia, a suburb of Goldfield. A spur line branched off this railroad at McSweeny Junction and ran into Tonopah.

From Columbia the line followed the Las Vegas & Tonopah Railroad tracks to a point near Wagner, where a crossover was made to the Bullfrog & Goldfield tracks along which the line was run into Beatty. Here the line returned to the Las Vegas & Truckee Railway which it followed into Las Vegas, where a satisfactory connection was made with the bench marks of the Coast and Geodetic Survey established in a previous year.

Throughout the line many connections were made with bench marks of the United States Geological Survey. Coast and Geodetic Survey bench marks, consisting of reinforced concrete posts with standard bronze disks set in their tops, iron posts capped with standard bronze caps, and standard bronze disks set in concrete or masonry were used to supplement the Geological Survey bench marks. Very few permanent masonry structures were available along the line for setting bench marks.

The country through which the leveling was done was rough, with heavy grades.

On the narrow-gauge line over the Sierra Nevada the railway tracks wound up and down on the mountain sides so that in two places it was found economical to leave the track and run along the mountain sides. Cutting across these horseshoe curves saved in each instance from 1 to 4 miles in distance.

Work was closed at Las Vegas on November 2.

The total progress for the season was 548 miles (484 miles after July 1), and the average monthly progress was 102.5 miles.

IDAHO, OREGON, AND WASHINGTON.

[J. S. BILBY.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 385 statute miles, 14,700 square miles of area covered, 78 lines of intervisibility determined as per sketch submitted, 30 points selected for scheme, 3 Laplace stations selected. Base lines: 1 primary, 15,800 meters in length. Triangulation: 17 observing stands built and stations marked.

At the beginning of the fiscal year work was in progress on the reconnoissance for primary triangulation from northern Utah to a

connection with the California-Washington arc of the primary triangulation.

By July 1 the stations from Pilot Peak and Ogden in Utah, northward to Middlebutte and Caribou, in Idaho, had been prepared for occupation, and the reconnoissance, marking the stations, and building had been extended from stations Cache and Bigbutte westward to the vicinity of Boise, Idaho.

By August 31 the reconnoissance had been completed to stations Red, Larch, and Star of the California-Washington arc in the States of Oregon and Washington, where the new arc ended. During the progress of the reconnoissance all of the stations from Cache-Bigbutte to and including stations Job and Expansion of the Stanfield base net were marked and prepared for the observing party.

From stations Job and Expansion westward to the California-Washington arc the stations were not marked or prepared for occupation.

A motor truck was used for the first time in a reconnoissance party for the transportation of the party and equipment in this work. The results were most satisfactory, for an analysis of the cost shows that the work can be advanced more rapidly by the use of the trucks than by the using of horses and wagons and that the unit cost is lessened thereby.

The total length of the reconnoissance scheme from stations Cache and Bigbutte in Idaho to stations Red, Larch, and Star of the California-Washington arc is 520 miles. In all, there are 37 stations in the main scheme and 3 Laplace stations. One base line site was selected, provision made for connecting with 4 precise level bench marks, with the Idaho-Oregon boundary and with several stations of the United States Geological Survey triangulation. Twenty-four of the stations selected were marked, instrument stands were built, and the stations prepared for occupation. The distance traveled during the progress of the work by motor truck was 3,160 miles. The actual field work was completed in 64 working days.

ARKANSAS AND TENNESSEE.

[J. S. BILBY.]

SUMMARY OF RESULTS.—Triangulation: Primary traverse 130 miles in length, 55 observing tripods and scaffolds built, average height 9 feet.

In the latter part of January, 1916, work was begun on the preparation for measurement of a traverse line between the cities of Memphis and Little Rock and also to make such observations at points along the line as were necessary to control the azimuths, preparatory to the measurement of the traverse line with invar tapes.

Arrangements were made with the Chicago, Rock Island & Pacific Railway Co. for permission to use motor-velocipede cars for the transportation of the party and equipment over that road. While the motor car was being put in order, several portable tripods and a portable scaffold were constructed.

It was not practicable to build high signals along the railroad with which to obtain long lines of sight. It was therefore decided that the lines should be from 1 to 4 miles in length. This made it necessary to elevate the instrument only from 8 to 16 feet.

Angles were measured at 55 primary stations, and all of the stations were marked with permanent reference marks.

The actual field work connected with the angle measurements was begun February 6 and completed on April 25.

At Memphis the work was connected with the primary triangulation stations Exchange and Hopefield.

COLORADO AND NEW MEXICO.

[E. H. PAGENHART.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 510 statute miles, 11,800 square miles of area covered, 145 lines of intervisibility determined, and 81 points selected for the scheme or arc.

A reconnoissance for primary triangulation along the one hundred and fourth meridian between the thirty-ninth parallel and the Texas-California arc was begun at the southern end August 4, 1915.

Stations Sist, Ingle, and Round of the Texas-California arc were recovered, and the reconnoissance was extended northward from them.

The scheme is near the one hundred and fourth meridian, and follows the Santa Fe Railway from Pecos, Tex., to the vicinity of Roswell, N. M. It then inclines to the eastward. It continues north to the vicinity of Ray, where it includes several Geological Survey stations; it then bends easterly again to the vicinity of Clayton for a connection with the western boundary of Texas. It then runs north to the thirty-ninth parallel.

Connection was made with stations Adobe, Aroya, and Overland of the thirty-ninth parallel arc. The last station was recovered on November 17. Field work was closed for the season on November 18.

IDAHO.

[C. V. HODGSON.]

SUMMARY OF RESULTS.—Reconnoissance: 1 point selected for scheme. Triangulation: 21,100 square miles of area covered; 1 observing tripod and scaffold built, with a height of 10 feet; 19 stations in the main scheme occupied for horizontal measures; 8 stations in supplemental schemes occupied for horizontal measures; 27 stations occupied for vertical measures; 36 geographic positions determined; 36 elevations determined trigonometrically. Azimuth: 7 stations occupied on 10 nights for observations of azimuth.

The observations in primary triangulation from the most northern stations of the transcontinental triangulation in Utah northward to the vicinity of Pocatello, Idaho, and thence westward along the Oregon Short Line Railroad were begun by this party in the latter part of June, 1915.

The reconnoissance from the transcontinental triangulation to the vicinity of Pocatello had been made by J. S. Bilby in 1913, and the same officer had been instructed to carry the reconnoissance from Pocatello westward during the season of 1915.

The reconnoissance provided for Laplace stations at intervals of four to six figures, and where the lines of a figure in the direction of progress exceeded 40 miles in length, additional stations to be observed upon but not to be occupied, were interpolated. Connection with precise level bench marks at intervals of 100 to 150 miles was provided for, and provision was made for connection with the monuments of the Idaho and Oregon boundary.

During the progress of the triangulation an astronomic azimuth was observed at each of the Laplace stations and at other stations of the triangulation which are not closer together than 40 miles nor farther apart than 80 miles.

Automobile trucks were used for the first time in the United States for the transportation of a primary triangulation party and its equipment.

An analysis of the costs of the work showed that the cost of the triangulation was lower with trucks than it would have been with horses and wagons as the means of transportation.

Almost the entire area covered by the triangulation is arid, with a succession of mountain ridges and narrow valleys, except where the Snake River cuts through what was formerly known as the Snake River Desert, which is a rolling plateau reaching back to the mountains on its edges and bearing in many places evidences of former extensive volcanic activity. Drinking water for the party in some localities had to be purchased or hauled for a long distance.

Many of the stations were on mountains over 7,000 feet high and a few were more than 9,000 feet in height, necessitating the use of pack horses for the last 5 or 6 miles of the climb. The longest pack of the season was about 12 miles each way.

During the early part of the season the party was greatly hampered by the combination of long lines and a thick atmosphere due to dust and smoke. Coupled with many scattered fires were the dust storms on the plains, which produced a constant heavy haze. At Big Butte, for instance, the party remained for 17 days, during 13 successive days of which period not a primary observation was obtained. The party was forced to abandon the station temporarily and reoccupy it later for the omitted lines. During the latter part of the season the party made excellent progress as the atmosphere was clearer, due to the autumn rains, and the lines shorter.

Although the line Ogden-Pilot, of the thirty-ninth parallel triangulation, was the base line from which the past season's work was really to start, it was not necessary to occupy those stations because observations had in a previous year been made from them on stations Oxford and Cache in southern Idaho, which were the first stations in the new work. The first two figures, which were completed by the occupation of six primary stations, contained several lines each more than 100 miles in length. The line from Oxford to Pilot was over 134 miles in length, slightly longer it is believed than any previous line observed in the main scheme in this country by the use of lamps.

After the completion of the two large figures the work progressed much more favorably, even though holdups of a few days were not uncommon, since some of the lines on the west end of the work were more than 75 miles long, and the Snake River Valley was often filled with haze and smoke. But after September 20 an average of about eight stations a month was made.

On November 7 the last observations were made, and on the following day the party went to Nampa, Idaho, to overhaul the outfit and trucks, and store same for the winter. Only two days after reaching Nampa there came a heavy fall of snow, lasting intermittently for several days, which would have put a stop very effectively to any further work had the party remained longer in the field.

OREGON.

[C. V. HODGSON.]

SUMMARY OF RESULTS.—Base lines: 1 primary, 16,597 meters in length. Triangulation: 1,300 square miles of area covered, 11 instrument stands built and stations marked. 1 observing tripod and scaffold built, height 10 feet; 10 stations in main scheme occupied for horizontal measures, 4 stations in supplemental schemes occupied for horizontal measures, 10 stations occupied for vertical measures, 17 geographic positions determined, 17 elevations determined trigonometrically. Leveling: 10 miles of levels run (base line). Azimuth: 2 azimuth stations occupied.

Work on the Oregon end of the Utah-Oregon arc of primary triangulation was begun early in May, 1916.

The automobile trucks stored at Nampa, Idaho, at the close of the previous season were sent to Stanfield, Oreg., on May 6 and arrived there on the 10th.

On May 12 one truck with two men was started out to mark the stations and build the instrument stands to the westward, while the remainder of the party began the work of lining out and clearing the base line at Stanfield.

The clearing of the base line, driving the stakes, leveling, and measuring occupied the time of the party until June 8, although part of the men were employed during that time in preparations for the triangulation to follow, such as signal practice, overhauling and repairing property, etc. During this period the connection was also made with the triangulation of the United States Engineers of the Columbia River at Umatilla.

On June 12 the first lightkeepers left for their stations, and triangulation observations were begun on the 14th, and by the end of the month 10 stations in the primary scheme had been occupied. The chief of party reported that this most satisfactory progress was due largely to two factors, the first one being the comparative accessibility of the stations so that a near approach could be made to them with the trucks, and also to the personnel of the party, which was made up largely of experienced men from previous seasons.

MONTANA.

[J. H. PETERS.]

SUMMARY OF RESULTS.—Leveling: 296.6 miles of levels run; 110 permanent bench marks established.

Field work on the line of levels between Huntley and Snowden, Mont., was begun June 29. Actual leveling began July 6 and was continued without interruption until September 10 when the work was completed. The field season closed at Sydney, Mont., on September 16, 1915. The time between the first and last observations was 67 days. Therefore the rate of progress for a 30-day month was 133 miles.

The line of leveling begins with a precise leveling bench mark at Huntley, Mont., and follows the Northern Pacific Railway, through the towns of Forsyth, Miles City, Glendive, and Sydney to a connection with bench mark of the precise level net at Snowden, a small station on the Great Northern Railway near Mondak, Mont.

Two motor-velocipede cars were used in transporting the party and outfit to and from the working ground in this work.

The bench marks used for this line were reinforced concrete posts with brass disk tablets set in one end, and these tablets were placed in substantial structures of masonry such as public buildings, bridge abutments, etc. For the entire line the average distance between bench marks is 2.7 miles.

MONTANA, NORTH DAKOTA, SOUTH DAKOTA, WYOMING, NEBRASKA, IOWA, MARYLAND, AND VIRGINIA.

[C. L. GARNER.]

A standardization of the "A" set of pendulums was made in the early part of July, 1915, and the values obtained agreed well with the standardization of January, 1915.

Work in the field was begun early in August, and the following stations were occupied in the order named: Aberdeen, S. Dak.; Faith, S. Dak.; Towner, N. Dak.; Crosby, N. Dak.; Poplar, Mont.; Marmarth, N. Dak.; Miles City, Mont.; Huntley, Mont.; Lander, Wyo.; Edgemont, S. Dak.; Moorcroft, Wyo.; Wasta, S. Dak.; Valentine, Nebr.; Randolph, Nebr.; Leon, Iowa; Laurel, Md.; Rockville, Md.; Fairfax, Va.; Upper Marlboro, Md.; and Hagerstown, Md.

The "A" set of pendulums was again standardized at Washington after the close of the field work. The results showed a slight increase in the periods of all of the pendulums, as compared with the previous standardization.

During the season 20 stations were occupied in 143 days or an average of 7.1 days per station, including Sundays and holidays and delays of all kinds.

The average probable error of observed gravity was 0.0007 dyne.

Western Union time signals were used in this work as during the previous season.

MINNESOTA AND NEBRASKA.

[C. H. SINCLAIR and O. B. FRENCH.]

Between July 2 and 25 a determination was made of the difference of longitude between Minneapolis and Warroad, Minn., using Minneapolis as the base station and the position of the longitude pier at Minneapolis was checked from Omaha, Nebr.

A small observatory was erected in the grounds of the university at Minneapolis and was completed by July 10, and the station at Warroad prepared by July 15, but a succession of bad nights prevented observations until the 19th. Observations were made every night thereafter until the work was completed on July 25, four complete nights' observations and exchange of signals having been secured.

On July 21 observations for latitude were made after the completion of the time observations, 15 pairs being obtained.

On July 28 preparations were begun for the erection of an observatory at Omaha around the pier of 1907, which was found in good condition. The observatory was completed by the evening of July 29. Observations were made on July 30 and every night there-

after except one until the completion of the work on August 9. Owing to persistent cloudy weather no complete night's work was secured until August 6, after which four consecutive nights were obtained.

The result indicates that the pier at Minneapolis is practically in the same place where the original determination was made.

After the completion of observations at Minneapolis, C. H. Sinclair proceeded to International Falls, Minn., to arrange for connecting the Canadian astronomical station of 1910 at Fort Frances, Ontario, with the azimuth station East Base, about 1,900 feet to the westward. The necessary connection was made August 15, and the observer then proceeded to Baudette to connect the Canadian astronomical pier of 1910 with the triangulation along Rainy River in the town of Rainy River. A signal was put up at Bachtel on the American side, and the necessary angles were observed and distances measured on the 16th to complete the connection required.

Afterwards the monument marking the north end of the base line at Warroad, Minn., which was found to lean about 8 inches from the perpendicular, was replaced in a vertical position and concrete was added to the foundation to insure the stability of the monument in the future.

MICHIGAN, WISCONSIN, IOWA, MINNESOTA, WEST VIRGINIA, PENNSYLVANIA, DELAWARE, MARYLAND, AND VIRGINIA.

[JOHN D. POWELL.]

SUMMARY OF RESULTS.—Latitude work: 11 latitude stations occupied. Gravity work: 22 pendulum stations occupied.

Between July 12, 1915, and January 16, 1916, determinations of the relative intensity of gravity were made at various stations located in the North Central and Central Atlantic States.

In June and July, 1915, a complete standardization of the three pendulums B4, B5, and B6 was made in the pendulum room in the basement of the Coast Survey building in Washington. The values of the periods derived from this standardization were used throughout the field season. Upon the return of the observer to Washington in January, 1916, after the completion of the field work, the values as derived from a restandardization so nearly checked those referred to above that no changes in the results of the season's work, for this cause, were necessary.

This close agreement between standardizations shows that these pendulums are retaining their values, and is especially gratifying in proving that the serious trouble which for five years existed in the B4 pendulum has been corrected.

The field season began on July 12, 1915, at Traverse City, Mich., and closed January 15, 1916, at Fredericksburg, Va. The actual number of working days in the field season was 137 and in that time 22 gravity stations were occupied. The average time per station was therefore six and one fourth days.

The stations occupied were as follows: Traverse City, Mich.; Seney, Mich.; Oconto, Wis.; Grand Rapids, Wis.; Winona, Minn.; Cambridge, Minn.; Baldwin, Wis.; Cumberland, Wis.; Crookston, Minn.; Brainerd, Minn.; Faribault, Minn.; St. James, Minn.; Daw-

son, Minn.; Cokato, Minn.; Duluth, Minn.; Osage, Iowa; Wheeling, W. Va.; Pittsburgh, Pa.; Harrisburg, Pa.; Dover, Del.; Crisfield, Md.; and Fredericksburg, Va.

The computed probable error for all stations was uniformly ±0.001 dyne.

Besides the regular gravity determinations, latitude was determined approximately at each of the following 11 stations: Seney, Mich.; Grand Rapids, Wis.; Cambridge, Minn.; Baldwin, Wis.; Cumberland, Wis.; Crookston, Minn.; Faribault, Minn.; St. James, Minn.; Dawson, Minn.; Cokato, Minn.; Osage, Iowa.

Methods.—No changes were made in the methods of observing or computing. Toward the end of the season a prismatic attachment was furnished upon request for use with the flash apparatus. This was made in the office and shipped to the field party. It enables the observer to sit in a chair and read the coincidence, flexure, and other observations instead of having to sit on the concrete floor, as the old form of apparatus necessitated. It has proved a great convenience and has added considerably to the comfort of the observer.

Much interest was taken in this work by the public. Frequently in towns where Federal buildings are not available, it became necessary to call upon the school authorities for space in their schoolhouses for a pendulum room. In such cases the teachers and students showed great interest and enthusiasm in the work. Newspaper men were eager to secure articles for their papers and the public generally was insistent with questions as to the nature of the work and requests to visit and examine the apparatus.

For three seasons the gravity work has been carried on by use of the Western Union time signals, instead of as formerly by stellar observations. It has been found that by this method the cost has been very greatly reduced from what it was formerly.

INDIANA, ILLINOIS, AND MICHIGAN.

[J. H. PETERS.]

SUMMARY OF RESULTS.—Leveling: 296.6 miles of levels run, 110 permanent bench marks established.

On April 1, 1916, at the request of the United States Geological Survey, work was begun on an extension of the precise level net, including seven lines of leveling in Indiana, Illinois, and Michigan, as follows: Lawrenceburg, Ind., to Indianapolis, Ind.; Terre Haute, Ind., to Indianapolis, Ind.; Indianapolis, Ind., to Warsaw, Ind.; Chicago, Ill., to Warsaw, Ind.; Warsaw, Ind., to Jackson, Mich.; Mackinaw City, Mich., to Jackson, Mich.; Jackson, Mich., to Detroit, Mich.

Leveling began April 3 at Lawrenceburg, Ind., on the line from Lawrenceburg to Indianapolis. This line, which is 90 miles in length, follows the line of the Cleveland, Cincinnati, Chicago & St. Louis Railway through the towns of Greensburg and Shelbyville.

Leveling began April 24 on the line Terre Haute to Indianapolis. This line, which is 83 miles in length, follows the line of the Cleveland, Cincinnati, Chicago & St. Louis Railway through the towns of Greencastle and Danville.

A satisfactory connection was made at Indianapolis between the two above-named lines on May 13, a rate of progress of 129 miles per month having been made between Lawrenceburg and Terre Haute.

Leveling was begun on May 15 at Indianapolis on the line from Indianapolis to Warsaw. This line, which is 119 miles in length, follows the line of the Cleveland, Cincinnati, Chicago & St. Louis Railway through the towns of Anderson, Alexandria, Marion, and Wabash.

Leveling began June 12 at Chicago on the line from Chicago to Warsaw. This line, which is 113 miles in length, follows the main line of the Pennsylvania Railroad through the towns of Indiana Harbor, Gary, Valparaiso, and Plymouth.

On July 1 work was yet in progress on this line. The rate of progress between Indianapolis and Chicago was 130 miles per month.

As had been done previously by G. D. Cowie in Florida, Mr. Peters used the spikes along the railroad as the rod supports.

On all the work during this fiscal year two motor velocipedes were used to transport the party and equipment both while moving or en route to the field and while leveling. During the latter portion of the fiscal year an adding and listing machine was used to record the observations and compute the results.

On May 15 a method was provided for mounting the instrument on the motor velocipede in such a way that observations could be taken without removing the instrument from the velocipede as was heretofore done.

So far as known no leveling has been done previously in any country with the tripod and level mounted on a car, nor with the rod readings recorded on an adding machine. The use of these improved methods has materially increased the progress and lowered the cost of precise leveling. These methods are now in general use in this Bureau.

ARKANSAS AND TENNESSEE.

[E. H. PAGENHART.]

SUMMARY OF RESULTS.—Triangulation: 1 primary base line, 7.5 kilometers in length. Leveling: 4.6 miles run, 2 permanent bench marks established.

The measurement of a primary traverse from Little Rock, Ark., to Memphis, Tenn., was begun May 18 from Northwest Base near Little Rock. The work was under the direction of E. H. Pagenhart, who was assisted by J. S. Bilby. Mr. Bilby had previously observed the angles along this traverse. The traverse was completed to Hopefield just across the river from Memphis, a distance of 200 kilometers, on June 25. The party then returned to Little Rock to take up and complete the measurement of a base line at Little Rock, June 27 to 30.

The traverse was measured along the rails of the Chicago, Rock Island & Pacific Railway from the vicinity of Little Rock to Hopefield, Ark. Triangulation stations had been placed at points along the tangents and at the curves. At the curves it was necessary to stake out the line from the point of curve to the station, which was generally located at the point of intersection of tangents; otherwise measurement was made on the rails with the tape supported throughout its length.

A new tape stretcher used for the first time on rail work proved very satisfactory.

The base line at Little Rock was measured immediately after the completion of the Little Rock-Memphis traverse, and was practically an extension of the traverse. It will be used as the place of starting for the arc of primary triangulation, which will extend to Oklahoma City, Okla. The base line is about 5 kilometers east of Little Rock. Six kilometers of the base were measured over the Cotton Belt tracks; the remaining 1½ kilometers were over cultivated fields.

The actual work was begun late on the morning of June 27 and the backward line of levels, which completed the field work, was finished at noon on June 30.

The rapid and economical execution of the measurement of the traverse between Little Rock and Memphis and the base at Little Rock reflects credit upon the engineers in charge of the work and also upon those assisting them.

[WM. BOWIE.]

In August, 1915, the chief of the division of geodesy inspected the surveying instruments exhibited at the Panama-Pacific Exposition at San Francisco, Cal. There was no exhibit of such instruments from abroad and the instruments by American manufacturers were of types familiar to the Coast and Geodetic Survey office. Instrument factories in San Francisco were also inspected.

The inspector attended some of the meetings of the American Association for the Advancement of Science held at Berkeley, Cal.

The parties of the Survey engaged in leveling and triangulation work in the Western States were visited and the methods of work inspected.

Among items of interest noted was a systematic error in single lines of leveling caused by the micrometer screw which raises or lowers the eye end of the telescope not remaining in the same position for backward and forward sights. This error is eliminated by running two single lines in opposite directions and in one party a method had been devised of eliminating it in a single line by facing first right and then left in setting up the instruments.

The use of additional lamps and larger heliotrope mirrors on some of the longer lines in triangulation was recommended to the chief of the triangulation party.

The use of a more powerful signal lamp such as has been designed at the Coast and Geodetic Survey office, will it is thought, be sufficiently powerful to counteract the rather frequent unfavorable atmospheric conditions encountered in many parts of the country.

The use of automobile trucks for transportation of a party engaged in reconnoissance was found to result in a saving both in time and money. Railroad officials were visited in Salt Lake City, San Francisco, Minneapolis, St. Paul, and Chicago. These officials were told of the work done by the Survey in the interior of the country and in each case they expressed appreciation of the value of the primary triangulation and precise leveling.

Magnetic Work.

CONNECTICUT, MAINE, MASSACHUSETTS, NEW HAMPSHIRE, AND RHODE ISLAND.

[F. L. Adams.]

Stations occupied.—Connecticut: New Haven.† Maine: Alfred, Calais, Eastport, Ellsworth, Machias, and Wiscasset. Massachusetts: Barnstable, Boston,† Fall River, Newburyport, Provincetown, and Taunton. New Hampshire: Rochester.† Rhode Island: Kingston † and Providence.†

Between April 8 and June 30 observations of the three magnetic elements were made at each of the above-named stations. Old stations were reoccupied at the stations marked by daggers (†). Auxiliary stations were occupied near Alfred and Calais, Me., and Rochester, N. H. The auxiliary observations at Rochester, N. H., developed the fact that the local disturbance there was of small extent. At New Haven the old station was reoccupied, and a new station was established in a place less disturbed. The old station at Newburyport was approximately reoccupied, and a new station was established.

MARYLAND.

[George Hartnell.]

The regular work of the Cheltenham Magnetic Observatory was continued during the year. This includes the operation of two magnetographs and a seismograph, absolute observations for declination, dip and horizontal intensity, sun observations for time, the scaling of hourly ordinates from the magnetograms and the computation of the absolute observations, and of the base-line values for both magnetographs.

Instruments used in the field were standardized as usual. A magnetometer from the United States Naval Observatory was standardized.

Special observations were made in November to determine the effects of the ex-meridian adjustments of earth indicator No. 26, and the results of these observations were discussed.

ARIZONA, COLORADO, KANSAS, KENTUCKY, MARYLAND, NEW MEXICO, OHIO, AND WEST VIRGINIA.

[Frank Neumann.]

Stations occupied.—Arizona: Holbrook and Ash Fork. Colorado: Brighton, Littleton, Seibert, and Ramah. Kansas: Columbus and Winfield. Kentucky: Anchorage, Buckner, Eastview, Pendleton, Shelbyville, and Spring Lick. Maryland: Oakland, New Mexico, Taos, and Gallup. Ohio: Cincinnati. West Virginia: Parkersburg.

Between April 10 and May 22, 1916, the three magnetic elements were determined at the stations named.

Meridian lines were established at Columbus, Kans., and Shelbyville, Ky.

At Winfield, Oakland, and Parkersburg old stations were reoccupied; at Holbrook, Ash Fork, and Cincinnati new stations were established not far from the old ones.

INDIANA, KENTUCKY, OHIO, TENNESSEE, VIRGINIA, AND WEST VIRGINIA.

[FRANK NEUMANN.]

STATIONS OCCUPIED.—Indiana: Alton, Corydon, Jeffersonville, New Albany,* and New Salisbury, Kentucky; Argillite, Ashland, Brumfield, Burnside, Chenaultt, Coalton, Concord, Dover, Ekron, Garrison, Junction City, Lebanon, Lebanon Junction, Louisville, Marshall, Maysville, Parkers Lake, Peckenpaugh Pine Knot, Rugless, Shepherdsville, Stanford, Stephensport, Limeville, and West Point. Ohio: Amsterdam, Barnesville, Beallsville, Bowerstown, Coolville, Dillonville, Minerva, Piedmont, Portsmouth,* Salineville, Summerfield, Warner, and Waverly. Tennessee: Glenmary and Jacksboro.* Virginia: Bristol. West Virginia: Bristol, Glenwood, Jacksonburg, Moundsville, Murraysville, New Cumberland,* Pennsboro, Point Pleasant,* Sisterville, Walker, Wallace, Wellsburg,* Wheeling, and Woodlands.

Meridian lines were established at stations marked with an asterisk (*).

Between July 1 and November 29, 1915, the three magnetic elements were determined at the stations named, of which seven were repeat stations and five were new stations to replace old ones.

Besides these, 10 auxiliary stations were established at Portsmouth, Ohio, 4 at Waverly, Ohio, 4 at Maysville, Ky., 4 at Corydon, Ind., 4 at Stanford, Ky., and 4 at Lancaster, Ky.

ILLINOIS, MASSACHUSETTS, MICHIGAN, MINNESOTA, MISSOURI, NEW YORK, AND WISCONSIN.

[F. L. ADAMS.]

STATIONS OCCUPIED.—Illinois: Durand, Edwardsville, Galesburg, Lacon, Mendota, Rockton, and Springfield. Massachusetts: East Brookfield, Hinsdale, Palmer, Springfield, Sterling, and Westfield. Michigan: Bay City, Channing, Detroit, Dublin, Eagle River, Engadine, Escanaba, Forsyth, Grand Marais, Honor, L'Anse, Levering, Mackinac Island, Matchwood, Michigamme, Nestoria, Northland, Petoskey, Rudyard, St. Ignace, Seney, Thompsonville, Traverse City, and Trout Lake. Minnesota: Kingsdale, St. Paul, and Two Harbors. Missouri: St. Louis. New York: Albany, Buffalo, and Rochester. Wisconsin: Alma, Clear Lake, East End, Ellsworth, Lavalle, Madison, Washburn, and Webster.

During the period from July 1 to November 15, 1915, the magnetic elements were observed at the stations listed above.

Of these, St. Louis, Mo.; Springfield, Ill.; Madison, Wis.; St. Paul, Minn.; Michigamme, Mackinac Island, Traverse City, Bay City, and Detroit, Mich.; Buffalo, Rochester, and Albany, N. Y.; and Palmer, Mass., were old stations reoccupied.

New stations to replace old ones were established at Bay City, Mich., and Springfield, Mass.

A meridian line was set at Petoskey, Mich.

Auxiliary stations were occupied in vicinity of Edwardsville, Ill., Kingsdale, Minn., Eagle River, Mich., Nestoria, Mich., Michigamme, Mich., Honor, Mich., and Palmer, Mass.

Five auxiliary stations were occupied about Michigamme, Mich., and some rough exploring work was done also. Magnetic disturbances were noted in this area. At one of the stations an inclination of nearly 86° was observed. It was found that in places the magnetic bearing of a line differed at the two ends by several degrees. It was a rich mining district and the whole section is underlaid by beds of iron-bearing rock.

Ledges of iron-bearing rock are also reported in the vicinity of Palmer, Mass., and probably account for the local disturbance at that place. Five auxiliary stations were occupied about Palmer.

MISSISSIPPI, NEW MEXICO, OKLAHOMA, AND TEXAS.

[WALLACE M. HILL.]

STATIONS OCCUPIED.—New Mexico: Bernalillo, Clovis, Estancia, Fort Sumner, Hillsboro, Los Lunas, Rincon, Santa Fe, Texico, and Vaughn. Oklahoma: Arnett, Binger, Buffalo, Carmen, Geary, Hammon, Hollis, Medford, Okeene, Rust Springs, Thomas, Trail, Waurika, Weatherford, Woodward, and Waynoka. Texas: Archer City, Crosbytown, Lamesa, Tahoka, and Wheeler.

Between July 22 and November 20, 1915, observations of the three magnetic elements were made at each of the above stations. Between November 21 and 24 a verification was made of the meridian line at Brookhaven, Miss.

Meridian lines were established at Arnett, Buffalo, Trail, Woodward, and Waurika, Okla., and at Crosbytown and Wheeler, Tex.

The local surveyors at Crosbytown, Tex., stated that the canyon of the Salt Fork of the Brazos River, about 5 or 6 miles distant, caused a local disturbance of the magnetic declination. This may be the reason for the high magnetic declination obtained at Crosbytown.

The county surveyor of Jim Wells County, Tex., reports that there is considerable disturbance of the magnetic declination near an oil well half a mile northwest from Noledo, Tex. Irregularities in declination are reported in regions of Mississippi and Louisiana where surface indications of petroleum are found. In Bulletin No. 401 of the Geological Survey for 1909, George F. Becker calls attention to the presence of local magnetic disturbances in regions known to contain petroleum, and suggests that the action of water upon iron carbides may account for the petroleum deposits in these regions.

ARKANSAS, LOUISIANA, MISSISSIPPI, NORTH CAROLINA, AND VIRGINIA.

[WALLACE M. HILL.]

STATIONS OCCUPIED.—Arkansas: Malvern,† Rison,† Sparkman, and Star City. Louisiana: Jena, Jonesboro, Ruston,† and Tallulah.† Mississippi: Belzoni, Holly Springs,† Sumner,* and Water Valley. North Carolina: Chapel Hill,† Halifax,† Morganton,*† and Salisbury.† Virginia: Emporia,*† Palmyra,*† and Richmond.†

Between March 23 and June 30, 1916, observations of the three magnetic elements were made at each of the above stations.

Meridian lines were established at the places marked by asterisks (*). Old stations were reoccupied at the stations marked by daggers (†).

Auxiliary magnetic stations to trace local magnetic disturbances were occupied at Palmyra, Carys Brook, and Central Plains, Va.

Other tests for magnetic declination were made at different points.

At Rison, Ark., the local magnetic disturbance was very great, due probably to a large mass of magnetic iron ore.

In the town of Rison the magnetic declination is about 1° 55′ E., while at McLerdan's farm, about 4½ miles distant, the declination is 21° 32′ E.

ALABAMA, FLORIDA, GEORGIA, AND TENNESSEE.

[J. R. BENTON.]

STATIONS OCCUPIED.—Alabama: Atmore, Calvert, Florala, Georgiana, Jackson, Maplesville, Montevallo, New Market, Opp, Paint Rock, Pine Hill, Safford, Samson, Scottsboro, Scranage, Stevenson, Warrior. Florida: Crestview, Fort White, Gainesville, Interlachen. Georgia: Acworth, Atlanta, Boxspring, Fair Mount, Fort Valley, Manchester, and Rockmart. Tennessee: Elora and Sherwood.

Complete magnetic observations were made at the stations named between July 1 and September 15.

All of these were new stations except Scottsboro, Elora, and Atlanta, at which old stations were occupied. At each of these places the station marks were found in good condition. No permanent marks were placed at any of the new stations.

At all of the stations except Paint Rock the declination came within 1° of the expected value. Auxiliary stations were occupied near Paint Rock and Elora.

COLORADO, IOWA, KANSAS, MINNESOTA, MISSOURI, NEBRASKA, NORTH DAKOTA, SOUTH DAKOTA, UTAH, AND WYOMING.

[H. E. MCCOMB.]

STATIONS OCCUPIED.—Colorado: Canon City, Eads, Lake City, Montrose, Ordway, and Walden. Iowa: Blanchard. Kansas: Atwood, Concordia,* Lawrence, Oakley, Russell Springs, St. Francis, and Scott.* Minnesota: Monument No. 853. Missouri: Maryville, Maysville, Stanberry, and Union Star. Nebraska: Alma,* Bassett, Butte, Center, Chadron,* Cody, Newport, Papillion, and Ponca. North Dakota: International boundary monuments Nos. 816 and 798, Pembina. South Dakota: Gregory, Wheeler, and Winner. Utah: Cisco, Farmington, Ogden,* Prince, and Tooele. Wyoming: Bitter Creek, Cheyenne,* Evanston, Fox Park, Green River,* Kemmerer, Laramie, Lusk, Medicine Bow, Rawlins, and Torrington.

Observations of the three magnetic elements were made at the above-named stations between July 1 and 13 and August 9 to November 23, 1915. The stations on the international boundary were observed during the first period.

Old stations were reoccupied at the places marked by asterisks (*).

A meridian line was established at Maryville, Mo., in the grounds of the State Normal School.

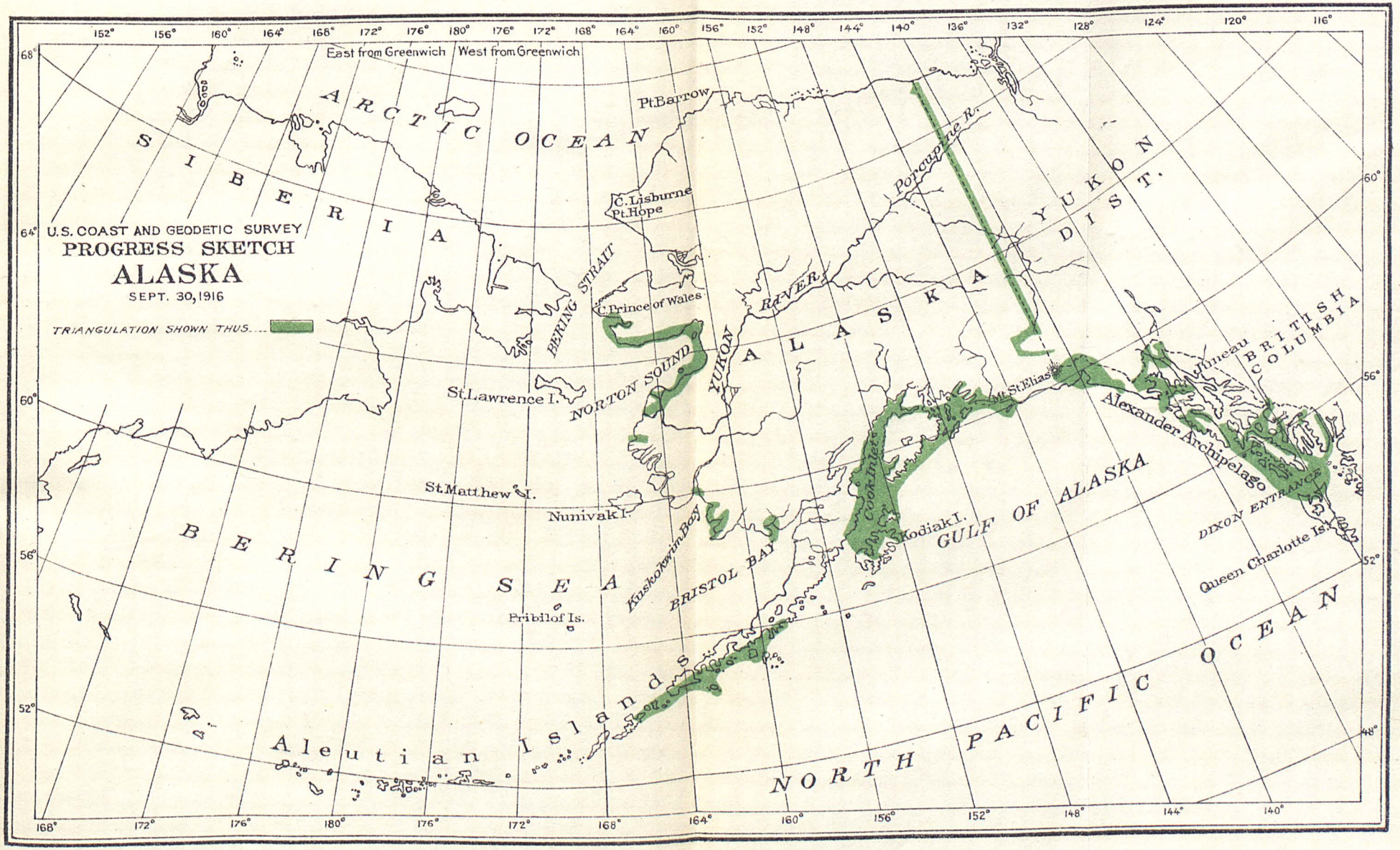
Auxiliary stations were established in the vicinity of Papillion, Nebraska, and Stanberry, Mo., on account of local disturbance.

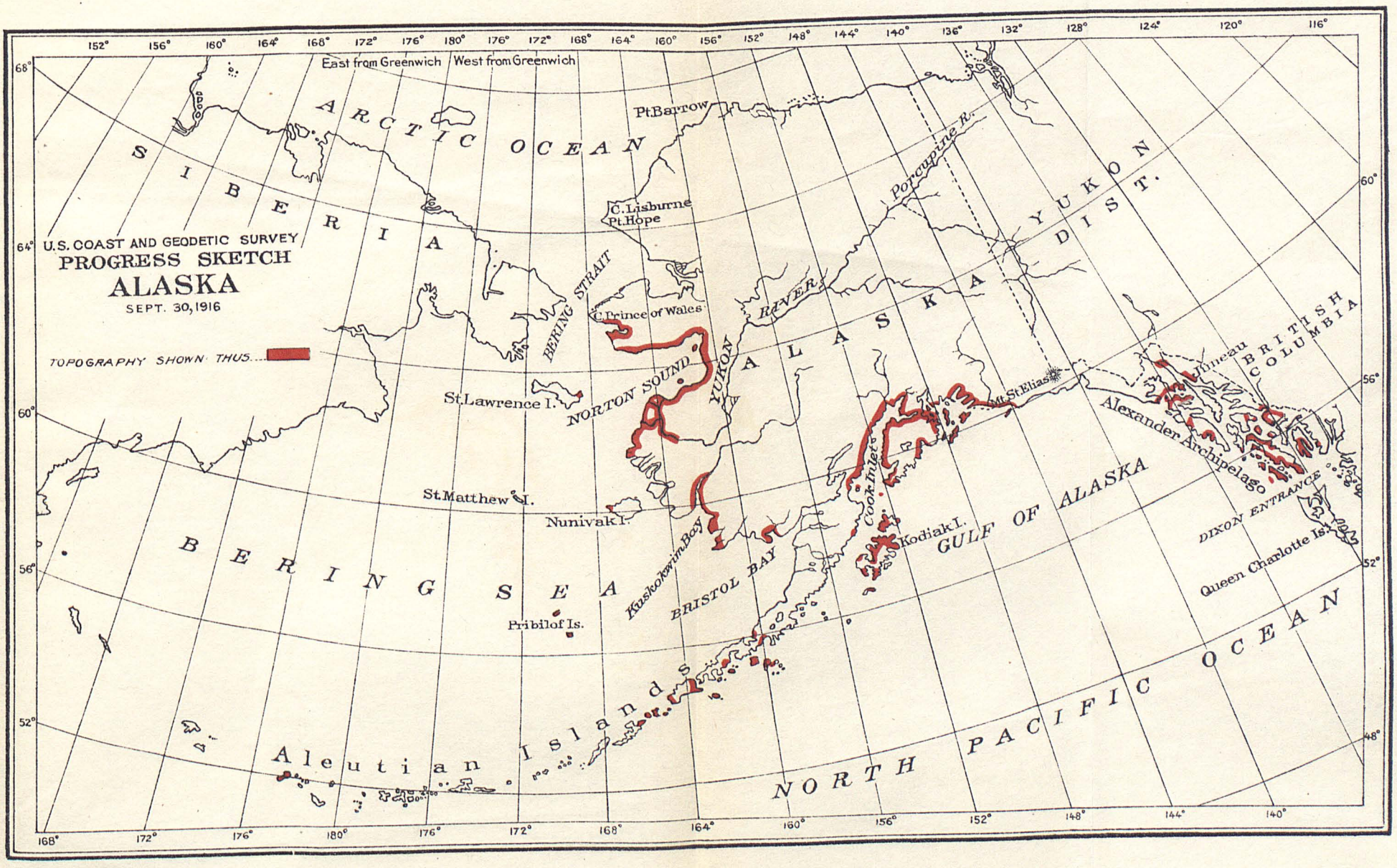
IOWA, MISSOURI, MONTANA, NORTH DAKOTA, AND SOUTH DAKOTA.

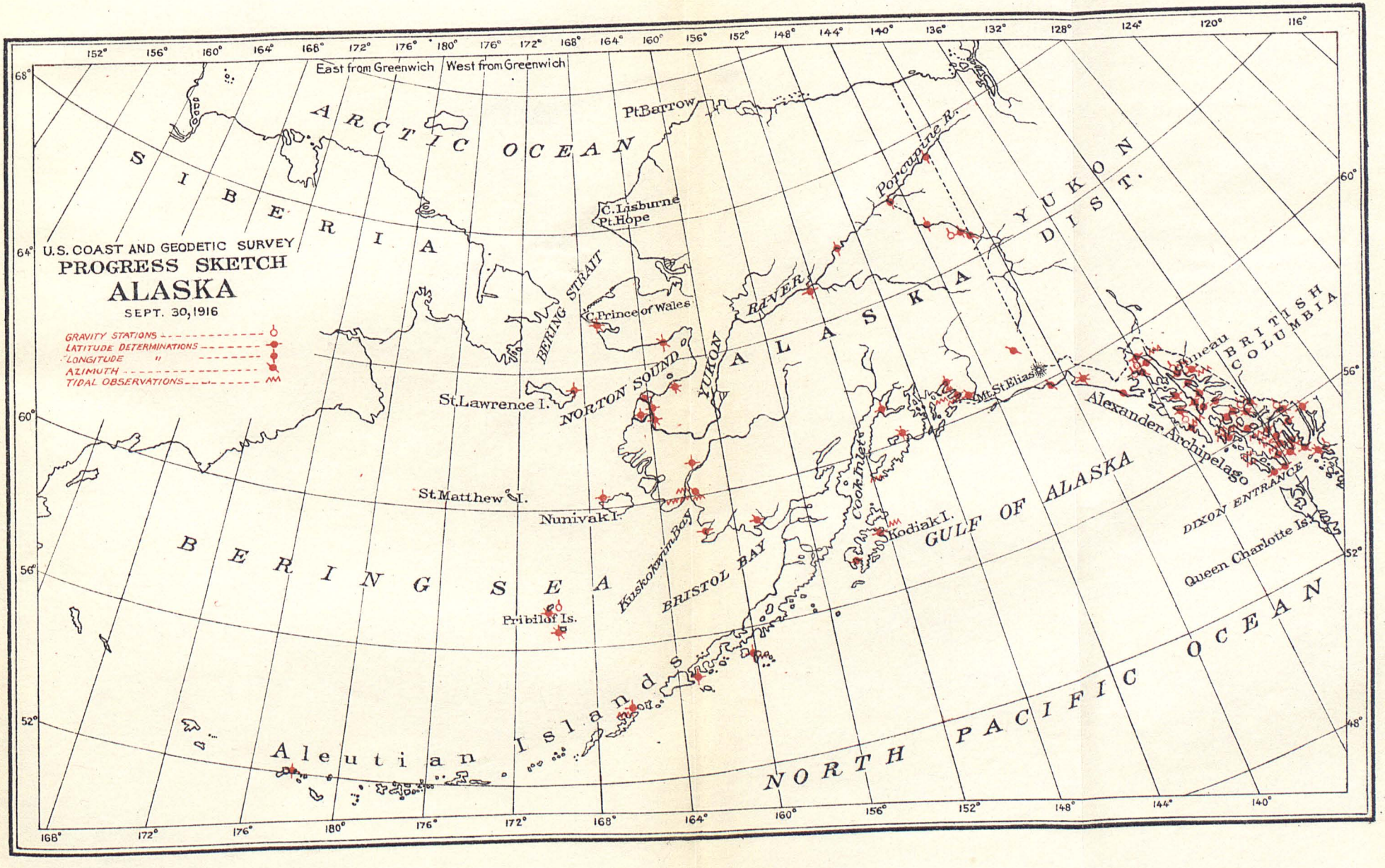
[H. E. MCCOMB.]

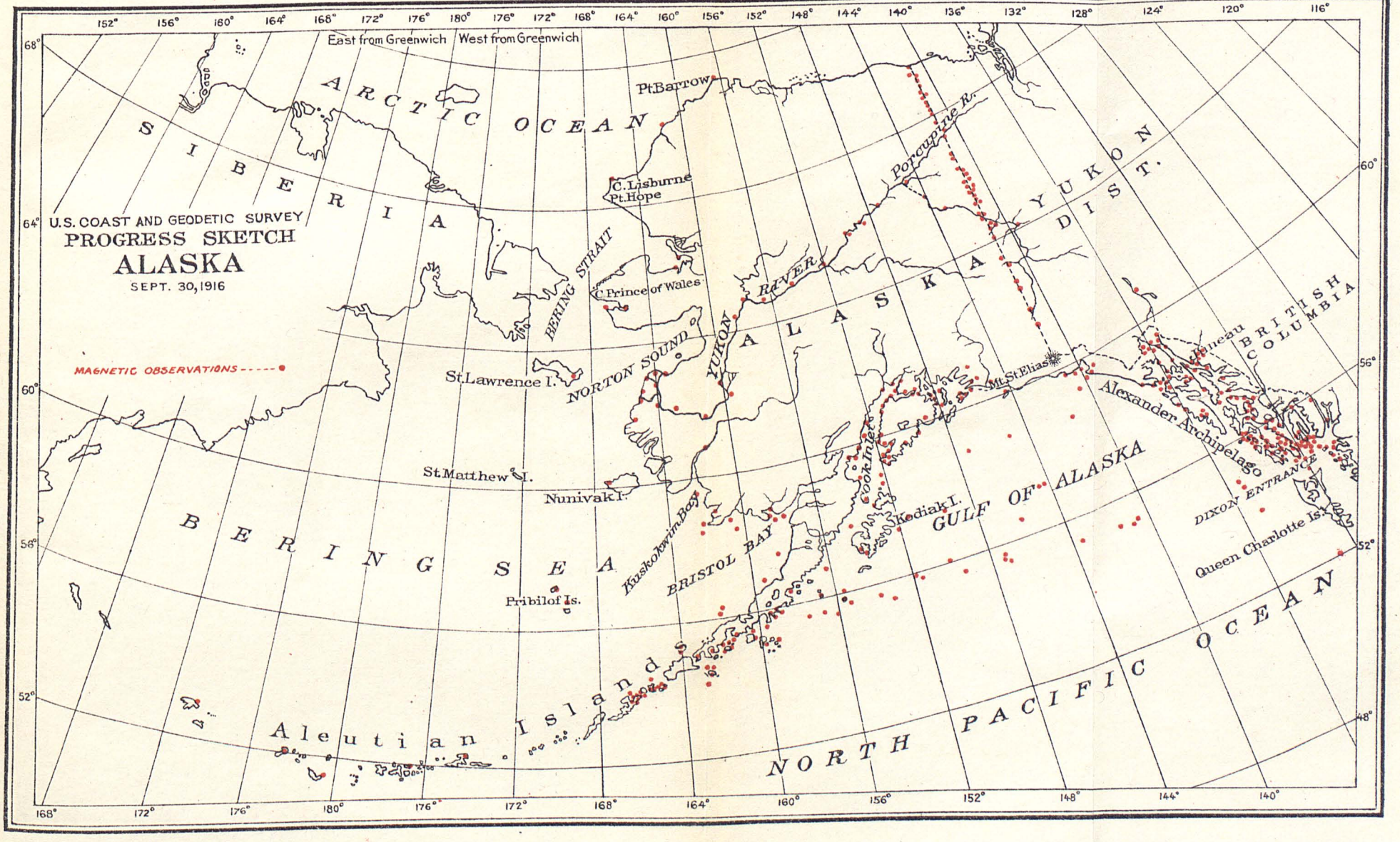
STATIONS OCCUPIED.—Iowa: Adair, Avoca, Earlham, Keosauqua, and Oskaloosa.† Missouri: Kahoka, Memphis, Monticello,* New London, Paris, Shelbyville, and Troy.* Montana: Plentywood, international boundary monuments Nos. 350, 365, 389, 403, 420, 443, 461, 481, 496. 509, 527, 542, 566, 583, 601, 613. North Dakota: Bowbells, Cavalier, monuments Nos. 629, 641, 661, 680, 696. 712, 733, 755, 776. South Dakota: Yankton†

Between April 3 and June 30, 1916, observations of the three magnetic elements were made at the stations named.


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
SEPT. 30, 1916
TRIANGULATION SHOWN THUS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt Barrow
C. Lisburne
Pt. Hope
Porcupine R.
YUKON DIST.
BERING STRAIT
C. Prince of Wales
YUKON RIVER
ALASKA
BRITISH COLUMBIA
Juneau
St. Lawrence I.
NORTON SOUND
Mt. St. Elias
Alexander Archipelago
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BERING SEA
BRISTOL BAY
Cook Inlet
Kodiak I.
GULF OF ALASKA
DIXON ENTRANCE
Queen Charlotte Is.
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
SEPT. 30, 1916
TOPOGRAPHY SHOWN THUS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
C. Prince of Wales
BERING STRAIT
NORTON SOUND
St. Lawrence I.
YUKON RIVER
Porcupine R.
YUKON DIST.
ALASKA
BRITISH COLUMBIA
Juneau
Mt. St. Elias
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BERING SEA
BRISTOL BAY
Cook Inlet
Kodiak I.
GULF OF ALASKA
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
SEPT. 30, 1916
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
Porcupine R.
YUKON DIST.
YUKON
RIVER
ALASKA
BRITISH COLUMBIA
Juneau
Mt. St. Elias
St. Lawrence I.
NORTON SOUND
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BRISTOL BAY
Cook Inlet
Kodiak I.
GULF OF ALASKA
BERING SEA
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
SEPT. 30, 1916
MAGNETIC OBSERVATIONS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
C. Prince of Wales
BERING STRAIT
Porcupine R.
YUKON
DIST.
ALASKA
YUKON RIVER
BRITISH COLUMBIA
Juneau
Mt. St. Elias
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
St. Lawrence I.
NORTON SOUND
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BERING SEA
BRISTOL BAY
Pribilof Is.
Cook Inlet
Kodiak I.
GULF OF ALASKA
Aleutian Islands
NORTH PACIFIC OCEAN

Meridian lines were established at the places marked by asterisks (*). Old stations were reoccupied at the places marked by daggers (†).

Observations at Kahoka and Memphis, Mo., were made on meridian lines established by the United States Geological Survey.

The stations along the international boundary between Canada and the United States were not marked by the observer. Other stations were marked as usual.

IOWA, MINNESOTA, NORTH DAKOTA, AND SOUTH DAKOTA.

[H. E. McComb.]

Stations occupied.—Iowa: Correctionville, Dubuque,* Lake Mills, Mallard, Moorehead, Oelwein, Plainfield, Pocahontas, Rolfe, Sibley,* Smithland, Sioux Rapids, Strawberry Point, Waucoma, Waukon, Walker. Minnesota: Amboy, Blooming Prairie, Breckenridge,* Buffalo Lake, Cannon Falls, Chaska, Chatfield, Claremont, Elbow Lake, Ellendale, Kenyon, Kiester, LeRoy, Mabel, Mankato,* Olivia, Rushford, St. Peter, Wells, Winnebago. North Dakota: Bismarck, Jamestown. South Dakota: Aberdeen, Alexandria, Castlewood, Clear Lake, Colton, Humboldt, Ipswich, Leola, Milbank, Miller, Olivet, Pierre,* Sisseton, Toronto, and Watertown.

Observations of the three magnetic elements were made at the stations named during the period from June 30 to November 14, 1914.

Old stations were occupied at the places marked with asterisks (*).

At several places where local disturbances were indicated auxiliary stations were occupied.

This abstract was accidentally omitted from the Annual Report for 1915, and although the work was done in another fiscal year it is here included in order to make the record of magnetic work complete.

ARIZONA.

[Franklin P. Ulrich.]

At the magnetic observatory at Tucson, Ariz., the usual records were obtained during the year. The magnetograph was in continuous operation. Absolute observations were made twice each week. Daily meteorological observations were made and the results reported to the local office of the Weather Bureau.

The Bosch-Omori seismograph was kept in almost continuous operation, and 41 earthquakes were recorded.

ALASKA.

[J. A. Daniels.]

Summary of results.—Reconnoissance: Length of scheme 69 statute miles, 374 square miles of area covered, 88 lines of intervisibility determined, 45 points selected for scheme. Base lines: 1 secondary, 2 miles in length. Triangulation: 374 square miles of area covered, 49 signal poles erected, 43 stations in main scheme occupied for horizontal measures, 31 stations occupied for vertical measures, 81 geographic positions determined, 70 elevations determined trigonometrically. Leveling: One-half mile of levels run, 6 permanent bench marks established. Topography: 88 miles of general coast line surveyed. Scale of topography, 1:20,000. Hydrography: 424.6 square miles of area dragged, 449.58 miles run while dragging, 4,465 angles measured, 58 soundings made, scale of hydrographic sheets 1:40,000 and 1:80,000, 2 tide stations established.

The work of this wire-drag party in Revillagigedo Channel and Clarence Strait was begun May 12 and closed October 22, 1915.

The progress made to June 30 was detailed in the annual report for the last fiscal year.

Work in Revillagigedo Channel was continued after June 30, and, as completed, extends from Twin Islands southward to the Canadian boundary. It includes all area within the 50-fathom curve and the entrance to Boca de Quadra for a distance of about 3 miles.

Triangulation was executed by the party to locate all signals used except those placed upon recovered stations. The topography was revised from the entrance to Boca de Quadra to Foggy Point, including a survey of Very Inlet, an unsurveyed arm extending northward from Foggy Bay.

In Clarence Strait the drag work covered the entire channel from the 1914 work in Tongass Narrows to Lemesurier Point. Northward from this point work was done in the main ship channel and along the western shore of the strait as far as Zarembo Island.

Triangulation was done over the entire strait from Vallenar Point to Zarembo Island. No topography was done in this locality.

In Revillagigedo Channel the main ship channel from Twin Islands southward to the international boundary and the entrance to Boca de Quadra were dragged. The area covered extends on an average from about one-fourth mile from shore out to or beyond the 50-fathom curve. The entrance of Boca de Quadra was dragged for a distance of about 3 miles and one line was carried into the entrance of Foggy Bay.

Within the area of 125 square miles covered, only four dangerous rocks were found and none of these were of primary importance.

The effective depth verified was not less than 45 feet where that depth existed, but nearly all of the work was taken to a depth of 50 feet or more. The entire area was remarkably clear of uncharted shoals. The greater part of this work was done in the fiscal year 1915.

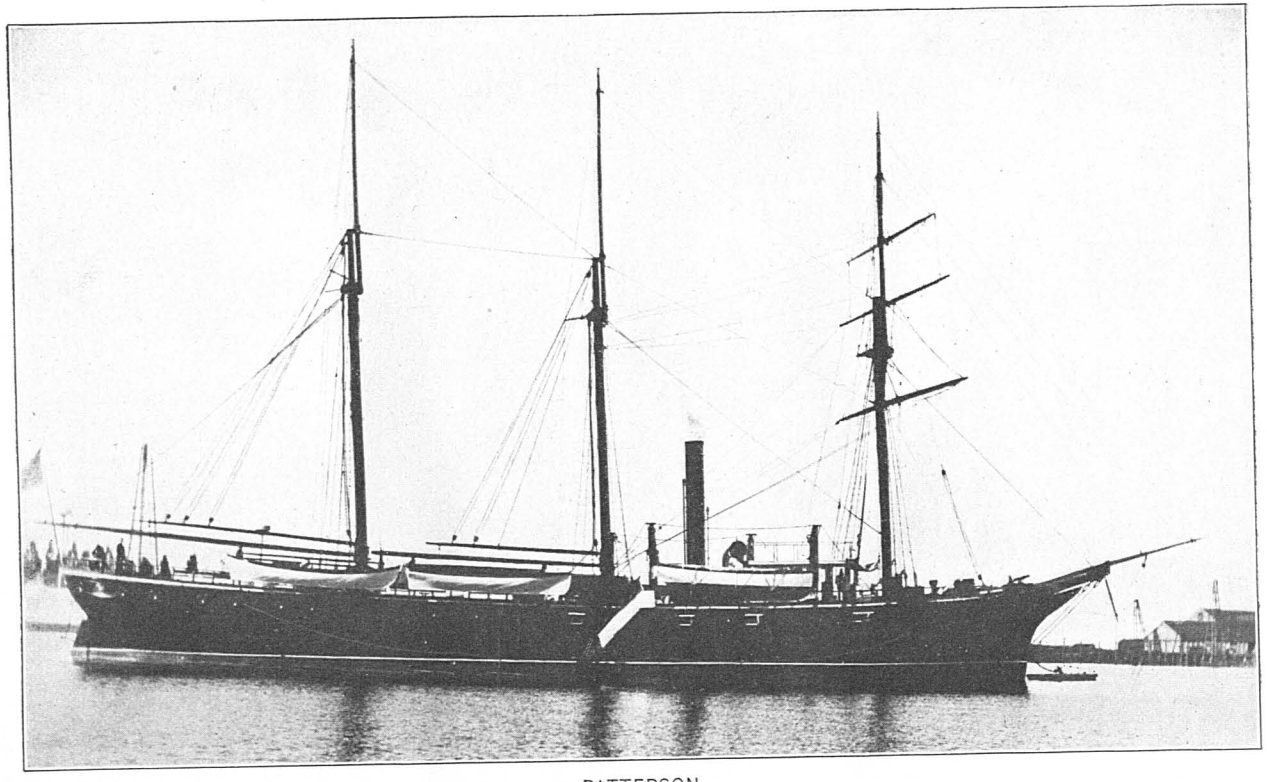
Kah Shakes Cove was sounded out and a few lines of soundings were taken into Very Inlet, although the latter was not thoroughly developed. No other regular hydrography was done.

In Clarence Strait all of the area from Caamano Point to Lemesurier Point was covered, including the passages inside of Ship Island and Streets Island. From Guard Island to Caamano Point a strip about 1 mile wide in the main track of vessels was covered. Northward of Lemesurier Point nearly all of the regular steamer course was covered as far as Steamer Point and Snow Passage. The work was not completed in the locality, however, as there was a large area left in the entrance to Ernest Sound and in the eastern half of the strait from Ernest Sound to Point Stanhope.

Vessels on the regular run through this part of the strait favor Narrow Point Light, which is located on the side of the channel which was dragged.

An automatic tide gauge was maintained at Ketchikan by the party on the steamer *McArthur*, and the observations obtained there were depended upon for the reduction of the wire-drag work. Comparative readings were taken at Kah Shakes Cove, Hadley (Lyman Anchorage), and Steamer Bay. Each series of readings was connected with permanent bench marks.

In Clarence Strait it was found that weather conditions had considerable effect upon the direction and strength of the tidal current,



PATTERSON.

Wooden auxiliary steam barkentine of 719 tons displacement, 500 gross tons, and 453 net tons; registered length 163 feet, breadth 27.3 feet, draft 14.2 feet; indicated horsepower 215; speed steaming 8 knots; coal capacity 133 tons; complement 12 officers and 49 men. Built at Brooklyn, N. Y., in the year 1882. Present duty, general surveys in southeastern Alaska.

especially during moderate tides and during hot weather that caused large amounts of glacier water to come down from the mountains. Numerous instances were observed where the currents flowed contrary to the predicted direction on account of wind. Other cases were noted where surface currents opposed the normal tidal currents, causing troublesome undertows and cross currents. After a storm normal tidal conditions did not prevail for one or two days. The currents in most cases were found to be about 1 knot weaker than indicated on the charts.

The dangers found and reported after July 1 were a rock with a depth of 20 feet off Point Harrington, a 6-foot rock marked by kelp off Point Stanhope, a reef with a least depth of 18 feet in Snow Passage, and a large shoal southwestward from Nesbitt Reef.

Wire-drag party No. 3 arrived in Ketchikan April 2, 1916, to take up the work in Clarence Strait and Ernest Sound. The launch *Sunrise* was inspected April 3 and accepted for charter. The hired launch *Roosevelt* arrived April 4 and the *Equator* April 6.

Preliminary arrangements, installation of machinery, etc., occupied the time until April 18, and upon that date the party left for the working grounds.

The first work undertaken was to cover several unfinished places in the area covered by the work of 1915, southward of Lemesurier Point. From that locality the dragging was continued systematically up the strait until all the open water area had been completed to Zarembo Island. Then the more exposed portions of Ernest Sound were taken up, and work on it was in progress at the close of the fiscal year.

The signals in Ernest Sound were built and located by the party on the steamer *Patterson* and were ready when the wire-drag party took up that work.

A 5-horsepower, 4-cycle gas engine was installed in a ship's dinghy, transferred to the party in the spring, and made a satisfactory power tender. A similar 8-horsepower engine was installed in a whaleboat for the use of the topographic party in camp.

The work of primary triangulation was begun June 1 from a camp in Quiet Harbor, Stikine Strait, and good progress had been made at the close of the year.

Topographic work was done in the vicinity of Lemesurier Point, on the south side of Zarembo Island, and on the west side of Clarence Strait between Tolstoi Bay and Coffman Cove. Three sheets were begun, but none had been completed at the end of June.

[L. O. COLBERT.]

SUMMARY OF RESULTS.—Triangulation: 579.2 square miles of area covered, 42 signal poles erected, 43 stations in main scheme occupied for horizontal measures, 6 stations in supplemental schemes occupied for horizontal measures, 99 geographic positions determined. Leveling: 12 permanent bench marks established. Topography: 110.5 square miles of area surveyed, 111.7 miles of general coast line surveyed, 5 topographic sheets finished, scale 1:20,000. Hydrography: 235.9 square miles of area dragged, 536.3 miles run while dragging, 140 soundings retained, 3 tide stations established, 7 hydrographic sheets finished, scale 1:20,000.

The work done by wire-drag party No. 4 during the season of 1915 after July 1 was in Sumner Strait, beginning in the vicinity of Bluff Island, which is about 16 miles inside the entrance to the strait.

The work was carried northward around Point Baker and eastward as far as Vichnefski Rock, which lies off the northwest corner of Zarembo Island.

The hydrography consisted of a wire-drag examination of the above area. One day's current observations were made and tides were observed at three stations. The area covered was swept to a depth of 48 feet below mean lower low water except where less than this depth was charted. North of Calder Rocks the entire channel of the strait was swept. In the southern part the work was extended offshore only to the 100-fathom curve. This depth was considered a sufficient limit at the beginning of the season when this work was done, but later on a shoal was found which indicated that even the 100-fathom curve was not a safe limit. This shoal, having but 33 feet over it and located only one-third mile from where a sounding of 84 fathoms was shown on the chart, is further described under a later paragraph. The drag was not carried inshore of the outer line of reefs or islands nor did it follow the indentation of the shore line except in a general way in the larger bights. The channels into Shakan Bay and Port Protection were swept, but the effective depth was less.

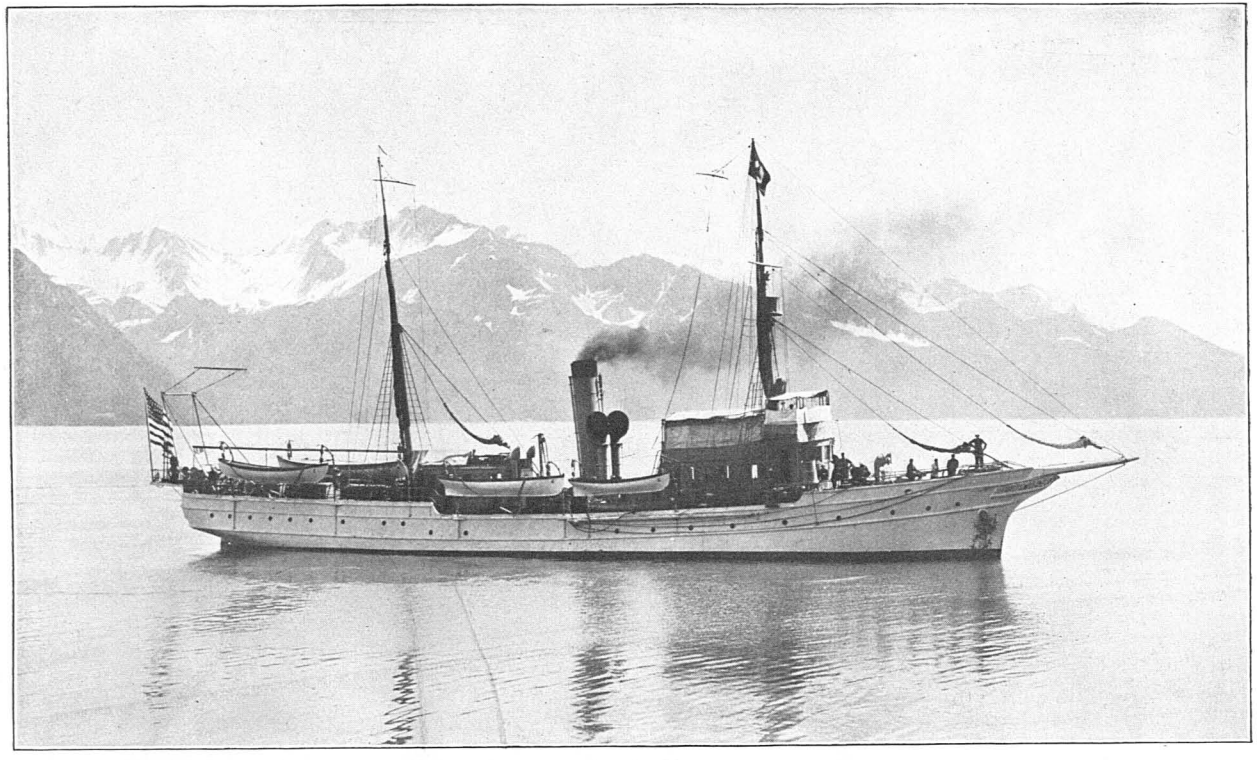
A pinnacle with 29 feet was located where 8 fathoms was charted on the west side of Sumner Strait and in the usual track of large steamers bound in from Cape Decision.

Another pinnacle with 16 feet was found three-fourths mile off Barrier Islands in the passage between those islands and Calder Rocks, which is used by freight and passenger steamers entering Shakan Bay. No outlying dangers in the vicinity of Calder Rocks were found, as the waters were dragged close up to those rocks. With the exception of the above two, no shoals were found in the waters lying between Bluff and Strait Islands. Inshore, however, a number of shoals with less depth than charted were located.

In the entrance to Shakan Bay 11 shoals were discovered. The majority of these are extensions of the reefs and islets on the north side of the bay. A rocky reef marked by kelp was charted just north of Barrier Islands. Outside the entrance to Labouchere Bay the positions of 7 shoals were determined. Two shoals were found off the southern point of the entrance to Port Protection. In the vicinity of Point Baker 9 shoals were located. In the northern part of the channel between Point Barrie and the Eye Opener Beacon and off the south shore of Kupreanof Island 18 shoals were found. In the immediate vicinity of the Eye Opener 2 more were located.

In mid-channel between the Eye Opener Beacon and Point Colpoys and in the direct track of all large steamers passing through this channel a pinnacle rock with 33 feet at mean lower low water was found. The nearest sounding shown on the chart to this spot was 84 fathoms at a distance of one-third mile. Four rocks were investigated which were not within the area dragged, but whose position was rather doubtful or of which there was no information at all.

These rocks were determined and their positions and characters noted in the records of this party. The first of these was in Port Protection. The depth over this rock was reduced from 18 to 10 feet. The second rock was an uncharted rock in Red Bay, information of which was furnished by the manager of the Vermont Marble



EXPLORER.

Wooden steam vessel of 450 tons displacement, 335 gross tons, and 228 net tons; registered length 135 feet, breadth 27 feet, draft 10 feet; indicated horsepower 400; speed 10.3 knots; coal capacity 85 tons; complement 7 officers and 40 men. Built at Wilmington, Del., in the year 1904. Present duty, surveys of southeastern Alaska.

Quarry located in the bay. The third was a rock in the bight of the shore line west of Red Bay. The fourth was a rock marked "P. D." southeast of the entrance to Keku Strait.

It was noticed during the first part of the season that the tidal flow in the strait was subject to sudden changes which did not conform to the tidal predictions. The action of the currents was noted at various stages of the tidal flow while dragging in order to take advantage of favorable directions. Frequently the direction would be contrary to or the velocity would differ from that expected according to previous observations.

In order to obtain better data one day was spent observing the direction and velocity of the current during flood at several places between Point Baker and Shakan Bay. The results were interesting, though not taken over a sufficient period or area to obtain information which might be published for the benefit of navigators.

Tides were observed during the progress of the work at three stations. Between May 19 and June 2 observations were made on a staff erected in a small cove east of Station Island on the south side of Shakan Bay. On May 28 an automatic tide gauge was established in Port Protection, and after connecting the series of observations at Shakan Bay with those at Port Protection by 48-hour simultaneous readings the staff at Shakan Bay was discontinued. The gauge continued in operation until October. A series of observations had been made in 1912–13 by the steamer *Explorer* in the small cove about a mile east of Point Baker. A staff was erected at this place, connected by levels with the bench marks previously established, and simultaneous readings for 48 hours were made with the gauge at Port Protection.

The shore line was surveyed on Prince of Wales Island and Kosciusko Island in three different sections. The first sheet was in the vicinity of Shakan Islands, beginning at the south limit of the topographic sheet of Shakan Bay, previously executed in 1886 on a scale of 1:20,000, and ending at the northern entrance point of Shipley Bay. On this sheet were entered all the outlying islands, rocks, and kelp patches visible during the progress of this work.

The second sheet began at the north limit of the sheet of Shakan Bay, and extended north along the shore line of Prince of Wales Island to the southern limit of the topographic sheet of Port Protection, previously executed in 1886 on a scale of 1:20,000. Sheet 3 began at the eastern limit of a previously executed topographic sheet of Point Baker by the steamer *Explorer* and extended along the north shore of Prince of Wales Island to Point Colpoys, excepting the shore line of Red Bay, which had already been surveyed on a scale of 1:20,000.

The result of these sheets has been to make continuous the detailed surveys of the shore line from Shipley Bay to Point Colpoys. The only exception in this entire stretch is the shore line of Labouchere Bay, which was omitted on account of a lack of present importance and the extremely foul condition of the entrance. A complete hydrographic survey of this bay is necessary before further work could be done. This party was not equipped to make such a survey economically in addition to the much more important work waiting to be done. The shore line was hence left until such time as a party should

be detailed for the survey of this bay, at which time the shore line could be run in conjunction with locating signals. The work could be readily joined to the topographic sheet executed by this party.

For the above surveys, triangulation and hydrographic stations were first established and located by triangulation. These signals were never more than 3 miles apart, so that short traverses only were necessary and frequent checks were obtained. The contours were cut in partly from shore and partly from the ship while anchored offshore. It was a simple matter to anchor in 100 fathoms or more, using the wire cable of the *King and Winge.*

These surveys were made at times when it would not interfere with the progress of the wire-drag work. The topographic parties consisted of two officers and one man, usually in a pulling boat with a detachable motor and tendered at times by the power schooner *King and Winge.*

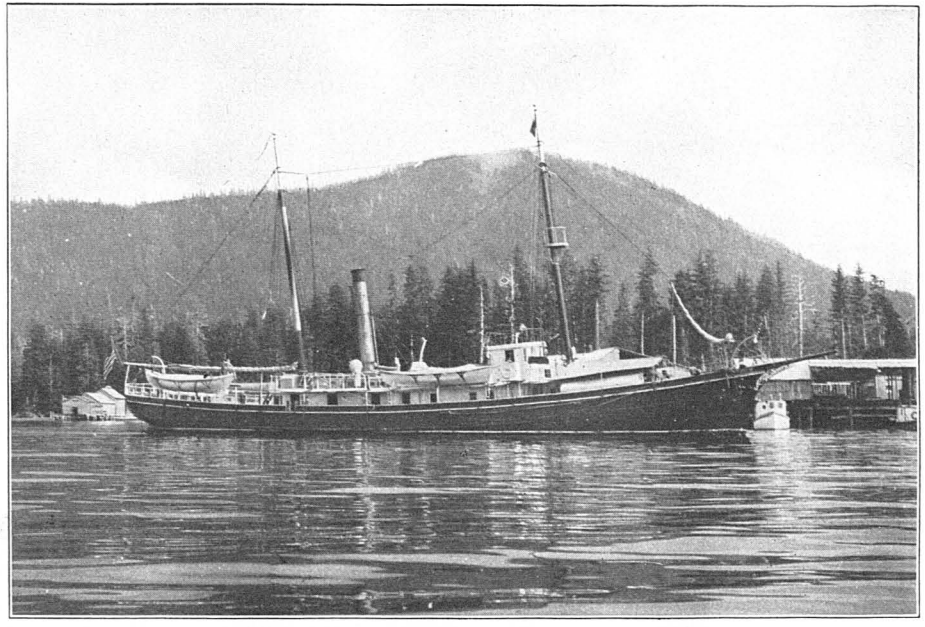
Beginning at base lines joining three stations of the work of J. M. Helm (1886), a scheme of triangulation was carried around Point Baker to a base between stations on Level Island and Point St. John on Zarembo Island. This scheme included as many of the old stations of the previous work in 1886 as could be recovered. Three sets of six repetitions " D & R " were made at each station and the results brought within the limit of secondary triangulation. In the last quadrilaterals observed the results were not quite as satisfactory, but weather conditions prevented further observations being made before the close of the season. These observations can be made when the work is taken up from this point another season.

Wire-drag party No. 4 resumed field work in Sumner Strait on April 19, 1916.

Signals were erected on the working grounds in the vicinity of Vichnefski Rock and on April 22 wire-drag work was begun in this section. On May 1 the party was transferred from the eastern to the southern end of Sumner Strait, and work was continued in that section until the 22d. On that date an accident to the machinery of the launch *Gony* made it necessary to tow the launch to Wrangell for repairs. During the remainder of the month work was continued at the eastern end of Sumner Strait. On June 10 the work at the entrance to Sumner Strait was resumed and was completed to the inshore limits along the western side of the strait as far as Cape Decision. Work in that locality was then discontinued and the party returned to the eastern end of the strait, where the work was in progress at the end of the month.

The hydrography consisted of the wire-drag examination. In the southern part of the strait the area covered consisted of the inshore work between Amelius Islands and Cape Decision, and a section west of Calder Rocks, in the space left between the limits of the previous season's work and a small area covered on the east side of the strait in the vicinity of Bluff Island. In the east part of Sumner Strait the area dragged extended from the previous season's work to a point 2 miles east of the entrance to Wrangell Strait.

During the progress of the dragging in the south end of Sumner Strait five shoals were found and a recently reported rock was definitely located. These shoals vary from depths of 18 feet to 53 feet and lie in the vicinity of Point St. Albans. In the eastern end of the work two shoals were located, one with 10 feet and the second



GEDNEY.

Composite steam vessel of 244 gross tons, 174 net tons; registered length 140 feet, breadth 23.8 feet, draft 8.4 feet; indicated horsepower 250; speed 9 knots; coal capacity 60 tons; complement 7 officers and 28 men. Built at New York, N. Y., in the year 1875. Condemned and sold on February 8, 1916.

with 32 feet. The location of these shoals was forwarded to the office June 6.

Two tidal stations were established. On the south end of the work an automatic tide gauge was erected at Pole Anchorage and observations made during the continuance of the work in this section. Later the gauge was removed to St. John Harbor on Zarembo Island, and observations have been continued since in that place.

A topographic survey was made of the southeastern shore of Kuiu Island from the vicinity of triangulation station "Cleve" to Point St. Albans, also from Port McArthur to Cape Decision, including Fairway Islands and the islands and reefs offshore. In the eastern end of the work a topographic sheet was completed, which embraced the northwestern shore line of Zarembo Island between Point McNamara and Point Craig, also the southern shore of Mitkof Island between Point Alexander and Station Island. This topography was controlled by frequent triangulation stations.

At the south end of the work the triangulation was carried from the limit of last season's work to a junction with three points of the work of Assistant E. F. Dickins in 1899. On the eastern end the work was advanced from last season's observations to a line joining Station Island with Point Craig. As a part of this scheme connection was made with three stations of the work of Assistant R. B. Derickson in 1910. The observations were made within the accuracy required for secondary triangulation. A number of prominent mountain peaks on Coronation, Warren, and Kosciusko Islands were determined, and their locations forwarded to Assistant F. H. Hardy of the steamer *Explorer* engaged in sounding offshore from the west coast of Dall Island.

[F. H. HARDY, Commanding Steamer *Gedney*.]

SUMMARY OF RESULTS.—Triangulation: 560 square miles of area covered, 41 signal poles erected, 36 stations in main scheme occupied for horizontal measures, 4 stations occupied for vertical measures, 34 geographic positions determined. Leveling: One-fourth mile of levels run, 3 permanent bench marks established. Topography: 184 square miles of area surveyed, 136.2 miles of general coast line surveyed, 5 topographic sheets finished, scales 1:20,000, 1:10,000, and 1:5,000. Hydrography: 87.5 square miles of area covered, 1,124.2 miles run while sounding, 10,576 angles measured, 25,157 soundings made, 3 tide stations established, 4 hydrographic sheets finished, scales 1:20,000 and 1:10,000.

At the beginning of the fiscal year the steamer *Gedney* was engaged in general surveys on the west coast of Prince of Wales Island. Progress to June 30 is stated in the annual report for the last fiscal year. Work was steadily prosecuted until October 21, when the vessel left Ketchikan for Seattle, arriving at that place on October 25.

The work accomplished during the season includes a survey of Bucareli Bay from area previously surveyed to Capes Bartolome and Felix to join work of the last season in Meares Passage.

Forrester Island, Wolf Rock, Cape Lookout, and prominent peaks on Dall Island were located by triangulation.

Port Real Marina from Bucareli Bay to the west end of Cone Island and Portillo Channel were surveyed, and also the hydrography west of San Juan Bautista Island to join with work done by the steamer *Gedney* in 1912 in San Alberta Bay.

In Bucareli Bay the work was extended to a line from Cape Felix to a point about a mile outside of Cape Bartolome. The inshore hydrography was done around Cape Felix and also some work outside of Meares Passage.

The sounding lines and soundings were spaced rather closely for the depth on account of the very irregular bottom along this section of the coast.

A close survey was made of Ports Dolores, Santa Cruz, Asumcion, and San Antonio, which was supplemented by going over the area with the wire drag. The drag was passed over all localities where there were indications of dangerous shoals.

The steam sounding machine installed in 1912 was used with satisfactory results.

In Port Real Marina the sounding lines were spaced 100 meters and soundings about 80 meters apart. All indications of shoals were developed with the hand lead, but no drag work was done. Some work was done with the launch *Cosmos* in Sea Otter Sound.

The hydrography of Portillo Channel was done on a scale of 1:10,000 using launch *117*. The lines were spaced 100 meters and soundings about 80 meters apart. Cross lines in the channel were also run. At the northern end of the sheet one day's work was done by the *Cosmos*.

In the passage west of San Juan Bautista Island the lines were spaced 200 meters apart and shoal indications were developed. This work was included, as the survey of this passage makes the chart of the locality complete. The passage may be used by steamers entering Bucareli Bay from the sea.

The matter of spacing sounding lines and soundings received careful study, and a formula was developed to determine the maximum distance in proportion to depth that may be safely used and its relation to cost of work.

The shore line of Ulloa Channel necessary to complete the charting of that locality was surveyed while the triangulation of Bucareli Bay was in progress.

With line Baptiste-Flores (work of 1907) as a base, the triangulation was carried down Bucareli Bay to Capes Felix and Bartolome, and numerous intersection stations were determined for the use of the topographer. The work was also extended to Forrester Island, Wolf Rock, and Cape Lookout, from which stations numerous mountains on Dall Island and the outside coast from Cape Addington to Cape Muzon, a distance of 40 miles, were determined.

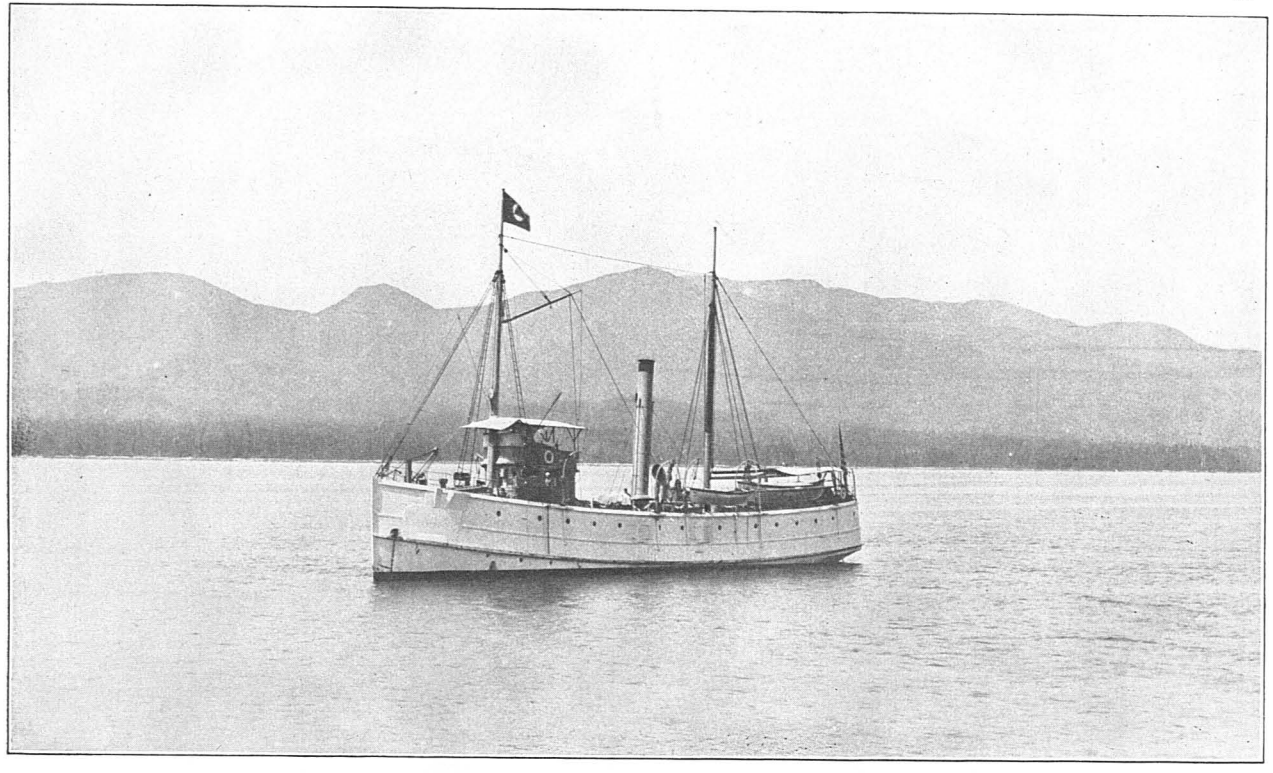
With the line Mond to Foul as a base, triangulation was taken through Port Real Marina to Sea Otter Sound.

[F. H. HARDY, Commanding Steamer *Explorer*, April to June, 1916.]

SUMMARY OF RESULTS.—Triangulation: 445 square miles of area covered, 19 stations occupied for horizontal measures. Topography: 46.1 miles of shore line surveyed. Hydrography: 556 square miles of area covered, 619 miles run while sounding, 1,981 angles measured, and 1,986 soundings made.

The party on the steamer *Explorer* left Seattle April 4, 1916, for Metlakatla, southeast Alaska, and left Metlakatla April 18 for the working ground on the west coast of Dall Island.

Field work was begun April 20 and was in progress at the close of the fiscal year.



McARTHUR.

Wooden steam vessel of 299 tons displacement, 220 gross tons, and 130 net tons; registered length 115 feet, breadth 20 feet, draft 12 feet; indicated horsepower 250; speed 8.5 knots; coal capacity 48 tons; complement 7 officers and 30 men. Built at the Mare Island Navy Yard, Cal., in the year 1876. Condemned and sold on February 8, 1916.

The work assigned to the *Explorer* for the season of 1916 was in Kaigani Strait and the outside coast of Dall, Baker, Suemez, and other islands. It was desired to complete the survey of the outside coast, harbors, and offshore work continuously from Cape Muzon northward.

By June 30 the offshore hydrography had been completed from Point Muzon to about latitude 55° 10′. The limit of the hydrography to the westward is the meridian of 133° 30′, approximately.

The shore line of Forrester Island and of Port Bazan had been surveyed.

The triangulation for the control of the topography and hydrography was practically completed from Point Cornwallis to Meares Passage.

[C. G. QUILLIAN, Commanding Steamer *McArthur*.]

SUMMARY OF RESULTS.—Triangulation: 54 square miles of area covered, 20 signal poles erected, 21 stations in main scheme occupied for horizontal measures, 34 geographic positions determined. Magnetic work: 3 land stations occupied for magnetic declination. Topography: 108 square miles of area surveyed, 192 miles of shore line of rivers surveyed, 7 miles of shore line of creeks surveyed. Hydrography: 107.4 square miles of area covered, 1,268 miles run while sounding, 9,631 angles measured, 22,689 soundings made, 2 tide stations established.

At the beginning of the fiscal year the steamer *McArthur* was engaged in general surveys in Sealed Passage, Tamgas Harbor, and the lower part of Felice Strait, using Ryus Bay, the nearest anchorage, as a base.

When the work was further advanced a base was selected on the west side of Cat Island, from which the remainder of Felice Strait was surveyed. A tide gauge was maintained here. This anchorage was poor and the holding ground unsatisfactory. The launch *Delta* could not find shelter in southwest breezes and at times had to seek shelter in Dog Bay, an additional three-fourths hour run.

Only sufficient triangulation was done to control the survey. The triangulation of 1914 controlled the area very well, and only supplementary work was required. Points were determined in Ryus Bay and a minor scheme extended through Cat Passage and joined to a minor scheme extended through Danger Passage. Points were also determined in Hassler Harbor.

About 241 miles of shore line were run. The shore line of Percy Islands was completed and a traverse was carried down the west shore of Duke Island to the limit of the sheet. The necessity of completing Felice Strait prevented the topography from being carried farther on Duke Island.

This sheet was controlled by plane-table triangulation. Several triangulation points on the sheet were occupied and cuts taken and resections made and all checked up closely before continuing the shore-line survey.

The shore line on the north shore of Duke Island, Pond Bay, Cat Island, Danger Passage, and the greater part of Reef Harbor was run. This work was done on the scale of 1:10,000 in order to connect with previous work done in 1892.

The south shore of Annette Island was resurveyed to correct a few minor inaccuracies.

Ryus Bay was resurveyed on a 1:10,000 scale to permit a closer hydrographic development. This bay, as now surveyed, forms an excellent and well-sheltered anchorage for small vessels, and may be used by vessels up to 200 feet in length.

The harbor is easy of access and, if frequented, a buoy placed on the shoal off Goose Tongue Island will render it accessible to strangers relying on the chart alone.

The topography along the east and north shores of Annette Island was completed and the hills contoured back to join with the work of 1914. The survey of Annette Island is now completed.

The shore line and contours along Revillagigedo Channel were completed to the limits prescribed by the instructions. The shore line of Mary Island was also resurveyed including Custom House Cove.

The party completed all of the hydrography laid out in the instructions for the season. In Sealed Passage the lines of soundings with the launch were laid out to split those of the 1892 work and thus to make the development fairly close. Channel lines were run, and one rock with 28 feet was discovered near the channel. This passage is not recommended for large vessels until dragged.

The ship developed an area beyond the limits of the launch work and made a search for Hassler Reef. Soundings were extended 2 miles southward as a reconnoissance. A portion of this region has very irregular bottom, and dangers may exist. Thick kelp was observed in the vicinity of the 3 and 4 fathom soundings some half mile southwest of Bee Rocks, and pinnacle rocks may be found in these kelp patches.

Hassler Reef does not exist in the vicinity charted, and no reef which bares was seen nearer than Bee Rocks.

The hydrography of Tamgas Harbor was completed to a junction with the work of 1914 and disclosed no great changes from the chart.

The entire area of Felice Strait was completed. Sounding lines were spaced from 175 to 300 meters and soundings spaced from 50 to 200 meters.

Pond Bay, Cat Passage, and Danger Passage were resurveyed on a 1:10,000 scale. Supplementary lines were run in Custom House Cove and Mary Island Anchorage, and a close development was made of the passages connecting Felice Strait and Revillagigedo Channel in the vicinity of Walker Island.

The inshore hydrography along Annette Island was completed and Hassler Harbor was resurveyed on a 1:5,000 scale, the same as that of the original survey.

A few lines were run on the north side of Bold Island.

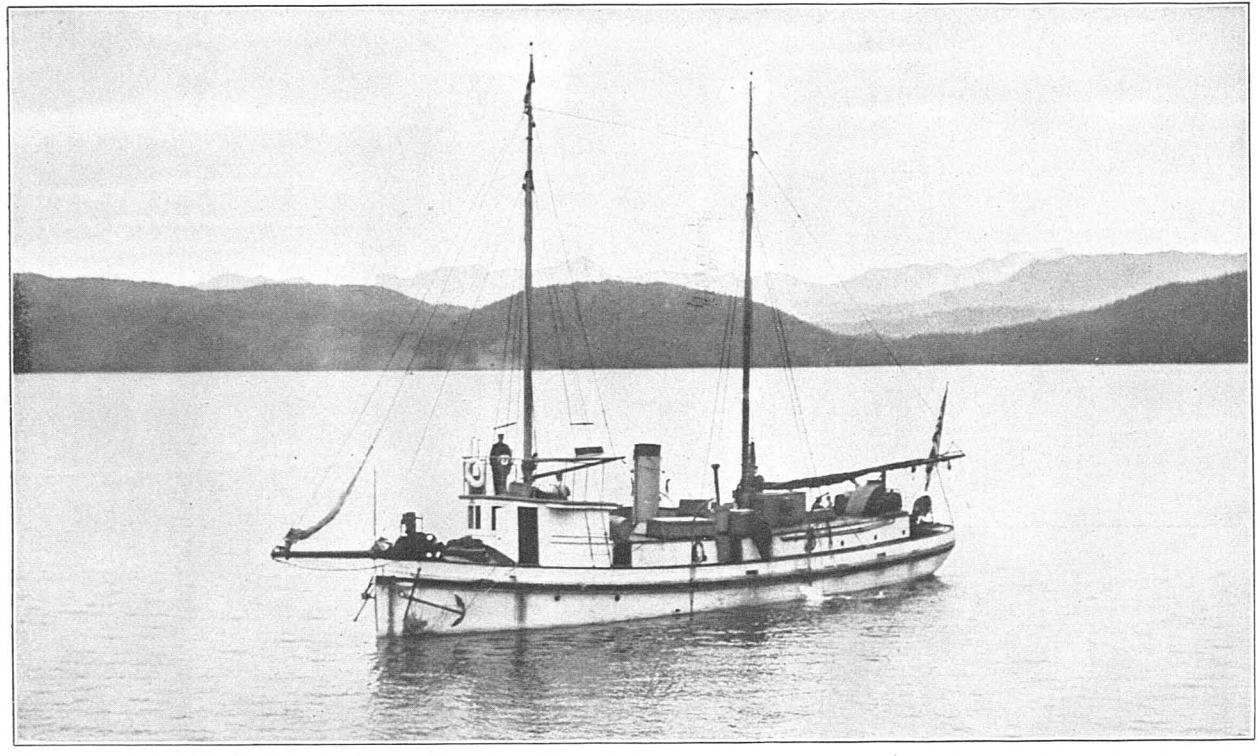
All soundings were carefully taken. When the sounding machine was used the vessel was brought to a stop and care taken to insure that the sounding wire was perpendicular. The soundings were spaced much closer than has been usual in the depths found.

An automatic tide gauge was maintained at Ketchikan as a base and staff gauges at Ryus Bay, Cat Island, and Hassler Harbor.

Work was closed for the season on October 16.

[C. G. QUILLIAN Commanding Steamer *Patterson.*]

SUMMARY OF RESULTS.—Triangulation: 260 square miles of area covered, 125 signal poles erected, 67 stations occupied for horizontal measures, 124 geographic positions determined. Magnetic work: 2 stations occupied for magnetic



TAKU.

Wooden steam vessel of 54 gross tons and 25 net tons; registered length 70.6 feet, breadth 16.5 feet, draft 5.5 feet; speed 6 knots; coal capacity 14 tons; complement 4 officers and 13 men. Built at San Francisco, Cal., in the year 1898. Present duty, general surveys in Prince William Sound, Alaska.

declination, dip, and intensity. Topography: 40 square miles of area surveyed, 150.3 miles of general coast line surveyed, 5 miles of shore line of creeks surveyed, 8 miles of shore line of ponds surveyed, scale of topographic sheets 1:20,000. Hydrography: 30 square miles of area covered, 309 miles run while sounding, 6,162 angles measured, 8,923 soundings made, 2 tide stations established, scale of hydrographic sheets 1:20,000.

After completing necessary repairs the steamer *Patterson* sailed from Seattle on April 5, 1916, for her working ground in Kashevarof Passage and Ernest Sound, Alaska.

The ship anchored in Port Chester on April 11, and the work of putting the launch *Delta* in commission was at once begun. This work was delayed by severe weather and by the death of a member of the crew which necessitated a trip to Ketchikan.

The vessel returned to Ketchikan, launched the *Delta*, and proceeded to Lake Bay, Alaska, on April 19. Surveying operations were begun with that port as a base, working through Kashevarof Passage.

A scheme of primary triangulation was extended through Kashevarof Passage to control the topography.

Three topographic sheets were laid out for Kashevarof Passage, the first covering the greater part of Whale Passage and Indian Creek; the second, Blashke, West, and Middle Islands; and the third, the lower part of Shrubby Island, the northern part of Thorne Island and adjacent shore. The second sheet comprises a mass of detail and small islets. The upper sheet takes the remainder of the passage to Point Colpoys and includes Bushy Island.

A topographic party was placed in camp at Exchange Cove early in May.

The *Patterson* went into Ernest Sound to prosecute the triangulation in localities that were to be dragged.

A subparty with the *Delta* and boats erected signals and made the necessary observations between Eaton Point and Zimovia Strait and in Seward Passage.

Another subparty erected signals and made the observations between Zimovia Strait and Eastern Passage.

The ship completed the triangulation from a line of Assistant J. A. Daniel's work of 1915 to join that of the other parties.

The triangulation up Ernest Sound was tertiary in character, and the positions required were furnished to wire-drag party No. 3.

The triangulation in Ernest Sound was in progress from May 8 to May 28. On the completion of this work the vessel returned to the vicinity of the Kashevarof Islands and during the remainder of the fiscal year was at work in that vicinity.

The camp in Exchange Cove was enlarged by a sounding party and a second topographic and triangulation party. The vessel made Lake Bay its headquarters and operated a sounding party and a topographic party.

The hydrography through the narrow portions of Kashevarof Passage was closely done, particularly where it was not intended to drag. Irregular bottom was found with strong currents and swirls.

An automatic gauge was placed at Lake Bay. One of the old bench marks was recovered, viz, a spike in a tree; the others were nails in the sill of the cannery and were lost when new sills were laid. Three permanent benches were established. A staff was main-

tained at Exchange Cove and permanent benches established, viz, marks cemented into rocks in place.

The tidal streams and currents through the narrower parts of Kashevarof Passage are quite swift, the launches making slow headway against them.

[A. J. ELA.]

On May 31, 1916, a field revision was begun of the Alaska Coast Pilot, Part I, from Dixon Entrance to Yakutat Bay, including the examination of several doubtful areas and uncharted rocks.

The officer engaged on this work traveled by the usual steamer routes and on chartered launches.

During the month of June the locations of 12 uncharted rocks and doubtful positions were determined, and other information obtained for the correction of the charts and sailing directions.

[GILBERT T. RUDE, Commanding Steamer *Taku*.]

SUMMARY OF RESULTS.—Triangulation: 22 square miles of area covered, 14 signal poles erected, 12 stations in main scheme occupied for horizontal measures, 20 geographic positions determined. Topography: 111 square miles of area surveyed, 94 miles of general coast line surveyed, 15.5 miles of shore line of creeks surveyed, 3½ topographic sheets finished, scale 1: 20,000. Magnetic work: 1 land station occupied for magnetic observations. Hydrography: 117 square miles of area covered, 965 miles run while sounding, 4,641 angles measured, 12,819 soundings made, 2 tide stations established, 2¾ hydrographic sheets finished, scale 1: 20,000.

At the beginning of the fiscal year the party on the steamer *Taku* was engaged on general surveys of Port Gravina, Prince William Sound, including topography and hydrography. The triangulation for the control of this work had been executed by the party on the *Taku* during the season of 1913.

An automatic tide gauge was kept in operation at Comfort Cove, and a continuous tidal record was obtained until the work at Port Gravina was completed on August 16. All soundings were referred to the datum plane obtained from this station.

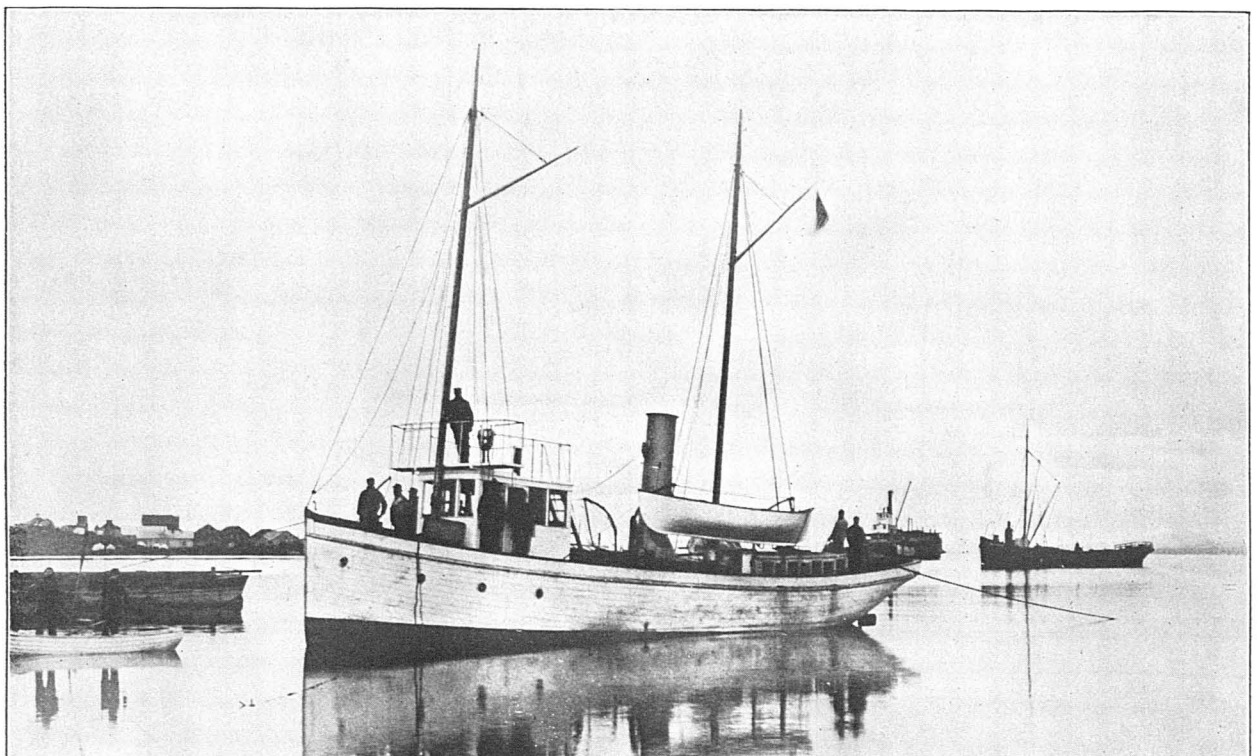
The topography of Port Gravina was done on two sheets on a scale of 1:20,000, with a contour interval of 100 feet. The topographic work was completed August 7.

The hydrography of Port Gravina was completed on August 20. This work was done on two projections (scale, 1:20,000), each covering the whole of Port Gravina, including Comfort Cove, Bear Trap Bay, Parsha Bay, Olsen Bay, and St. Matthews Bay, and extending well out into Orca Bay at the south end. One of these sheets was used by the steamer *Taku*, and the whole area was covered by the vessel except the portions close along shore and at the heads of the bays, which were done by the whaleboat party on the other projection.

The sounding was done with the ordinary hand lead, Bassnett pressure tubes, Tanner-Bliss pressure tubes, and the regular sounding sheave.

A special method was devised for drying the Tanner-Bliss tubes after sounding.

No aids to navigation have as yet been placed in Port Gravina and none are needed, unless in time this bay becomes more important commercially. It is used now by small craft only and the small



YUKON.

Composite steam vessel of 38 gross tons and 25 net tons; registered length 75 feet, breadth 15.7 feet, draft 5 feet; indicated horsepower 100; speed 7.5 knots; coal capacity 16 tons; complement 4 officers and 13 men. Built at New York, N. Y., in the year 1898, taken down and shipped in pieces to St. Michael, Alaska, and there assembled on the beach. The vessel is at present hauled out at King Cove, in the Alaska Peninsula, and will be used only as a tender for a larger vessel operating in that vicinity.

steamers of the Northwestern Fisheries Co. during the fishing season in that neighborhood, which is during the months of July and August.

The main channels of Port Gravina and its bays are clear, with the exception of a rock in mid-channel in Bear Trap Bay and a shoal making well across the mouth of St. Matthews Bay. Attention is called to these and to other reefs, shoals, and foul areas in the descriptive report accompanying the boat sheets of this work. This has been submitted and will not be repeated as a part of this report.

The work in Port Gravina having been completed, on August 19 camp was broken at Comfort Cove and on the 20th the *Taku* ran to Snug Corner Cove. On the 21st the party ran to Fish Bay and established a camp for the use of the topographic and triangulation party, which was to begin this part of the work in Port Fidalgo while the party on the *Taku* was executing the hydrographic work from Red Head to Knowles Head.

The topographic work between Red Head and Knowles Head was done mainly to locate signals for the use of the steamer on hydrographic work. Very little contouring was done as the chart showed that the contouring in this vicinity had been done by a previous party. The work was done on a scale of 1:20,000.

The triangulation for this work was done by the party on the *Taku* in 1913 and by a former party which located stations Knowles and Red Head.

The hydrography was executed from August 28 to September 8 by the *Taku* on a scale of 1:20,000. No whaleboat work was done. The sheet extends from the shore on the north to the 50-fathom curve on the south and on the west from a line south (true) from station Knowles on Knowles Head to a junction on the east with the hydrographic sheet of Port Gravina.

The bottom is very regular, sloping gradually from 3 to 5 fathoms along the shores out to 50 fathoms. The same method of survey was used as on the Port Gravina work, ordinary hand lead, Tanner-Bliss pressure tubes, and sounding sheave.

A plain tide staff was erected in Snug Corner Cove and connected by a checked line of levels with bench marks established in 1902 and again used in 1905. A tidal plane was established in Fish Bay by observations simultaneous with the staff in Landlocked Bay, established by the party on the *Taku* in 1913. Simultaneous observations were then made between Fish Bay and Snug Corner Cove. These observations give a datum plane at Snug Corner Cove about a mean between the other two previously determined.

No rocks or shoals dangerous to navigation exist within the limits of this sheet. This area is reported on in detail in descriptive report accompanying the boat sheet of this vicinity and will not be repeated here.

While the *Taku* was engaged on the hydrographic work between Knowles Head and Red Head, a subparty worked from a camp in Fish Bay, extending the triangulation up Fidalgo Bay from the line Fish-Irish, determined by the party on the *Taku* in 1914.

The observations for this were begun August 28 and completed September 9 and a system of quadrilaterals carried from the scheme of 1914 to the head of the bay.

The topographic work was done on one projection on a scale of 1:20,000. This work was begun on September 11 and completed on September 29. It covers the whole of Fidalgo Bay and surrounding country from a line between Fish Bay and Irish Cove on the south to the head of the lagoon at the head of Fidalgo Bay. The contour interval is 100 feet.

The shore line is rocky except at the heads of the bays along the flats, where it is low and marshy.

The sounding extends from a junction with the work of the *Taku* executed by Assistant H. P. Ritter's party to the head of Fidalgo Bay, including Whalen Bay. It is controlled by the triangulation stations and signals located by the topographic party while that work was in progress.

Fidalgo Bay is deep throughout its length and from shore to shore, ranging from 50 to 100 fathoms. Near its head it shoals quickly from 50 fathoms to 15 and 20 fathoms, sticky bottom, affording a good anchorage for all size craft. This shoaling is probably due to the depositing of silt brought down the valleys by the many glacier streams.

A plain tide staff was erected in Fish Bay, on which a datum plane was established by observations simultaneous with Landlock Bay station, established in 1914 by the party on the *Taku*.

One triangulation station, Lor, near the head of Fidalgo Bay, was occupied for magnetics with declinometer No. 8 for magnetic variation.

The hydrographic work in Fidalgo Bay having been completed, the topographic party was left in camp in Fish Bay to complete the topography of Fidalgo Bay, and the other members of the party began the reconnoissance for extending the triangulation from Valdez Arm to Columbia Bay on September 27.

This work was handicapped by bad weather and little progress made. A station was marked on Bushy Island and other points visited with the steamer, but landing was impossible on account of heavy southeast swells. Nevertheless a tentative scheme of triangulation was laid out.

On September 30 all work having been completed in Fidalgo Bay and the season too far advanced for further work to the westward of Valdez Arm, the party left Fish Bay for Cordova.

From this date to October 6 the officers and crew were engaged on inventories and work preparatory to laying up the steamer for the winter.

The small boats were hauled out at Orca and put in a shed; and launch *39* was hauled out on a gravel beach near the winter moorings of the *Taku*, jacked up above high water, and securely moored and covered with old canvas sails and tents.

The party left Cordova on the steamer *Alameda* on October 6 and arrived in Seattle October 12. The crew was discharged October 13.

When opportunity offered during the season the chart agencies at Cordova and Valdez were inspected and reports made thereon.

During the season data for the coast pilot and chart divisions were obtained whenever possible.

A detached survey was made at Orca, locating the dock and sufficient signals for sounding work which was done around the dock.

When the trip was made to Valdez by launch to inspect the chart agency the docks at that place were measured, sketches of them made, and soundings taken along and off the faces of the docks.

In addition to the above, data were obtained from masters of vessels regarding other docks on Valdez Arm and in Hobo Bay up Port Wells.

In the course of the season's work it became necessary to build special platforms for the automatic tide gauge. Two forms of support were devised—one, for soft bottom, consisted of long poles driven into the bottom upon which the structure was built; the other, for rocky bottom, was a crib of poles and scantling weighted by bags of sand and gravel.

A pipe line was constructed from a water supply on shore to furnish water directly into the tanks of the steamer.

[R. S. PATTON, Commanding Steamer *Explorer*.]

SUMMARY OF RESULTS.—Base lines: 1, secondary, 297.431 meters in length. Triangulation: 53 square miles of area covered, 10 signal poles erected, 8 stations in supplemental schemes occupied for horizontal measures, 6 geographic positions determined. Leveling: 0.3 mile of levels run, 5 permanent bench marks established. Azimuth: 1 azimuth station occupied. Magnetic work: ship swung at one station at sea. Topography: 60 square miles of area surveyed, 87.8 miles of general coast line surveyed, 3 topographic sheets, scales 1:20,000 and 1:2,500, finished. Hydrography: 2,415 square miles of area covered, 3,452.9 miles run while sounding, 7,317 angles measured, 14,260 soundings made, 3 tide stations established, 1 current station occupied. 7 hydrographic sheets finished, scales, 1:120,000, 1:60,000, 1:20,000, 1:10,000, and 1:2,500.

At the beginning of the fiscal year the steamer *Explorer* was engaged in the survey of the approaches to Cook Inlet, Alaska. Progress made during June is stated in the last annual report.

The work contemplated by the instructions to this party included: First, and most important, the hydrography from a line between Pye and Marmot Islands and from the shores southward to deep water in latitude 50° 40′, thence westward through the pass between the Chugach and Barren Islands to longitude 153° and north to the latitude of Seldovia; second, the topography and inside hydrography from Port Graham to Point Gore; third, a search for two shoals of doubtful existence shown on the chart south of the Barren Islands; fourth, additional surveys in Port Graham and Port Chatham.

Of the above work the following was accomplished: The general ship work within the limits mentioned was completed, including a search for the break (existence doubtful) shown on the chart 10 miles south of East Chugach Island and for the 13 and 17 fathom soundings east of the Barren Islands. The topography was carried from Port Graham to the point at the southern entrance to Windy Bay, including the survey of the three islands of the Chugach group. The inshore hydrography was carried from Port Graham to the western end of East Chugach Island, and, in addition, Gore Rock was located and developed. Sufficient triangulation was done to determine one station at the western entrance to Port Dick, such a station being essential as an initial point for the topographic surveys in the vicinity. Additional detailed work was done in Port Graham and Port Chatham.

The inshore hydrography was done by both ship and launch working in conjunction, the strong currents and rough water making it impossible to use pulling boats or outboard motors on this work.

The sounding by the ship in all depths of over 20 fathoms was done by means of pressure tubes, up and down soundings being taken with sufficient frequency to furnish a check as to the accuracy of the tubes.

The topography and launch hydrography were done in the usual manner.

The launch was equipped this year with a steam sounding machine which gave excellent results.

On September 30 the *Explorer* sailed from Seward on her return south.

Chart agencies at Haines and Juneau were inspected on October 3 and 4, respectively, and the vessel arrived at Seattle on October 9.

[R. R. LUKENS, Commanding Steamer *Yukon*.]

SUMMARY OF RESULTS.—Traverse: 22 miles of traverse line run. Triangulation: 100 square miles of area covered, 18 signal poles erected, 2 observing tripods and scaffolds built, 12 stations in main scheme occupied for horizontal measures, 14 geographic positions determined. Leveling: 2.5 miles of levels run, 4 permanent bench marks established. Magnetic work: 3 land stations occupied for magnetic declination. Topography: 22 miles of general coast line surveyed, 2 topographic sheets finished, scale 1:20,000. Hydrography: 64 square miles of area covered, 398.6 miles run while sounding, 1,668 angles measured, 8,102 soundings made, 5 tide stations established, 9 current stations occupied, 2 hydrographic sheets finished, scales 1:20,000 and 1:200,000.

The party for the survey of the Kuskokwim River was landed at Goodnews Bay, Alaska, by the steamer *Alliance* on June 22, 1915. All of the freight intended for the steamer *Yukon* was put on shore on the morning of the 23d, and on the following day the *Alliance* left Goodnews Bay for Bethel.

H. A. Cotton was detailed to accompany the *Alliance* to Bethel and from there to proceed up the river on the steamer *Quickstep*. He was instructed on this trip to make a running survey of the river and to collect all available information concerning the geography and commercial aspects of the country. This duty was well performed.

While on the way to Bethel, Mr. Cotton navigated the *Alliance* through the complicated channels of Kuskokwim Bay and River delta and up Eek Channel by means of three-point fixes on the distant mountains.

The main party at Goodnews Bay immediately made preparations for launching the *Yukon*. The *Yukon* was put in the water on the morning of June 28, and on July 2, everything being in readiness, the vessel sailed for Apokak. A stop was made at Carter Spit, where a large beacon was built to be used for navigational purposes. By means of this beacon a position may be obtained near the entrance of Eek Channel in hazy weather, when the mountain peaks are invisible.

The *Yukon* arrived at Apokak at noon on July 3, and after landing supplies, coaling ship, etc., active survey work was begun on July 6. Hydrographic work in the West Channel abreast Eek Island was first taken up. Rainy weather prevailed, but the work was continued until July 24, when it was dropped to take up the

precise traverse, 22 miles in length, connecting the Eek Island and Goodnews Bay triangulation schemes.

This traverse covers a shore line that is almost inaccessible owing to the extensive mud flats making out into the bay. It is only on the higher tides that even a dory can get near the shore. Advantage was taken of the higher tides during the month to land lumber for the signals to be used in carrying along the azimuth of the traverse. A large tower signal was built on Warehouse Bluff to be used also as an aid to navigation.

During the greater part of the work the *Yukon* was anchored in Warehouse Creek, the traverse work being carried in both directions from there. The lower end of the work was done from a camp at Quinhagak, the party being transported there and back by the steam launch *Alpha*. The channel off Quinhagak appears to be shoaling as it was difficult to take the *Alpha* into the Kanektok River, while it is said that in years past good-sized schooners have gone into the river here.

The traverse was completed on August 9. It proved to be a more difficult task than had been anticipated. Several deep tidal sloughs were encountered, and much of the line ran over soft or marshy tundra.

The results of the traverse showed the Eek Island datum to be somewhat in error, but not enough to affect navigation. The azimuth as carried from Goodnews Bay and from Apokak varies only by seven seconds, there being 80 miles of traverse and triangulation involved.

Upon the completion of the traverse, hydrographic work in Eek Channel was begun. The upper part of this channel for a distance of 5 miles was developed and the crossover to the West Channel was closely surveyed. This crossover was marked by a range constructed on the west bank at Popokamute. In order to use the large tower signal as a front mark two tripods were erected as rear marks, each equidistant from the range line. This range proved very effective, being easier to follow than the usual type where the low mark is in front. This crossover has been a difficult one to navigate, but with the present ranges the difficulty is much lessened.

On August 15 the Warehouse Channel was developed as far as Quinhagak. This work is controlled by distant mountain peaks, and perfectly clear weather is required to see them. The Warehouse Channel is not a practicable one for entering the river but is often used by vessels desiring to discharge cargo for Quinhagak.

During the present year the power schooner *Ruby* discharged cargo at Quinhagak, then crossed over to Eek Channel at high water, and proceeded up the river by that channel.

On August 19 the *Yukon* proceeded to Bethel, where certain condemned property was sold.

The *Yukon* was taken by an old native pilot through the channel along the east side of the river just above Eek Island. There seems to be a good channel here, but the pilots are not very familiar with it. The track of 1914 was then followed until Fowlers Slough was reached, where a channel just outside the island was followed.

On August 29 the *Yukon* with the *Alpha* in tow proceeded to Goodnews Bay, and on September 6 was convoyed by the steamer *Patterson* to Kings Cove, being delayed by stormy weather en route.

The *Yukon* and *Alpha* were laid up at this place, and on October 3 the party took passage for Seattle, arriving on the 23d.

[H. A. COTTON.]

A reconnoissance of the Kuskokwim River above Bethel was made in July, 1915, by H. A. Cotton, who was detailed for that purpose from the party on the steamer *Yukon*.

Transportation was furnished by the river steamer *Quickstep*, which is operated during the summer freighting supplies up the river from Bethel, the head of deep-water navigation and the main supply point for the whole river valley.

A reconnoissance survey of the river as far as Bethel had been made by the party on the steamer *Yukon* in 1914, connecting that point with the surveys at the mouth of the river. The object of the reconnoissance in 1915 was to carry the reconnoissance up the river as far as McGrath, and to gather such information as might be useful for navigation and for mapping the upper part of the river.

Using Bethel as a starting point a traverse was carried up the river to be checked by such geographic positions as could be determined during the journey or secured from other sources.

Upon the traverse as a framework the shore line of the river and adjacent topography were sketched by noting bearings and distances to prominent points. Heights of peaks were estimated or roughly determined by angles of elevation when an approximate distance could be secured.

A full report was submitted describing the river and tributaries and the region through which it flows, as far as the examination extended.

The Kuskokwim is navigable for steamers drawing not more than 4½ feet for 600 miles above its mouth.

[EDGAR E. SMITH, Commanding Steamer *Taku*.]

SUMMARY OF RESULTS.—Triangulation: 5 signal poles erected. Leveling: One-fourth mile of levels run. Topography: 8 square miles of area surveyed, 15 miles of general coast line surveyed, 12 miles of roads surveyed, 2 topographic sheets partly finished, scale 1:20,000. Hydrography: 22.5 square miles of area covered, 344.9 miles run while sounding, 1,829 angles measured, 12,703 soundings made, 2 tide stations established, 4 hydrographic sheets begun, scales 1:80,000 and 1:20,000.

In April, 1916, a party for the *Taku* was organized at Seattle. One officer and two men of this party arrived at Cordova, Alaska, on April 25, and at once began to prepare the vessel for the season's work. The chief and other members of the party arrived at Cordova April 29.

During May the *Taku* was overhauled and repaired, a camp was established on Orca Island, an automatic tide gauge erected and connected with bench marks by leveling, and field work was begun.

After the first week in June good progress was made. A week was spent on a reconnoissance as far as Kokenhenic. Three days of this time were spent in a search for a channel in the stream from Kokenhenic to the railroad bridge at Alaganik. This examination was made at the request of the local cannery company. It was found that the desired channel does not exist.

An automatic tide gauge was established at Cape Whitshed, and a continuous record was obtained from the middle of May to the close of the fiscal year.

In Orca Inlet all triangulation stations were readily found, but none of those established in the delta flats could be discovered. It was accordingly arranged to extend the triangulations over the flats.

On beginning the sounding it was necessary to do first that work which would enable the *Taku* to pass freely from one part of the working grounds to another. The hydrography done during the first part of the season therefore extends along the channels from Cordova to Alaganik Slough and to Boswell Bay, but the development in those places was not completed.

At the request of the War Department a topographic survey was begun of the military reservations at the head of Orca Inlet.

[H. C. DENSON, Commanding Steamer *Patterson*.]

SUMMARY OF RESULTS.—Base lines: 1, length 1,188 meters. Triangulation: 400 square miles of area covered, 44 signal poles erected, 22 stations occupied for horizontal measures, 46 geographic positions determined, 6 stations occupied for vertical measures, 32 elevations determined. Magnetic work: 2 land stations occupied for magnetic declination. Topography: 40½ square miles of area surveyed, 105 miles of general shore line surveyed, 48½ miles of shore line of ponds surveyed, 4 topographic sheets finished, scales 1:5,000 and 1:20,000. Hydrography: 1,339 square miles of area covered, 2,618½ miles run while sounding, 15,660 angles measured, 17,711 soundings made, 1 tide station established, 5 hydrographic sheets finished, scales 1:50,000; 1:20,000 and 1:10,000.

The *Patterson* sailed from Port Townsend for Alaska on June 3, stopped at Ketchikan for coal and supplies, and arrived at Kodiak on June 15. The voyage to the Shumagin Islands was resumed the following day.

A stop of two days was made at Whale Island Pass to locate a rock reported by the steamer *Santa Ana*. After this work was accomplished the vessel proceeded to Mist Harbor, Nagai Island, Shumagin Group, arriving there on the afternoon of June 21. The vessel was anchored for the remainder of the month in Mist Harbor, all hands being employed in establishing a camp for the shore party.

Between July 1 and 19 trips were made to different islands of the group transporting signal building and reconnoissance parties.

During the interval from July 20 to 28 the vessel made a voyage to and from Unalaska, a distance of 520 miles, remaining at that point three days to obtain coal and clean boilers.

On returning to the working grounds the weather conditions were unfavorable for offshore hydrography until July 21, but from that date until August 25 the vessel was constantly engaged in this work.

On August 26 the *Patterson* left the Shumagin Islands for Goodnews Bay, via Unalaska for coal, to convoy the steamer *Yukon* to Isanotski Strait. Unfavorable weather conditions were encountered during the trip and at Goodnews Bay, where the vessel was delayed for three days.

On September 6 the *Patterson* and the *Yukon* left Goodnews Bay. Bad weather was encountered on September 8 when within 10 miles of Isanotski Strait.

When the *Yukon* had safely passed over the bar into protected waters the *Patterson* proceeded to Unalaska, arriving September 9,

and thence to the camp site in the Shumagin Islands, arriving September 16.

The vessel was engaged in offshore hydrography from October 1 to 5. On October 6 and 7 the camp equipment was brought on board, and the vessel sailed for Kodiak, via Uyak Bay, on the morning of October 8.

On October 10 an investigation was made of Harvester Island Spit where the steamer *Bertha* had grounded.

On the way from Uyak Bay to Kodiak observations were made to investigate reported magnetic disturbances in Kupreanof Strait. No indications of such disturbances were found.

The *Patterson* left Kodiak October 18 and arrived at Seattle November 8.

The triangulation done during the season was confined to the Shumagin Group, that on the adjacent mainland having been completed during the preceding season. After signals had been erected over the selected points in the main scheme weather conditions became such that no observations on the longer lines could be made. Consequently an auxiliary base of 1,100 meters was measured and connected with one of the lines of the previous season's work, thus furnishing data for use by the topographic and inshore hydrographic parties. All stations were permanently marked, and sufficient geographic positions were determined to permit the continuation of next season's work without delay. The positions of all of the principal mountain peaks in the Shumagins have been determined.

Topographical work was completed on the east coast of Nagai Island from Cape Wedge to a point 5 miles south of East Bight and on Peninsula Island, Spectacle Island, Bendel Island, Turner Island, and the greater portion of the west shore of Big Koniuji Island. This work was accomplished under difficult conditions, the shore line being very precipitous and landing difficult.

The inshore hydrography is complete along all of the coast surveyed, with the exception of Turner Island, which remains to be done. Many anchorages were developed, but Mist Harbor is the only protected one falling within the area surveyed.

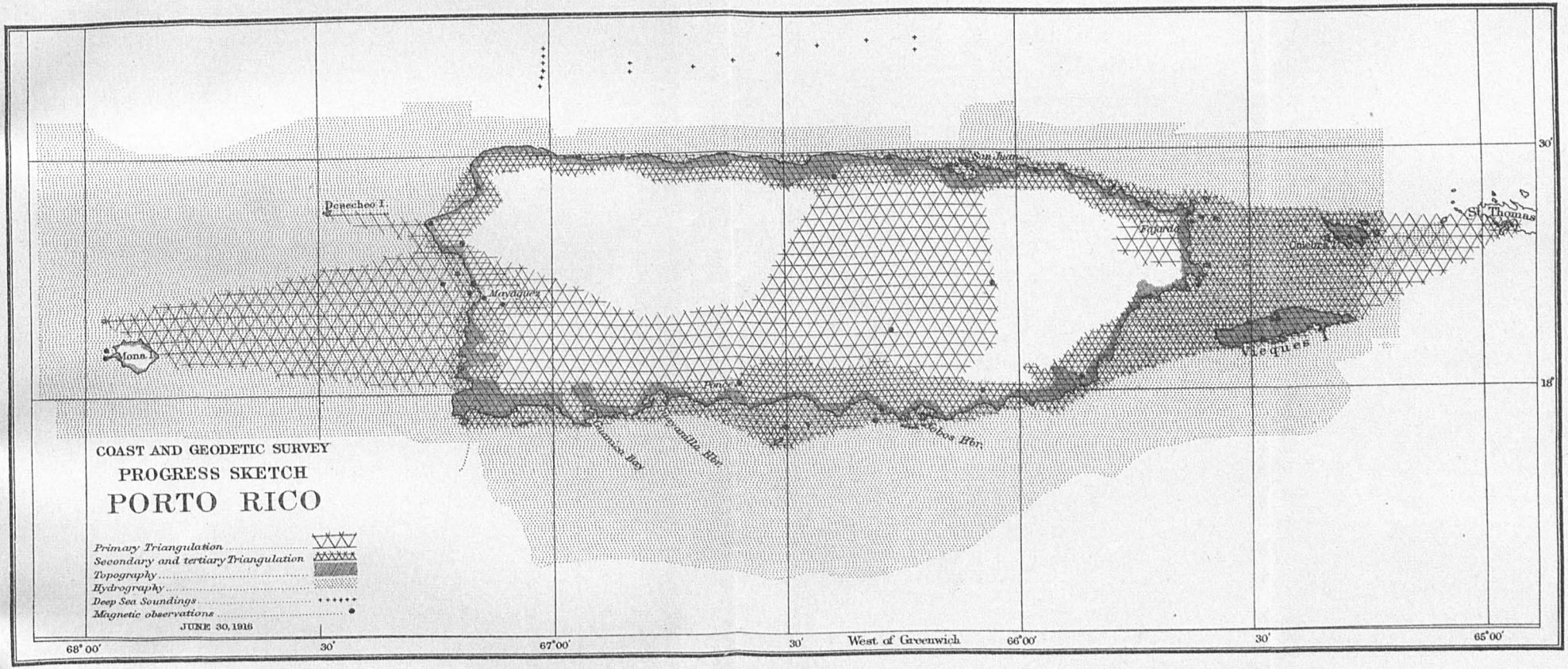
The offshore hydrography covers the area between the Shumagins east of Nagai Island and the main land as far east as Chiachi Island. Sufficient points determined during the previous season were available for this work.

An area of 1,227 square miles was developed without finding any obstructions to navigation. The depths range between 30 and 100 fathoms, and soundings were spaced according to the depths and the character of the bottom. Bassnett pressure tubes were used in this work up to depths of 90 fathoms. For greater depths the vessel was stopped and up and down casts were made. The submarine sentry set at 20 fathoms was towed during the entire time that the ship was employed on this work and at all other times while cruising among the islands.

In order to tow the sentry while using the pressure tubes, an outrigger with proper pulley arrangements was placed on the starboard quarter, and the towing wire leading to the sentry thus cleared the sides of the vessel about 6 feet, so that fouling with the sounding wire was avoided.

No. 46.

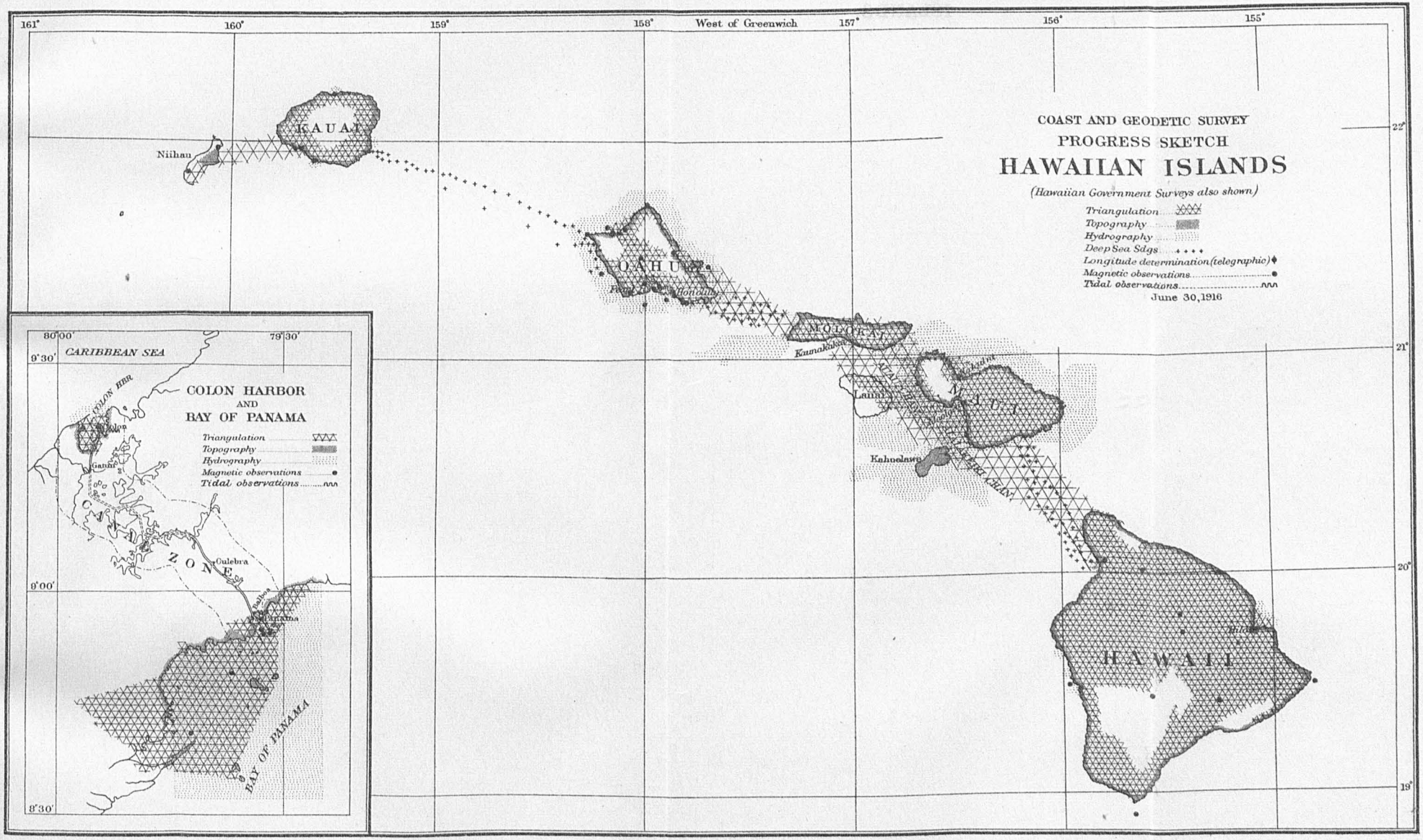
PROGRESS SKETCH, PORTO RICO.



House Doc. 1489; 64th Cong., 2d Sess.

No. 47.

PROGRESS SKETCH, HAWAIIAN ISLANDS.

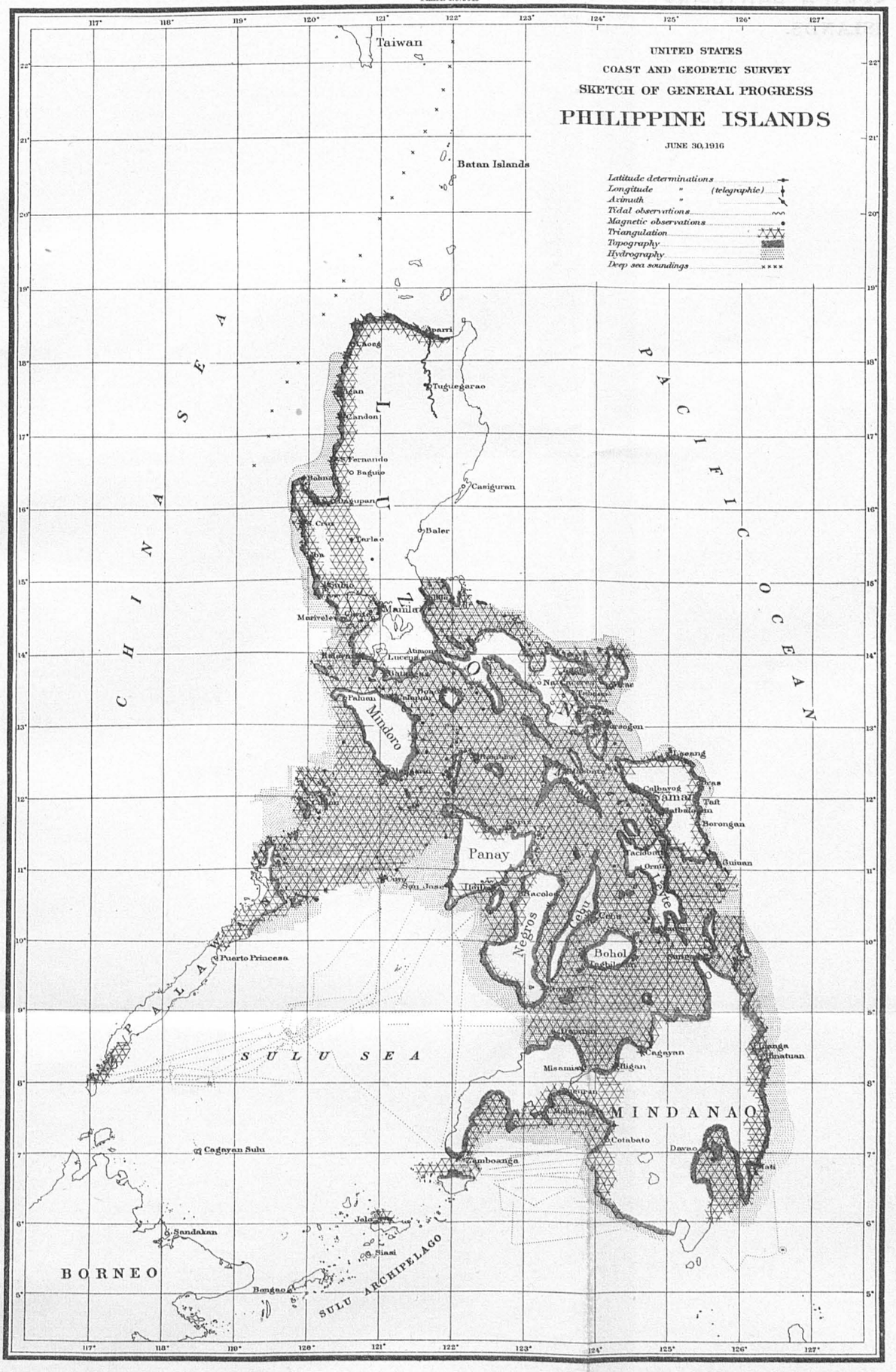


House Doc. 1489; 64th Cong., 2d Sess.

No. 48.

PROGRESS SKETCH, PHILIPPINE ISLANDS.

PLATE No. 2949



House Doc. 1489; 64th Cong., 2d Sess.

A search was made for a reported kelp patch surrounded by 22 fathoms or more of water off the north coast of Unga Island. No kelp or other indication of shoal water was found.

A development of the area about Tuscarora Rock, Unalaska, was made. Investigation of the spit extending from Harvester Island, Uyak Bay, and development work in Whale Island Pass, Kupreanof Strait, were parts of the work done during the season.

Unsurveyed anchorages in the Shumagin Islands were visited, including Northeast Harbor, Sandy Cove, Northwest Harbor, Little Koniuji Island, and Yukon Harbor, Big Koniuji Island.

An automatic tide gauge was established at Mist Harbor, and a continuous record for three months was obtained.

In order to avoid the necessity of taking water aboard in small boats, a water-supply system was arranged by damming a small stream and building a pipe line which could be connected with a hose from the vessel. Taking water in this way obviated running the evaporator and resulted in a saving of coal.

An economical method was devised for coaling ship, by means of which much time and labor were saved.

Through the recommendation of the inspector at Seattle a whaleboat was fitted with a motor and proved to be the most serviceable and economical of all the motor boats carried by the *Patterson*.

[J. W. GREEN.]

The usual observations were continued without interruption during the year with the photographic recording instruments at the magnetic observatory at Sitka.

Absolute observations, consisting of three sets of declination, two sets of dip, and the regular double set of horizontal intensity, were obtained on one day of each week. Time observations from noon transits of the sun were obtained when practicable.

Eleven magnetic storms were recorded during the year, six of greater and five of less intensity.

The seismograph was kept in constant operation throughout the year, and 19 earthquakes were recorded, all of small magnitude.

Arrangements were made for the erection of a new office and residence building for the observatory.

PORTO RICO.

[HAROLD W. PEASE.]

At the magnetic observatory at Vieques, P. R., a continuous record has been obtained from the magnetograph and seismograph.

Absolute observations were made twice each week. Scale-value observations were made at least once each month. Time observations were made about once in 10 days.

Twenty earthquakes of slight intensity were recorded during the year.

Necessary repairs to the observatory property have been made, and a house for the maximum and minimum thermometers has been constructed.

HAWAII.

[WM. WALTER MERRYMON.]

The usual magnetic, seismographic, and temperature variation observations have been recorded continuously during the year at the magnetic observatory at Ewa, Hawaii.

The regular routine work of the observatory had been attended to, including the work of keeping the recording instruments in operation, taking weekly absolute observations of the magnetic components, caring for the observatory property, and keeping up the usual reports and correspondence.

During the year, 24 magnetic storms and 139 earthquakes were recorded.

Meteorological observations were made twice daily and sun altitudes for time about four times each month.

PHILIPPINE ISLANDS.

[W. C. HODGKINS, Director of Coast Surveys, July 1, 1915, to March 1, 1916; Fremont Morse, Director of Coast Surveys, March 2 to June 30, 1916.]

No change was made during the year in the general plan of cooperation between the United States and the Philippine government, and the division of expenses has continued as in previous years. In effect the Federal Government pays about two-thirds of the expenses incidental to the work and the Philippine government one-third. The appropriations made by the Philippine Legislature now cover a fiscal year that is identical with the calendar year, so that the period covered by this report comes under two different Philippine appropriations. Both of these were liberal in amount, especially when the local conditions due to the European war are considered.

The steamers of the Survey were actively engaged during most of the year, being absent from the field only for the purpose of renewing coal and other supplies and having the necessary repairs made, except that the *Fathomer* was laid up owing to lack of funds during October, November, and December.

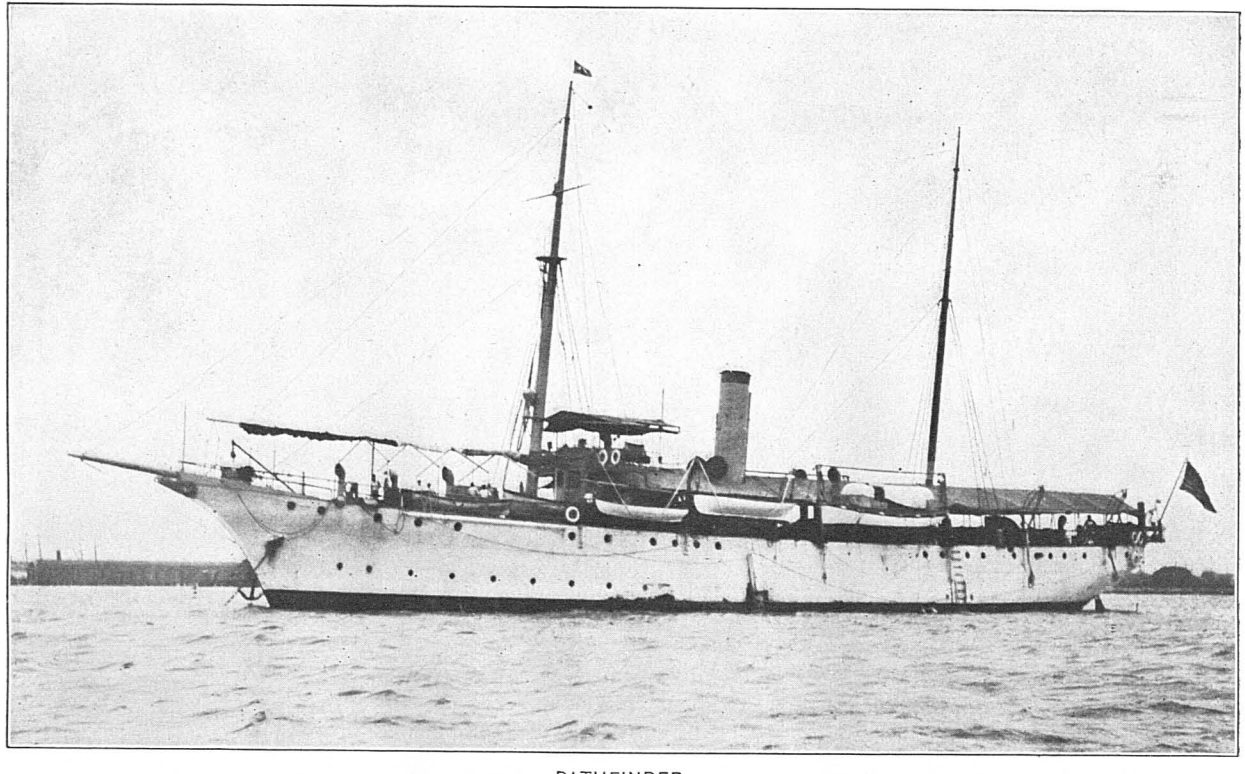
The work of the Manila office was conducted by the director, the chief clerk, and the chiefs of the four divisions of the office force.

The computation and adjustment of the triangulation, the reduction of soundings and tidal observations, and the registration and classification of the records of the triangulation, hydrography, and tides were continued. Information required for the use of field parties and for other purposes was supplied.

The automatic tide gauge at Manila was kept in operation.

The work of collating the work of the field parties engaged on topography and hydrography in order to produce charts needed for the use of navigators was continued. After the completion and verification of the drawings for such charts, tracings are made and sent to the office at Washington for publication and issue.

The collection and preparation for publication of all kinds of nautical information was continued. The collection, compilation, and preparation of topographic information concerning the interior of the islands were continued in the geographical division. One new



PATHFINDER.

Steel steam vessel of 875 tons displacement, 690 gross tons, and 469 net tons; registered length 168 feet, breadth 33.6 feet, draft 13 feet; indicated horsepower 846; speed 12.6 knots; coal capacity 240 tons; complement 15 officers and 70 men. Built at Elizabeth, N. J., in the year 1899. Present duty, general surveys in the Philippine Islands.

lithograph map, No. 15, Cebu and Bohol, was published, and drawings for map No. 8, Southern Luzon (central sheet), were sent to Washington for publication. Progress was made in the compilation of a number of other maps of this series.

[R. B. DERICKSON, Commanding Steamer *Pathfinder*, July 1–16, 1915.]

SUMMARY OF RESULTS.—Triangulation: 2 stations occupied for horizontal measures. Topography: 9.8 miles of shore line surveyed. Hydrography: 112.6 square miles of area covered, 4,603 soundings made, 2 tide stations established.

At the beginning of the fiscal year the steamer *Pathfinder* was engaged in a survey of San Bernardino Straits and approaches, the principal object of which was to determine the existence or nonexistence of a reported 3-fathom rock 1.4 miles south-southeast of San Bernardino Island, and said to have been struck by the United States Army transports *Sherman* and *Dix* while entering the straits south of San Bernardino Island.

Six stations of the former triangulation were recovered, and three additional points were determined for control of the hydrography.

A tide staff was erected at the boat landing on San Bernardino Island, and tide observations were recorded from June 9 to July 16.

An area 18 square miles was closely developed by lines of soundings spaced approximately 100 meters apart, and no dangers were found in this area other than those adjacent to San Bernardino Island.

The survey covers in all an area of 112.6 square miles. The most important discovery was a 4-fathom rock six-tenths mile east of San Bernardino Light.

A channel 350 meters in width with 9 fathoms of water separates this rock from the rocks adjacent to the coast of the island. A sharp rock with 6 fathoms over it was discovered 1½ miles northwest of Biri Head. This rock is surrounded by 32 fathoms. The limits of the surveyed area extend three-tenths mile inshore from the discovered pinnacle.

About 3 miles west from the north end of Macarite Island a shoal with a least depth of 8 fathoms was found where 16 and 18 fathoms are charted.

On the banks north-northeast of San Bernardino Island a least depth of 11 fathoms was found, and on the long coral reef 6 miles northeast by north of San Bernardino Island a least depth of 14 fathoms was found. This reef extends in an east and west direction and is about 3 miles long and approximately 200 meters wide. It is composed of white sand and is distinctly visible at a distance of half a mile.

Off the southwest corner of the specially developed area the water deepens abruptly from 45 fathoms to depths of 90 and 100 fathoms extending in a narrow channel down the axis of the straits. There is also a small basin with 55 fathoms extending in a northeast and southwest direction in mid-channel between Biri Head and San Bernardino Island. The completed work extends from the limits of the survey by the steamer *Research* west of Simaga Point, in a northeast by north direction to the parallel of 12° 50′, through the passage southeast of San Bernardino Island, and is sufficient to show that a

good clear channel exists for vessels passing in and out of the straits.

The currents in San Bernardino Straits were observed and their direction and velocity noted.

The flood tidal current comes from the southwest, while the ebb is from the northeast. The velocity of flood tide was estimated at 8 knots and the ebb at about 4 knots. The tidal current is strongest at and northeast of a line joining Biri Head and San Bernardino Island.

A survey was made of Bobon Anchorage and extended in a northwest direction through the channel south of Cabauan Island and into Biri Channel as far as the anchorage west of Makadlao Island. The entire anchorage was developed and also the inshore hydrography extending from south of Tinau Island around to the northeast side of the Balicuatro Islands to the north end of Talisay Island.

A small bay in the Balicuatro Islands is the only typhoon anchorage in the vicinity of San Bernardino Straits.

A reported 3-fathom shoal south of Wright Shoal was examined and a least depth of 5 fathoms found.

[R. B. DERICKSON, Commanding Steamer *Pathfinder*, July 16 to October 31, 1915.]

SUMMARY OF RESULTS.—Topography: 20 miles of general coast line surveyed, 7 miles of shore line of rivers surveyed, 9 miles of roads surveyed, 1 topographic sheet finished, scale 1:20,000. Hydrography: 160 square miles of area covered, 1,006 miles run while sounding, 6,953 soundings made, 1 tide station established, 1 current station occupied, 1 hydrographic sheet finished.

The survey of San Bernardino Straits in progress on July 1 was continued until July 16, when the *Pathfinder* proceeded to Manila for docking and repairs.

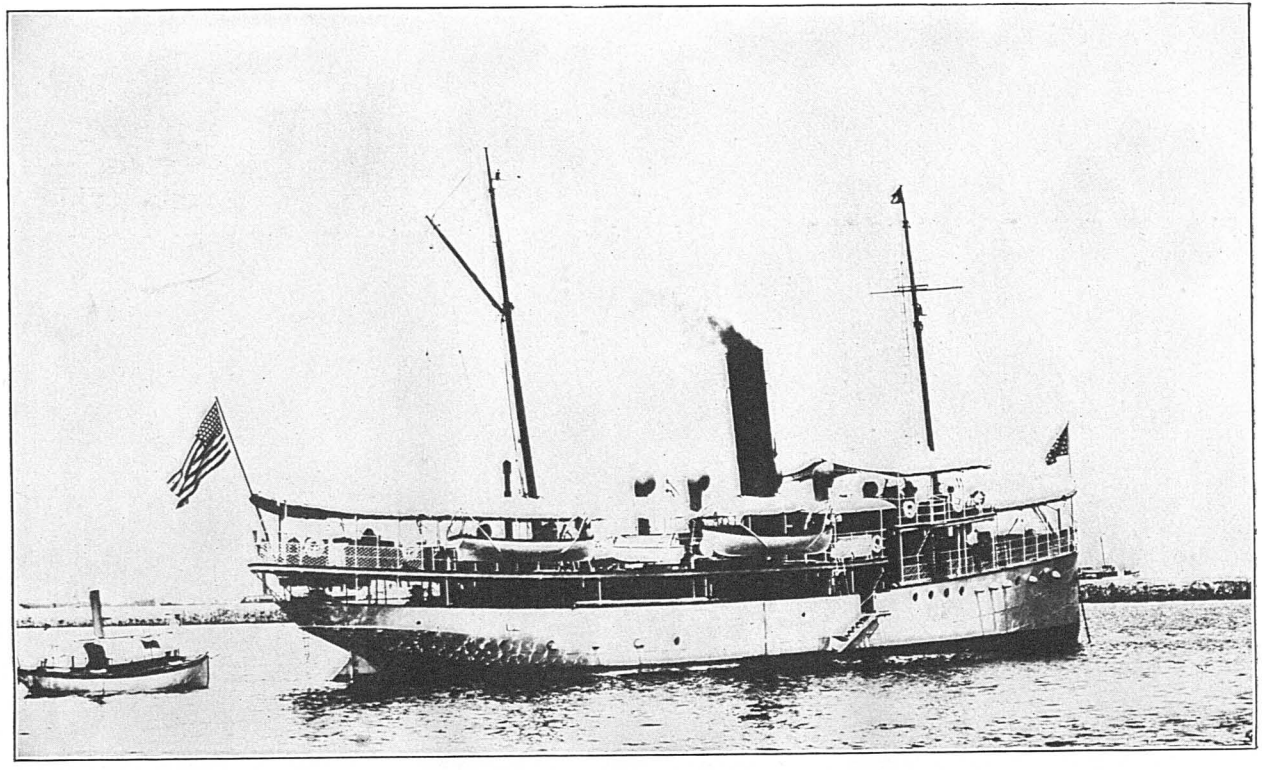
On August 17 surveys were begun at the entrance of Manila Bay and were continued until September 23. During this period typhoon weather prevailed at times, but the work across the entrance to the bay was completed, joining previously completed work off Jamelo Cove and westward of Mariveles. The south channel was completed as far in as San Nicholas Shoals. The topography of the south shore was completed from north of Jamelo Cove to San Nicholas Shoals.

A small amount of triangulation was done in order to determine sufficient points along the coast for control of the topography and inshore hydrography.

[T. J. MAHER, Commanding Steamer *Pathfinder*, December 11, 1915, to February 4, 1916.]

SUMMARY OF RESULTS.—Base lines: 1, secondary, 8,386.513 meters in length; 1, tertiary, 2,058.87 meters in length. Triangulation: 52 square miles of area covered; 17 signal poles erected; 1 observing tripod and scaffold built, height 130 feet; 14 stations in supplemental schemes occupied for horizontal measures. Magnetic work: ship swung at one station at sea. Topography: 9 square miles of area surveyed, 23.4 miles of general coast line surveyed, 2 topographic sheets partly finished. Hydrography: 1,866.8 square miles of area covered, 1,353.6 miles run while sounding, 1,435 angles measured, 4,980 soundings made, 1 tide station established, 1 hydrographic sheet finished, scale 1:20,000.

To the *Pathfinder* was assigned the triangulation at the south end of Palawan Island, where in December a base line was selected on



FATHOMER.

Steel steam vessel of 550 tons displacement and 431 gross tons; registered length 144 feet, breadth 25 feet, draft 9.5 feet; indicated horsepower 400; speed 10 knots; coal capacity 95 tons; complement 7 officers and 41 men. Built at Hongkong, China, in the year 1904. Present duty, general surveys in the Philippine Islands. This vessel is the property of the Philippine Government and is used only for surveys in the Philippines by officers of the United States Coast and Geodetic Survey.

Mantangule Island. The base was measured, and the erection of signals was begun before the ship returned to Manila.

Hydrographic work was done southwest of Mindoro and the Semirara Group over an area previously surveyed by the *Fathomer.*

A line of soundings was begun at Imalauan and run to Piedra Blanca, thence south to Calusa Island, Cavilli and Arena Islands to Jessie Beazley Reef, the location of which was determined. The ship then proceeded to South Islet Light. Afterwards a line was run from Jessie Beazley Reef towards Nicholson Shoal and thence to South Islet, on which a landing was made to determine the relative position of the islet and Jessie Beazley Reef. The ship then proceeded south to Quesada or South Tubbataha, sounding en route. No indications of a shoal were found. The vessel then proceeded to Balabac, where an automatic tide gauge was set up and reconnoissance begun. A base site was selected on Mantangule Island and the clearing of the site begun. In the meanwhile a short base 2,058.87 meters long was measured from which to start a small scheme of triangulation. Triangulation, topography, and hydrography were then begun, and the principal base line 8,386.513 meters in length was measured.

On February 3 the vessel returned to Manila, sounding en route and running past Ginn and Wakefield Shoals. Indications of another shoal were found in an area in which no soundings had previously been taken.

Sounding was discontinued at Imalauan Shoal and the course set for Manila.

The command of the vessel was transferred on February 14.

[H. C. DENSON, Commanding Steamer *Pathfinder*, February 14 to June 30, 1916.]

SUMMARY OF RESULTS.—Triangulation: 695 square miles of area covered; 22 signal poles erected; 8 observing tripods and scaffolds erected, heights from 96 to 235 feet; 9 stations in main scheme occupied for horizontal measures; 16 stations in secondary scheme occupied for horizontal measures; 13 stations occupied for vertical measures; 32 geographic positions determined; 1 azimuth station occupied. Topography: 66 square miles of area surveyed, 86 miles of detail coast line surveyed, 1 topographic sheet finished and 4 partly finished. Hydrography: 83 square miles of area covered, 1,550 miles run while sounding, 21,966 soundings taken, 1 tide station established, 2 hydrographic sheets finished.

Between February 17 and 25, the *Pathfinder* was engaged in a preliminary survey at the entrance to Manila Bay.

The vessel proceeded on March 4 to Balabac and arrived on the working ground on March 8. On the following day field operations were begun in the vicinity of Balabac and were in progress at the south end of Palawan Island on June 30.

At 11.30 p. m. June 23 the *Pathfinder* responded to an SOS call from the Spanish steamer *Fernando Poo*, which vessel was found stranded on Tubbataha Reef, Sulu Sea. The passengers, mail, and baggage were transported from the wreck to Iloilo.

The triangulation was expanded from the Mantangule base, previously measured, through three figures northward to Palawan Island and one figure to the southward to Balabac Island, all covering an area of 695 square miles.

Unusual difficulties had to be surmounted in the triangulation. Eight of the nine stations occupied in the main scheme were scaffold signals ranging in height from 96 to 235 feet, which had to be constructed by the ship's force alone as no other labor was available. With the exception of one signal, all of the timber used was cut in the adjacent forests, and quite often had to be transported by hand 2 miles to the station site.

The topography includes the coasts of the following islands: Byan, Gabung, Ramos, Caxisigan and parts of Bugsuk, Pandanan, Bancalan, and Balabac. All of these islands with the exception of Balabac are low and heavily wooded, the entire coast line being fringed with dense mangrove swamps.

While en route from Balabac to Sandakan and to Zamboanga, deep-sea soundings were taken. The depths obtained on the course between Balabac and Sandakan, via Cagayan Island, correspond with those shown on the chart. No dangers to navigation were found on the course followed by the *Pathfinder*. En route to Zamboanga, soundings were made over the area marked Quesada Reef, latitude 8° 05′ N., longitude 119° 50′ E., but no indications of shoaling were found, the depths recorded being in excess of 2,000 fathoms.

On the return voyage from Zamboanga a search was made for the rock marked "P. D." south of Quesada Reef, but nothing was found.

Inshore hydrographic work was confined to the waters between Pandanan, Bancalan, Mantangule, and Bugsuk Islands, and a detailed survey of Port Ciego, north coast of Balabac Island. The survey of Port Ciego developed a protected harbor, the entrance to which, however, is obstructed by numerous reefs with deep-water passages between them.

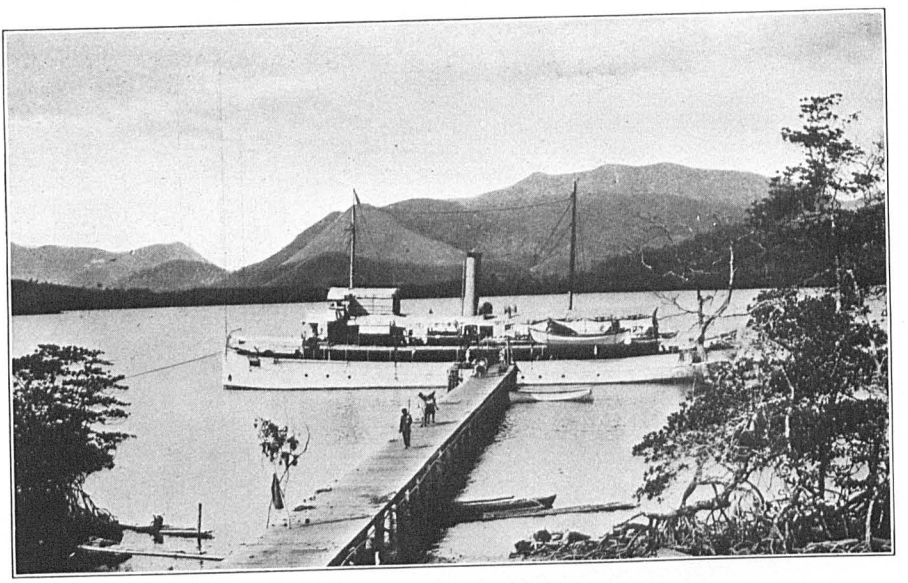
An automatic tide gauge established at Balabac March 9 was kept in continuous operation.

[T. J. MAHER, Commanding Steamer *Fathomer*, July 1 to October 31, 1915.]

SUMMARY OF RESULTS.—Triangulation: 184.2 square miles of area covered, 7 signal poles erected, 3 stations in main scheme occupied for horizontal measures, 4 stations in supplemental schemes occupied for horizontal measures, 4 geographic positions determined. Topography: One-twelfth square mile of area surveyed, 1 mile of general coast line surveyed, 1 topographic sheet finished, scale 1:20,000. Hydrography: 608 square miles of area covered, 3,386.7 miles run while sounding, 12,941 angles measured, 34,661 soundings made, 10 current stations occupied, 1 hydrographic sheet partly finished, scale 1:100,000.

Work was continued by the steamer *Fathomer* during the season of 1915 in the region in the northern part of the Sulu Sea, from Nogas Island Light to Apo Reef from Panay and Mindoro westward across the Calamianes Group.

On July 1 the vessel was at work between Panay Island and the Cuyos. Two large gaps in the hydrography in that locality and numerous gaps in the hydrography of the northern parts of the Cuyos were filled in. Areta Shoals and the Chinaman Shoals were developed and additional work was done on Luzon Bank. Attention was paid to the area in the vicinity of Sombrero Rock, which is steep-to, rising out of deep water.



ROMBLON.

Composite steam vessel of 345 tons displacement, 411 gross tons, and 198 net tons; registered length 132 feet, breadth 23 feet, draft 10.2 feet; indicated horsepower 300; speed 8 knots; coal capacity 75 tons; complement 9 officers and 37 men. Built at Uraga, Japan, in the year 1901. Present duty, general surveys in the Philippine Islands. This vessel is the property of the Philippine Government and is used only for surveys in the Philippine Islands by officers of the United States Coast and Geodetic Survey.

A shoal, with 13 fathoms on it, three-fourths mile northwest by north from the rock was developed. A depth of 87 fathoms was found between the two. Indications of the existence of this shoal were given by the submarine sentry. Sombrero Rock was occupied and connected by triangulation with the Cuyo Group.

The progress of the work was restricted by a shortage in the appropriation for coal. Ship work was stopped and inshore work in the vicinity of Cuyo Island was taken up. A small scheme of triangulation to locate the wireless station at Cuyo and points on Bararin Island was finished, and some hydrography was done with small boats.

On September 29 the ship sailed for Manila, making soundings en route. The automatic tide gauge at Port Uson was discontinued.

All shoals in the Sulu Sea between Panay and Cuyos and between Mindoro and Busuanga have been located and developed. The general system of hydrography has been finished. The waters are now charted from Apo Passes to Nogas Island Light, and safe courses can be run over surveyed waters from Apo Reef Light to Iloilo. Since 1911 over 30,000 miles of sounding lines have been run in this area. In the ship work every second sounding has been located by angles to mountain peaks or summits; none depend on dead reckoning or compass bearings.

[F. B. T. SIEMS, Commanding Steamer *Fathomer*, January 1 to February 12, 1916.]

SUMMARY OF RESULTS.—Triangulation: 39 square miles of area covered, 9 signal poles erected, 6 stations in supplemental schemes occupied for horizontal measures, 8 geographic positions determined. Topography: 42 square miles of area surveyed, 23.1 miles of general coast line surveyed, 2.5 miles of rivers surveyed, 2.3 miles of roads surveyed, 1 topographic sheet finished, scale 1: 20,000. Hydrography: 56 square miles of area covered, 617.1 miles run while sounding, 3,397 angles measured, 19,143 soundings made, 2 tide stations established.

On January 8, 1916, the repairs and outfitting of the steamer *Fathomer* being completed the vessel left Manila for Green Island Bay, east coast of Palawan Island, to take up temporarily work in the region where the steamer *Romblon* had been working during the previous year.

The hydrography completed consists of a stretch of inshore hydrography for 13 miles along the coast of Palawan westward from Flechas Point, and extending offshore 2 to 4 miles. This inshore area is freer from shoals than the area farther offshore, and it is thought probable that a practicable inside route will be developed. One course was run by the steamer *Fathomer* from Flechas Point to Shell Island over the above surveyed area, sounding and using the submarine sentry, without finding any irregularity in depths.

The topography was extended 13 miles along the Palawan coast westward from Flechas Point. A careful topographic survey was made of prominent peaks near Flechas Point. The following small off-lying islands were included in the topography: Green, Reef, Puerco, and Shell Islands.

One quadrilateral of the coastal scheme of triangulation was completed and another quadrilateral was added to the scheme, extending this triangulation to the line Islet-Campo.

An automatic tide gauge was established at Puerto Princesa and a subsidiary staff at Green Island.

[JOHN W. MAUPIN, Commanding Steamer *Fathomer*, February 12 to June 30, 1916.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 62 miles, 776 miles of area covered, 48 lines of intervisibility determined, 25 points selected for scheme. Triangulation: 708 square miles of area covered; 19 signal poles erected, 18 observing scaffolds and tripods built, heights from 30 to 143 feet; 15 stations in main scheme occupied for horizontal measures; 1 station in supplemental scheme occupied for horizontal measures; 13 stations occupied for vertical measures; 18 geographic positions determined; 20 elevations determined trigonometrically. Physical hydrography: 500 miles run in deep-sea sounding, 34 deep-sea soundings made.

On March 6, after having been repaired and outfitted at Manila, the steamer *Fathomer* sailed for her working grounds on the southeastern coast of Mindanao to take up the work of carrying the main triangulation southward from the line Binaca-Turukan.

During the remainder of the fiscal year this triangulation was extended through seven figures over a distance of about 50 miles.

On the passage to Zamboanga a line of deep-sea soundings was taken up near Nogas Island Lighthouse and continued toward Basilan Strait. In this work difficulty was experienced with the sounding apparatus, which was out of repair, causing frequent breakage and loss of sounding wire and other equipment. The apparatus was afterwards thoroughly overhauled and put into working condition.

Field work was begun at Linao Bay on March 13. Three and sometimes four parties were kept in the field continuously from this date until the close of the season.

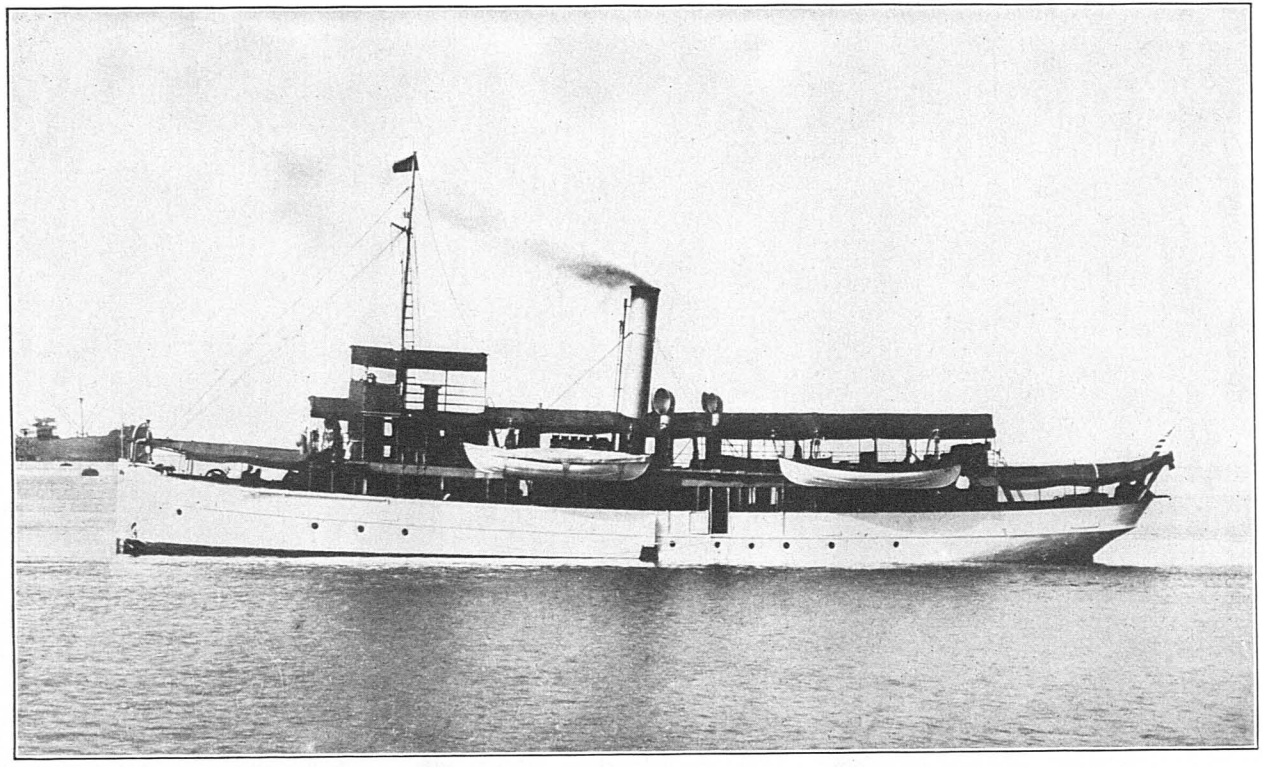
The work of reconnoissance was done by the vessel and was kept well in advance of the work of the shore parties at all times. Points were selected and temporarily located by sextant cuts and bearings, and lines of intervisibility were determined either from the ship or from small boats or sometimes from land stations. In this work the entire triangulation scheme was laid out, and the points selected were ready for the signal-building party.

The conditions under which the shore parties labored were extremely arduous. The country is covered with a growth of large trees, some of which are upwards of 200 feet in height and most of them of very hard wood. These trees had to be either cleared out or scaffolds built to see over them, or partly both. The topography is very rugged and mountainous and a heavy tropical undergrowth adds to the difficulties of travel on foot, so that the parties always selected stream beds for ingress whenever they were available. All of the hardships of camp life in the Tropics were experienced by these parties.

Native guides were employed when obtainable and their services were practically indispensable in some cases.

In laying out the scheme of triangulation every effort was made to use the most economical length of line and to advance the work as rapidly as possible, consistent with the standards for strength of figures.

Of the 17 stations in the main scheme 12 are scaffold signals and 5 are ground signals. The scaffolds range from 30 to 143 feet in height. Owing to the great size of the trees it was usually preferable to build a scaffold to see over them, rather than to attempt to



MARINDUQUE.

Composite steel vessel of 345 tons displacement, 411 gross tons, and 197 net tons; registered length 132 feet, breadth 23 feet, draft 10.2 feet; indicated horsepower 300; speed 8 knots; coal capacity 75 tons; complement 9 officers and 37 men. Built at Uraga, Japan, in the year 1901. Present duty, general surveys in the Philippine Islands. This vessel is the property of the Philippine Government and is used only for surveys in the Philippines by officers of the United States Coast and Geodetic Survey.

clear the lines of sight. Some of the scaffolds were built around trees.

Besides the line of deep-sea soundings carried south from Nogas Island, two lines were carried across the Moro Gulf, and another line was carried from Basilan Strait to the south coast of Panay. A total of 439 miles of deep-sea sounding lines was run. The deepest sounding was taken in crossing the Sulu Sea, where a depth of 2,824 fathoms, or 3½ miles, was obtained.

Four current stations were established.

Work was closed for the season in the latter part of June and the vessel proceeded to Manila for repairs, arriving there on June 30.

[F. B. T. SIEMS, Commanding Steamer *Romblon*, July 1 to December 31, 1915.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 6 miles, 50 square miles of area covered, 4 lines of intervisibility determined, 2 points selected for scheme. Triangulation: 59 square miles of area covered, 4 stations in main scheme occupied for horizontal measures, 6 stations in supplemental schemes occupied for horizontal measures, 9 geographic positions determined. Topography: 41 square miles of area surveyed, 74.4 miles of general coast line surveyed, 2 topographic sheets finished, scale 1:20,000. Hydrography: 628 square miles of area covered, 4,197.3 miles run while sounding, 12,976 angles measured, 69,266 soundings made, 5 tide stations established, 11 hydrographic sheets finished, scales 1:20,000, 1:40,000, 1:80,000, and 1:100,000.

In July, 1915, hydrography was in progress in Taytay Bay, east coast of Palawan Island. This work was completed August 12.

Numerous dangerous coral heads were discovered eastward of the islands in Taytay Bay.

A shore party was left in the field to complete the hydrography in an unsurveyed area between Norte Point, Dumaran Island, and Bay Point, Palawan Island, while the *Romblon* went to Manila for minor repairs. On the return of the vessel work was continued to fill in gaps in the hydrography and to develop a large number of shoals east of Paly Island and north of Dumaran Island. Many dangerous coral heads were discovered in these areas.

The hydrography of two unsurveyed areas, one north of Iloc Island and the other stretching northward from Binulbulan Island along the Palawan coast, together with the topography of the latter coast, was then taken up, and after their completion the inshore hydrography and topography were carried around the north end of Palawan to Bacuit, a municipality on the west coast. At the same time the offshore hydrography north of Palawan Island was carried westward from former limits to longitude 119° 23⅓′, joining on the north with the work of the steamer *Fathomer*.

One additional triangulation point in the coastal triangulation scheme of northwestern Palawan was established and determined, and a reconnoissance determining the next figure in the triangulation was made. A few intersection points were also established for control of the detail surveys.

The work done completes the survey of the coast from Bacuit on the west coast around the north end of Palawan to Flechas Point on the east coast, including Dumaran and other off-lying islands.

Tide stations were established at Darocotan Island and Bacuit. The automatic tide gauge at Araceli was kept in operation until November 22.

Work was closed for the season on December 1.

[R. R. LUKENS, Commanding Steamer *Romblon*, February 29 to June 30, 1916.]

SUMMARY OF RESULTS.—Triangulation: 200 square miles of area covered, 6 observing tripods and scaffolds built, 8 stations in main scheme occupied for horizontal measures, 2 stations in supplemental schemes occupied for horizontal measures, 3 stations occupied for vertical measures, 18 geographic positions determined. Leveling: 5 permanent bench marks established, 0.7 mile of levels run. Magnetic work: Ship swung for compass deviation at 1 station at sea. Topography: 5 square miles of area surveyed, 26 miles of general coast line surveyed, 2 topographic sheets finished, scale 1:20,000. Hydrography: 272 square miles of area covered, 2,339 miles run while sounding, 7,398 angles measured, 22,102 soundings made, 2 tide stations established, 1 current station occupied, 3 hydrographic sheets finished, scales 1:20,000 and 1:40,000.

On April 10, 1916, necessary repairs being completed, the steamer *Romblon* sailed from Manila for the working grounds in the vicinity of the Cabulauan Islands, North Palawan, arriving at Coron on the following day. Hydrographic work was begun immediately and was continued until April 28, when it was necessary to proceed to Manila for minor repairs. The vessel returned to the working ground on May 6.

When possible, four parties were operated, one engaged on triangulation, one on topography, and two on hydrography.

The hydrography was the principal work done during the season. Besides the new work necessary to complete the chart of the vicinity there were many split lines to be run and shoals to be developed in work left by a previous party. In all there were about 40 shoals and banks developed.

The topography consisted of the delineation of five small islands.

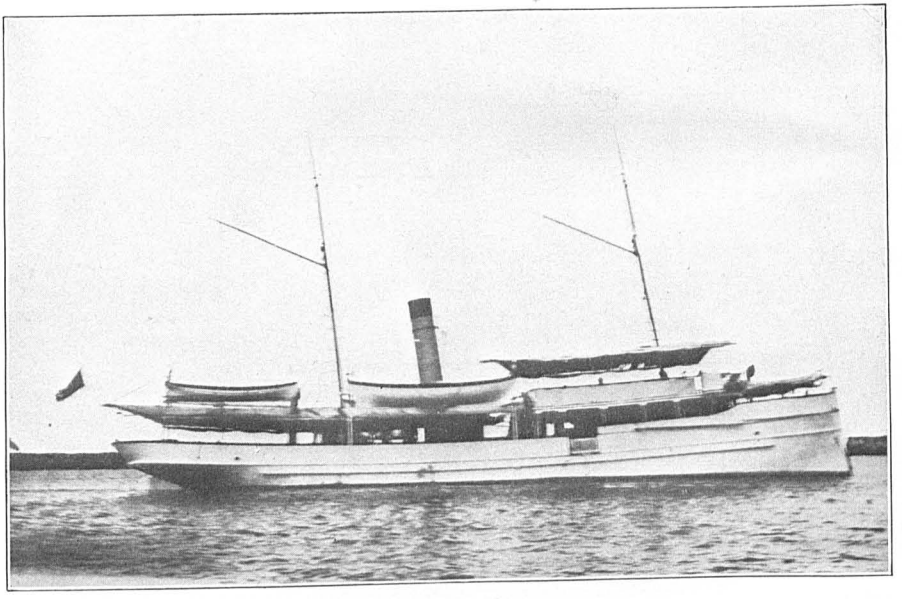
The triangulation consisted of two figures extended from the secondary line Cabulauan-Linapacan and was tertiary in character. From the main stations several intersection stations were cut in to serve as control for the topography and hydrography. The summits of all of the islands had been cut in from the triangulation of the Cuyos and Palawan in previous years. Signals were now built on these peaks, the determinations of which agreed closely with the old work.

A tide staff was erected in the bight on the southwestern side of Cabulauan Island, and observations were made for connecting it with the Puerto Princesa staff. This staff being carried away by the waves another was erected near the southwestern end of Nangalao Island.

[P. M. TRUEBLOOD, Commanding Steamer *Marinduque*, July 1 to December 29, 1915.]

SUMMARY OF RESULTS.—Triangulation: 2 square miles of area covered, 13 signal poles erected, 10 stations occupied for horizontal measures, 15 geographic positions determined. Topography: 49 square miles of area surveyed, 104 miles of detail coast line surveyed, 1 mile of creeks surveyed, 5 miles of roads surveyed, 3 topographic sheets finished. Hydrography: 373 square miles of area covered, 4,170 miles run while sounding, 56,670 soundings made, 2 tide stations established, 4 hydrographic sheets finished.

This vessel was employed on combined surveys of the eastern coast of Busuanga and adjacent islands and offshore hydrography north of Busuanga Island until the middle of October. She was then transferred to the western approach to Coron Bay, where she worked until the middle of December and then proceeded to Manila.



RESEARCH.

Wooden steam vessel of 95 tons displacement, 95 gross tons, and 62 net tons; registered length 94.6 feet, breadth 15 feet, draft 8.2 feet; indicated horsepower 48; speed 9 knots; coal capacity 45 tons; complement 4 officers and 23 men. Built at Hongkong, China, in the year 1898. Present duty, general surveys in the Philippine Islands. This vessel is the property of the Philippine Government and is used only for surveys in the Philippines by officers of the United States Coast and Geodetice Survey.

[A. M. SOBIERALSKI, Commanding Steamer *Marinduque*, February 1 to June 30, 1916.]

SUMMARY OF RESULTS.—Triangulation: 60 square miles of area covered; 9 signal poles erected; 3 observing tripods and scaffolds built, heights 34, 56, and 94 feet; 6 stations in supplemental schemes occupied for horizontal measures; 3 stations occupied for vertical measures; 7 geographic positions determined; 7 elevations determined trigonometrically. Topography: 15 square miles of area surveyed, 67 miles of detail coast line surveyed, 9 miles of shore line of rivers surveyed, 3 topographic sheets finished, scale 1:20,000. Hydrography: 280 square miles of area covered, 1,754 miles run while sounding, 6,019 angles measured, 22,588 soundings made, 3 tide stations established, 5 hydrographic sheets partly finished, scales 1:20,000, 1:40,000, and 1:80,000.

After completing repairs at Engineers Island the steamer *Marinduque* took up at the end of February the work begun by the steamer *Pathfinder* in the North Channel, Manila Bay. Hydrographic and topographic work were carried on. Signals were built and located by plane table all around Corregidor Island and on the north shore of Manila Bay from Station Lasisi to Station Jose. A cursory examination revealed no indication of a reported 2½-fathom spot in latitude 14° 27′, longitude 120° 36.5′.

The vessel returned to Manila on March 4 and on March 9 finally left Manila for the working grounds in Green Island Bay, Palawan Island. On the 12th the ship arrived at Puerto Princesa, where a tide gauge previously established by the steamer *Fathomer* was put in operation.

A topographic party was put in camp on shore and the hydrography to the eastward was begun. A tide staff was kept in operation at the anchorage on the north side of Green Island while the work was in progress. The bottom of Green Island Bay is mud with numerous coral shoals rising abruptly from the bottom. Most of these shoals are steep-to and are easily visible, but there are a few of small extent which are not visible even under the best conditions except when immediately over them. A few of the latter type were found which were unknown to the natives.

On account of the frequency of these coral shoals great care must be exercised in navigating these waters, and the unsurveyed portions should not be entered by vessels except with local knowledge. Even launches have come to grief in this vicinity.

As soon as the northeast monsoon abated and the weather cleared, the reconnoissance and signal building for the main-scheme triangulation was begun.

A 96-foot scaffold was built at triangulation station Fondeado, and station Escarpado was recovered and the signal rebuilt. The subsidiary triangulation was carried along the shores of Green Island Bay to Bold Point, and a connection was made with the main scheme on the line Escarpado-Mayday.

The topography of Green Island Bay was completed to Bold Point.

The hydrography was completed out to the 30-fathom curve east of longitude 119° 25′, and a strip 3½ miles wide between latitude 10° 06.5′ and latitude 10° 10′ was completed from the Verde Islands to the 30-fathom curve. All shoals were thoroughly developed.

On June 3 after a temporary absence at Manila, the ship returned to the working ground, the hydrographic shore party was taken on

board, and work was resumed on the main-scheme triangulation. The vessel was transferred to the west coast of Palawan. A new station, Limestone Ridge, was established and station Mayday was occupied, and afterwards station Stripe Peak (4,800 feet) was occupied. Station Arrecife was established to take the place of Fondeado, and parties were sent to occupy Mount Peel and Limestone Ridge.

[O. W. SWAINSON, Commanding Steamer *Research*, July 1, 1915, to May 9, 1916.]

SUMMARY OF RESULTS.—Reconnoisance: Length of scheme 47¼ miles, 400 square miles of area covered, 66 lines of intervisibility determined, 8 points selected for scheme. Triangulation: 400 square miles of area covered, 47 signal poles erected, 20 observing tripods and scaffolds built, 13 stations in main scheme occupied for horizontal measures, 4 stations in supplemental schemes occupied for horizontal measures, 8 stations occupied for vertical measures, 43 geographic positions determined. Leveling: 3 permanent bench marks established. Topography: 248 square miles of area surveyed, 197.3 miles of general coast line surveyed, 22 miles of shore line of creeks surveyed, 4.7 miles of roads surveyed, 11 topographic sheets finished, scales 1: 10,000 and 1: 20,000. Hydrography: 639 square miles of area covered, 3,767.7 miles run while sounding, 13,339 angles measured, 43,412 soundings made, 2 tide stations established, 17 hydrographic sheets finished, scales 1: 10,000, 1: 20,000, and 1: 40,000.

At the beginning of July, 1915, the party on the steamer *Research* was engaged in topography and hydrography off the east coast of Masbate Island in the vicinity of Masbate Harbor. The work progressed northward until on July 23 it connected with the old work on a line from Port Barrera to the south end of Burias Island. After this date work was resumed at the south end of Burias Island and carried northward to Colorado Point and Anima Solo Island and then down the Luzon coast from Caurusan Point to Port Putiao. After the hydrography and topography at this area were finished, at the end of November, the work in Sorsogon Bay was taken up.

The triangulation of Burias Pass south of Enganoso-Macoto had been done during the last half of the previous fiscal year. Consequently, no more triangulation was required until August 1, by which time the work had progressed as far north along the east coast of Burias as Buyo Point.

Upon the return of the vessel from Cebu the triangulation north of Enganoso-Macoto was taken up. Seven days were required to build the 18 signals and five days for the observing. Two days were required to clear the line Macoto-Caurusan.

The triangulation of Sorsogon Bay was begun on December 10 and finished December 16. Four of the old stations were recovered. The Ticao Pass scheme was joined to the 1902 Sorsogon Bay scheme on the line Wet-Rock. As the station Wet was too low for survey purposes, a new station Dry was established.

Signals for the hydrography were located by triangulation.

The topography was controlled by triangulation stations from 2 to 4 miles apart. Traverses were run with the plane table between these stations. The contours were obtained as far inland as could be seen. These were supplemented by elevations determined offshore from the ship.

The ship hydrography and launch hydrography were carried on simultaneously with the topography until October 1, after which date and until the end of December most of the hydrography was done with the launch.

The automatic tide gauge in Port San Miguel was kept in continuous operation until November 26. A tide station was established in Port Boca Engano and another one in Port Busuanga. Tides were read at the Bagatao station for the Sorsogon work.

After the general survey of Sorsogon Bay was completed on February 11 the offshore hydrography at the north end of Burias Pass was resumed and carried to completion. While in this vicinity a search was made for a reported rock back of Refugio Island in Pasacao Harbor, but no indications of the rock were found.

Upon the completion of the work in Burias Pass on Februrary 25 the triangulation across southern Luzon to connect Ticao Pass with the eastern coast of Luzon was begun. On account of unfavorable weather this was not finished until April 20.

On April 22 the vessel proceeded to Iloilo to obtain bids for repairs and to make a survey of Oton Bank and other places in that vicinity. The work on Oton Bank had been begun when the vessel was ordered to Manila for repairs, arriving there May 12.

The survey of Sorsogon Bay included a hydrographic survey of the entire bay and a topographic survey of the eastern half.

During the course of the work a typhoon anchorage large enough to accommodate one coasting steamer was discovered back of Sablayan Island.

In February large signals were built at the triangulation stations in Burias Pass.

Triangulation was carried across southern Luzon just north of Sorsogon Bay in order to connect the Ticao Pass scheme with that along the eastern coast of Luzon. In this work the *Research* worked in conjunction with a land party on the eastern coast. Two months were required to accomplish this.

[F. S. BORDEN.]

SUMMARY OF RESULTS.—Triangulation: 285 square miles of area covered, 3 signals and scaffolds erected, 3 stations occupied for horizontal measures, 2 stations occupied for vertical measures, 2 geographic positions determined.

On February 23 instructions were issued for the work of reconnoissance and triangulation needed to complete the quadrilateral spanning the island of Luzon with Mount Mayon as its northwest angle, also a reconnoissance for and the erection of signals at the next two stations to be located on Batan Island and San Miguel Island, respectively.

The party for this work arrived at Legaspi February 26 and went into camp at Libog, and on the following day selected a suitable point for the station on Mount Mayon. The signal on Mount Mayon was completed on March 2. On March 3 a point was selected on San Miguel Island, and the signal completed on March 5. On March 7 the party proceeded to Batan Island to build the signal on Mount Vizcaya. Considerable clearing was necessary here. By March 10 the signal was built and lines cleared to Rock Dome, Mayon, and San Miguel. On March 10 the angle Mayon to San Miguel was measured. The signal at Rock Dome at this time had not been built, so that no other observing could be done at this station and the party returned to Libog.

On March 12 the party went into camp on Mount Mayon. Heliotropes were shown from this time to signal Donsol, Castilla, and Rock Dome for the use of the party on the steamer *Research*. During the remainder of the month clouds obscured Rock Dome and no observations could be made on that signal. On April 1 the weather cleared and Rock Dome was visible at intervals long enough to finish observations at Mayon. During this period of clear weather which lasted four days a heliotrope was shown to Rock Dome from San Miguel as well as from Mayon.

On April 10 supplemental instructions were received to continue showing heliotropes to Rock Dome until observations were completed at that station and in the meantime to occupy San Miguel and Vizcaya if possible. On April 18 Rock Dome again cleared and observations were completed at San Miguel on the 20th. A telegram was received on the 21st from the steamer *Research* stating that observations had been completed at Rock Dome. The party returned to Legaspi April 22, and in accordance with instructions left Legaspi on the first available steamer, April 26, arriving at Manila on the 28th.

SPECIAL DUTY.

MASSACHUSETTS.

VERIFICATION OF SPEED TRIAL COURSE.

[H. P. RITTER.]

In August, at the request of the Navy Department, instructions were given for the verification and marking of a trial course for submarines in Cape Cod Bay.

The course (1 nautical mile) as originally laid out by the Electric Boat Co., of Quincy, Mass., had been verified by the Coast and Geodetic Survey in 1909.

It consisted of five parallel ranges. Ranges Nos. 1 (Wood-End) and 5 (Long Point) determined the mile; while the intermediate ones, Nos. 2, 3, and 4, determined the quarter, half, and three-quarter mile.

Each range had a front and rear pole, to the top of which was fastened a target.

The targets were circular in form, 4 feet in diameter, and constructed of narrow strips of wood placed horizontally with open spaces between. Each target was originally painted black and red. The targets of ranges Nos. 1 and 5 are now black and white.

The poles were hickory weir poles, 7 or 8 inches in diameter, and their lengths above ground from 25 to 35 feet.

Each pole had four wire guys fastened to it just below the target leading to the ground at an angle of about 45° and anchored in the sand.

The location of the course, as shown on the plan, had not less than 100 feet depth of water, and was approximately 2,100 feet from the shore line at range No. 1, 1,650 feet at ranges Nos. 2 and 3, 1,800 feet at range No. 4, and 2,400 feet at range No. 5.

The positions of the range poles were verified, and the positions of those that were found to have been moved were determined.

The directions of the ranges were verified by means of the original range hubs and checked by angular measures from United States Coast and Geodetic Survey triangulation stations, which had been used in verifying the ranges in 1909.

The ranges were then made ready for immediate use by making the range poles perpendicular. All of the guy wires were made taut and replaced where missing.

The cross-range signal between ranges Nos. 1 and 2 was replaced. This signal with the front target of range No. 2 makes a cross range that intersects the end of the course on range No. 5.

The front range pole of range No. 2 is now near the edge of the shore, but as it forms part of the cross range it was thought best not to move it at present. The base of the pole was strengthened and protected from the wash of the waves by incasing it in a block of concrete. As the front range pole of range No. 4 was found to have been moved back about 42 feet, a cross-range signal was erected between ranges Nos. 4 and 5. It is so placed that with the front target of range No. 5 it makes a range that intersects the end of the course on range No. 1.

A profile was constructed showing the heights and positions of the range targets with reference to sea level and to one another.

An examination was also made of the range signals of the speed trial course lying to the northwestward of the submarine course to ascertain their condition and the probable cost of repairing and repainting them.

CURRENT OBSERVATIONS IN CAPE COD CANAL.

[H. P. RITTER.]

At the request of the chief engineer of the Cape Cod Construction Co., and with the cooperation of that company, a party was organized and a series of observations of currents was begun in December, 1915.

The current observations were made in the center of canal section No. 225, this being a station at which current observations had been made during the previous summer by the engineers of the canal company.

Observations of currents were made on December 3, 4, 7, and 8.

In determining the velocities both current meter and floats were used. The velocities were observed at depths of 2 feet and 4 feet and then continued at 4-foot intervals until the bottom was reached. Two hundred and fifteen velocities were measured with the meter.

The float observations consisted in timing the passage of the float between two ranges 500 feet apart. The ranges were at right angles to the axis of the canal, one of them coinciding with the section on which the meter observations were made.

One hundred and nineteen float determinations were made.

The elevation of the surface of the water at the section, referred to a fixed datum, was taken at frequent intervals during the time that current observations were made.

During the period when current work was under way the stage of the tide at both ends of the canal was recorded by automatic tide gauges augmented by staff readings.

In the latter part of December a comparison was made between the observations obtained by the Coast and Geodetic Survey observer

and those made by the canal company's observers. The comparison showed that the velocities obtained by the Survey observer agreed closely with those obtained by the company, and the reduction of the data gave a close agreement of the deduced mean results.

An independent reduction of the observations was afterwards made by the section of tides and currents of the Coast and Geodetic Survey, and the result was furnished to the chief engineer of the construction company.

NEW YORK.

DETERMINATION OF THE LONGITUDE OF THE OBSERVATORY OF THE BAUSCH & LOMB OPTICAL CO. AT ROCHESTER, N. Y.

[C. H. SINCLAIR and C. H. SWICK.]

In November, 1915, a determination was made by observers of the Coast and Geodetic Survey of the longitude of the observatory of the Bausch & Lomb Optical Co. at Rochester, N. Y.

The field expenses were paid by the company, but the Survey furnished the observers and instruments. This cooperation was entered into by the Survey as the results will be of value to the public and not only to the optical company.

Signals were exchanged with the Washington station on November 17, 24, and 25, and observations were made also on the 26th, but owing to difficulty with the telegraph wires no exchange was possible on that night.

It was impossible at that time to get a point on the ground in the meridian by means of which outside objects might be referred to the observatory.

The observer returned from Rochester to Washington on December 8.

In June the Coast and Geodetic Survey observer returned to Rochester for the purpose of determining the latitude of the Bausch & Lomb observatory, which, on account of unfavorable weather, had not been possible when the longitude was determined.

The instrument was mounted on the pier of the transit circle in the observatory on June 6, but it was not until the 12th and 13th that the weather cleared and the determination was made on 24 pairs of stars.

On the 22d a meridian was determined and marked on the ground, and on the 23d and 24th theodolite angles were observed on prominent local objects, and bases along St. Paul Street were furnished partly by the city engineer, so that their position became known.

KENTUCKY AND TENNESSEE.

DETERMINATION OF THE LATITUDE OF TWO POINTS ON THE KENTUCKY AND TENNESSEE BOUNDARY.

[C. H. SINCLAIR.]

Between March 27 and April 24, at the request of the State officials, a determination was made of the latitude of two points known as the Reelfoot Lake Stone and the Bushy Pond Stone on the boundary between Kentucky and Tennessee.

Observations were obtained at Reelfoot Lake between March 31 and April 12 and at Bushy Pond on April 16, 17, 18, and 19, and the observer returned to Washington on April 20.

DISTRICT OF COLUMBIA.

[F. B. T. SIEMS.]

On June 6, 1916, the elevations of two temporary points, respectively on the southeast corner of slip No. 2 and the southeast corner of slip No. 4 of the United States Navy Yard, Washington, D. C., were determined and referred to bench mark No. 14 in terms of mean low water.

The two points referred to are nails driven in the outer timbers of the piers and their elevations are the heads of these nails. Their locations were selected with a view to their being used for placing tide staffs so as to read tides directly referred to a datum of 3 feet below mean low water for the use of ships coming into the harbor.

EXHIBIT OF UNITED STATES COAST AND GEODETIC SURVEY AT NEW NATIONAL MUSEUM.

[W. E. PARKER.]

This year marks the one-hundredth anniversary of the organization of the Coast Survey, which in recent years has been known as the Coast and Geodetic Survey. It was accordingly deemed fitting that this long period of useful work should be commemorated in a suitable manner, and the most appropriate form of celebration seemed to be an illustrated exposition of the work of the Service. Eminent men were invited to speak upon those phases of the Survey's activities with which they are best acquainted, and in this way practically all of the various kinds of work which this Bureau undertakes were commented upon by experts not connected with the Bureau. These papers covered the past and present work of the Bureau and in a measure the possibilities for greater results to be accomplished.

This report is descriptive of the exhibition which was held in conjunction with these exercises, and in a measure serves to illustrate the papers presented there.

The exercises were held in the auditorium of the New National Museum at Washington, D. C., on the afternoons of April 5 and 6 and on the evening of April 5, 1916. The exhibits were placed in the foyer of this building, occupying nearly the entire hall, and were open to the public from 10 a. m. until 11 p. m. of April 5 and from 10 a. m. until 6 p. m. of April 6. Arrangements were then made to continue the exhibition beyond the intended period, and it was maintained until April 10, but was open to the public only during the usual hours of the museum.

General descriptions of exhibits.—Briefly, the exhibition consisted of samples of the products of the Bureau, the tools with which these products were made, and views of the processes.

The development of each particular instrument and process was illustrated, as far as possible, by the oldest and newest types of instrument or apparatus which have been and are now in use in this Bureau and by photographs or cuts showing the methods of using these

instruments and appliances. Charts and maps were given a prominent place in the exhibition, and nearly all types which are now issued, or have been issued in the past, were included.

The instruments were arranged along the left side of the foyer, as approached from the street entrance. They were grouped in accordance with the particular kind of work for which they are used, an effort being made to take up each step in the gathering of data for chart making in its logical sequence. The first group consisted of field astronomical instruments; the second, of magnetic surveying instruments; the third, of base-measuring and triangulation instruments; the fourth, of hydrographic surveying instruments, including apparatus for recording and predicting tides; the fifth, of topographic surveying instruments; and the sixth, of leveling and gravity-measuring instruments. The fifth group should have preceded the fourth in order to preserve exactly this program, but the other arrangement was better suited to the space.

The charts and maps were fastened to screens and were arranged along the right side of the foyer in two rows. As far as possible the oldest obtainable chart was placed beside a recent Coast and Geodetic Survey chart of the same locality. The knowledge of the coast of the United States before the creation of the Coast Survey was shown by a volume of the Atlantic Neptune, which contains about the best set of charts of that date.

The work of the officers of the Coast Survey during the Civil War was shown by a series of maps, sketches, and tracings, which were prepared by these gentlemen for military purposes while attached to the staffs of the various military and naval commanders.

The methods of printing charts were illustrated by an engraved plate and by a lithograph plate and stone. These were placed with the chart exhibit.

The progress of the surveys to date was shown by several base maps of the United States and possessions upon which the present extent of the surveyed areas was indicated in colors. These maps, too, were included with the charts on the right side of the hall, as were also several tables of statistics and various publications, including a full set of the Superintendent's annual reports and samples of field and office records.

A set of more than one hundred enlarged prints from the collection of negatives in the office and from several private collections were displayed from cases arranged along the central line of the foyer. These photographs depicted methods of transporting field outfits, usual and unusual methods of surveying, and camp and ship life.

On the columns on each side of the foyer, beginning at the first column on the left and ending at the first on the right, were hung in order of service the photographs of the past Superintendents of the Bureau.

The decoration of the space was confined to three spans of flags extending across the central aisle with the name of the Bureau and the dates, 1816–1916, suspended against the first set of flags. The first span consisted of the Coast and Geodetic Survey flag and the Superintendent's flag; the second span, of two national ensigns; and the third span, of two Coast and Geodetic Survey flags.

A supply of each of the following publications, together with a program of the exercises held in the auditorium, were distributed freely from a table near the street entrance to the exhibits: The Work of the United States Coast and Geodetic Survey; Military and Naval Service of the United States Coast Survey; and the special chart of San Francisco, which was prepared for the Panama-Pacific International Exposition. Other publications were supplied on request, or, if not on hand in sufficient quantities, were mailed from the office.

EXHIBIT OF COAST AND GEODETIC SURVEY AT "SAFETY-FIRST" EXPOSITION.

[W. F. PEABODY.]

An exhibit was made by the Coast and Geodetic Survey at the "Safety-First" Exposition held at the United States National Museum, Washington, D. C., during the week beginning February 21, 1916, to demonstrate the fact that a correct nautical chart is the most important safety appliance that the navigator can have.

The exhibit was designed especially to illustrate the various steps necessary in the construction of a chart from the first work of the surveying party to the printing of the completed chart. The instruments and appliances used in the field and office work were also illustrated.

The exhibit of the Coast and Geodetic Survey consisted of a model of the wire drag, a series of sketches illustrating the development of a mariner's chart, and grouped near each sketch some of the instruments, tools, and data used in the work illustrated. Copies of charts and other publications were also shown.

The exhibit was further designed to demonstrate the great value of a chart in preventing loss of life and property at sea and on the inland waters and to exhibit in a popular manner the detail work necessary to construct the safest chart for the mariner.

In logical order were shown the means for locating the starting point of a survey (determination of latitude and longitude), determination of the true and magnetic north from this point, measurement of base line, determination of triangulation points, topographic surveying, hydrographic surveying, tidal observations, computing, compiling, drawing, engraving, electrotyping, printing, etc.

On February 25 the Superintendent gave an address at the National Museum on the subject of the Coast and Geodetic Survey in relation to "safety first."

CALIFORNIA.

PANAMA-PACIFIC INTERNATIONAL EXPOSITION.

[E. F. DICKINS.]

The Panama-Pacific International Exposition closed at midnight on December 4, 1915.

The articles forming the Coast and Geodetic Survey exhibit were packed and shipped by the naval collier *Mars* by way of the Panama Canal to the office of the Survey at Washington.

The exhibit of the Survey attracted much attention from surveyors, educators, and students, who manifested great interest in the instruments and apparatus shown.

The special chart of San Francisco Entrance and Special Publication No. 23, The United States Coast and Geodetic Survey, Description of its Work, Methods and Organization, were distributed to persons interested.

Several awards of medals and diplomas were made to the Survey by the board of awards of the exposition.

DISTRICT OF COLUMBIA.

EXHIBIT OF COAST AND GEODETIC SURVEY AT MEETING OF UNITED STATES CHAMBER OF COMMERCE.

[ISAAC WINSTON.]

By the direction of the Department an exhibit was prepared illustrative of the work of the Coast and Geodetic Survey as a part of an exhibit intended to show the activities of the bureaus of the Department in relation to commerce and industry, which was open during the meeting of the Chamber of Commerce of the United States held in Washington, February 8, 9, and 10.

The exhibit was ready for inspection by the secretaries of chambers of commerce of cities of 100,000 or more inhabitants, who were invited by the Secretary of Commerce to assemble in Washington on February 4 and 5 in advance of the annual meeting of the delegates.

The exhibit was installed in the small ballroom of the Willard Hotel, and the following bureaus participated: Bureau of Standards, Bureau of Lighthouses, Coast and Geodetic Survey, Bureau of the Census, Bureau of Fisheries, Bureau of Navigation, Steamboat-Inspection Service, and Bureau of Foreign and Domestic Commerce. In addition certain articles from the Department of Agriculture and from the Bureau of Education of the Interior Department were on exhibition.

In addition to examples of technical and chart publications of the Coast and Geodetic Survey, there were shown a large diagram representing the organization of the Survey and a number of placards stating briefly the work accomplished and yet to be done and the requirements of the service.

The condition of the hydrography on the Atlantic, Gulf, and Pacific coasts was shown by a series of special charts. Maps exhibiting the triangulation net in the United States; the precise leveling net; the triangulation and leveling needed in Alaska; and the magnetic, telegraphic longitude, leveling, and astronomic work completed or proposed to be done by the Survey were shown.

A chart of New York Harbor was exhibited, showing the corrections necessary during one year, and also charts showing changes of shore line that have occurred in New York Entrance, Assateague Anchorage, and the Mississippi Delta. Typical charts were shown of Portland Harbor, Boston Harbor, Narragansett Bay, New York Entrance (Bay and Harbor), Delaware Bay, Baltimore Harbor, Hampton Roads, Charleston, Key West, Port Arthur, Galveston, San Diego, San Francisco, and Seattle.

MAINE.

EXHIBIT OF THE COAST AND GEODETIC SURVEY AT THE FISH FAIR HELD AT EASTPORT, ME.

[E. B. LATHAM.]

At the Fish Fair held at Eastport, Me., on December 22, a number of charts of the coast of Maine and a few other charts published by the Coast and Geodetic Survey were shown, together with coast pilots, tide tables, and other publications of the Bureau. These and publications of the Bureau of Navigation, Steamboat-Inspection Service, Bureau of Foreign and Domestic Commerce, and Bureau of Lighthouses comprised the exhibit.

The fair was attended by about 5,000 people.

The officials of the fair expressed their satisfaction as to the exhibit made by the Survey.

NEW YORK.

EXHIBIT OF THE COAST AND GEODETIC SURVEY AT NATIONAL MOTOR BOAT SHOW.

[E. B. LATHAM.]

An exhibit was made of the charts and publications of the Coast and Geodetic Survey and of publications of some of the other bureaus of the Department of Commerce at the National Motor Boat Show held in the Grand Central Palace, New York City, January 29 to February 5, 1916.

An officer of the Survey was assigned to prepare and take charge of the Bureau's exhibit.

The attendance at the show during the seven days it was open was, approximately, 100,000.

Charts, maps, photographs, and sketches illustrating the work of the Survey were displayed on the wall space assigned for the purpose, and the various publications of the Survey and other bureaus of the Department of Commerce were shown on a counter in front of the space occupied.

Much interest was shown, and the various publications were extensively examined.

Charts of various parts of the coasts, harbor charts of the Atlantic and Pacific coasts and the Canal Zone, and charts of the vicinity of New York to the number of 56 were displayed. Besides these a number of other charts were on hand and were shown to persons who expressed a wish to see them.

Among other objects exhibited were a diagram published by the Bureau of Standards showing the units of the metric system, a card showing the flags of the Department, two charts issued by the Bureau of Fisheries calling attention to the tile fish and sea mussel as valuable articles of food, a complete file of coast-pilot volumes, inside-route pilots, and tide tables published by the Coast and Geodetic Survey.

One hundred and twelve different publications of the Department were exhibited and a number were distributed to the public.

A standard chart showing the extent, date of, and the source from which the information was obtained for the chart, and also the dates on which the various changes, etc., were applied to the plate from which the chart was printed, was exhibited.

Pictures of the wire drag and of the apparatus used in its operation attracted much attention.

Of the visitors who manifested an interest in the display made by the Survey, many were motor-boat men or persons directly interested in the charts and publications of the Bureau and of the Department.

The managers of the motor-boat show expressed themselves as being greatly pleased with the exhibits made by the Survey.

Respectfully,

E. LESTER JONES,
Superintendent.

To Hon. WILLIAM C. REDFIELD,
Secretary of Commerce.

INDEX.

Page.

Adams, F. L. 111,112
Adding machines 98
Alabama, magnetic observations 114
Alaganik Slough 133
Alaska, details of field operations 115
general statement of progress 47
hydrography 117, 121,122,123,125,126,129,130,132,133
leveling 40
magnetic observations 135
reconnoissance 115
tide observations 115,117, 121,122,123,124,126,129,130,131,132,133
topography 40,115,117, 121,122,123,125,126,129,130,131,132,133
triangulation 40,115,117, 121,122,123,124,126,129,130,131,132,133
wire-drag work 115,117
Aleman, Silverio 98,99
Allen, H. C., chief, printing and sales section 11
Alliance, steamer 130
Alpha, launch 48,131,132
Amelius Islands, Alaska 120
Annette Island, Alaska 123,124
Apalachicola River, Fla 98
Apo Passes, P. I. 141
Apo Reef, P. I. 140
Apokak, Alaska 131
Appropriations and disbursements 64
Appropriations and salaries 29,31
Areta Shoals, P. I. 140
Argo, bark 91
Arizona, magnetic observations 111,114,115
Arkansas, magnetic observations 113
triangulation 102,109
Assateague Anchorage, Va 75
Assateague Island, Va 75
Assateague Point, Va 75
Assistance rendered 50,86,91
Assistant in charge of office 8
Assistants 27
Atlantic City, N. J. 76
Atlantic coast, general statement of progress 45
details of field operations 68
Atlantic Deeper Waterways Convention 78
Augustus Welt, schooner 51,86
Automobile truck 102,104,105,110
Azimuth, Oregon 105

Bache, steamer 36,45,47,51,54,76,77,80,81,90
Balabac, P. I. 140
Baldwin, Fla 98
Baldwin, A. L., assistant chief, division 11
Balicuatro Islands, P. I. 138
Baltimore Harbor, Md. 95

Page.

Baltimore Harbor Board 95
Baltimore Topographical Survey Commission 95
Barnard, United States Engineer's dredge 51,86
Barnegat, N. J. 74,78
Barnegat Inlet, N. J. 80,94
Barnegat Lighthouse 77
Barren Islands, Alaska 129
Base lines 101,105,107,109,115,129,133,138,139
Basilan Strait, P. I. 143
Batan Island, P. I. 147
Bausch & Lomb Optical Co 150
Beaufort, S. C. 89
Beaufort River, S. C. 89
Bee Rocks, Alaska 124
Benefits of organization 12
Benton, J. R. 114
Berkley, Va. 83
Bethel, Alaska 130,132
Beverly, Mass. 71
Bilby, J. S. 101,102,103,109
Binulbulan Island, P. I. 143
Blacklidge, C. F., chief, photographic section 11
Block Island, R. I. 75
Bluff Island, Alaska 120
Bobon, P. I. 138
Boca de Quadra, Alaska 116
Bold Island, Alaska 124
Borden, F. S. 147
Bori Channel, P. I. 138
Boston, Mass. 68
Boston Bay 73
Boston Light 70
Boswell Bay, Alaska 133
Bottom specimens 85,90
Boundary, Canada 94
Boutelle, J. B., inspector, Galveston suboffice 11,91
Bowie, Wm., chief, division of geodesy 11,110
Brant Island Shoal Lighthouse, N. C. 87,88
Broad River, S. C. 89
Brown, R. M., chief, library and archives section 11
Bucareli Bay, Alaska 121,122
Buildings 15,18
Bureau of Lighthouses 100
Burias Island, P. I. 146
Burias Pass 147
Busuanga Island, P. I. 141,144
Butler, Gen. Benj. F. 15
Buzzards Bay, Mass. 69,70

Caamano Point, Alaska 116
Cabauan Island, P. I. 138
Cabulauan Islands, P. I. 50,144
Calamianes Islands, P. I. 140
Calder Rocks, Alaska 118,120

Page.

California, Coast Pilot work ... 93
hydrography ... 92
inspection duty ... 93
leveling ... 101
tide observations ... 92
triangulation ... 92, 100
California—Washington arc ... 102
Cape Ann, Mass ... 71
Cape Charles, Va ... 78, 80
Cape Cod Bay, Mass ... 73, 148
Cape Cod Canal ... 66, 70, 149
Cape Cod Construction Co ... 149
Cape Decision, Alaska ... 120
Cape Henry, Va ... 80
Carpenters ... 20
Carson City, Nev ... 101
Cat Passage, Alaska ... 123, 124
Cebu Island, P. I ... 146
Cedar Keys, Fla ... 97, 98
Centennial of the United States Coast and Geodetic Survey ... 67, 151
Chamber of Commerce, United States ... 67
Charleston, S. C ... 82
Charleston Harbor, S. C ... 84
Charleston Light Vessel ... 82
Chart agencies, inspection of ... 92
Chart plates ... 16, 19
Chart printing ... 13, 17
Charts ... 12, 13, 14
Cheltenham Magnetic Observatory ... 111
Chesapeake Bay ... 78, 79, 80, 91
Chiachi Island, Alaska ... 34
Chicago, Rock Island & Pacific Railway ... 102, 109
Chinaman Shoals, P. I ... 140
Chincoteague Inlet Bar, Va ... 75
Chincoteague Shoal, Va ... 75, 76
Clarence Strait, Alaska ... 115, 116
Clerks ... 22, 23, 24
Coast Pilots ... 76
Coast Pilot work ... 47, 49, 54, 76, 93, 126
Colbert, L. O ... 117
Colorado, magnetic observations ... 111
reconnoissance ... 103
Columbia Bay, Alaska ... 128
Columbia River, Oreg ... 105
Comparison of salaries ... 29, 30
Computers ... 20
Connecticut, inspection duty ... 80
magnetic observations ... 111
Cook Inlet, Alaska ... 129
Cordova, Alaska ... 132, 133
Core Sound, N. C ... 88
Coron Bay, P. I ... 144
Cotton, H. A ... 130, 132
Cotton Exchange, Galveston, Tex ... 91
Cowie, George D ... 97, 98, 101, 109
Croatan Sound, N. C ... 86, 87
Current observations ... 54, 74, 82, 84, 85, 87, 89, 90, 94, 149
Currents ... 54, 117, 118, 119, 126, 138, 149
Custom House Cove, Alaska ... 124
Cuyos Islands, P. I ... 140, 141, 144
Cypress, lighthouse tender ... 78

Dall Island, Alaska ... 122, 123
Danger Passage, Alaska ... 123, 124

Page.

Dangers to navigation ... 70, 71, 93, 117, 118, 119, 124, 126, 127, 129, 134, 135, 137, 140, 141, 145, 147
Daniels, John A ... 115
Deep-sea soundings ... 140, 141, 142, 143
Delaware, Coast Pilot work ... 76
latitude ... 107
Delaware Bay ... 80
Delta, launch ... 123, 125
Denson, H. C ... 133, 139
Derickson, R. B ... 11, 121, 137, 138
Details of field operations ... 68
Dickins, E. F., inspector, San Francisco suboffice ... 11, 93, 121, 153
District of Columbia, leveling ... 68, 151
Division of Accounts ... 11
Division of Charts ... 11
Division of Geodesy ... 10, 55
Division of Hydrography and Topography ... 9, 45
Division of Terrestrial Magnetism ... 11, 59
Dolphin, U. S. S ... 78
Donna, Tex ... 99
Drafting Tables ... 19
Draftsmen ... 20
Duke Island, Alaska ... 123
Dumaran Island, P. I ... 143
Dutch Harbor, Alaska, proposed purchase of, for Government base ... 44

East River, N. Y ... 72
Eastport, Me ... 155
Eek Channel, Alaska ... 130
Eek Island, Alaska ... 130
Eickelberg, E. W ... 95
Ela, A. J ... 126
Elevators ... 18
Elizabeth River, Va ... 83
Engle, F. G ... 74, 89
Ernest Sound, Alaska ... 116, 117, 125
Exhibits by Coast and Geodetic Survey ... 67, 68, 151, 153, 154, 155
Expansion of work ... 27
Explorer, steamer ... 36, 47, 94, 119, 122, 129

Faris, R. L., Assistant Superintendent ... 11
Fathomer, steamer ... 50, 136, 140, 141, 142, 143, 145
Felice Strait, Alaska ... 123, 124
Ferguson, O. W ... 86
Fernandina, Fla ... 97, 98
Fernando Poo, steamer ... 50, 51, 139
Fidalgo Bay, Alaska ... 127, 128
Field officers ... 28, 29
Fire protection ... 17
Fischer, E. G., chief, instrument section ... 11
Fish Fair at Eastport, Me ... 68, 155
Fishing Point, Va ... 75
Flechas Point, P. I ... 143
Florida, Coast Pilot work ... 76
leveling ... 97
magnetic observations ... 114
Florida East Coast Railway ... 98
Flower, G. L., assistant chief, division ... 11
Foggy Bay, Alaska ... 116
Ford, C. A., chief, miscellaneous section ... 11
Forney, Stehman ... 73
Fort Frances, Ontario ... 107
Forrester Island, Alaska ... 123
Freight elevator ... 18

Page.

French, O. B 79, 96, 106
Functions of the Bureau 8
Furniture 19

Gainesville, Fla 97
Galveston, Tex., suboffice 91
Galveston Commercial Association 91
Gardiners Bay, N. Y 75
Garner, C. L 106
Gedney, steamer 47, 121
General statement of progress 45
Geodetic work, details of field operations 94
general statement of progress 39, 40, 43, 54, 55
Georgia, Coast Pilot work 76
hydrography 82
magnetic observations 82, 114
signal building 96
tide observations 82
topography 82
triangulation 82
Goodnews Bay, Alaska 131, 133
Graves, H. C., chief, Division of Hydrography and Topography 11
Gravity, Iowa 106
Maryland 106
Montana 106
Nebraska 106
North Dakota 106
South Dakota 106
Virginia 106
Wyoming 106
Great Salt Pond, N. Y 75
Green, J. W 135
Green Island Bay, P. I 145
Griffin, J. M., chief, Division of Accounts 11
Gulf of Mexico 91
Gunboat Point, Va 74

Hampton Roads, Va 81
Hardy, F. H 121, 122
Hartnell, George 111
Harvester Island Spit, Alaska 134, 135
Hassler, Ferdinand R 13
Hassler Harbor, Alaska 123, 124
Hassler Reef, Alaska 124
Hawaiian Islands, magnetic work 136
Hawley, J. H 71
Hazard, D. L., chief, Division of Terrestrial Magnetism 11
Heck, N. H 68
Hill, Wallace M 113
Hobo Bay, Alaska 129
Hodgkins, W. C 136
Hodgson, C. V 98, 103, 105
Hunting Island Lighthouse 84
Huntley, Mont 105
Hydrographer, steamer 36, 45, 46, 54, 74, 75, 89
Hydrographic signals 77, 79, 82, 88, 90, 94, 95, 96
surveys 43
Hydrographic and geodetic engineers 27, 28, 29
Hydrographic and topographic sheets 16
Hydrography, Alaska 47, 117, 121, 122, 123, 125, 126, 129, 130, 132, 133
Atlantic coast 45
Georgia 82
Massachusetts 68, 71
Hydrography, New Jersey 71, 76, 77
New York 71, 74
North Carolina 86, 87
Pacific coast 47
Philippine Islands 137, 138, 139, 140, 141, 143, 144, 145, 146
South Carolina 77, 82, 89
Virginia 74, 76, 81, 82

Idaho, reconnoissance 101, 103
triangulation 101
Idaho–Oregon boundary 103
Illinois, magnetic observations 112
leveling 108
Iloc Island, P. I 143
Iloilo, P. I 141
Imalauan Shoal, P. I 139
Indiana, leveling 108
magnetic observations 112
Inspection duty, California 93
New Jersey 80
New York 80
Oregon 94
Rhode Island 80
Texas 93
Washington 94
Instrument makers 20
Instruments 21, 110
Interior States, details of field operations 94
International Falls, Minn 107
International Geodetic Association 66
International Latitude Observatory 66
Introduction 7
Iowa, gravity 106
latitude 107
magnetic observations 114, 115
Isabel, steamer 74
Isis, steamer 46, 47, 51, 52, 54, 77, 80, 82, 83

Jacksonville, Fla 98
Jarstein, schooner 51, 91
Jesse Beazley Reef, P. I 139
Joachims, A 96
Jones, E. Lester, Superintendent 11, 156

Kah Shakes Cove, Alaska 116
Kaigani Strait, Alaska 123
Kanawha, steam yacht 75
Kansas, magnetic observations 111, 114
Kashevarof Passage, Alaska 125, 126
Kentucky, latitude 150
Magnetic observations 111, 112
Kentucky–Tennessee boundary 150
Key West, Fla 76
Kuiul Island, Alaska 21
Kupreanof Island, Alaska 118, 134
Kuskokwim Bay, Alaska 130
Kuskokwim River, Alaska 130, 132

Labouchere Bay, Alaska 119
Lake Bay, Alaska 125
Landlocked Bay, Alaska 127
Las Vegas, Nev 101
Latham, E. B 74, 77, 78, 80, 92, 94, 95, 100, 155
Latitude 58, 66
Delaware 107
Iowa 107

	Page.
Latitude, Kentucky	67,150
Maryland	107
Michigan	107
Minnesota	107
New York	66
Pennsylvania	107
Tennessee	67,150
Virginia	107
West Virginia	107
Wisconsin	107
Launches	36
Laws, Cal	101
Lemesurier Point, Alaska	116
Leveling	41,98,109,110
General statement of progress	12, 16,39,41,54,57,58
Alaska	40,117,121,129,130,132
California	101
District of Columbia	67,151
Florida	97
Illinois	108
Indiana	108
Maine	94
Michigan	108
Montana	105
Oregon	105
Nevada	101
Philippine Islands	144,146
Librarian	20
Lifeboat men, inspection of	92
Linao Bay, P. I	142
Little Egg Inlet, N. J	74
Little Rock, Ark	102,109,110
Long Island Sound, N. Y	75
Longitude	58,66
New York	66,150
Luce, R. F., chief tides and currents section	11, 77,81
Lukens, R. R	130,144
Luzon Bank, P. I	140
Luzon Island, P. I	146,147
Lynnhaven Bay, Va	79
Lynnhaven Roads, Va	91
McArthur, steamer	36,47,116,123
McComb, H. E	114,115
Macarite Island, P. I	137
Machine shop	19
Magnetic observations	42,61,111
General statement of progress	59
Alabama	114
Alaska	123,124,126,129,130,133,135
Arizona	111,114,115
Arkansas	113
Colorado	111,114
Connecticut	111
Florida	114
Georgia	82,114
Hawaii	136
Illinois	112
Indiana	112
Iowa	114,115
Kansas	111,114
Michigan	112
Minnesota	112,114,115
Mississippi	113
Missouri	112,114
Magnetic observations, Montana	114
Nebraska	114
New Hampshire	111
New Jersey	77
New Mexico	111,113
New York	74,112
North Carolina	113
North Dakota	114,115
Ohio	111,112
Oklahoma	113
Philippine Islands	138,144
Porto Rico	135
Rhode Island	111
South Carolina	77,82,90
South Dakota	114,115
Tennessee	112,114
Texas	113
Utah	114
Virginia	77,82,90,112,113
West Virginia	111,112
Wisconsin	112
Wyoming	114
Magnetic publications	62
Magnetic stations	60
Maher, T. J	138,140
Maine, leveling	94
magnetic observations	111
Makadlac Island, P. I	138
Manila, P. I., suboffice	136
Manila Bay, P. I	138,139,145
Mantangule Island, P. I	139,140
Marblehead, Mass	71
Marinduque, steamer	50,144,145
Mariveles, P. I	138
Martins Industry Light Vessel	82,84
Mary Island, Alaska	124
Maryland, Coast Pilot work	76
gravity	106
latitude	107
magnetic observations	111
triangulation	95
Masbate Harbor, P. I	146
Masbate Island, P. I	146
Massachusetts, hydrography	68,71
magnetic observations	111,112
special duty	148
tide observations	68
topography	68,71
triangulation	68,71
Matchless, schooner	27,36,46,86,87
Maupin, J. W	142
Meares Passage, Alaska	121,122,123
Memphis, Tenn	102,103,109,110
Meridian lines	111,112,113
Merrymon, Wm. Walter	136
Mexico	56,98,99
Michigan, latitude	107
leveling	108
magnetic observations	112
Mindanao Island, P. I	142
Mindoro Island, P. I	140,141
Minneapolis, Minn	106,107
Minnesota, latitude	107
longitude	106
magnetic observations	112,114,115
Minots Ledge Lighthouse	69
Mississippi, magnetic observations	113

Page.

Mississippi River Commission ... 66
Missouri, magnetic observations ... 112, 114
Mist Harbor, Alaska ... 133, 134
Mondak, Mont ... 105
Montana, gravity ... 106
  leveling ... 105
  magnetic observations ... 114
Moro Gulf, P. I ... 143
Morse, Fremont, director, Coast Surveys, Manila ... 11, 92, 136
Mosquito Elimination Commission of New Jersey ... 73
Motor velocipede cars ... 106
Motors for machine shop ... 19
Mount Mayon, P. I ... 147, 148

Nagai Island, Alaska ... 133, 134
Nampa, Idaho ... 104
Narragansett Bay, R. I ... 70, 80
National Motor Boat Show ... 68, 155
National Museum ... 151
Nautical charts ... 13, 14
Nautilus Shoal ... 78
Navy Department ... 148
Navy Yard, Washington, D. C ... 151
Neah Bay, Wash ... 94
Nebraska, gravity ... 106
  longitude ... 106
  magnetic observations ... 114
Needs of the Bureau ... 27
Neumann, Frank ... 111, 112
Nevada, leveling ... 101
Newark Bay, N. J ... 73, 80
New buildings ... 15, 18
New Hampshire, magnetic observations ... 111
New Jersey, coast pilot work ... 76
  hydrography ... 71, 73, 76, 77
  inspection duty ... 80
  magnetic observations ... 77
  signal building ... 94
  topography ... 71, 73
  triangulation ... 71, 73, 74
New Mexico, magnetic observations ... 111, 113
  reconnoissance ... 103
Newport News, Va ... 81
New York, hydrography ... 72, 74
  inspection duty ... 80
  longitude ... 150
  magnetic observations ... 74, 112
  suboffice ... 80
  tide observations ... 74
  topography ... 71, 73, 74
  triangulation ... 71, 73
Nogas Island Light, P. I ... 140, 141, 142, 143
Norfolk Harbor, Va ... 81, 83
North Carolina, coast pilot work ... 76
  hydrography ... 86, 87
  magnetic observations ... 113
  reconnoissance ... 86
  tide observations ... 86, 87
  topography ... 86, 87
  triangulation ... 86, 87
North Dakota, gravity ... 106
  magnetic observations ... 114, 115
North Star, launch ... 51, 86

Page.

Northern Pacific Railway ... 105
Northwestern Fisheries Co ... 127

Ocracoke, N. C ... 87
Ocracoke Inlet, N. C ... 88
Office accommodations ... 15, 18
  force ... 20
Ohio, magnetic observations ... 111, 112
Oklahoma, magnetic observations ... 113
Old Point Comfort, Va ... 83
Omaha, Nebr ... 106
Orca, Alaska ... 128
Orca Bay, Alaska ... 126
Orca Inlet, Alaska ... 67, 133
Oregon, coast pilot work ... 93
  hydrography ... 93
  inspection duty ... 94
  reconnoissance ... 101
  triangulation ... 101, 105
Oregon Inlet, N. C ... 86, 87
Oregon Short Line Railway ... 103
Organization of the Bureau ... 8
Ossabaw Sound ... 90
Oyster Bay, N. Y ... 73

Pacific coast, details of field operations ... 92
  general statement of progress ... 47
Pagenhart, E. H ... 103, 109
Palawan Island, P. I ... 138, 139, 141, 143, 144, 145, 146
Paly Island, P. I ... 143
Pamlico Sound, N. C ... 87, 88
Panama-Pacific International Exposition ... 67, 110, 153
Panay Island, P. I ... 140, 141, 143
Parker, W. E., chief, section, vessels and equipment ... 11, 151
Pasquotank River, N. C ... 86, 87
Patapsco River, Md ... 95
Pathfinder, steamer ... 49, 50, 51, 137, 138, 139, 145
Pattern makers ... 20
Patterson, steamer ... 36, 48, 117, 124, 125, 131, 133, 135
Patton, R. S., chief, Coast and Pilot section ... 11, 93, 94, 129
Pay, seamen ... 37, 38
Peabody, W. F., chief, engraving section ... 11, 153
Pease, Harold W ... 135
Pecos, Tex ... 103
Pennsylvania, Coast Pilot work ... 76
  latitude ... 107
Percy Islands, Alaska ... 123
Peters, John H ... 98, 105, 108, 109
Philippine Islands, details of field work ... 136
  general statement of progress ... 49
  hydrography ... 137, 138, 139, 140
  magnetic observations ... 138, 144
  reconnoissance ... 142, 143, 146
  tide observations ... 137, 138, 139, 141, 143, 144, 145, 146
  Topography ... 137, 138, 139, 140, 141, 143, 144, 145, 146
  triangulation ... 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147
Photographing ... 142, 143
Physical hydrography, Philippine Islands ... 142
Pigeon River ... 132
Plate printers, etc., pay of ... 18
Plymouth, Mass ... 69, 72, 73

	Page.
Pocatello, Idaho	103
Point Colpoys, Alaska	119, 125
Point Cornwallis, Alaska	123
Point Dume, Cal	93
Point Muzon, Alaska	123
Point St. Albans, Alaska	120
Pollock Rip Slough	73
Poloris, steamer	37
Pond Bay, Alaska	123, 124
Port Asuncion, Alaska	99
Port Bazan, Alaska	123
Port Chatham, Alaska	129
Port Chester, Alaska	96, 100
Port Ciego, P. I	140
Port Fidalgo, Alaska	103
Port Gamble, Wash	94
Port Graham, Alaska	129
Port Gravina, Alaska	126, 127
Port McArthur, Alaska	21
Port Newark Terminal	80
Port Protection, Alaska	118, 119
Port Real Marina, Alaska	121, 122
Port Royal Sound, S. C	89
Port Wells, Alaska	129
Portillo Channel, Alaska	121, 122
Porto Rico, magnetic work	135
Portsmouth, N. C	87
Portsmouth Island, N. C	88
Potter, L. A	76
Powell, John D	94, 107
Powells Point, N. C	86, 87
Pratt, J. F., inspector, Seattle suboffice	11, 94
Primary Traverse	102, 109
Prince of Wales Island, Alaska	119, 121
Prince William Sound, Alaska	126
Printing office	26
Publications	25, 62, 63
Publicity	25
Puerto Princesca, P. I	141, 144
Quesada Reef, P. I	140
Quicks Hole, Mass	69
Quickstep, steamer	130, 132
Quillian, C. G	123, 124
Quinhagak, Alaska	131
Rainy River	107
Reconnaissance, Alaska	115, 130, 132
Colorado	103
Idaho	103
New Mexico	103
Oregon	107
Philippine Islands	142, 143, 146
Washington	101
Red Bay, Alaska	118, 119
Redfield, William C., Secretary of Commerce	156
Reef Harbor, Alaska	123
Reese, E. E	73
Refugio Island, P. I	147
Reno, Nev	101
Reorganization of Bureau	12
Research, steamer	50, 137, 146, 147, 148
Retirement	44
Revillagigedo Channel, Alaska	115, 116, 124
Rhode Island, hydrography	68, 74
inspection duty	80
magnetic observations	111
Rhode Island, tide observations	68
topography	68, 74
triangulation	68
Richards, T. and A. T	15
Rio Grande, steamer	51, 91
Rio Grande River	98, 99
Ritter, H. P	128, 148, 149
River Junction, Fla	98
Roanoke Island, N. C	86
Roanoke Sound, N. C	86, 87
Rochester, N. Y	150
Romblon, steamer	50, 141, 143, 144
Roswell, N. Mex	103
Rude, G. T	82, 126
Ryus Bay, Alaska	123, 124
Sablayan Island, P. I	147
Sacramento River, Cal	93
"Safety First" Exposition	68, 153
Sag Harbor, N. Y	75
St. Augustine, Fla	97
St. Matthews Bay, Alaska	126, 127
St. Simons Lighthouse	90, 91
Salaries	28, 29
Salem, Mass	71
San Bernardino Island, P. I	137, 138
San Bernardino Straits, P. I	137, 138
San Francisco, Cal	93
San Joaquin River, Cal	93
San Juan Bautista Island, Alaska	121, 122
San Miguel Island, P. I	147, 148
San Nicolas Shoals, P. I	138
Sandakan, P. I	140
Sandy Hook, N. J	74
Sanitary conditions	17
Santa Ana, steamer	133
Santa Fe Railway	103
Scituate, Mass	69, 71, 72
Sea Otter Sound, Alaska	122
Seaboard Air Line Railway	98
Sealed Passage, Alaska	123, 124
Seattle, Wash., suboffice	94
Section of field records	53
Section of field work	52
Section of instruments	9, 22
Section of library and archives	9
Section of miscellaneous	9
Section of printing and sales	9
Section of vessels and equipment	53
Seward Passage, Alaska	125
Seyboldt, J. M., assistant chief division	11
Shakan Bay, Alaska	118, 119
Shakan Islands, Alaska	118, 119
Sheep Island Slough, N. C	87
Shipley Bay, Alaska	119
Shumagin Islands, Alaska	133, 134, 135
Siems, F. B. T	76, 141, 143, 151
Signal Building	94, 95, 96, 101, 102, 140, 147
Signal Lamp	110
Sinclair, C. H	106, 107, 150
Smith, E. E	132
Snake River	104
Snow Passage, Alaska	116
Snowden, Mont	105
Sobieralski, A. M	145
Sombrero Rock, P. I	141
Sorsogon Bay, P. I	146, 147

Page.

Sounding machines ... 91
South Carolina, Coast Pilot work ... 76
magnetic observations ... 82, 88
hydrography ... 77, 82, 89, 90
signal building ... 96
tide observations ... 82, 89, 90
topography ... 89
triangulation ... 82, 89, 90
South Dakota, Gravity ... 106
magnetic observations ... 82, 114, 115
South Tubbataha, P. I ... 139
Special duty, details of operations ... 148
general statement of progress ... 66
Speed trial course ... 148
Steirnagle, W. M ... 76
Suboffice, Galveston, Tex ... 91
Manila, P. I ... 136
New York, N. Y ... 80
San Francisco, Cal ... 93
Seattle, Wash ... 94
Suboffices ... 44
Suisun Bay, Cal ... 92
Sulu Sea ... 140, 141, 143
Summer Strait, Alaska ... 117, 120
Surveyor, steamer ... 27, 36, 52
Surveys requested ... 65
Swainson, O. W ... 146
Swick, C. H ... 150
Sydney, Mont ... 105

Taku, steamer ... 48, 126, 127, 128, 132
Talisay Island, P. I ... 138
Tamgas Harbor, Alaska ... 123, 124
Tatoosh Island, Wash ... 93, 94
Taytay Bay, P. I ... 143
Temperature Observations ... 91
Tennessee, latitude ... 150
magnetic observations ... 112, 114
triangulation ... 102, 109
Texas, inspection duty ... 91
magnetic observations ... 113
triangulation ... 98, 99
Texas-California Arc ... 103
Ticao Pass, P. I ... 146, 147
Tide gauge platforms ... 129
Tide Observations, Alaska ... 117, 121, 123, 125, 126, 129, 130, 132
New York ... 74
North Carolina ... 86, 87
Philippine Islands ... 137, 138, 139, 141, 143, 144, 145, 146
South Carolina ... 82, 85, 89, 90
Virginia ... 74, 81, 82
Tide stations ... 76
Tides and currents ... 55
Tompkinsville, N. Y ... 76, 77
Tongass Narrows, Alaska ... 116
Tonopah Junction, Nev ... 101
Topography, Alaska ... 117, 121, 122, 123, 125, 126, 129, 130, 132, 133
District of Columbia ... 126
Georgia ... 82
Massachusetts ... 68, 71

Page.

Topography, New Jersey ... 71, 73
New York ... 71, 73, 74
North Carolina ... 86, 87
Philippine Islands ... 137, 138, 139, 140, 141, 143, 144, 145, 146
South Carolina ... 82, 89, 90
Virginia ... 74, 81, 82
Town Creek, S. C ... 82
Traverse, Alaska ... 130
Arkansas ... 102, 109
Tennessee ... 102, 109
Trial course for submarines ... 66
Triangulation ... 40, 54
Alaska ... 40, 111, 115, 117, 121, 122, 123, 124, 126, 129, 130, 131, 132, 133
Arkansas ... 102, 109
California ... 100
Georgia ... 82, 96
Idaho ... 103
Maryland ... 95
Massachusetts ... 68, 71
New Jersey ... 71, 73
New York ... 68, 71, 73
North Carolina ... 86, 87
Oregon ... 105
Philippine Island ... 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147
South Carolina ... 82, 89, 90, 96
Tennessee ... 102, 109
Texas and Mexico ... 98, 99
Virginia ... 81, 82
Trueblood, P. M ... 87, 144
Tubbataha Reef, P. I ... 139
Turning points ... 98
Tuscarora Rock ... 135

Ulloa Channel, Alaska ... 122
Ulrich, Franklin P ... 115
Umatilla, Oreg ... 105
Unga Island, Alaska ... 135
United States Chamber of Commerce ... 154

Valdez Arm, Alaska ... 128, 129
Vanceboro, Me ... 94
Vaults ... 20
Vega, bark ... 51
Verde Islands, P. I ... 145
Vessels ... 35, 51
Vieques, P. R ... 135
Virginia, Coast Pilot work ... 76
Gravity ... 106
hydrography ... 74, 76, 77, 80, 81, 82
latitude ... 107
magnetic work ... 74, 82, 112, 113
Signal building ... 95
Tide Observations ... 82, 81
Topography ... 74, 81, 82
Triangulation ... 81, 82

Wainwright, D. B., Chief, Division of Charts 11
Warroad, Minn ... 106, 107
Washington, Coast Pilot work ... 93
hydrography ... 93, 94

	Page.
Washington, inspection duty	94
reconnoissance	101
triangulation	94, 101
Watkins, J. T., chief, section of field records	11
Welker, P. A., Assistant in Charge	11
Welt, Augustus, schooner	51, 86
West Virginia, latitude	107
magnetic observations	111, 112
Westdahl, F	93
Western Union Telegraph	106, 108
Whale Island Pass, Alaska	133, 135
Whitney, Paul C	77, 80, 90
Winston, Isaac, inspector, New York sub-office	11, 80, 154
Wire-drag work	35, 68, 71, 115, 117
Wisconsin, latitude	107
magnetic observations	112
Wrangell Strait, Alaska	120
Wyoming, gravity	106
magnetic observations	114
Yamacraw, Coast Guard cutter	78
Yukon, steamer	27, 48, 130, 131, 132, 133
Zamboanga, P. I	140, 142
Zarembo Island, Alaska	116, 117, 118, 120, 121
Zimovia Strait, Alaska	125