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ANNUAL REPORT

OF THE

SUPERINTENDENT, UNITED STATES COAST AND GEODETIC SURVEY

TO THE

SECRETARY OF COMMERCE

FOR THE

FISCAL YEAR ENDED JUNE 30, 1918

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National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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THIRTY PER CENT OF THE ENTIRE PERSONNEL ON ACTIVE DUTY WITH THE ARMY AND NAVY; 70 PER CENT ENGAGED ON WORK CONNECTED WITH THE WAR.

REPORT

OF THE

SUPERINTENDENT, U. S. COAST AND GEODETIC SURVEY.

DEPARTMENT OF COMMERCE,
COAST AND GEODETIC SURVEY,
Washington, October 5, 1918.

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, 1918. This is the eighty-seventh annual report of this Bureau.

INTRODUCTION.

In this annual report the same plan of division and discussion is followed as in the annual report for the fiscal year ended June 30, 1917, with the exception that it contains an added chapter on the war work of the Bureau.

In Part I, Chapter I, is a discussion of the field accomplishments of the Bureau during the year. In Chapter II is a statement of the needs of the Bureau to better accomplish its field work.

In Chapter I of Part II is outlined what has been done in the Washington office of the Bureau during the fiscal year, and in Chapter II of Part II are pointed out some of the needs of the Washington office. Chapter III of Part II contains a statement of the activities of the Bureau in connection with the war.

In Part III is given a résumé of the work accomplished in the field and office during the year.

Part I.—FIELD WORK AND NEEDS OF THE FIELD SERVICE.

CHAPTER I.

WHAT HAS BEEN DONE DURING THE FISCAL YEAR.

In the report of this Bureau for the fiscal year ended June 30, 1917, were shown in the main the characteristics of the coast lines of the United States and possessions, under four general classifications, and this was followed by a detailed statement of the conditions and progress of the hydrographic surveys up to that time. (See pp. 8 to 41, inclusive, of the Report of the Superintendent of the United States Coast and Geodetic Survey for the year ended June 30, 1917.) It is unnecessary to repeat here the discussion in that report, except so far as it relates to the hydrographic work accomplished during the present fiscal year, but it is referred to, as it contains a statement of the hydrographic problem before the Survey and will lend assistance in considering the relation of the hydrographic work done during the fiscal year to what yet needs to be done.

Considered from the standpoint of units of classification, the field work accomplished by the Bureau during the fiscal year ended June 30, 1918, is best expressed as follows:

Hydrography: (1) Ship and launch hydrography, (2) wire-drag surveys, (3) revision work, (4) current observations, (5) tidal observations, and (6) topography.

Geodesy: (1) Triangulation, (2) precise levels, and (3) magnetic observations.

HYDROGRAPHY.

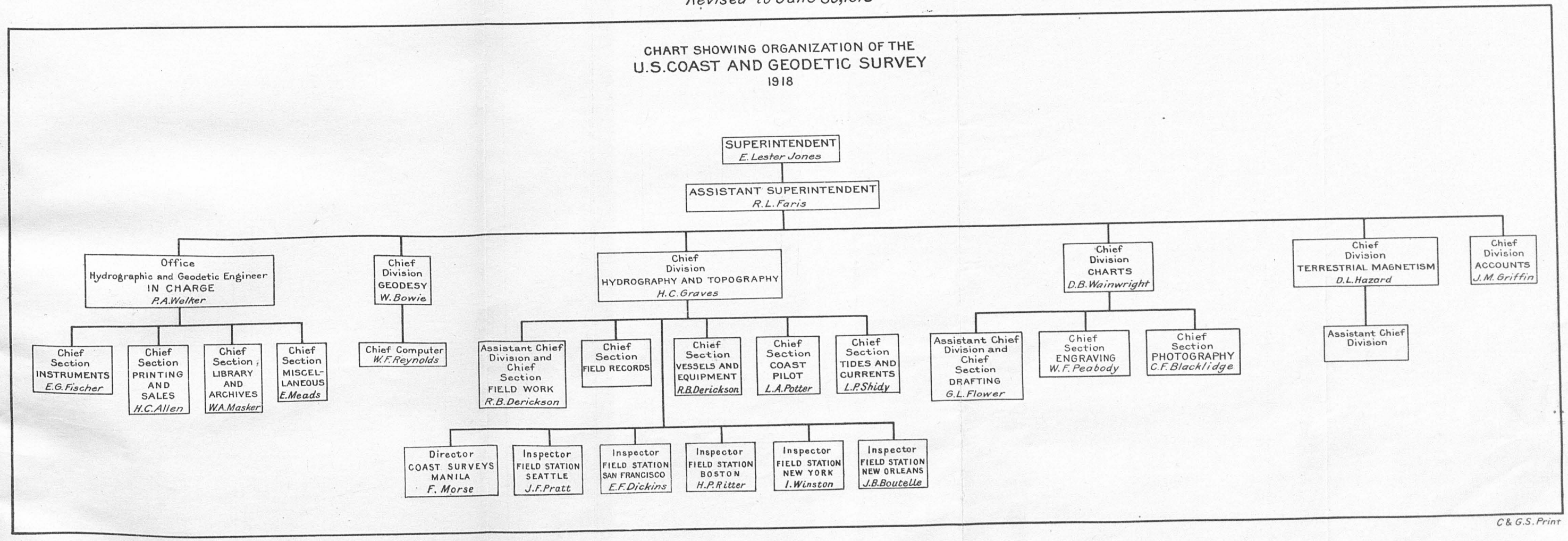
1. *Ship and launch hydrography.*—The vessels of the Bureau in commission within the year were as follows: *Surveyor*, *Bache*, *Isis*, *Matchless*, *Hydrographer*, *Patterson*, *Explorer*, *Yukon*, *Taku*, *Pathfinder*, *Fathomer*, *Marinduque*, *Research*, and *Romblon*.

The *Surveyor*, *Bache*, *and Isis* were requisitioned by the Navy Department as auxiliaries to the naval fleet, and taken over by Executive order on September 24, 1917. From that time throughout the fiscal year they have been under the control of the Navy Department.

The *Explorer* was on field duty only during the first month of the fiscal year, the *Patterson* from the beginning of the year to the close of September 23, and the *Taku* less than a month. During 1918 the Navy Department felt the need of additional vessels to patrol the waters of the Pacific coast, and on May 16, 1918, the *Patterson*, now the U. S. S. *Forward*, and the *Explorer* were transferred to the naval fleet by Executive order. The surveying seasons of the *Explorer* and *Taku* were necessarily prematurely closed because of the mutiny and desertion of their crews, and the *Patterson*, *Explorer*, and *Taku* were not sent to the field in the spring of 1918, because of the lack of officers and the difficulty of enlisting crews owing to labor conditions.

Effective Oct. 15, 1915
Revised to June 30, 1918

CHART SHOWING ORGANIZATION OF THE
U.S. COAST AND GEODETIC SURVEY
1918



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The form of enlistment under which seamen are employed on the vessels of this Bureau amounts to no more than a civil contract, and this form of enlistment is as favorable as can be drawn for the Government under the present laws. Under normal conditions, when there was no keen competition for seamen, this enlistment served the purpose of the Bureau very well, though even then if a sailor chose to desert there was no recourse but to give him an "unfavorable discharge." As the demand for skilled labor has grown under present war conditions, the weakness of such a form of enlistment has become more and more evident. Employment on a vessel of the Coast and Geodetic Survey is not looked upon with as much favor by seamen as is employment on a vessel of the merchant marine, for the reasons that employment on a vessel of the merchant marine may be continuous, while on a vessel of the Coast and Geodetic Survey on the west coast it is only during the surveying season, with the certainty that at the termination of the season the employment ends at least for months. The duties required to be performed by a seaman on a merchant-marine vessel are less exacting than on a vessel of the Coast and Geodetic Survey. A seaman on a merchant-marine vessel receives overtime pay for overtime service, while such a condition of employment is impracticable on a Government vessel. I have presented this matter of enlistment of seamen on vessels of the Coast and Geodetic Survey more in detail under the head of "Needs of the field service" in another chapter, and hope that the requisite legislation may be enacted which will make possible an enlistment of seamen on the vessels of the Coast and Geodetic Survey that will insure adequate service.

Of the five vessels that have been in use by this Bureau in the surveys of the waters of the Philippine Islands, four belong to the insular government, namely, the *Fathomer*, *Marinduque*, *Research*, and *Romblon*. The officers of these four vessels were of the technical force of this Bureau. When the need became manifest for men with the technical qualifications of the officers of the Coast and Geodetic Survey in the Army and Navy in the prosecution of the war, more than half of this technical force was transferred to the military branches of the Government by Executive order, as authorized by section 16 of the "Act to temporarily increase the commissioned and warrant and enlisted strength of Navy and Marine Corps, and for other purposes," approved May 22, 1917. This necessitated the withdrawal of a number of these officers from service on the vessels loaned by the insular government. In view of this shortage of officers and the fact that the *Research* had practically completed the survey of all sheltered waters where it was safe for her to go, and further on account of her age and weakened condition it was unsafe to send her to survey exposed waters, she was turned back to the insular government the latter part of December, and the *Marinduque* was transferred back temporarily to the insular government on March 19, 1918.

1. The *ship and launch hydrography* performed during the fiscal year was as follows:

Sewall Point, Va.: 3 square statute miles. This survey was asked for by the Navy Department. It was accomplished in small boats and may be classed as launch hydrography.

Pamlico, Croatan, and Roanoke Sounds, N. C.: 395 square statute miles. This is in completion of revision surveys of these sounds, the need of which was cited in my annual report for 1917, on pages 27 and 28. This work was accomplished in launches and pulling boats.

York River, Va.: 4.5 square statute miles. The surveys in the York River, Va., were made at the request of the Navy Department. This was all launch work.

Mississippi Sound and Mobile Bay: 1,690 square statute miles. The need of this and other surveys along the Gulf coast is shown on page 32 of my report for 1917. About half of this work may be classed as ship hydrography and the remaining half classed as launch hydrography.

Chesapeake Bay: 35 miles of soundings, all ship work.

Approaches to Cross Sound, Lisianski Inlet and Strait, Alaska: 2,317 square statute miles. About seven-eighths of this work may be classed as ship hydrography. The remainder was launch hydrography.

Northward from Cape Muzon, Alaska: 8.8 square statute miles. About two-thirds of this work may be classed as ship hydrography. The remainder was launch hydrography.

Prince William Sound, Alaska: 32 square statute miles, all launch hydrography.

Approaches to Burdeus Bay, Polillo Island, north coast of Polillo Island, and Cuyo Islands, P. I.: 1,516.5 square statute miles. About seven-tenths of this work was done by the vessel and the remainder by launches.

West coast of Busuanga Island, P. I.: 2,443.6 square miles. Nine-tenths of this was done by the ship and the remainder by launches.

Southeast coast of Palawan Island, P. I.: 1,312 square miles. About half of this was done by the ship and half by launches.

East coast of Palawan Island, P. I.: 1,134.4 square statute miles. About half of this was done by the ship and half by launches.

Manila Bay, P. I.: 315.5 square statute miles. About nine-tenths of this was done by the ship and the remainder by launches.

2. *Wire-drag surveys.*—There were five wire-drag parties in the field within the year. For purposes of identification they were given designation numbers.

Wire-drag party No. 1 operated in the approaches to Portsmouth Harbor, N. H., and in the vicinity of Block Island. This party was in the field from July 1 to September 27, 1917, and from May 6 to June 30, 1918. Ninety-seven square statute miles were dragged.

Wire-drag party No. 2 operated in Block Island Sound, Narragansett Bay and approaches, Long Island Sound, and vicinity of Eastport, Me. The party was in the field from July 1 to November 27, 1917, and from May 7 to June 30, 1918, and covered 167 square miles.

Wire-drag party No. 3 operated in Frederick Sound and Cook Inlet, Alaska. The party was in the field from July 1 to September 28, 1917, and from May 3 to June 30, 1918, and covered 230.2 square miles.

Wire-drag party No. 4 operated in the vicinity of Juneau, Alaska. The party was in the field from July 1 to September 11, 1917, and covered 72.7 square miles.

Wire-drag party No. 5 operated in the vicinity of Dry Tortugas, off the southern coast of Florida. The party was in the field from July 1 to September 29, 1917, and covered 140 square miles.

3. *Revision work.*—Revision work was done in the localities named below:

Plymouth, Mass.: 217.5 miles of sounding lines run.

Buzzards Bay, Mass.: 5 miles of triangulation and 3 square miles of hydrography.

South shore of Long Island Sound: 11 triangulation stations occupied, 34 miles of shore line run, and 27.5 miles of railroads and other roads.

Vicinity of Seattle, Wash., Lake Washington Ship Canal: 3 triangulation stations occupied, 14½ square miles of topography and 3.75 square miles of hydrography completed.

4. *Current observations.*—The following are the general localities of the principal current observations made during the year and the number of stations occupied at each of these localities:

Locality:	Number of stations.
Block Island Sound	7
Coast of Maine	7
Hampton Roads, Va	1
Long Island Sound	26
Port Jefferson, N. Y	2
The Race, Long Island Sound	4

5. *Tidal observations.*—Tidal observations were made throughout the year at the following permanent tidal stations:

1. Portland, Me.
2. Fort Hamilton, N. Y.
3. Atlantic City, N. J.
4. Philadelphia, Pa.
5. Baltimore, Md.
6. Fernandina, Fla.
7. St. Augustine, Fla.
8. Key West, Fla.
9. Cedar Keys, Fla.
10. Galveston, Tex.
11. San Diego, Cal.
12. San Francisco, Cal.
13. Seattle, Wash.
14. Craig, Alaska.

Important tidal observations were made at the following stations:

1. New London, Conn.
2. New Haven, Conn.
3. Port Jefferson, N. Y.
4. Gloucester Point, Va.
5. Pascagoula, Miss.
6. Bay St. Louis, Miss.
7. Petersburg, Alaska.
8. Canoe Cove, Alaska.
9. Miner Island, Alaska.
10. Auke Bay, Alaska.
11. McClure Bay, Alaska.
12. King Cove, Alaska.

6. *Topography* in connection with hydrographic work was executed as follows:

Narragansett Bay and east end of Long Island Sound: 41.3 square miles.

Sewall Point, Va.: 1 square mile.

North Carolina sounds: 15 square miles of topography, 71 miles of shore line, and 18½ miles of railroads and other roads surveyed.

Mississippi Sound and Mobile Bay: 140 square miles of topography and 194.5 miles of shore line.

Cross Sound, Alaska: 32 square miles.

St. Thomas, Virgin Islands: 10 square miles.

Prince William Sound, Alaska: 40 square miles.

Stephens Passage, Alaska: 14.9 square miles.

Frederick Sound, Alaska: 126.25 square miles.

Coast of Alaska north of Cape Muzon: 10.5 square miles.

Knik Arm, Alaska: 2 square miles.
East coast of Palawan, P. I.: 57 square miles.
Burdeus Bay, P. I.: 32.5 square miles.
Southeast coast of Palawan, P. I. : 45 square miles.
Manila Bay, P. I. : 47.2 square miles.
Northwest coast of Busuauga, P. I. : 4.5 square miles.

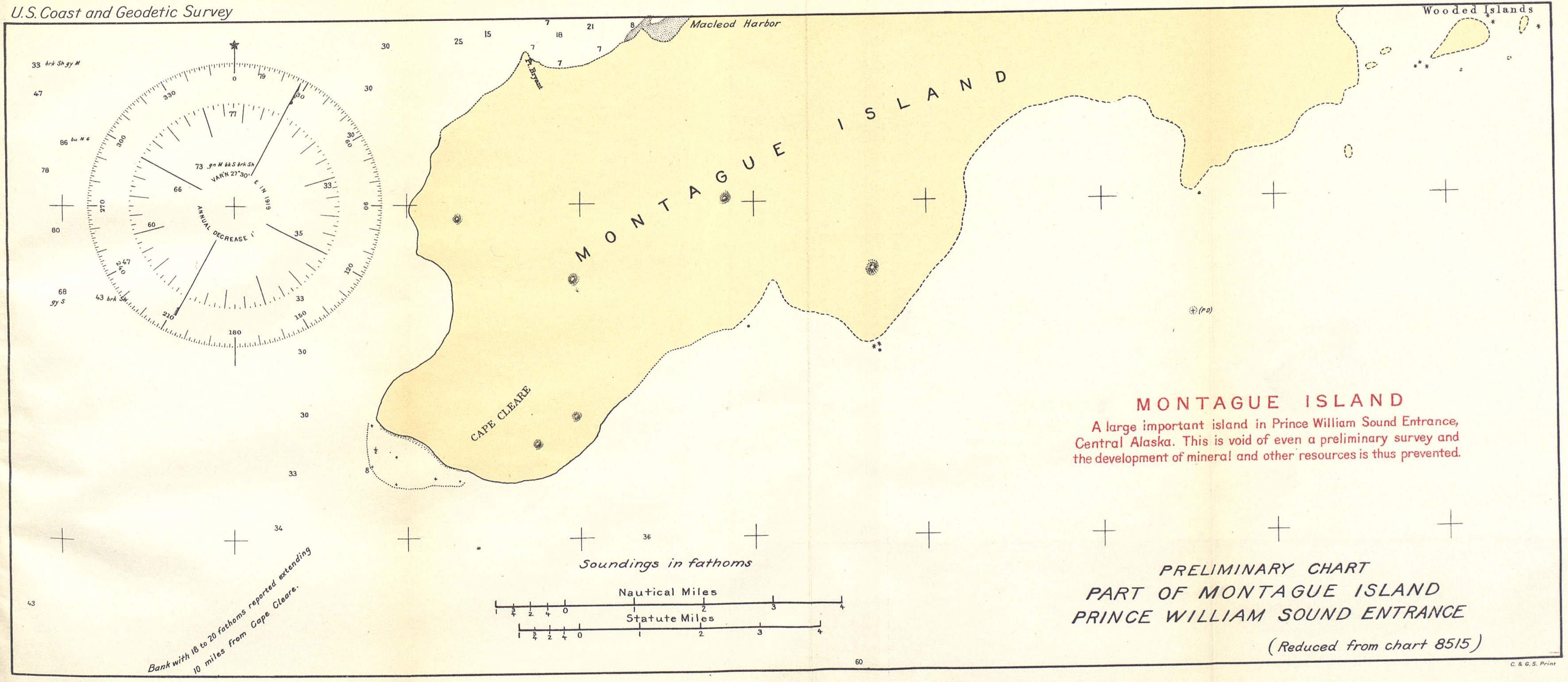
GEODESY.

1. *Triangulation.*—Primary triangulation was accomplished in the following localities: Along the Rio Grande in Texas and in the vicinity of Stephens Passage and Lynn Canal, southeast Alaska. The total extent of this triangulation is 639 miles. Primary traverse was carried on in the following localities: Mostly in Georgia but also in South Carolina and Virginia. The extent of this traverse is 940 miles. Tertiary triangulation was executed in the following locality: Along the Cape Fear River in North Carolina. The extent of this tertiary triangulation is 70 miles.

2. *Precise levels.*—During the year 2,367 miles of precise levels were run as follows: In Texas, Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina, North Carolina, and Virginia.

3. *Magnetic observations.*—In the continuation of the magnetic survey of the United States, observations were made during the year at 275 stations in 21 States, of which 118 were new primary stations, 114 auxiliary stations, 34 repeat stations for the determination of secular change, and 9 new stations in old localities. Meridian lines were established when they were requested by the local authorities. The number of county seats at which magnetic observations have not been made was reduced from 163 to 138.

The observatories at Cheltenham, Md.; Vieques, P. R.; Tucson, Ariz.; Sitka, Alaska; and near Honolulu, Hawaii, were in operation throughout the year. Continuous photographic records were secured of the variations of declination, horizontal intensity, and vertical intensity. Absolute observations were made at least once a week and scale value determinations once a month. Beginning with January, 1918, horizontal intensity observations as well as dip and declination were made both in the morning and in the afternoon on the same day to secure additional data regarding the relation between the variation and absolute instruments.


Macleod Harbor
Wooded Islands
MONTAGUE ISLAND
CAPE CLEARE
VAR'N 27°30' E IN 1919
ANNUAL DECREASE 1'
Soundings in fathoms
Nautical Miles
Statute Miles
Bank with 18 to 20 fathoms reported extending 10 miles from Cape Cleare.
MONTAGUE ISLAND
A large important island in Prince William Sound Entrance, Central Alaska. This is void of even a preliminary survey and the development of mineral and other resources is thus prevented.
PRELIMINARY CHART
PART OF MONTAGUE ISLAND
PRINCE WILLIAM SOUND ENTRANCE
(Reduced from chart 8515)
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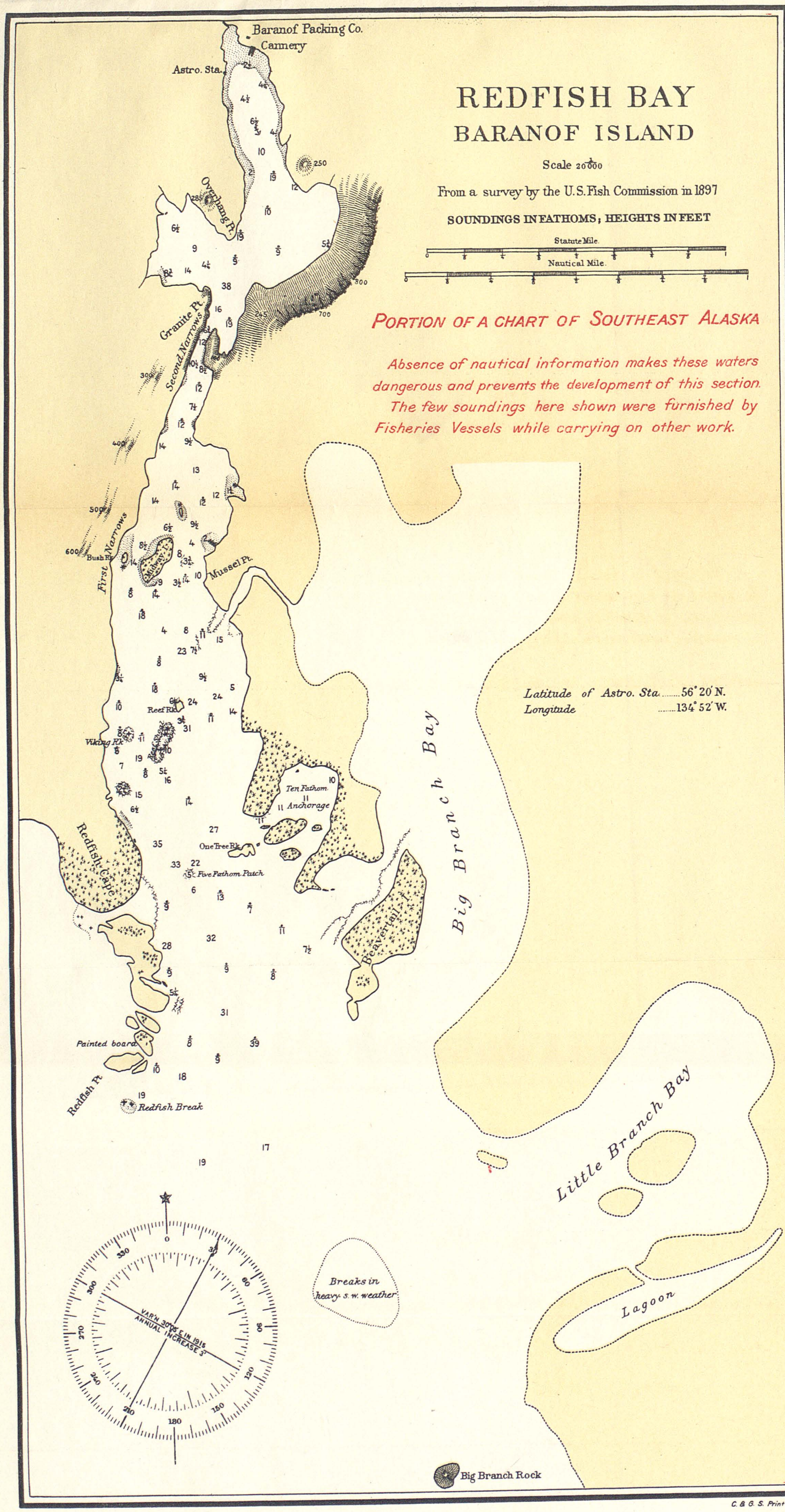

REDFISH BAY
BARANOF ISLAND
Scale 1/20000
From a survey by the U.S. Fish Commission in 1897
SOUNDINGS IN FATHOMS; HEIGHTS IN FEET
Statute Mile.
Nautical Mile.
PORTION OF A CHART OF SOUTHEAST ALASKA
Absence of nautical information makes these waters dangerous and prevents the development of this section. The few soundings here shown were furnished by Fisheries Vessels while carrying on other work.
Baranof Packing Co. Cannery
Astro. Sta.
Overhang Pt.
Granite Pt.
Second Narrows
First Narrows
Bush Rk.
Midway Rk.
Mussel Pt.
Reef Rk.
Viking Rk.
Ten Fathom Anchorage
One Tree Rk.
Five Fathom Patch
Redfish Cape
Big Branch Bay
Beaverfall I.
Painted board
Redfish Pt.
Redfish Break
Little Branch Bay
Lagoon
Breaks in heavy s.w. weather
Big Branch Rock
Latitude of Astro. Sta. 56° 20′ N.
Longitude 134° 52′ W.
VAR'N 30°15′ E IN 1915
ANNUAL INCREASE 3′

C. & G. S. Print

CHAPTER II.

NEEDS OF THE FIELD SERVICE.

SURVEYING VESSELS.

In my report for last year there was given a specific and detailed statement so far as information was available regarding the progress and condition of hydrographic surveys of all the waters contiguous to the United States and possessions, and incidental to this a discussion of the various classes of hydrographic surveying.

The most costly class of hydrography, and from many points of view the most important, is ship hydrography. There are thousands upon thousands of square miles of this class of hydrography that should be executed without further delay. These are areas removed from the sight of land, exposed waters in extensive bays and sounds, and waters of those regions nearer shore where there is no refuge for smaller craft, relatively costly because of the large unit of organization that is required to perform the work. On the other hand, the results obtained can be secured in no other way and by no other means, and are of the utmost importance to maritime commerce, and in many instances the development of industries is actually retarded or prohibited because of the lack of these surveys.

Alaska presents the most striking example of this state of affairs. The latent commercial possibilities of this great Territory have been but little exploited, and the natural resources of the country in the way of the known vast deposits of coal, copper, etc., lay dormant largely because the country is commercially only accessible through her waterways, and these are but meagerly surveyed. Charts of these waters are issued continually, which from the nature of their origin are known to be indifferent approximations of what should be represented. They are of many important regions, mere compilations from surveys dating as far back as the time when Russia owned the territory, from incidental soundings by fishing schooners and other vessels that venture into unsurveyed waters, and from soundings by other Government vessels venturing into these waters on other missions. Such charts may be in many instances worse than useless to the navigator, because they lend assurance where danger lurks and purport to guide the navigator to safety where if he escapes destruction it results more from chance than from representations on the chart. And even the charts that are issued of many localities are void of information because no official surveys have been made by the Government, and no official examinations have been made by other agencies. (See figs. 3 and 4.)

This lack of adequate surveys is keenly felt by the shipping interests that risk their vessels in Alaskan waters. There are regions where industries are awaiting development, where these companies will under no consideration send their vessels because of the unknown dangers, and this caution is grounded on experience such as is shown

by a letter received from the general manager of the Pacific Steamship Co., under date of May 2, 1918, wherein he says, in part:

At the present moment the Pacific Steamship Co. has two passenger steamers in trouble in southeastern Alaska as the result of unavoidable strandings. First, the *Admiral Evans*, which struck an uncharted rock in the entrance of Hawke Inlet, as a result of which it was necessary to beach her immediately, where she now lies with her stern in 11 fathoms of water. Thirty days' salvage operations have failed of results, and the best we can hope for is the loss of the use of the vessel for six months, and a total expense of from $300,000 to $400,000 for recovery and repairs. After the accident a Survey vessel was sent to the spot and discovered and buoyed the rock, thus adding one more expensive unit to the accidental survey of Alaskan waters.

Our S. S. *Admiral Farragut*, while steaming north from Petersburg on April 26, struck an unknown obstruction, but where the chart showed 3 and 3¼ fathoms of water, and the tide one hour to go, with the vessel drawing 19 feet and 6 inches aft, probably not over 16 feet forward. Her Nos. 1, 2, 3, and 5 tanks are leaking. The pumps were able to keep her afloat until she arrived at Juneau, where she is now discharging cargo, and it will undoubtedly be necessary to bring her to Seattle for extensive repairs. I understand some of the Coast and Geodetic Survey people were aboard the *Admiral Farragut* when she struck, and you will probably be apprised of the details.

Here the loss to a single company operating steamers in Alaskan waters, in two instances, has been in excess of the entire appropriations for the Coast and Geodetic Survey by this Government for the current year for surveying the waters of Alaska, Washington, Oregon, California, the Philippine Islands, and Hawaii, and the yearly loss of vessels in the unsurveyed waters of Alaska alone would go far toward supplying vessels sufficient to make the necessary surveys to aid and assist commerce in these waters, but which should certainly now be expedited when commerce is pushing its way into these waters regardless of the lack of surveys, and paying the price in a loss of ships and cargoes that averaged $490,300 annually during the 10-year period from 1906 to 1915, inclusive.

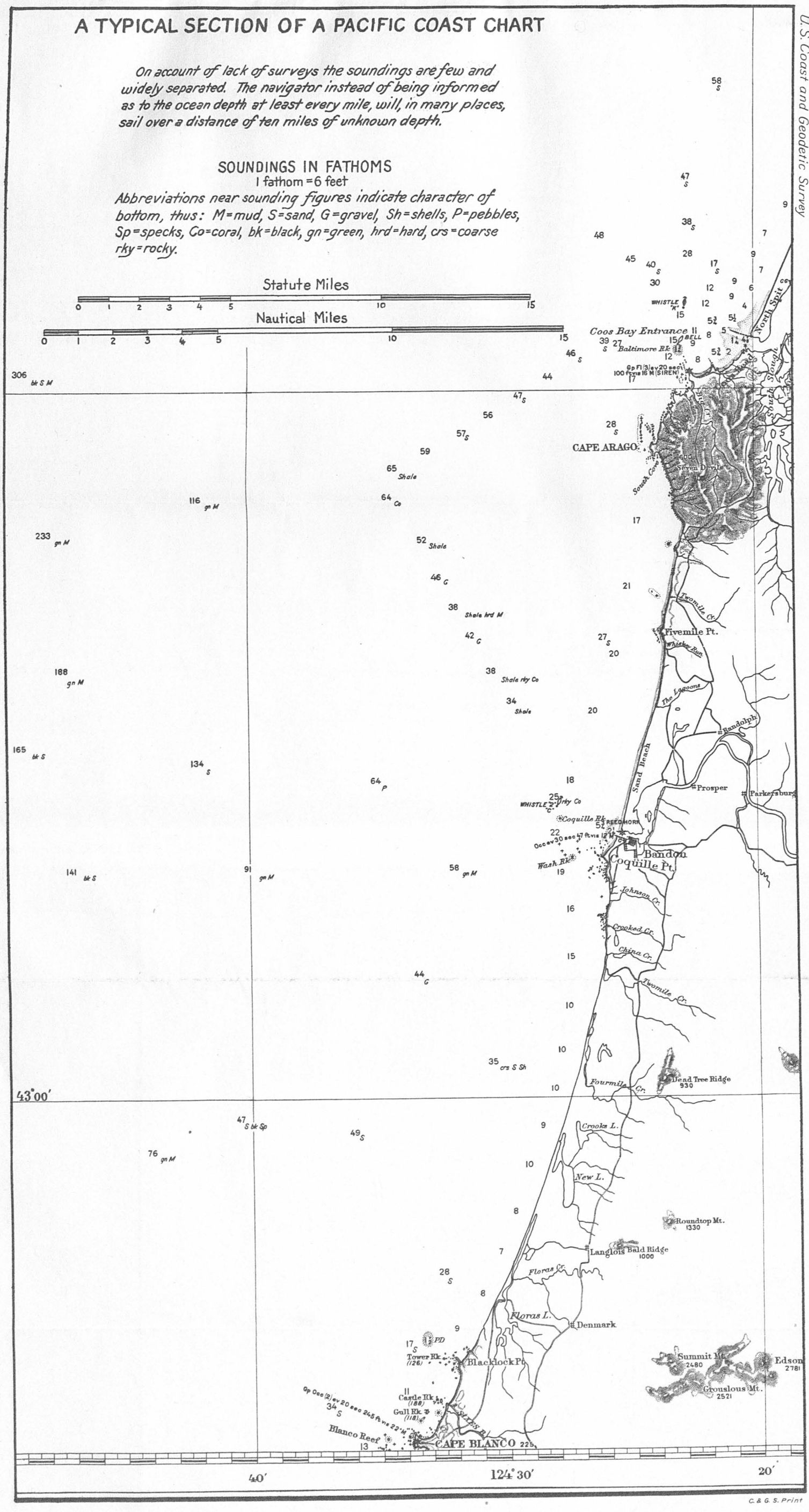
While the great stretches of unsurveyed or inadequately surveyed waters bordering the coasts of the Territory of Alaska present a most striking example of the retardation of a country's commerce and development, which could be stimulated to return a profit far in excess of the cost of proper surveys, this is not peculiar to Alaska alone. Ship-borne commerce is traversing the waters of some of the coasts of continental United States and escaping destruction more through the experience and knowledge of the navigator than by the guidance of charts that contain all the information that is necessary. The general surveys of the coasts of Washington were made between 1873 and 1894, of Oregon between 1868 and 1891, and of California between 1858 and 1901. These surveys were, for most of the sections of the coasts, in the nature of reconnaissance, and extended in but few instances beyond the 100-fathom curve, and indeed in some instances between the 50-fathom curve and the 100-fathom curve the charts are void of information. It was fully realized at the time that this survey must later be supplemented by other work, but the then pressing needs demanded a general knowledge of all waters of the coasts rather than definite knowledge as to a selected part and no knowledge as to the remainder. Therefore, the whole coast was covered by a quite general survey. Figure 5 affords a tangible illustration of the scant information that the resulting chart contains. The acquisition of Alaska in 1867 with her thousands of miles of shore line placed before the Bureau a task that its facilities have

A TYPICAL SECTION OF A PACIFIC COAST CHART

On account of lack of surveys the soundings are few and widely separated. The navigator instead of being informed as to the ocean depth at least every mile, will, in many places, sail over a distance of ten miles of unknown depth.

SOUNDINGS IN FATHOMS
1 fathom = 6 feet

Abbreviations near sounding figures indicate character of bottom, thus: M=mud, S=sand, G=gravel, Sh=shells, P=pebbles, Sp=specks, Co=coral, bk=black, gn=green, hrd=hard, crs=coarse rky=rocky.



U.S. Coast and Geodetic Survey

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5

never since been expanded to meet, and with the exception of fragmentary examinations here and there, supplemented by information of doubtful value accepted from unofficial sources, the charts of the coasts of Washington, Oregon, and California have been issued year after year which could contain only the data obtained from the above-mentioned reconnaissance surveys.

It might be urged that since 50 fathoms (300 feet) afford depth of water in which no vessel has a draft such that it will ever run afoul of the bottom, there is no apparent need of surveys of waters of greater depth. Based on the necessary depth for the draft of a vessel this is true, but a knowledge of the depths is essential to the navigator from a wholly different point of view, namely, that of assisting navigation.

The prevailing weather along the coasts of Washington, Oregon, and California is in nautical language "thick;" that is, heavy fogs are the rule. A vessel from San Francisco to Puget Sound may be for hours, or even throughout the trip, hidden in a mist that obscures land and sky. Under such circumstances the master judges the location of his vessel by the distances and direction he has run as shown by the speed of his engines, the time that has elapsed since leaving a known position, and his direction by the compass. There are other factors that may contribute to place a vessel in a position entirely different from that which would result from calculations based on the above elements. The currents of the waters adjacent to the Pacific coast line of the United States vary both in direction and strength and observations have not yet been made sufficient to predict these currents. These currents may retard or accelerate a vessel, or carry her toward or from the land, and after steaming for hours through a thick fog, a vessel that according to reckoning from speed and direction taken may be at the position according to her course as plotted on the chart or dangerously near destruction by running ashore. Under these circumstances a chart that showed depths out to the thousand-fathom curve would be of undeniable value. Given all the characteristic depths of the waters along the coasts out to the thousand-fathom curve, a navigating officer is nearly as well guided as is a citizen in a city by the names of the streets on the lamp-posts.

It is essential that surveys be extended out to the 1,000-fathom depths in order that we may be reasonably sure that no undiscovered shoal areas exist, which if found by the navigator might be mistaken for shoal areas already shown on the shart and thus lead him astray.

The examination of any chart where a close survey has been made will show from the varying depths that in but few places is the bottom of the ocean plane, but, on the other hand, is undulating, or may drop off to abrupt depths where there are underwater banks that correspond to the bluffs along a river or the seashore. Below moderate depths and the influence of waves and strong currents (probably below 50 fathoms) the topography of the ocean bed remains fairly constant. With then a chart showing these details out to the thousand-fathom curve, a vessel could proceed from San Francisco to Seattle, though engulfed in a dense fog throughout the journey, with assurance of the position as judged from the course run and checked by soundings, for though the vessel was thrown

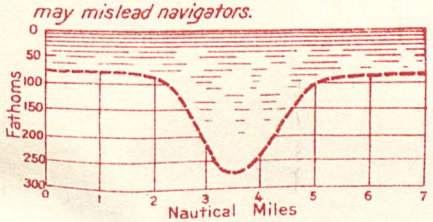
off her course by adverse currents, this would at once become apparent by the soundings showing depths different from those shown on the chart at the supposed position of the vessel, and it would be only a matter of further sounding and comparison of depths indicated on the chart to estimate the position of the vessel, for it is to be remembered that though other influences may vary, as the speed of the engine, the direction of the compass, and the direction and velocity of the currents, yet the depths when once known, below comparatively shallow ones, remain constant and are a sure guide. The assistance that known depths afford the navigator and how he may be misled by unknown depths are shown by figure 6.

Reference has been made above to the currents of the Pacific coast. The general conception of a hydrographic survey is one that develops the depths of the water and discloses the nature of the bottom, but the direction, strength, and time of ebb and flow of the currents of the Pacific coast of the United States are quite as important as is other nautical information, mainly because of the heavy fogs that hang over these waters making it necessary to determine the position of a vessel after hours of progress by taking into consideration all the known elements that may have influenced her position up to the time that it is desired to know her position. On the Pacific the ocean currents, mainly from lack of proper observations over a sufficient period, have so far eluded any exact estimate of their influences. A theory has long been held, and from which there is but little doubt, that practical results of the utmost value will be obtained from continuous observations taken for the Coast and Geodetic Survey from light vessels which are stationed at positions that present points of peculiar vantage, and from the information thus gained at least general predictions could be made that would be of material assistance to navigators.

While Alaska is suffering loss of shipping and her development retarded from the lack in some regions of any surveys and the Pacific coast of the United States is in need of more complete surveys, there is yet one other condition that must be met by the Coast and Geodetic Survey in order to keep the information current on the charts that are issued. This condition is aptly illustrated by the sandy formation beneath the waters adjacent to Cape Cod. Here is a section of the coast (and it is characteristic of many others) where a complete hydrographic survey may show the depths at the time the survey is made and be absolutely in error after a severe storm, should one occur directly after the completion of the survey, or it may be accurate for months, depending wholly upon how the loose sand forming the bottom may be shifted. It is difficult to draw the line as to just how often and how thorough surveys should be made of such localities, but certain it is that where the value of the vessels lost is equal to or in excess of the cost of proper surveys can be attributed to lack of information as to existing conditions, then, to this extent at least surveys should be made. And the vessels that are lost in such waters are not so small in number or value. The New England Fisheries, printed at Boston, Mass., is authority for the statement that along 40 miles of Cape Cod shore 592 vessels have been lost during 50 years, giving specifically the names of the vessels and dates of their loss. Figure 7 reproduced from that publication shows the positions where these vessels were lost.

PROFILE A

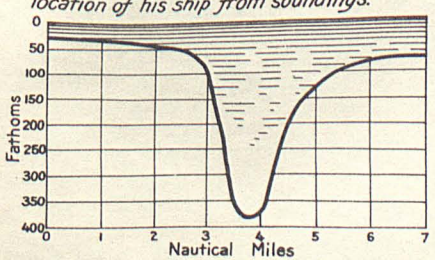
Part of a vessel's course inside the customary sailing line crossing a submarine valley north of Cape Mendocino, unsurveyed and until recently unknown, which until it is accurately charted may mislead navigators.

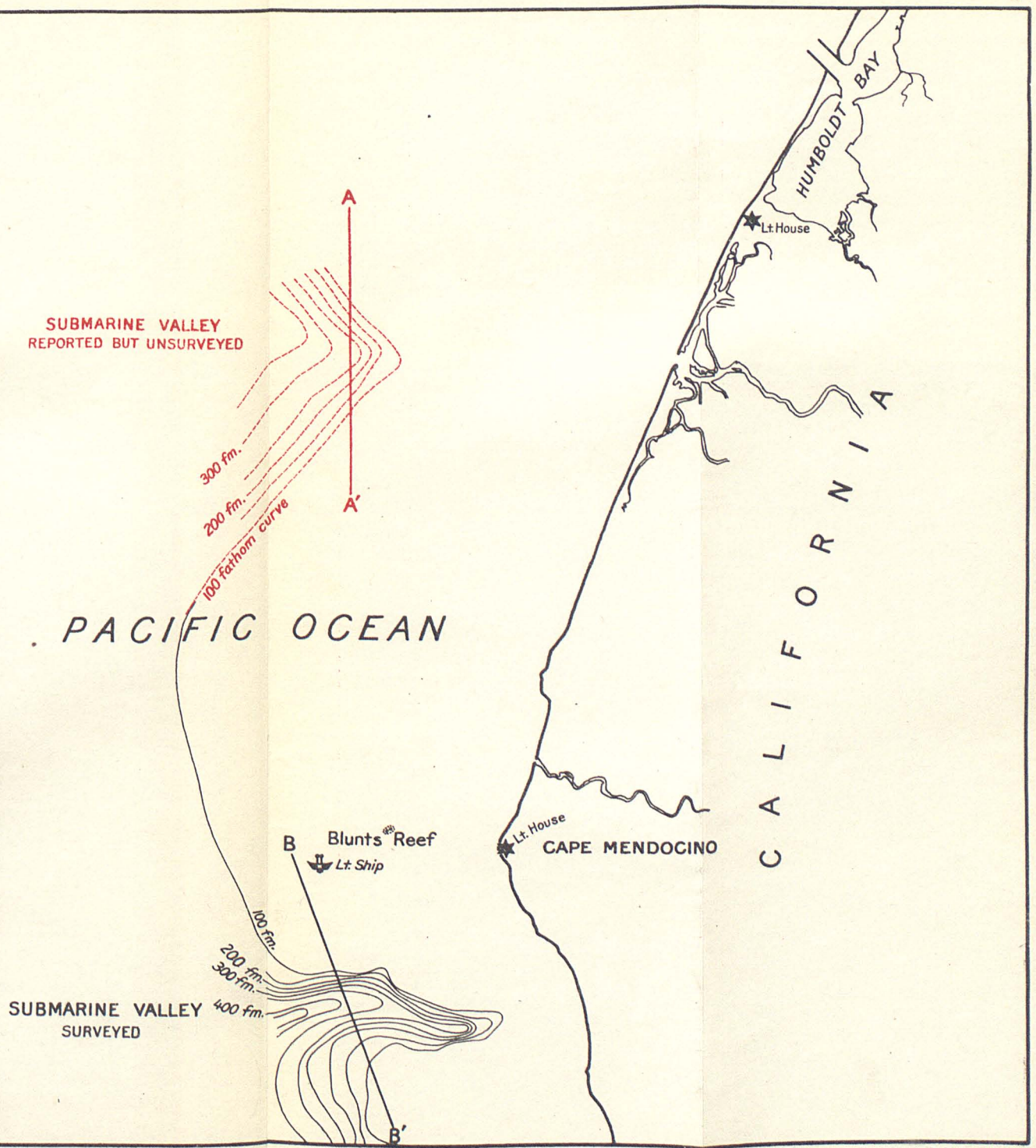


Note: 1 Nautical Mile = 1⅛ Statute Miles
1 Fathom = 6 Feet

PROFILE B

Part of customary sailing line crossing a submarine valley south of Cape Mendocino. This feature when accurately charted affords the navigator a valuable means to verify the location of his ship from soundings.





Submarine Valleys, Pacific Coast – their relation to Navigation.

C. & G. S. Print

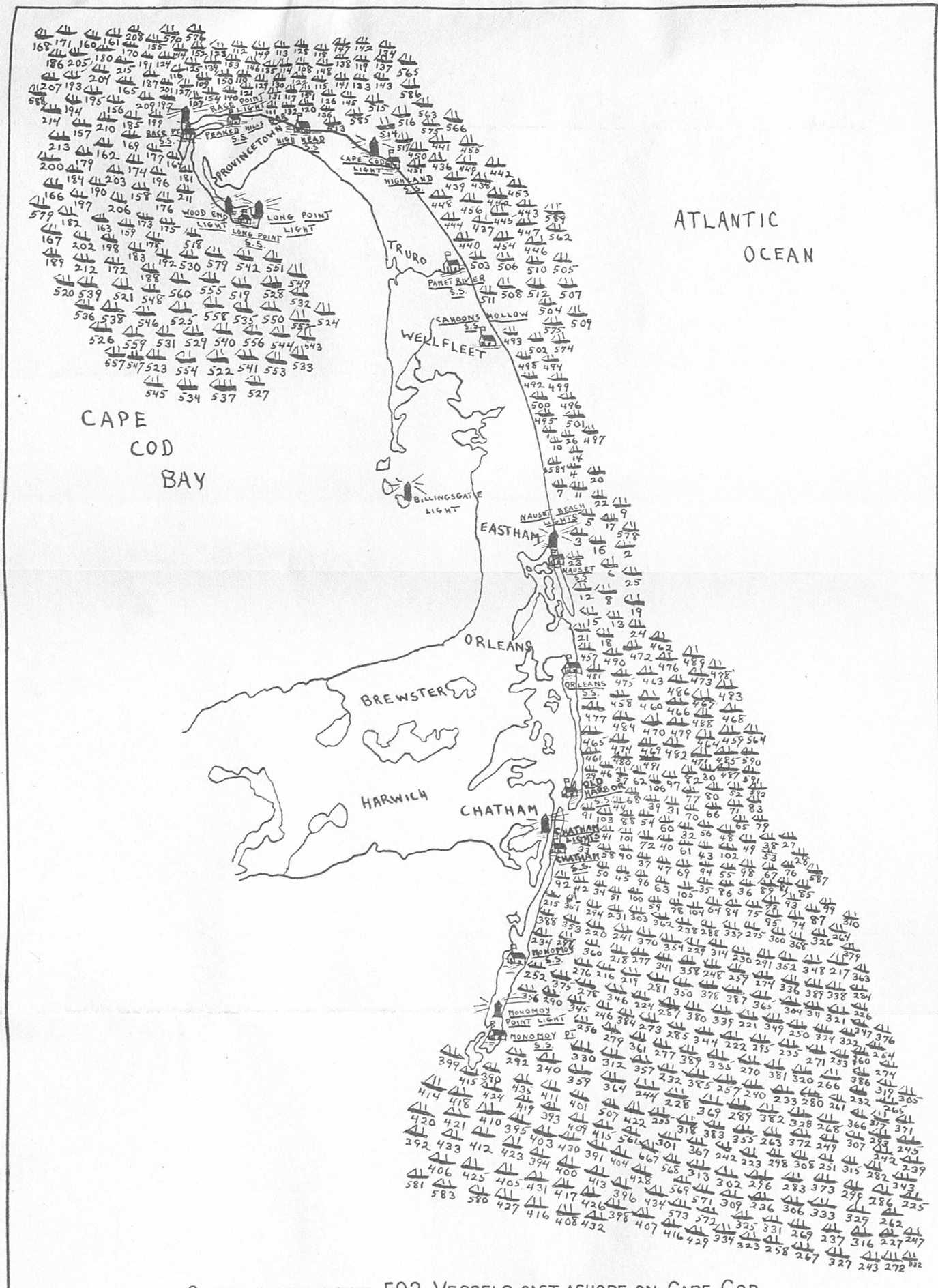
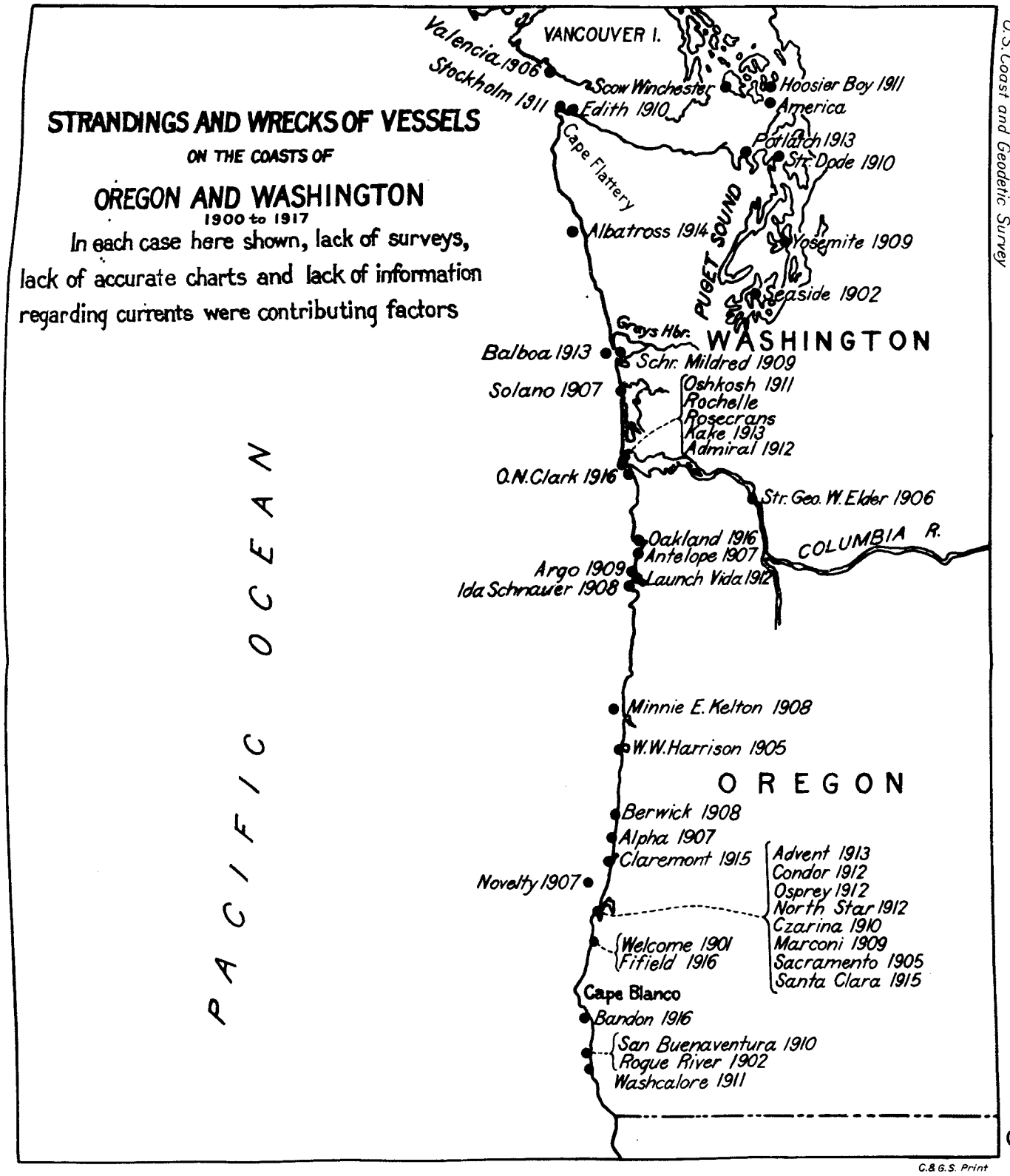


CHART SHOWING THE 592 VESSELS CAST ASHORE ON CAPE COD DURING THE PAST 50 YEARS

(From "The New England Fisheries," July, 1918)

C & G.S. Print



U.S. Coast and Geodetic Survey

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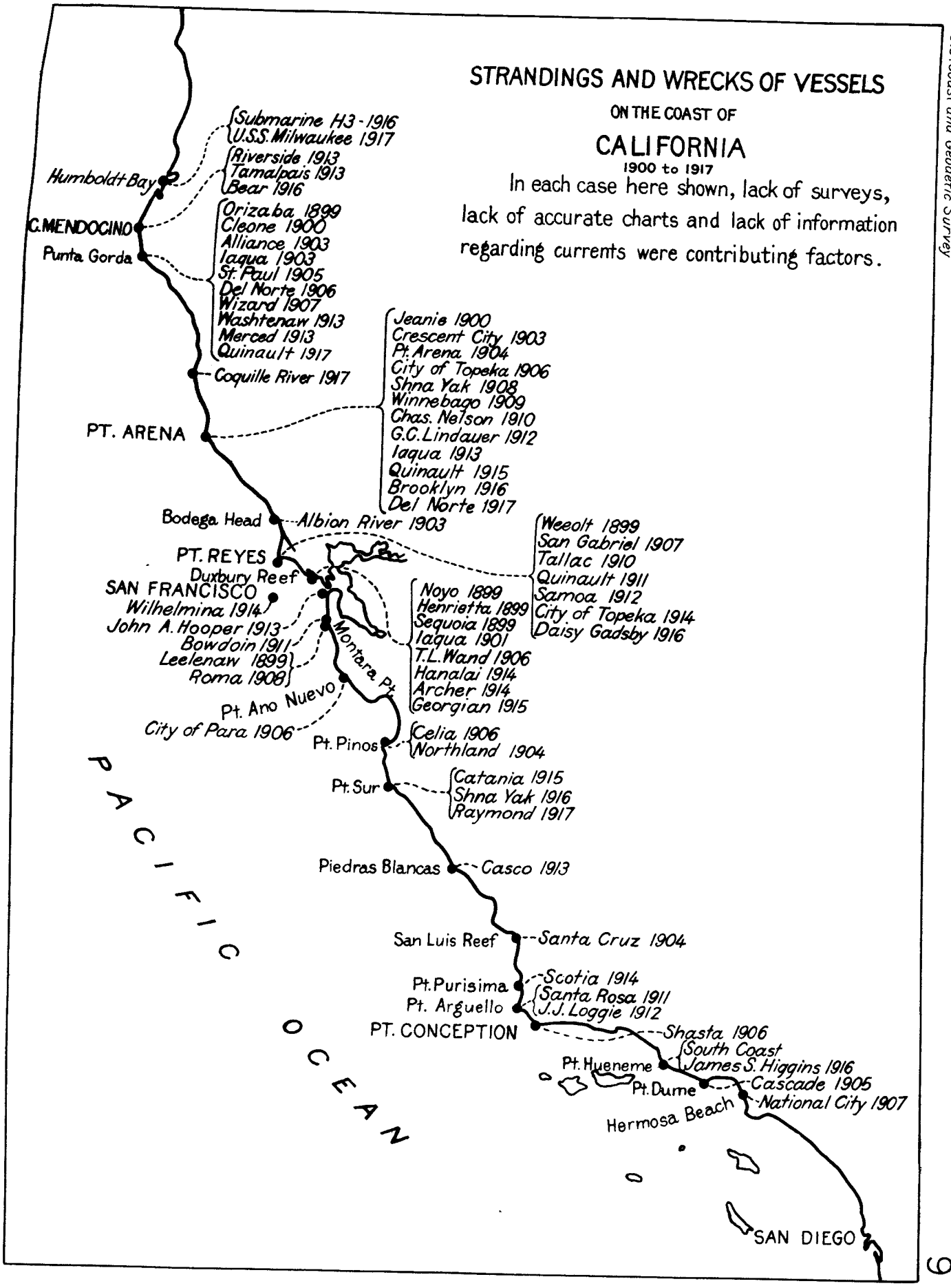
C.&G.S. Print


STRANDINGS AND WRECKS OF VESSELS
ON THE COAST OF
CALIFORNIA
1900 to 1917
In each case here shown, lack of surveys, lack of accurate charts and lack of information regarding currents were contributing factors.
Submarine H3 - 1916
U.S.S. Milwaukee 1917
Riverside 1913
Tamalpais 1913
Bear 1916
Humboldt Bay
C. MENDOCINO
Orizaba 1899
Cleone 1900
Alliance 1903
Iaqua 1903
St. Paul 1905
Del Norte 1906
Wizard 1907
Washtenaw 1913
Merced 1913
Quinault 1917
Punta Gorda
Coquille River 1917
Jeanie 1900
Crescent City 1903
Pt. Arena 1904
City of Topeka 1906
Shna Yak 1908
Winnebago 1909
Chas. Nelson 1910
G.C. Lindauer 1912
Iaqua 1913
Quinault 1915
Brooklyn 1916
Del Norte 1917
PT. ARENA
Bodega Head
Albion River 1903
Weeolt 1899
San Gabriel 1907
Tallac 1910
Quinault 1911
Samoa 1912
City of Topeka 1914
Daisy Gadsby 1916
PT. REYES
Duxbury Reef
SAN FRANCISCO
Wilhelmina 1914
John A. Hooper 1913
Bowdoin 1911
Leelenaw 1899
Roma 1908
Noyo 1899
Henrietta 1899
Sequoia 1899
Iaqua 1901
T.L. Wand 1906
Hanalai 1914
Archer 1914
Georgian 1915
Montara Pt.
Pt. Ano Nuevo
City of Para 1906
Pt. Pinos
Celia 1906
Northland 1904
Pt. Sur
Catania 1915
Shna Yak 1916
Raymond 1917
Piedras Blancas
Casco 1913
San Luis Reef
Santa Cruz 1904
Pt. Purisima
Scotia 1914
Pt. Arguello
Santa Rosa 1911
J.J. Loggie 1912
PT. CONCEPTION
Shasta 1906
South Coast
James S. Higgins 1916
Pt. Hueneme
Pt. Dume
Cascade 1905
National City 1907
Hermosa Beach
PACIFIC OCEAN
SAN DIEGO

It would be erroneous to assume that all these vessels or even a considerable proportion of them were lost because the Government charts lacked information they should have contained, or contained inaccurate information, but, on the other hand, it can not be asserted, in view of the known fact that changes occur in such localities oftener than surveys are made, that some of these vessels were not led to destruction by risking the shorter inside route where favorable depths that might not have existed at the time were shown on the charts, rather than taking the longer outside course.

The shifting sandy bottom around Cape Cod is but one example of such conditions. Wherever there is a combination of sandy bottom in waters of moderate depths and prevailing strong currents, or severe storms that cause strong currents, the depths over these areas do not remain constant, and continuous examinations are necessary. That these changes are more rapid beneath the waters to a depth not in excess of wave and current effects than above the surface of the water is beyond dispute, yet they are quite marked even above the surface of the water, instances of which are noted in the annual report of this Bureau for 1917, wherein it was shown that the shore of Rockaway Inlet has advanced 3¼ miles in 79 years, and that the sand spit that forms the protection for Assateague anchorage is being extended at the rate of 200 yards a year.

These then are the conditions that form the three prime requisites for additional vessels for the Coast and Geodetic Survey; a matter that should have the earnest consideration of all parties interested in affording reasonable protection to the safety to commerce and human lives that are carried upon the waters over which the Bureau is responsible for charts bearing proper data.

The totally unsurveyed areas in Alaskan waters should certainly have immediate attention that commerce between that country and the outside world may be quickened; the incompletely surveyed waters of the three Pacific Coast States from which the surveying vessels of the Bureau were diverted to Alaskan waters on the purchase of that Territory (with a coast line greater than the whole continental United States) ought to be closely examined out to the thousand-fathom curve so that vessels aggregating in value far in excess of the cost of needed surveys will not be lost on account of insufficient data (see figs. 8 and 9); and, finally, examinations should be made to the extent that the benefits are justifiable in comparison with the cost of surveys of those waters frequented by marine commerce where strong currents and severe storms shift the shore lines and the contour of the sea bottom.

A common-sense consideration of whether or not the Coast and Geodetic Survey is now supplied with a sufficient number of surveying vessels, and if not, what the required number is, must, it would seem, lead to a determination of some standard which shall be the measure of the proper completeness of surveys. It is obvious that it would be folly to have no Government or other surveys and leave the master of a vessel to seek his way without a chart from which to select his course and without aids to navigation to warn him of danger. On the other hand, it is conceded that Government surveys could be carried on to such an extent of completeness and minuteness that the cost would be wholly disproportionate to the benefits gained. Between these two extremes there must be a mean

that shall determine the standard of completeness of surveys, and while this mean can not be defined with exactness, it is sufficient to say that where the cause of the loss of vessels of a value in excess of the cost of proper surveys can reasonably be attributed to the lack of proper surveys, then, and to that extent at least, vessels should be provided for making proper surveys.

Measured by this standard, the Coast and Geodetic Survey has not now, and has not had for years past, enough surveying vessels to keep pace with the needs of maritime commerce.

I have already cited the fact that there are vast water areas along the coasts of Alaska where no hydrographic surveys have been made and other areas where the charts are based on soundings of Russian origin, and that to this day the charts of important waters adjacent to Washington, Oregon, and California are issued showing the results of little more than preliminary surveys made years ago. This is a state of affairs that now ought not to be. Vessels are being lost in these waters year after year of a value far in excess of the cost of surveying vessels for making proper surveys, to say nothing of the human lives that are also lost, and the loss of some of them at least can be attributed to the lack of proper surveys. I showed in my report for 1917 how the *Bear* was a total loss just north of Cape Mendocino through the master being misled by lack of information on the chart, and I have quoted earlier in this report a letter from the general manager of the Pacific Steamship Co. to the effect that two vessels of that company had come to grief, entailing a loss of hundreds of thousands of dollars. It is needless to burden this report with other similar citations.

I know of no better way to sum up the situation than by comparing the area surveyed by the vessels of the Coast and Geodetic Survey in the waters of the three Pacific Coast States and Alaska during one year with the total area of these waters that remain to be covered by surveys that can not be made by other than surveying vessels. In making this comparison it would be unfair to use the area covered by these vessels during the fiscal year ending June 30, 1918, because conditions were not normal in that some of the surveying vessels were unable to do a full season's work as men to man the vessels were unobtainable, and further because two of the surveying vessels were during the year taken over by the Navy Department. I shall therefore use as a basis of comparison the areas covered by the surveying vessels in these waters during the fiscal year ending June 30, 1917, which was a normal year. The table below gives a summation of the areas covered by the different vessels:

Name of vessel.	Field of operations.	Area covered, in square statute miles.
Explorer	Richs Passage, Washington	0.5
Do	Cape Muzon, Alaska	574
Do	Dall Island, Alaska	209
Patterson	Kashevarof Islands, Alaska	90
Do	Cross Sound, Alaska	5.9
Taku	Orca Inlet and Copper River, Alaska	111.5
	Oregon	None.
	California	None.
Total		990.90

The total area in square statute miles of waters adjacent to Alaska, Washington, Oregon, and California that can not be surveyed by other than vessels of seagoing size, and of which surveys are immediately necessary to make navigation safe, is as follows:

Alaska	587,000
Washington	11,500
Oregon	15,200
California	35,400
Total	649,100

The conclusion is inevitable that if these conditions are going to be remedied more surveying vessels must be put into the field in these waters to bring these surveys up to a standard of completeness where the value of the vessels lost yearly through the lack of proper nautical information will not be so entirely out of proportion to the cost of vessels to make proper surveys. And the wisdom of such a move is the more evident when it is considered that vessel for vessel the cost of a surveying vessel is usually but a fractional part of the cost of the merchant vessel that is lost. This is because a freight vessel to be operated with profit must be of several thousand tons displacement to have the most economic carrying capacity, while the most effective surveying vessel is of but about a thousand tons displacement.

The thought may arise that since surveys are so badly needed of the waters adjacent to Alaska, Washington, Oregon, and California, it might be well to withdraw vessels from other waters, such as the Atlantic coast or the Philippines to make these surveys. The Atlantic coast where such conditions exist as abound in the vicinity of Cape Cod, for example, is just as sorely in need of vessels to make necessary surveys as is the Pacific coast.

Proper surveys of the waters adjacent to the Philippine Islands are to-day more advanced than of any other Pacific coast waters over which this Bureau has jurisdiction, but this is because vessels for making surveys, with the exception of one, were furnished by the insular government, but as they belong to the Philippine Islands they can not be withdrawn to other waters.

There is one other consideration that has not yet made its effect felt through direct application, but which should have the greatest weight in connection with this problem, and that is, that in the past many of the vessels that have frequented our waters and which have been subject to danger through lack of proper surveys have been of foreign register, but with the great advance in shipbuilding in this country our own money invested in our own ships will of necessity in the future be subjected to this danger of loss, and it is good business to look to the future and consider that the cheapest form of marine insurance is to spend a few thousands of dollars for vessels to make proper surveys rather than lose many thousands or millions of dollars and also human lives in vessels lost through lack of proper surveys.

It is of the utmost encouragement to record that since the above was written an act has been approved authorizing one standard size and one smaller surveying vessel for the Coast and Geodetic Survey. This is heartening, and with these modern vessels much can be done

to relieve the situation in the Pacific coast waters, but the disparity between what can be done when these vessels are added to the fleet of the Coast and Geodetic Survey and what remains to be done is so great that the surveying fleet must still be augmented to bring our hydrographic surveys up to the standard of completeness that should prevail in order that navigation can be reasonably safeguarded.

WIRE-DRAG LAUNCHES.

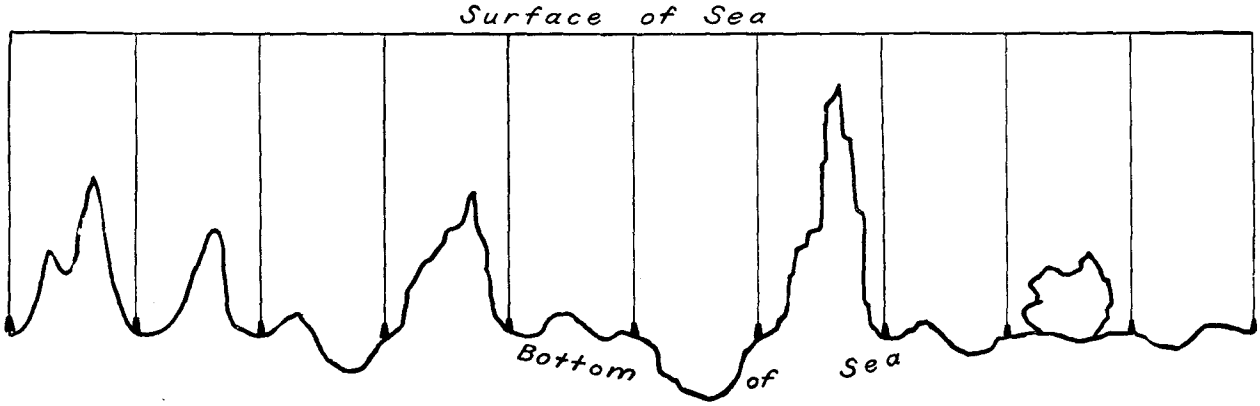
While surveys of water areas removed from the sight of land, exposed waters in extensive bays and sounds, and waters in those regions nearer the shore where there is no harbor for smaller craft to seek refuge during storms must necessarily be made by stanch surveying ships, there is another class of hydrographic surveys that can only be made with special power launches and special equipment—the wire-drag survey.

This is the only method of making effective surveys where from the soundings with the lead and line the prevailing depths are found to be in excess of the needs of navigation, and yet there may be between the soundings taken with the lead and line an obstruction sticking up from the bottom of the sea to within a few feet of the surface and which would damage or wreck a vessel that struck it.

Such an obstruction may be one of the isolated bowlders that are so frequently found in the waters of the coasts of the New England States, or one of the reefs of coral formation adjacent to the coast of southern Florida, Porto Rico, the Hawaiian Islands, Guam, or the Philippine Islands, or it may be one of the needlelike (pinnacle) rocks (see fig. 10) that stick up to unusual heights (sometimes 400 to 500 feet) from the bottom of the sea in the waters of southeastern Alaska (see fig. 11).

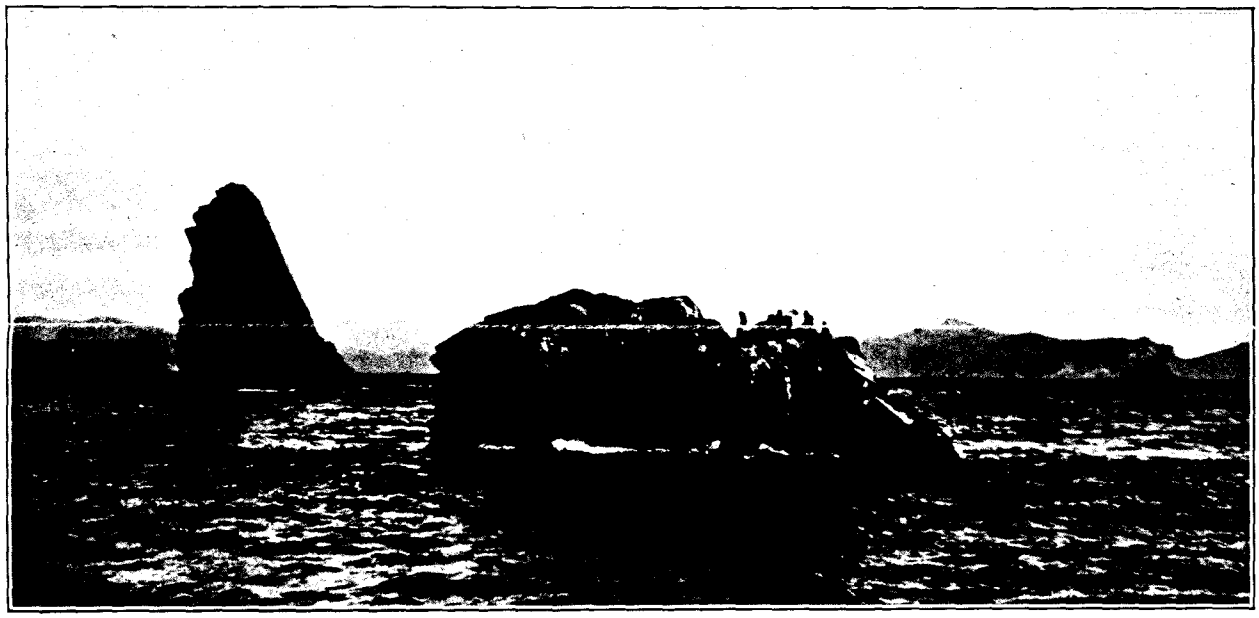
Such obstructions as these, hidden beneath the water, could hardly be found if there were no other means than by sounding for them with a hand lead, if it were known exactly where the obstructions were, and much less would this be probable if a needlelike rock were sticking up from a depth of 407 feet, somewhere in an area 3 miles wide and 6 miles long, such as the area north of Vank Island at the eastern end of Sumner Strait in southeastern Alaska.

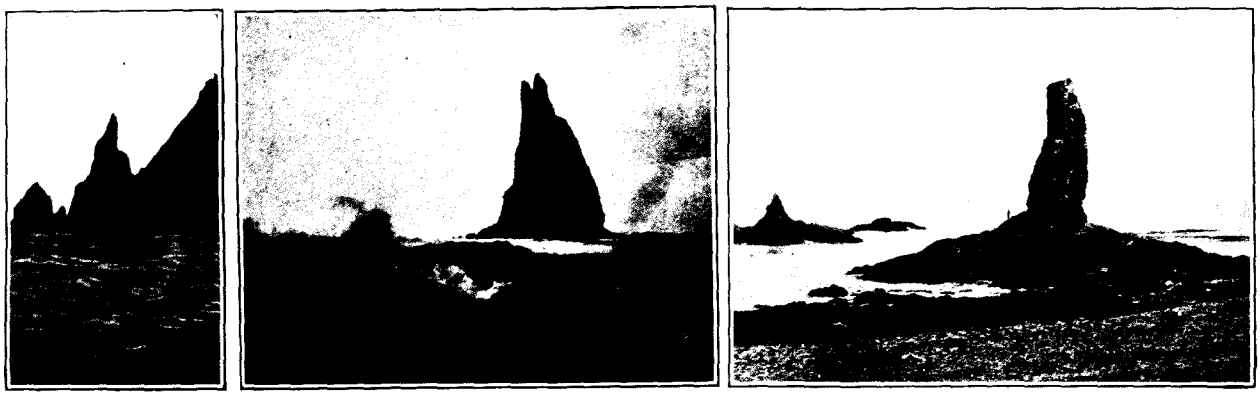
To find these isolated bowlders, coral reefs, and pinnacle rocks the wire drag must be used, which, without going into technical details, is substantially a strand of wire supported in a horizontal position about 30 feet beneath the surface of the water by floats and held down by sinkers, and the whole pulled through the water by power launches. Thus, any obstruction sticking up from the bottom of the ocean less than 30 feet from the surface of the water is caught by the horizontal wire as it is drawn through the water and its position is indicated by the place in the wire where it becomes engaged, on much the same principle that a rope if drawn along the ground by two men, one at each end, in a direction at right angles to its length, would be caught on any obstruction sticking above the smooth surface of the ground over which the rope was dragged, such as a tree stump, and the angle that the rope would form when caught by the tree stump and pulled taut by the men would indicate the position of the tree stump. While this crudely illustrates the main principle of the wire drag, it has been developed into a highly capable and most effi-



SKETCH SHOWING BOTTOM PROFILE FREQUENTLY ENCOUNTERED IN ALASKA WATERS.

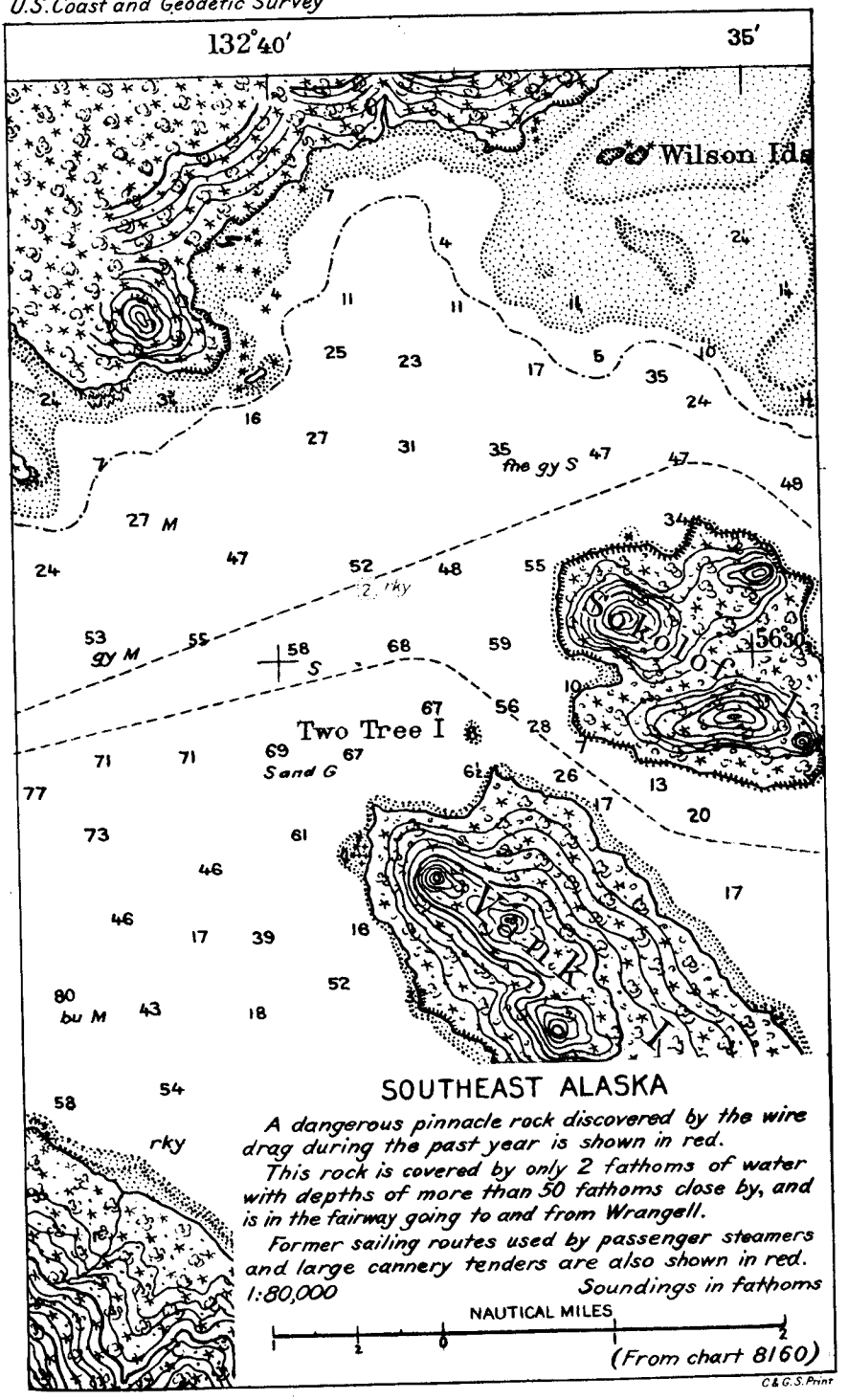
The lead line is of little use in charting regions where the ocean bottom is of this character, for there is little chance that a lead thrown at regular intervals from a moving vessel will strike the summits of these pinnacle rocks. Even if the lead should strike such a pinnacle (pointed rock), it would be likely to glance off and record the greater depth at the base of the rock.





TYPICAL ALASKAN PINNACLE ROCKS.

Towering rocks of this character abound below the surface of Alaska's coasts and waterways. One of these rocks reaches a height of 494 feet.



SOUTHEAST ALASKA

A dangerous pinnacle rock discovered by the wire drag during the past year is shown in red.

This rock is covered by only 2 fathoms of water with depths of more than 50 fathoms close by, and is in the fairway going to and from Wrangell.

Former sailing routes used by passenger steamers and large cannery tenders are also shown in red.

1:80,000 *Soundings in fathoms*

(From chart 8160)

C&G.S. Print

cient instrumentality for discovering those isolated bowlders, reefs, and pinnacle rocks that elude the efforts to find them with the lead and line.

While 30 feet was mentioned as the depth at which the horizontal wire is drawn through the water, it may be adjusted to any desired depth by an ingenious arrangement on the floats to which the vertical strands of wire supporting the horizontal wire are attached. In fact, by close study and by practical experience, every unit that goes to make up a wire drag has been developed to the highest degree of efficiency. To this there is one exception, and this exception is the principal handicap to rapid and economical wire-drag surveys at the present time.

This exception is that the Government has not owned the power launches that pull the wire drag through the water, nor has the Coast and Geodetic Survey funds which can be expended for the purchase or construction of suitable launches. There are certain fundamental features requisite so that such a launch will be efficient, and these features are not common to launches that can be rented for making these wire-drag surveys, though the requisites are approximated as nearly as those available for hire will permit. Pleasure launches, while they have the speed, are too frail of construction to stand the strain of pulling the wire drag (which in certain regions and under certain conditions is most economically operated up to a length of 12,000 feet). A launch that has not sufficient power may, if caught in a storm with the drag extended so that it must be cared for, become a menace to the safety of the lives of the officers and men in the party. The launches used by the fishermen generally have sufficient power but lack proper speed. When it is remembered that to insure a through survey some of the areas that must be covered by the wire drag in southeastern Alaska are considerably exposed, and that at the close of each day's work the wire drag must be taken up and the party must proceed in the power launches to some harbor of refuge for the night, it will be evident that speed is a very important factor because time lost in traveling to and from the fields of operations in a slow launch is time lost from making surveys, and while this seems a small factor a close scrutiny of every detail of efficient operations reveals that the loss accruing during an entire season, considering this phase alone, totals an amount that is worthy of serious consideration.

While it is impossible to reach the ideal in speed and power in procuring rented launches for making these surveys, even if this were attainable, to make them at all useful for making wire-drag surveys, there must be a certain amount of reconstruction on any rented launch. Auxiliary gasoline engines must be installed for operating the reels that carry the wire drag when not in operation. Proper provision must be made for stowing buoys, floats, and sinkers, and in some instances where the party must live on the launches, as in Alaskan waters, housing quarters must be built on the launches. This is an expensive and time-consuming operation in the preparation for a season's work, and at the close of the season the launch must be restored to the owner in its original condition. This cost approximates $800 per party for each season.

This condition should be remedied by the Government owning the power launches that are necessary to propel the wire drags. Every

other unit of the wire drag has been developed to the highest degree of perfection, and experience has shown exactly what is needed in a suitable wire-drag launch, and the time is now ripe for the construction of launches to meet exact conditions. The resulting economy in accomplishments and overhead charges saved in altering and restoring rented launches must far outweigh their cost.

While the results have been highly practical, the work with the wire drag in the past has been necessarily somewhat experimental, but the point has been reached now where it is definitely known what can be accomplished with the wire-drag survey, how it should be accomplished, and (with the exception of Alaskan waters, where, as I have pointed out earlier in this report, some of the areas lack even reconnaissance surveys) it is known what areas require the wire-drag surveys.

There is another important feature in connection with these power launches, and that is that when the season or conditions do not permit their being used in making wire-drag surveys, they can be employed in carrying on inshore hydrography, a class of work which is waiting to be done in many important localities and for which proper vessels are not always available for hire.

With respect to the extent of the wire-drag work done and to be done, below is a table that is enlightening.

Region.	Wire-drag surveys completed (square statute miles).	Wire-drag surveys to be made (square statute miles), approximated.
Coast of—		
New England	1,739	1,800
Florida	216	500
Porto Rico	14	2,300
Alaska	1,638	50,000
Entrance to the Canal Zone	200	200
Total	3,807	54,800

The above table gives particulars regarding the principal areas where wire-drag surveys have been made and must be made, but there are many smaller localities where examinations must be made and have been made with the wire drag (such as San Francisco Harbor) and extensive water areas where the wire-drag surveys must eventually be made (such as the coral-reef-infested waters of the Philippines, Hawaii, and Guam) but for which the facilities in personnel and equipment are not now available, and therefore they are not here considered.

NOTE.—In the sundry civil bill for 1919 there is an item of appropriation of funds sufficient to construct four wire-drag launches. Every possible step is being taken to have these constructed at the earliest practicable moment, and when they are put into the field it is certain that the results will demonstrate the economy of providing a highly efficient instrument for the accomplishment of a special class of work.

ENLISTMENT OF SEAMEN.

Mention has been made of the fact that the three vessels available for surveys in Alaskan waters were necessarily forced to lie idle in Seattle during most of the fiscal year, the *Explorer* and *Taku* being in the field but a month each and the *Patterson* less than three months, and that this was necessarily so because of the lack of officers and the difficulty of enlisting seamen to man the vessels.

The causes that lead to this state of affairs are many, and while the results have not been so manifest during normal times, yet, even then matters were not going in the harmonious way that was desirable, but during the stress of war, where conditions are abnormal, and an important arm of the Government service is crippled, the need of some remedial measures is keenly felt.

An inquiry into the causes of these conditions leads to a diversity of considerations.

I have already made mention of the fact that employment on a vessel of the Coast and Geodetic Survey is considered with little favor by seamen. Employment may be continuous on a merchant-marine vessel, while it is but for the surveying season on a Coast and Geodetic Survey vessel on the Pacific coast with the certainty that at the close of the surveying season his employment terminates for months. Further, that the duties required of a seaman on a merchant vessel are less exacting than on a Coast and Geodetic vessel, and that a seaman on a merchant-marine vessel receives overtime pay for overtime work which is impracticable on a Government vessel.

While the foregoing are, in a measure, results, the cause of these conditions may be summed up as follows:

The vessels of the Coast and Geodetic Survey that have been employed on Alaskan surveys are old. The quarters on these vessels for the crews are of the type found in such old vessels and uninviting. They are devoid of modern equipment, and the ordinary comforts are not possible. For this reason they are shunned by the better class of seamen who can command employment on modern vessels.

As a consequence of their age and unseaworthiness, these vessels can not be employed in open and exposed waters. Therefore, during the winter season they must tie up and undergo repairs. The result is that the crews must be discharged during the winter months and new crews enlisted at the beginning of the succeeding summer season. This enlistment is no more than a civil contract, and since a seaman is not usually possessed of means there is no way of effectually binding him. Hence, with the fluctuating wages that were being paid when the *Patterson* and *Explorer* reached the field of operations in Alaskan waters in 1917 and the seamen found that the wages ashore or on the cannery vessels were much in excess of what they were receiving, though they had signed a contract of enlistment in Seattle at what was conceded to be a fair wage for the season, they deserted the surveying vessels for employment elsewhere, and there were not funds available for the Coast and Geodetic Survey to meet this competition. Due to the fact that there was no Alaskan port where new crews could be recruited, there was nothing for the officers of the vessels to do but to close the surveying season and

return the vessels to Seattle as best they could. The matter has been given serious consideration, but it is doubted if a civil contract can be drawn that will effectually hold seamen who enlist under such a contract on a vessel at Seattle and immediately desert when the vessel reaches an Alaskan port. This being so, there is no known way to prevent seamen enlisting only for the purpose of getting to another port, as the only penalty that can be inflicted is a forfeiture of wages earned, and since it is only four days' run from Seattle to Ketchikan, the wages lost by the seaman is insignificant in comparison with the cost of transportation, and if they desert in numbers as in the cases cited, nothing remains to be done but to suspend operations and bring the vessels to their home ports, because the demands, industrial and otherwise, that have enticed the seamen from the surveying vessels have already called forth every available man in the locality, and there is no possibility of recruiting new crews.

It is believed that there is a permanent solution of this difficulty that is bound to result in highly increased efficiency and ultimately in great economy, though it involves an increased initial expenditure of Government funds and a somewhat radical departure from present methods.

It is perfectly evident that the highest degree of efficiency can never be attained in a service where the duties that its seamen are called upon to perform are sufficiently different from those performed by ordinary merchant seamen to require special training and instruction covering months before the seamen become proficient, when such seamen are only employed for the surveying season of some six or seven months, discharged, and an entirely new crew recruited when the vessel goes to the field the succeeding season.

Attention has been called to the need for additional surveys of the waters contiguous to Washington, Oregon, and California.

The remedy suggested is this:

1. That surveying vessels be provided of a type sufficiently stanch to make surveys in Alaskan waters during the summer months and in the exposed waters of Washington, Oregon, and California during the winter months.

2. That the appropriations for manning the vessels of the Coast and Geodetic Survey be increased so that a standard wage can be paid the seamen on the vessels of this service throughout the year.

3. That authority be granted to enlist seamen for service in the Coast and Geodetic Survey for a period of one year that will be binding upon them during the period of the enlistment as are enlistments in the Navy.

From such an arrangement benefits are bound to accrue to both the seamen and the Government. Employment for seamen will be continuous under conditions that are agreeable, the Government will have trained complements of men on its vessels familiar with the more or less intricate details of making surveys, and will be able to draw to the service competent and suitable seamen who will have before them prospects of continuous service and advancement in pay where good conduct merits it, and, what is most important, surveys that are of vital importance to the protection of life and property will be accelerated far in excess of possible accomplishment under present conditions.

RETIREMENT FOR COMMISSIONED OFFICERS.

From year to year in the annual reports of the Coast and Geodetic Survey mention has been made of the need of some system of retirement in order to bring about the maximum of results with the greatest economy. The Coast and Geodetic Survey is the oldest scientific Bureau of the Federal Government, and naturally the evils attendant on superannuation are quite apparent. In the hearings before the Appropriation Committee of the House of Representatives, in February, 1917, in summing up the situation regarding the Coast and Geodetic Survey the Superintendent said:

> We have to-day this condition: We have in the neighborhood of 20 men, employees of the Coast Survey, who are between 66 and 82 years old. A great many of those men were in authority two years ago. They were not able physically to carry the big load which was evidently necessary, if the real work was to be done. I have changed this the best I could by reducing them to positions where the salaries are more commensurate with the duties which they can and are performing and which their physical condition will permit; but you can see again that it would be better to have half as many younger men, for then we would get more work done. But, I ask, what is going to be done with them? They have served the Government faithfully; some of them had gone into the Government at 18 or 20 years of age, and they have worked for the Government throughout their lives. Their education is similar to the education of an Annapolis or West Point graduate, as far as civil engineering is concerned. They have paid their own tuition; they have stayed with the Survey all their lives at modest salaries; and now in their declining years they practically have no money. The Survey is really loaded with a portion of the force that is not returning the value it should, though not through its fault. I only speak of this to show another factor in the condition that has existed as an obstacle in the sense that we are handicapped in accomplishing everything we should with the positions that exist as shown, in fact, in the Book of Estimates.
>
> I have often thought that it would be well for the Survey if the committee could spend a short time in our office and see what has been accomplished and how conditions have changed through a century, and how an old Bureau suffers from superannuation, tradition, and, I might say, dry rot. They would see why something modern, something new, creates a natural interest among the public, and will therefore command a greater amount of interest and respect; and that is what we have right there.

In justice to these officers whose efforts and highest ambitions throughout their associations with the Coast and Geodetic Survey have been along the lines of scientific work peculiarly requisite to the purpose of the Coast and Geodetic Survey, but which have not provided a competence for old age, legislation providing for their retirement should be enacted.

The commissioned officers in the Coast and Geodetic Survey now number 124. Of these 10 are more than 64 years of age, and have had an average service of over 44 years in the Coast and Geodetic Survey. Sixteen are more than 60 years old, and have had an average service of 42 years in this Bureau. To retire those above 64 years of age on three-fourths pay would have required but an appropriation of $16,650 for the current year, and would have opened the way to bring into the service 10 new field officers whose services are sorely needed.

The fact that the pay these officers have received during the years that they have been identified with the Coast and Geodetic Survey has been too small to permit laying aside a competence for old age is not, however, the principal consideration in urging retirement for

them. The stronger reason is the privations endured and the risks incident to the service. The surveys that are made by the Coast and Geodetic Survey ought to, and generally do, precede commerce, and not infrequently civilization. The small surveying vessels of the Coast and Geodetic Survey must enter, explore, and survey unknown waters in advance of commerce, in advance of the vessels of the Navy, the Coast Guard, and all other vessels. The hydrographic parties of the Bureau must go into unexplored waters and make examinations that the commerce that follows may be safe. In the execution of this work these parties are cut off from communication and intercourse with civilization for weeks and even months at a time, and often in the Philippines are necessarily thrown in direct contact with the uncivilized natives of the tropical forests bordering the waters where these hydrographic surveys are made. Indeed, it is not infrequent that our officers by force of arms must overcome the resistance of these uncivilized tribes to the landing of shore parties for the purpose of erecting signals as a basis for the control of the hydrographic surveys. And, again, it is no safe task, in the tropical jungles of the Philippine Islands, with but a few facilities at hand, to build a triangulation signal station 235 feet high out of native timbers that must be cut from the trees on the spot. (See figs. 12 and 13.)

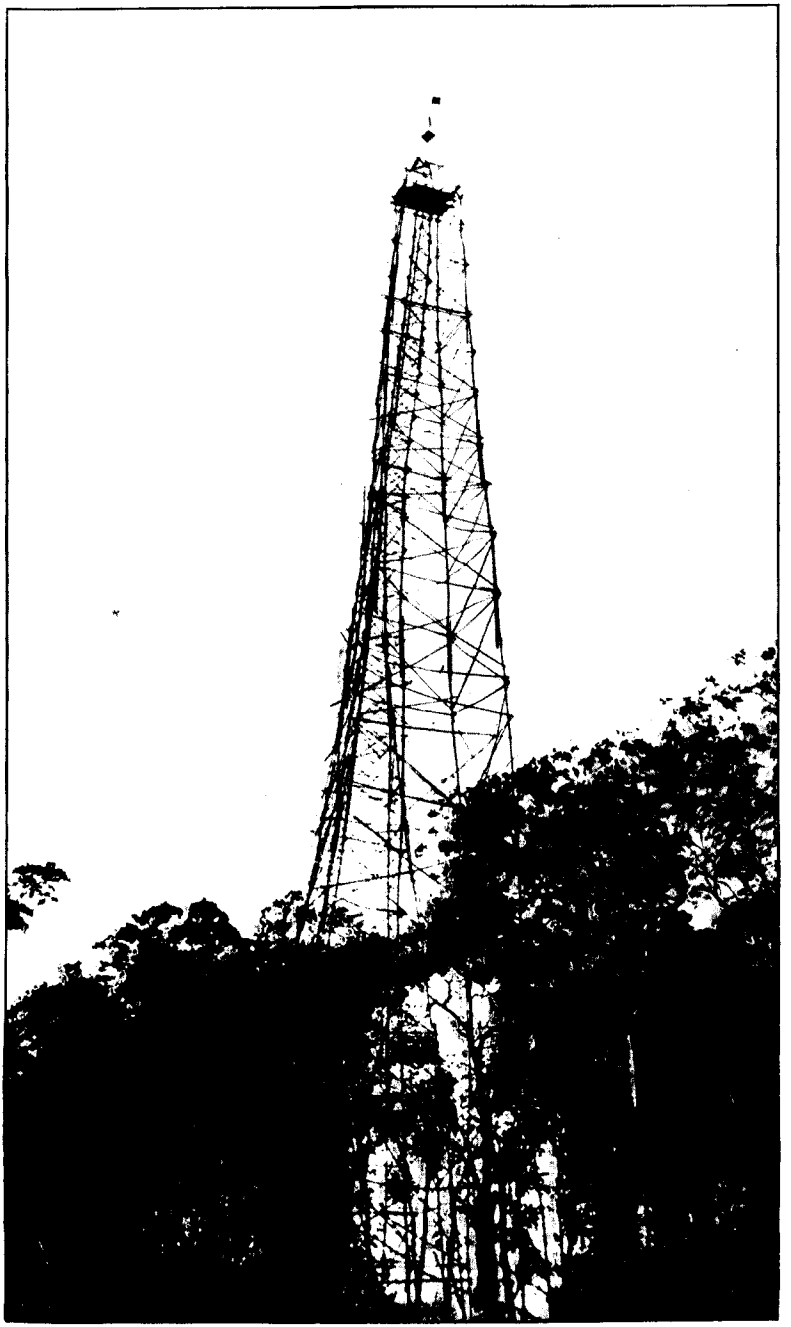
At this writing, one of our young officers of the age when he should be in the prime of life, and who when he came into the service was of strong physique, is in a sanitarium, stricken with disease which can be attributed to no other cause than the exposure to which he was subjected in the field work of this Bureau in the Philippines.

The surveying work of this Bureau extends over a wide field. Besides being exposed to the tropical diseases and dangers of the Philippines, its officers have been sent into the desolate Arctic regions in determination of the one hundred and forty-first meridian, the boundary line between Alaska and Canada, and for self-preservation have been forced to assume civil charge of the native Indian population and exercise strict authority to stamp out epidemics of smallpox.

In carrying out the work of primary triangulation of any country, triangulation stations to be intervisible must be on the highest promontories, and in mountainous or heavily timbered country much daring is required and considerable risk incurred in the construction of suitable signals. (See figs. 14 and 15.) One of the men engaged on the preparation of the triangulation station shown in figure 15 lost his life.

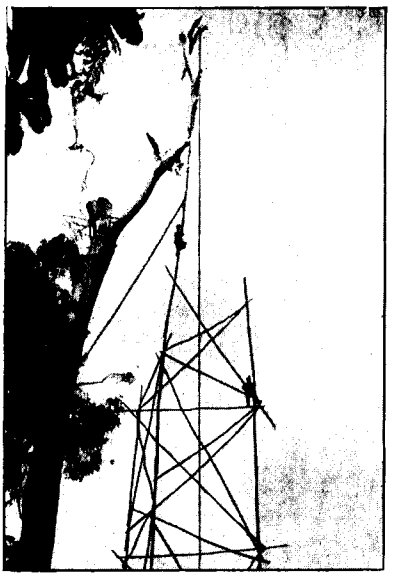
In making hydrographic surveys of Alaskan waters, the officers of the Coast and Geodetic Survey have been particularly exposed to dangers. The small surveying vessel is no match for the gales that are common to that country, and it is only through foresight in selecting harbors of refuge and good seamanship that disasters have been averted.

While it is not the regular function of the Bureau, its officers play no small part in saving lives and property. Almost monthly word comes to this office of assistance lent vessels in distress or lives and property saved. The *Tahoma* of the Revenue-Cutter Service struck an uncharted rock in the North Pacific Ocean, resulting in her total loss, and a part of her crew was only saved by the com-



THE ABOVE ILLUSTRATION REPRESENTS A TRIANGULATION SIGNAL BUILT FROM NATIVE TIMBER ON MANTAGULE ISLAND, P. I.; HEIGHT, 235 FEET.

The timber was cut in the adjacent forests and had to be transported through the jungles by hand, some of it a distance of 2 miles. The timber varies in diameter from 4 to 24 inches.



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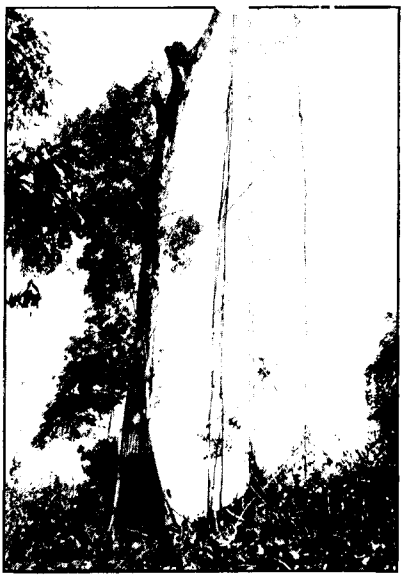

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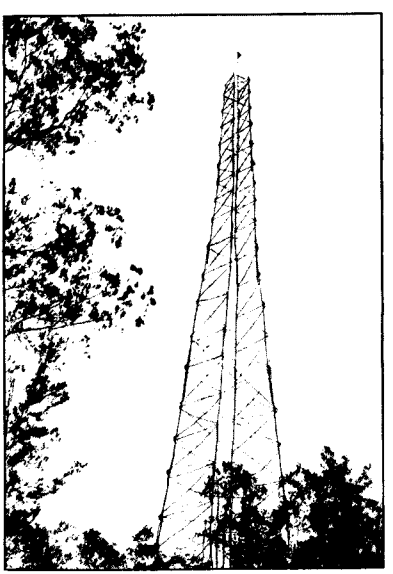

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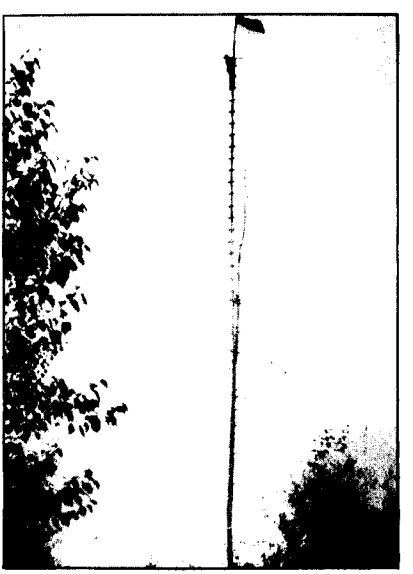

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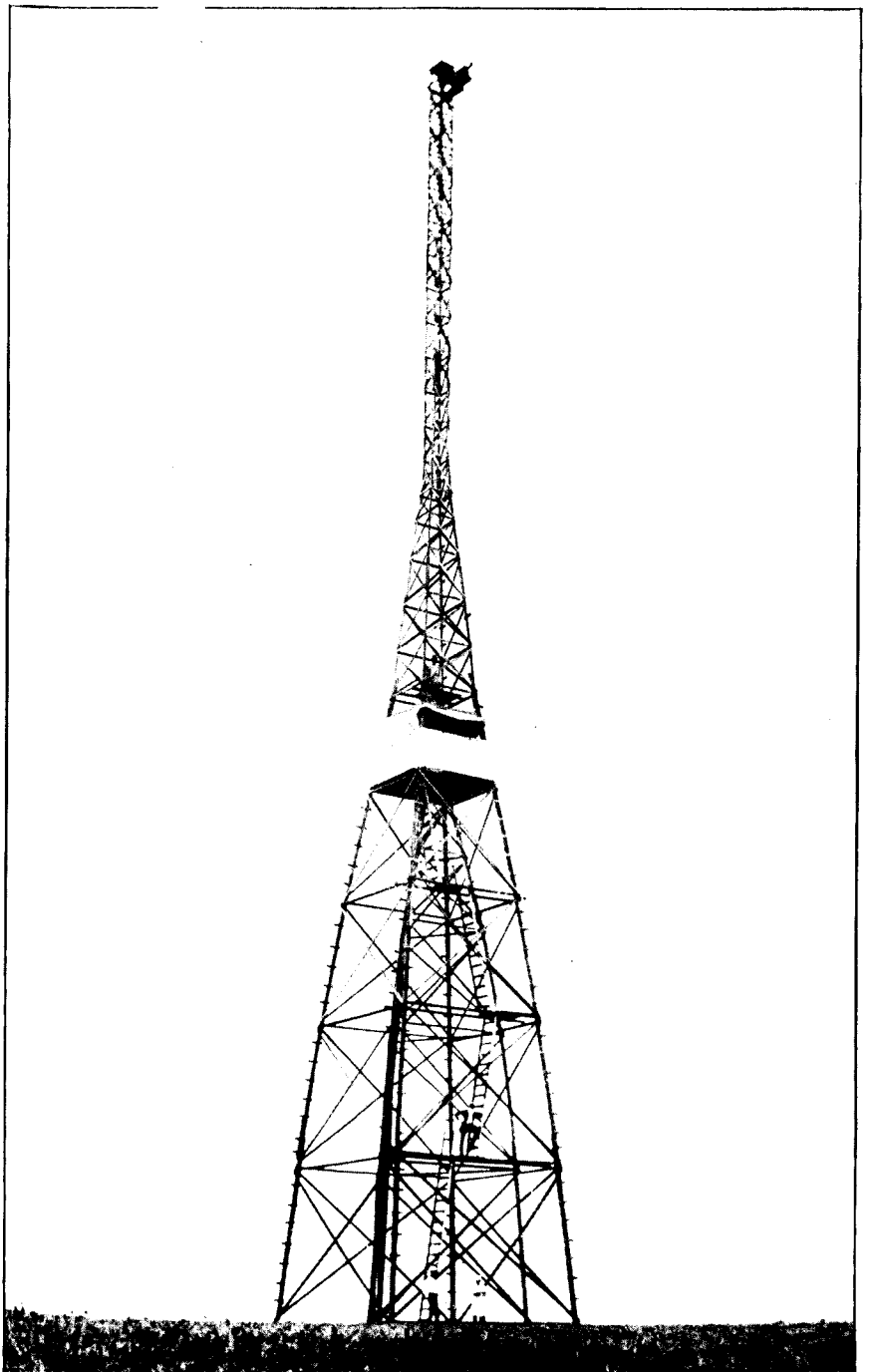
NOS. 1, 2, AND 3 ABOVE, REPRESENT DIFFERENT STAGES IN THE CONSTRUCTION OF TRIANGULATION SIGNALS IN THE TROPICAL JUNGLES OF THE PHILIPPINE ISLANDS; NO. 4 IS A RECONNAISSANCE SIGNAL.



THE ABOVE REPRESENTS A TRIANGULATION SIGNAL USED IN PRIMARY TRIANGULATION.

In triangulation it is often necessary to use high signals to overcome local obstructions and the curvature of the earth.

AN UNUSUAL FORM OF TRIANGULATION SIGNAL—ONE IMMENSE TREE AGAINST ANOTHER.

The tripod head on the observing platform was 145 feet from the ground. An idea of the size of the trees can be gained by comparison with the photograph of the man part way up the tree to the right.

manding officer of the Coast and Geodetic Survey steamer *Patterson* instantly responding to her call of distress and steaming 700 miles to the scene of the accident. Persons have been rescued from stranded ships in all our waters by officers of the Coast and Geodetic Survey.

These are the risks and hardships incident to the civil employment of the officers of the Coast and Geodetic Survey. In military activities, whenever the need has arisen, they have taken their part. Pages have been written of their participation in the Civil War in which 55 took an active part in the Army and 48 in the Navy, and while their services are shown to have been highly prized by the testimonials of the military and naval officers under whom they served, they were in the Army and Navy without any status, and, if captured, would not have been accorded the protection of prisoners of war but would have been subject to execution as spies. Permanent legislation has been enacted authorizing the President to transfer by Executive order to the Army and Navy the officers of the Coast and Geodetic Survey as necessity demands, in effect making the service a military reserve force. In the exercise of this authority 25 commissioned officers have been transferred to the Army and 42 to the Navy.

The commissioned officers of the Coast and Geodetic Survey to be of normal efficiency must be a permanent force. That is to say, the work of the Bureau is so specialized in particular branches of the field of engineering that the young men that come to the service from universities where they are highly trained in the science of engineering must have a long course of special training by the officers of the Coast and Geodetic Survey before they become proficient and render valuable service in carrying on the specialized work of the Bureau. Owing, therefore, to this special knowledge and training required, the field engineers of the Bureau must be a permanent staff, and it is only after years of experience and training that they become of the greatest value. It therefore follows that shortly after becoming identified with the Bureau the young engineer must take thought of these things and determine that he will cast his lot with the Coast and Geodetic Survey during his professional career, or, he must early seek other field of service because his engineering work with the Bureau is highly specialized, and long training in its parties rather tends to make the engineer less than more fit for successful competition in the broader field of engineering. It therefore follows that those who have been in the service more than a very few years will, and are devoting their lives to the advancement of this public service.

These, then, are the reasons that justify a claim for retirement for the commissioned officers of the Coast and Geodetic Survey.

It must certainly promote efficiency in the field force of the Bureau to retire at three-quarters pay those officers who have passed 64 years of age, and bring into the service young, vigorous officers who can endure the physical hardships incident to the service.

In justice to the officers who have risked their lives for years in the hazardous civil branch of the Government service, and who have taken and are taking an active part in the military services at times when the risks incident to such service are greatest, the benefits of retirement which are accorded those permanently in the military serv-

ices should be extended to those who go into it while the chances of sacrifice are greatest—namely, in time of war.

The following is a concrete and illuminating statement of the record of one of our commissioned officers (hydrographic and geodetic engineers) who has had 47 years of service with the Coast and Geodetic Survey.

He was born in 1848. After leaving Dartmouth with a science degree he entered the service of the Coast and Geodetic Survey in 1871 with pay at $30 a month and actual living expenses, a continuous service of 47 years. This officer has served the Coast and Geodetic Survey in nearly every State in the Union on practically every class of surveys made by the Bureau at various rates of pay, and his average pay throughout his identification with the Bureau has been $1,815 per annum. He has been in charge of parties on triangulation observations, on astronomic observations, on topography, in command of vessels of the Bureau on the Atlantic coast, on the Pacific coast, in Alaskan waters on the original survey of the Yukon delta and approaches, in Philippine waters, where he was in command of the largest vessel of the Bureau for some years; he has made surveys in the arctic regions of Alaska in the determination of the boundary line between Alaska and British Columbia, exploratory surveys in Alaska for the purpose of opening up the country at the time of the rush to the Alaskan gold fields; and he has been the principal surveyor for a commission to determine the site for a navy yard on the Pacific coast. In office work he has been chief of a division in the Washington office of the Coast and Geodetic Survey, and in charge of one of the most important stations of the Coast and Geodetic Survey on the Pacific coast, a position of responsibility and requiring a thorough knowledge of all the activities of the Coast and Geodetic Survey.

The above is a typical example of a number of others that could be cited, where an officer has unselfishly devoted the best years—in fact, all of the producing years—of his life to the advancement of a scientific bureau under conditions of living that have taken him to practically every State in the Union and all the possessions of the United States, have never permitted the establishment of a permanent place of residence or a home, and have necessitated an increased living expenditure which an average salary of $1,815 per annum has barely met.

NEED OF 28 ADDITIONAL HYDROGRAPHIC AND GEODETIC ENGINEERS.

In recognition of the greatest need, 67 commissioned officers of the Coast and Geodetic Survey have been relieved temporarily from their duties in the Coast and Geodetic Survey and have gone into active service in the War Department and the Navy Department. This is necessarily curtailing the field accomplishments of the Coast and Geodetic Survey, but the training and experience of these officers are such that they are of much value to the military branches of the Government, and during the national crisis it is far better to utilize the services of such number of them as can temporarily be spared in the Army and Navy than in civil employment with the Coast and Geodetic Survey.

While the regular work of the Coast and Geodetic Survey is thus curtailed and the energies of those remaining in civil employment

with the Bureau are directed toward accomplishments necessary to the Navy and requested by the Army, it is still proper to consider the needs of the Bureau in the way of field officers to adequately perform the duties that are properly assigned to the Coast and Geodetic Survey. In the report of the Bureau for 1916 it was urged that 48 additional commissioned officers were needed to properly carry on the field work of the Bureau. In partial recognition of this need, 20 new positions have been granted. While this added personnel has been of great assistance in putting new life into a public service that was languishing, we are yet short 28 officers to put it on a footing so that the commissioned personnel will be sufficient in number to properly take care of the field work.

Attention has been invited to the fact that for the purpose of properly safeguarding our new merchant marine closer surveys must necessarily be made of our navigable coastal waters, and this will require an increased commissioned personnel.

For years past this Bureau has earnestly urged a closer network of accurately determined control points throughout the United States as the basis for maps of the country. The present military necessity has served to emphasize this need as has nothing in the past, and the accurately determined positions already fixed by this Bureau, insufficient in number as they are, are serving as a nucleus for preparing maps of the highest degree of accuracy for the Army. The work of accurately determining these positions ought to be taken up vigorously. The results are not ephemeral as some of the results of other surveys must from their very nature be, but a position once accurately determined and permanently marked will ever after serve as a basic control for maps and engineering projects. To push this framework of control points, additional field officers are necessary.

Part II.—WORK AND NEEDS OF THE WASHINGTON OFFICE.

CHAPTER I.

WORK OF THE WASHINGTON OFFICE.

The organization of the Washington office throughout the year, by divisions and sections, was as follows:

Division of hydrographic and geodetic engineer in charge of the office: Section of instruments, section of printing and sales, section of library and archives, and section of miscellaneous.

Division of geodesy.

Division of hydrography and topography: Section of field work, section of field records, section of field equipment, section of coast pilot, and section of tides and currents.

Division of charts: Section of drafting, section of engraving, and section of photography.

Division of terrestrial magnetism.

Division of accounts.

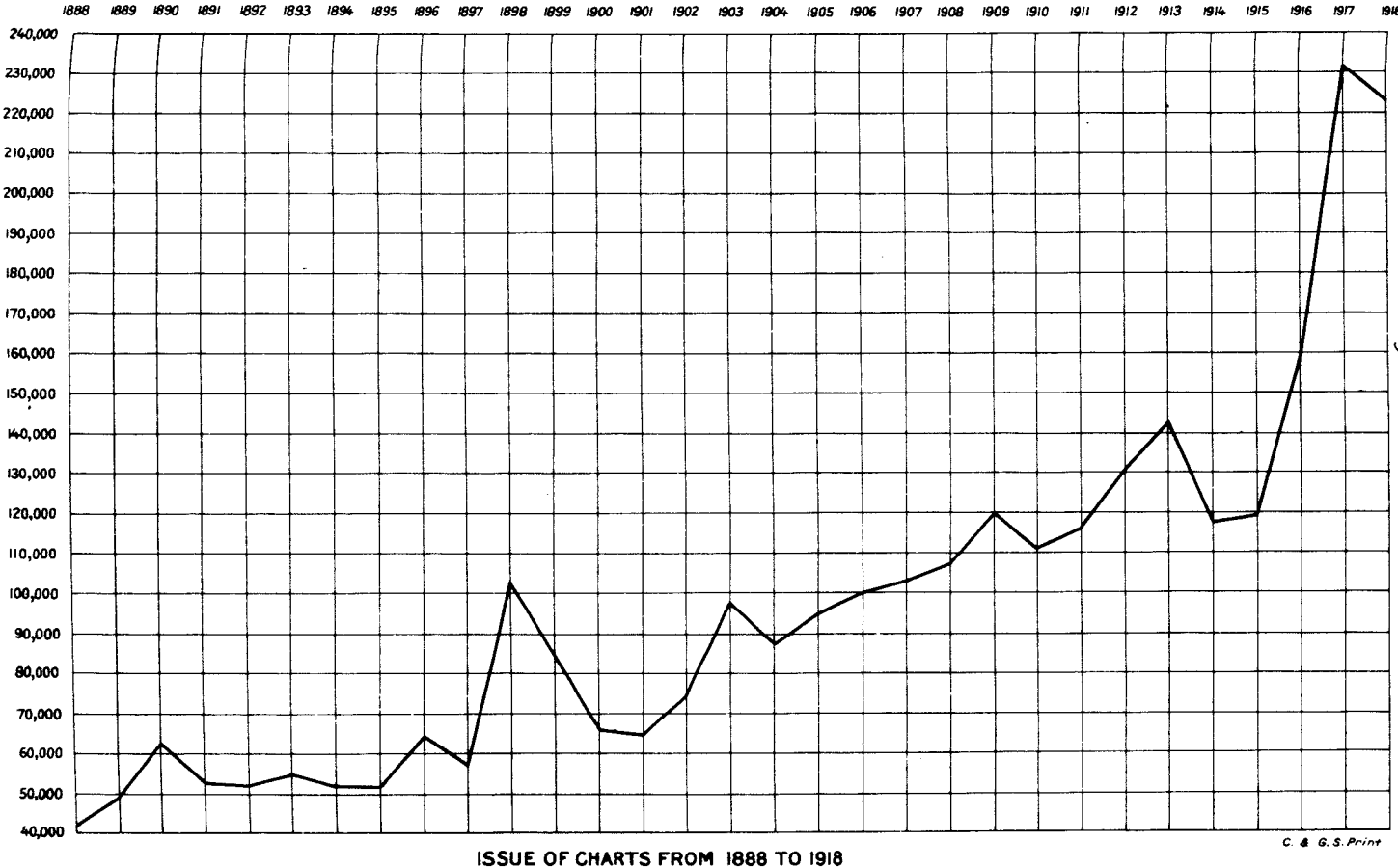
The work done by the Washington office during the fiscal year, by divisions of the office, was as follows:

Division of hydrographic and geodetic engineer in charge of the office: The general duties of this division are: The upkeep of the buildings occupied by the Bureau; the designing and repairing of surveying instruments and equipment, and packing and shipping them to the field parties; the printing of the charts issued by the Bureau, and the sale of the charts, coast pilots, and tide tables; the purchase of supplies for the office, for the chart printing work, and for the field; the care and custody of the original records of field surveys as well as the library of printed publications kept for the use of the Bureau; the keeping of the records of leave taken by the personnel of the Bureau; and the custody and accounting for the receipts from the sale of charts and publications sold by the Bureau.

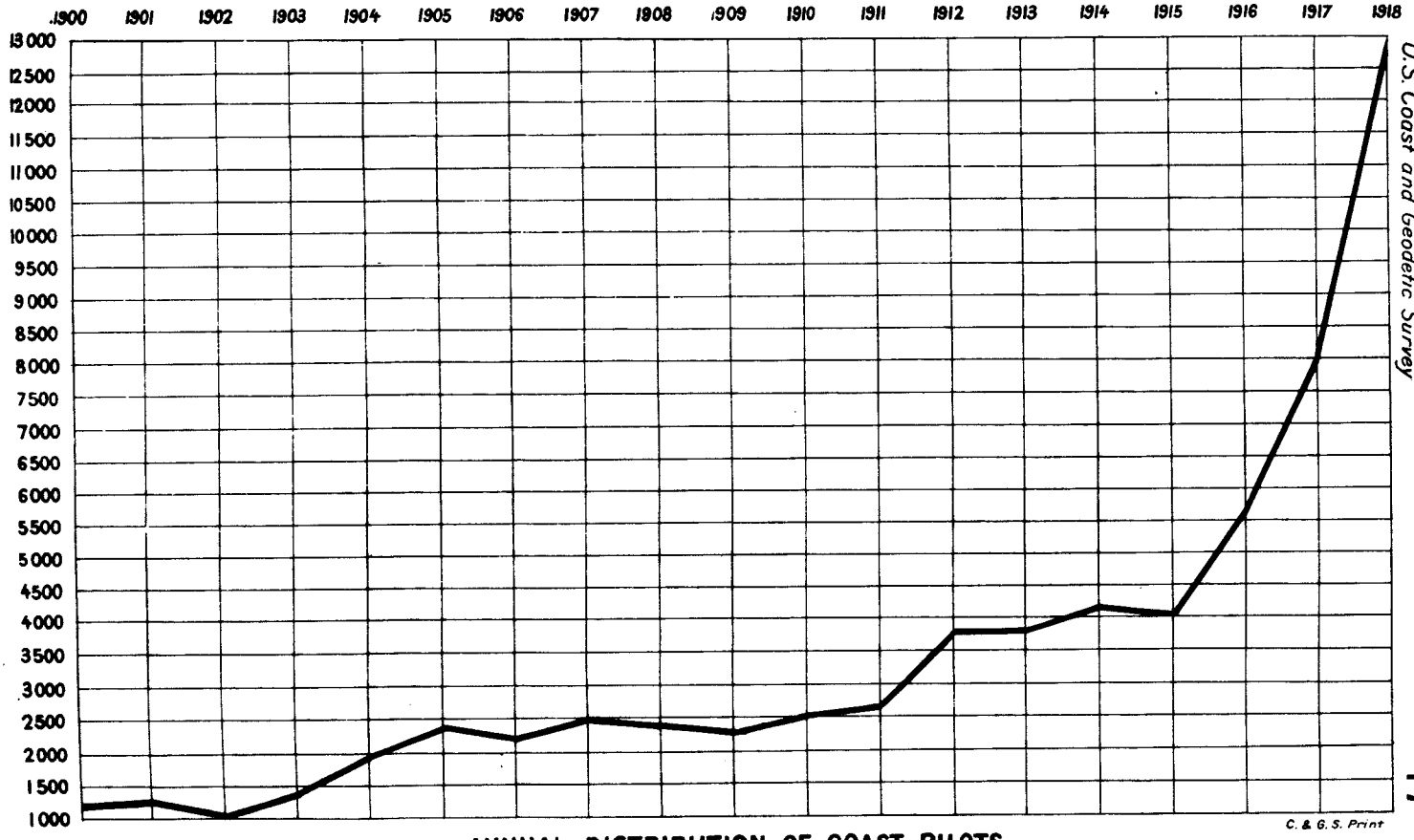
In addition to the general routine, special improvements were made by this division as follows:

Much apprehension has been felt in the past in view of the known danger of fire that would destroy records that are the results of surveys covering more than 100 years stored in the archives of the Survey. This apprehension is now removed. During the fiscal year an automatic sprinkler and fire-alarm system especially provided for by Congress was installed throughout the buildings occupied by the Bureau but with special protection for the part of the buildings in which are stored the original records and field sheets which are the results of field surveys.

The most valuable improvement and progress toward the establishment of efficiency in the office was secured through the installation of an additional modern offset press in the printing plant. The Bureau is now supplied with a modern offset press and



ISSUE OF CHARTS FROM 1888 TO 1918



ANNUAL DISTRIBUTION OF COAST PILOTS

a flat-bed press, and this has provided the means for a much more rapid production of charts of a better quality than it has been previously possible to produce. Without this additional modern press the extraordinary demands for navigational charts by the Army, Navy, and merchant marine under the existing war conditions could not have been met with efficient promptness.

In September, 1917, an automatic elevator controlled by push buttons was installed in the printing building, and a runway constructed connecting the second story of the new printing building with the paper room in the old printing building and Butler buildings. These two improvements have greatly facilitated the work. In November a new 57-inch Oswego paper-cutting machine was installed in the pressroom of the printing office, and in January, 1918, an offset proving press, motor-driven, was installed in the transfer room of the printing office.

The issues of charts for the fiscal year was slightly less than for the previous year, but the issue of coast pilots increased remarkably. (See fig. 16, showing the issue of charts from 1888 to 1918, inclusive, and fig. 17, showing the issue of coast pilots from 1900 to 1918, inclusive.)

During the year 1,115 instruments, apparatus, tools, etc., were repaired in the instrument shops; 948 instruments, apparatus, tools, etc., were made; and 2,610 instruments were purchased.

Instruments issued to the field during the year	2,816
Instruments received from the field during the year	3,301
Articles of general property issued to the field during the year	7,788
Articles of general property received from the field during the year	4,608

Much special investigation that was contemplated looking to the improvement of instruments and the designing of new instruments has necessarily been suspended due to the fact that so much time in the instrument section has been devoted to war work.

The fact that the country is on a war basis has necessitated the purchase of additional supplies to produce the increased output of the Bureau, and this has placed greater burdens on the purchasing section of the office. The expenditures from appropriations for the office for 1917 were $89,985, while for 1918 they were $120,127.

Effort has been made to reduce the volumes in the reference library to actual necessity, and in carrying out this purpose a list of those publications deemed of no further use to the Bureau has been sent to the various departments and selections have been made by a number of the bureaus of the departments, thus reducing those on hand in the library of this Bureau to what are actually needed.

Sixty-one hydrographic, 44 topographic sheets, and 3,552 field, office, and observatory records were received during the year and filed in the archives.

The total number of permanent and temporary employees in the field and office, excluding hands, etc., not appointed through civil-service certification, was:

Office force	210
Field force	135
Total	345

The average number of days of annual and sick leave taken by the combined field and office force was 19 and the average number of days of sick leave taken by the combined field and office force was less than 4½. The overtime service performed by the employees of the office during the fiscal year amounted to 1,438 days, or approximately 7 days for each employee.

The receipts from the sale of charts, publications, old property, etc., amounted to $21,622.96.

DIVISION OF GEODESY.

The most important pieces of work which were completed during the past fiscal year or which were in progress during that time are the following:

Computation and adjustment of the following pieces of triangulation:

1. In Maryland.
2. In Rhode Island.
3. In Massachusetts.
4. Utah–Washington arc of primary triangulation.
5. Pasquotank River, N. C.
6. Ninety-eighth meridian south, connecting with the ninety-eighth meridian triangulation.
7. Laguna Madre, Tex.
8. Tampa Bay, Fla.
9. Rio Grande arc of primary triangulation.
10. Atlanta–Griffin, Ga., primary triangulation.

The computation of the following lines of primary traverse:

1. Brunswick–Columbus, Ga.
2. Jacksonville, Fla.–Columbus, Ga.
3. Macon–Griffin, Ga.
4. Albany, Ga.–Callahan, Fla.
5. Savannah–Everett, Ga.
6. Macon–Savannah, Ga.
7. Norfolk, Va.–Savannah, Ga.

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

1. Little Rock, Ark.–Memphis, Tenn.
2. Marquette–Escanaba, Mich.
3. Algonac–St. Clair Flats, Mich.
4. Brunswick–Macon, Ga.
5. Macon–Columbus, Ga.
6. Jacksonville, Fla.–Columbus, Ga.
7. Macon–McDonough, Ga.
8. Albany, Ga.–Callahan, Fla.
9. Sierra Blanca–San Antonio, Tex.
10. San Antonio–Laredo, Tex.
11. New Braunfels–Brownsville, Tex.
12. Macon–Savannah, Ga.
13. Savannah, Ga.–Ulee, Fla.
14. Sinton, Tex.–New Orleans, La.

The computation of azimuth along the primary traverse lines in Georgia and Florida, and along the Rio Grande are of primary triangulation, the observations for which were made in 1917–18.

The computations of latitude and longitude along the primary traverse lines in Georgia and Florida.

The computation of tables for constructing a 1:10,000,000 base map for the United States on the Lambert zenithal equal area projection.

During the year, the computation of 3,517 kilometers of precise leveling was completed at an average cost of 21 cents per kilometer. The introduction of new methods in the computations, the elimination of minor corrections whose effect upon the final elevations of the bench marks proved to be negligible, and the introduction of the adding machine as a recording device in the field work has reduced the cost of computing until now it has reached a figure 40 per cent lower than the average cost from 1909 to 1916, and 6 per cent lower than the average cost previous to 1909.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY.

The office work of this division has been the 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 field stations, 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, have been 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.

During the year there were data collected and itemized memoranda prepared for 20 sets of instructions for field work. This embraces a careful study of the existing surveys, the nature of the bottom, the reviewing of reports upon previous work, and the required closeness of the work needed to obtain a comprehensive survey of the locality in question.

Original field sheets covering areas where changes frequently occur and where preliminary surveys only have been made were reviewed, in order to formulate plans for performing the field work necessary to bring the charts up to date.

As time permitted, completed field sheets were reviewed in the section preparatory to recommending them for the Superintendent's approval. There were 90 hydrographic sheets closely inspected, and memoranda bearing on the work were prepared for insertion in the descriptive report accompanying each sheet.

During the year the coast pilot section carried on field work on the North Atlantic coast, and as a result of the field work two coast pilots, Atlantic Coast Pilot, Section A, from Eastport, Me., to Cape Cod, and Atlantic Coast Pilot, Section B, from Cape Cod to Sandy Hook, were compiled. Numerous chart corrections collected during the course of the field work were submitted. The above volumes complete the issue of all coast pilots on the Atlantic and Pacific coasts of the United States and of Alaska in the new octavo form.

Reprints were obtained during the year of Atlantic Coast Pilots, parts 1, 2, 3, and 4, Sections C and D. Supplements for five volumes and such correction sheets as were necessary to keep the information in all volumes up to date were issued.

The Tide Tables for 1918 were received from the printer in September, 1917. These tables are similar to those of the preceding year, but full predictions are given for four additional ports, namely Savannah, Ga.; Anchorage, Cook Inlet, Alaska; Cebu, P. I.; and Port Hedland, Australia. The standard port of Amboy, China, has been discontinued, leaving 81 stations for which full predictions are given. Some other minor changes were made to make the volume more useful to navigators.

The manuscript of the Tide Tables for 1919 was prepared and submitted for printing in three separate parts as follows:

The manuscript of the Atlantic Coast Tide Tables was prepared and submitted in advance, before the other portions of the General Tide Tables had been predicted; then the Pacific Coast Tide Tables were prepared and submitted for printing; and last of all what remained of the General Tide Tables was prepared and submitted. This arrangement is convenient to carry out, and under peace conditions will greatly expedite the early receipt of the volumes for issue.

The Italian Government requested this Survey to furnish predicted tides for Venice, Italy, for the two years, 1918 and 1919, which was done. The government of Western Australia was furnished with copies of the proof sheets of the predicted tides for Port Hedland, Australia, for the two years, 1918 and 1919.

The computations for the graduation of the scales of the new form of sounding tube was completed in this section, and also the corrections to be applied for variations in the height of the barometer and for changes in the temperature of air and water.

DIVISION OF CHARTS.

The following statistics show the accomplishments of this division in the way of drafting, engraving, and photographic work for the past year, as well as the accomplishments for 1914, 1915, 1916, and 1917:

Work done.	1914	1915	1916	1917	1918
DRAFTING.					
Schemes approved for new charts	20	18	4	8	11
Approved schemes on hand, charts not started	4	11	5	5	8
Drawings for new charts finished	18	18	4	11	15
Drawings for new charts finished in hand	16	8	10	10	10
New drawings for new editions finished	7	4	10	11	7
New drawings for new editions in hand	.....	6	10	4	3
Extensive corrections finished	87	137	157	151	93
Extensive corrections finished in hand	9	18	11	14	10
Chart drawings from Manila for new charts finished	8	3	2	3	1
Chart drawings from Manila for new charts in hand	.....	.....	.....	.....	1
Chart drawings from Manila for new editions finished	10	4	5	14	4
ENGRAVING.					
New plates for new charts finished	6	3	2	8	6
New plates for new charts in hand	7	12	11	6	9
New plates for lithographic charts finished	.....	.....	.....	3	1
New plates for lithographic charts in hand	.....	1	3	2	8
New bassos for new editions finished	18	19	11	16	7
New bassos for new editions in hand	13	16	16	3	2

Work done.	1914	1915	1916	1917	1918
ENGRAVING—continued.					
New bassos for reissues finished	16	16	3	9	17
New bassos for reissues in hand	15	6	10	18	10
New editions using current plates finished	14	18	24	32	16
New editions using current plates in hand	6	4	2	2	14
Extensive corrections applied to plates	239	286	314	209	144
Extensive corrections applied to plates in hand	9	11	14	7	17
Miscellaneous plates engraved or corrected	11	11	22	21	1
Minor corrections applied to plates	1,198	1,145	1,158	696	719
Charts in section, engraving not started	.....	.....	.....	.....	.....
PHOTOGRAPHING.					
Glass negatives made	1,184	1,189	1,225	1,109	1,208
Paper negatives made	30	9	11	.....	6
Velox prints made	1,903	1,968	4,313	3,413	1,781
Vandyke prints made	244	64	52	36	8
Bromide prints made	317	259	500	391	489
Blue prints made	1,937	3,127	2,411	1,921	1,513
Photostat prints made	11,381	15,224	18,549	11,017	11,550
Lantern slides made	11	172	354	208	109
Matrices made	101	90	43	96	52
Redeveloped prints made	.....	.....	.....	197	267
Prints mounted	19	18	39	63	118
Negatives developed	.....	.....	22	41	22
Photolithographic negatives, number of charts	52	49	30	29	110

DIVISION OF TERRESTRIAL MAGNETISM.

The results of the field work executed during 1917 were computed and prepared for publication.

The reduction of the work of the five magnetic observatories for 1916 was completed, and the results for 1915–16 were prepared for publication. The reduction of the observatory work for 1917 was well advanced for each of the observatories.

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

An isogonic chart of New England for 1918 was prepared for the use of the Geological Survey.

A table giving the value of the magnetic declination at numerous places in the United States for 1918 was prepared for insertion in the World Almanac. Revised tables pertaining to terrestrial magnetism were prepared for a new edition of the Smithsonian Physical Tables.

Some progress was made in the reduction of the work of the San Antonio Observatory, 1890–1895. The card catalogue of the field results was very nearly completed.

Proof has been read of the following publications which have been sent to the printer during the year:

MAGNETIC TABLES AND MAGNETIC CHARTS FOR 1915.

Results of Magnetic Observations Made by the Coast and Geodetic Survey in 1917.

Results of Observations Made at the Tucson Magnetic Observatory in 1915 and 1916.

Results of Observations Made at the Honolulu Magnetic Observatory in 1915 and 1916.

Results of Observations Made at the Sitka Magnetic Observatory in 1915 and 1916.

Results of Observations Made at the Porto Rico Magnetic Observatory in 1915 and 1916.

Results of Observations Made at the Cheltenham Magnetic Observatory in 1915 and 1916.

Compass data were supplied for 200 charts.

PUBLICATIONS ISSUED DURING THE YEAR.

ANNUAL REPORT.

Annual report of the Superintendent, United States Coast and Geodetic Survey, 1917.

TIDE TABLES.

General Tide Tables for 1918.

Atlantic Coast Tide Tables for Eastern North America, 1918.

Pacific Coast Tide Tables for Western North America, Eastern Asia, and Many Island Groups, 1918.

COAST PILOTS.

United States Coast Pilot, Alaska, Part I.

Dixon Entrance to Yakutat Bay, sixth edition, 1917.

United States Coast Pilot, Pacific Coast, California, Oregon, and Washington, third edition, 1917.

SUPPLEMENTS TO COAST PILOTS.

Supplements to third edition, United States Coast Pilot, Atlantic Coast, Part III; Cape Ann to Point Judith, August 10, 1917. April 19, 1918.

Supplement to United States Coast Pilot, Atlantic Coast, section D. November 23, 1917.

Supplement to United States Coast Pilot, Atlantic Coast, Parts I–II. St. Croix River to Cape Ann, November 23, 1917.

SPECIAL PUBLICATIONS.

No. 42. Results of Magnetic Observations made by the United States Coast and Geodetic Survey in 1916. By Daniel L. Hazard.

No. 43. Triangulation in Georgia. By C. H. Swick.

No. 44. Magnetic Tables and Magnetic Charts, 1915. By Daniel L. Hazard.

No. 45. Descriptions of Triangulation Stations in Georgia. By C. H. Swick.

No. 46. Lambert's Conformal Conic Projection. By C. H. Deetz.

No. 48. The Neglected Waters of the Pacific Coast, Washington, Oregon, and California. By E. Lester Jones, Superintendent.

No. 49. Lambert Projection Tables, with Conversion Tables. By C. H. Deetz.

No. 50. Safeguard the Gateways of Alaska: Her Waterways. By E. Lester Jones, Superintendent.

No. 51. Results of Magnetic Observations made by the United States Coast and Geodetic Survey in 1917. By Daniel L. Hazard.

No. 52. Lambert Projection Tables for the United States. By Oscar S. Adams.

No. 53. General Theory of the Lambert Conformal Conic Projection. By Oscar S. Adams.

SEPARATE PUBLICATIONS.

Catalogue of Charts, Coast Pilots, and Tide Tables, 1918.

Supplement to Catalogue of Charts. February 14, 1918.

Rules and Regulations for the Government of the Washington Office of the United States Coast and Geodetic Survey, effective October 1, 1917.

Results of Observations made at the United States Coast and Geodetic Survey Magnetic Observatory near Tuscon, Ariz., 1915–16. By Daniel L. Hazard.

Supplement to the Regulations and Instructions for the Government of the United States Coast and Geodetic Survey, from January 1 to June 30, 1917.

Supplement to the Regulations and Instructions for the Government of the United States Coast and Geodetic Survey, from July 1 to December 31, 1917.

Results of Observations made at the United States Coast and Geodetic Survey Magnetic Observatory at Sitka, Alaska, 1915–16. By Daniel L. Hazard.

Results of Observations Made at the United States Coast and Geodetic Survey Magnetic Observatory near Honolulu, Hawaii, 1915–16. By Daniel L. Hazard.

Results of Observations Made at the United States Coast and Geodetic Survey Magnetic Observatory at Vieques, P. R., 1915–16. By Daniel L. Hazard.

BULLETINS.

Coast Survey Bulletins, issued monthly, from July, 1917, to June, 1918, inclusive.

CHAPTER II.

NEEDS OF THE WASHINGTON OFFICE.

The weakest units in the series of operations through which information is gathered from original surveys and issued to the public in the form of printed charts, coast pilots, tide tables, etc., is the lack of a sufficient number in certain classes of personnel in the Washington office of the Coast and Geodetic Survey. This lack of personnel has caused the flow of this information to become stagnant so that there are accumulations of data in the office from original field surveys that can not be passed on to the public in the printed output of the Bureau before some of it becomes antiquated, and even superseded in some changeable areas by later surveys because the personnel of the Bureau that handles phases of this output is not sufficient in number to cope with it. Stated in the order of the Bureau's present requirements, the classes of personnel where relief is urgently needed are as follows: (1) Draftsmen, (2) computers, and (3) clerks.

DRAFTSMEN.

The term "draftsmen" as applied to the employees of the Coast and Geodetic Survey who compile the charts is a misnomer. The mechanical drawing of the characteristics shown on the published chart is by far the least exacting of any duties of the force engaged on this work. The more serious problem is the examination of the mass of data from all sources, some of which are unquestionably accurate, other of doubtful reliability, and still others that may or may not be accurate, and out of these draft a chart that truly represents conditions. To be more explicit, the following are a few things that confront our men engaged on this work. Say a new edition of a chart of an important waterway is being drawn. The man compiling the information for this new edition of a chart has before him the old edition of the chart, the original field sheet of the surveys of the locality made 60 years ago, an original field sheet of an examination made in search of a reported danger in the locality made 5 years ago, an original field sheet of a resurvey made 20 years ago, some hundreds of blue prints of examinations made by the Corps of Engineers in different localities at different times for years past over the area covered by the chart, maps, and blue prints made by State authorities, by municipal authorities, and by county authorities of various areas covered by the chart, numerous reports made by the Bureau of Lighthouses regarding the changes in locations of aids to navigation, and reports by the Coast Guard of the location of wrecks and dangers to navigation.

From this mass of material and information must be determined the data that shall go on a new edition of a chart. These surveys made by different agencies and at different times may not be consistent one with the other in positions given for dangers located,

depths, or aids to navigation, or they may overlap and show inconsistent depths. In compiling this information for the purpose of printing a chart due regard must be given the object in view when the survey was made, for it is obvious that if soundings are made by the Corps of Engineers to determine the depths obtained in dredging a channel, then incidental scattered soundings made of adjacent waters, overlapping and inconsistent with closer surveys made at other times, may or may not be accurate as to conditions where these scattered soundings are made, yet these made in the channel are the last word as to accuracy as to the depths of the channel. Therefore, to take this mass of miscellaneous information and prepare an accurate chart requires far more than mere ability to draft, and the man engaged on such work in the Coast and Geodetic Survey is more than a draftsman in the sense in which the word is commonly used. And, even in the mere matter of drafting, the new appointee of the Bureau, fresh from school, is deficient in that the lettering and symbols which are later to be reproduced by photolithography from original drawings on vellum must be of the highest degree of accuracy and neatness, to be issued in the form of a finished product as a chart, and this is far beyond the capabilities of those who come to the Bureau fresh from school.

While the need of the military services has drawn from this Bureau some of its best and most experienced draftsmen, and while others are on temporary leave of absence undertaking work in connection with the war at the direct request of the President, this has only emphasized a condition that has existed for years, namely, that there is and has been a great mass of information in the form of results of original surveys by this Bureau, surveys by the Corps of Engineers, information from the Bureau of Lighthouses, and from other sources that has not and can not be applied to the charts of the Bureau at the time the information is current, because there is not the necessary force of cartographers to digest the information and apply it as fast as it comes to the office.

Because of the high attainments required of those engaged on this work, the salaries should be higher than at present, especially in the lower grades. Indeed, if the positions are to be filled and conditions continue as at present these salaries must be increased because candidates can not be found to fill them. Some of the lower-paid positions have been vacant for months.

COMPUTERS.

The services of computers are required and used in three divisions of this office:

1. In the division of geodesy in the computation of the results of geodetic surveys.
2. In the division of hydrography in making computations for the annual tide tables and discussion of current data.
3. In the division of terrestrial magnetism in the computations of the field and observatory observations and the discussion of the results therefrom.

While conditions are not as bad in these divisions and the masses of data from field observations, etc., are not so great as those before our draftsmen, yet there are many folios of results of field observa-

tions (geodetic, tidal, and magnetic) in our archives containing information that can only be effectively presented for public use in printed form that have not been reached by the computing force, and can not be reached for too long a time.

1. *Nature of work.*—The work done by the computers is technical in character, requiring thorough training, extensive research, continuous study, sound judgment, and expert accuracy, as shown by the character of the publications prepared under their direction. It involves the joining on of new work to old or the fitting together of the work of several seasons, and thus makes the information acquired by years of experience a very important factor in the efficiency of a computer.

2. *Importance of the work.*—It is especially important at this time to prevent any falling off of the quantity or quality of the output of the Survey because of the large amount of work being done for the Army and Navy. About 90 per cent of the time of the computers of the division of geodesy is now devoted to war work, and the demands from the office of the Chief of Engineers are so urgent that that office has authorized the employment of five temporary computers to help out the regular force.

With the present scale of salaries it is not possible to secure new computers of the required training and ability nor to hold the old computers whose value has been enhanced by experience in the work. Of the entire force (authorized) of 31 computers, there are only 6 now in the service who were here at the beginning of 1907. In the division of geodesy, to which 22 of the computers were assigned, there are now only 2 who were there in 1907. Twelve places are either vacant or filled by temporary appointees.

Recently four men took the examination and all four men were offered positions. One of these wanted $2,000, another $1,700 as an entrance salary, and the other two refused the position.

The circular announcing the examination was sent to all the leading colleges in the country. One college president wrote to the Survey stating that it was impossible to induce the graduates to accept the computer positions, which required such thorough training and paid such small salaries. During the last few years, every one whose name was on the register of eligibles has been offered a position.

It is impossible with the present salaries to secure and retain computers qualified to perform efficiently the work of this Bureau. It is recommended, therefore, that a readjustment of salaries be made so as to make their average pay more nearly conform to present conditions and to that paid for similar service in other branches of the Government.

The scales of salaries of examiners in the Patent Office and of associate physicists and assistant physicists in the Bureau of Standards are not much different from those proposed for the computers. The entrance requirements for the Patent Office are of the same grade as for computer in this Bureau, as evidenced by the fact that a large number of computers have left this Bureau from time to time to go to the Patent Office.

There has recently been a call for computers in the Ordnance Department, the requirements being substantially the same as for computers in the Coast and Geodetic Survey, the salaries ranging from

$1,400 to $1,800 a year. For master computer, with additional requirements of at least two years of experience in engineering or similar pursuits, salaries ranging from $1,800 to $2,400 a year are offered.

CLERKS.

While the flow of information from the raw material as gathered from field observations to the perfected printed output in the form of charts, tide tables, and geodetic publications is materially retarded through the lack of a sufficient number of draftsmen and computers, as pointed out above, the smooth working of an efficient organization is further handicapped through another shortage in that the Bureau has not a sufficient number and a stable force of clerks. Relatively it is more important that an additional number of draftsmen and computers be supplied than of clerks because the information that passes through the hands of the former goes to the public in the form of a printed product that is equally available to all and therefore has a broader field of service, yet we are far from able to meet as promptly and fully as is desirable the many requests that come to this office for special information for individuals, Government officials, shipping interests, etc., because we have not the proper number of experienced clerical employees to properly collate the data to supply this information.

This Bureau in relation to its clerical force has a few parallels in the Government service. The work of the Bureau is specialized. The clerical force is not large (42 in number). No two clerks in the Bureau have duties that are exactly similar, and the duties of many are highly technical. From this it follows that when a vacancy occurs in the clerical force the new appointee is assigned to duties which are different from any clerical experience he has ever had before, and there is no other clerk in the division to which he is assigned to assist him to acquire a knowledge of his duties. He acquires this information only at the expense of a great loss of time of the chief of the division where he is assigned, who must instruct him in the details of the work. Consequently frequent changes in the clerical force of this Bureau not only hinder the prompt supplying of the individual inquiries of the public but actually retard the technical work of the Bureau.

Owing to the disparity between the lower statutory salaries in this Bureau and those paid in other branches of the Government service, the changes in the clerical personnel of the Bureau are in excess of the average in other branches of the Government service.

The statutory salary of 50 per cent of the clerical force of the Bureau is not in excess of $1,000 per annum. There are 42 clerks in the Bureau. The statutory salaries of 21 are as follows: Six at $720 per annum, 10 at $900 per annum, and 5 at $1,000 per annum.

The result was that during the fiscal year no less than 27 persons occupied 5 of the statutory places at $720 per annum and 33 persons occupied the 10 statutory places for clerks at $900 per annum. The general average has been that these positions have been held by clerks somewhat less than three months, there being many intervals when candidates could not be found willing to accept such salaries.

The bare facts are that while the Government has really paid from its salary rolls a minimum price for clerical help, it has lost a large

amount of time of highly skilled technical employees who have instructed during one year each of these 60 different incumbents of different clerical positions, and the net result has been a financial loss far in excess of proper salaries that would retain a permanent force of experienced clerks.

INSTRUMENT MAKERS.

There is another need in the office personnel that, however, has a direct effect on field accomplishments, and that is an increased number of and higher entrance salary for instrument makers. These must be specially skilled men in the repairing and making of the intricate parts of delicate surveying instruments, such as theodolites, sextants, levels, etc.—men of a much higher class of attainments than are usually found in quantity production instrument shops of even manufacturers of surveying instruments, because such men are generally skilled only in the production in numbers of special parts of a given instrument, while such employees in the Coast and Geodetic Survey must be able to make necessary parts and repairs to any part of any delicate surveying instrument and with the highest degree of precision, because an inaccuracy in the instrument would bring inaccuracies in the results from surveys made with it.

The entrance salary of $1,200 is insufficient to attract men of the requisite experience to fill these positions. It is indeed insufficient to attract men at the present time. One of these positions was created July 1, 1917. It was only after a solicitation by correspondence and personal inquiry covering nearly six months that an incumbent was found, and another of the $1,200 positions has been vacant for months. We are unable to induce any one with any degree of mechanical ability to accept an appointment to fill the vacancy.

RETIREMENT FOR EMPLOYEES OTHER THAN COMMISSIONED OFFICERS.

In the chapter of the "Needs of the field service" attention has been called to the need of legislation authorizing the retirement of commissioned officers of the field force 64 or more years old who have devoted the producing years of their lives to the interest of the Coast and Geodetic Survey at rates of pay that have not permitted the accumulation of a competence for old age. Retirement for these old officers has been earned and is merited in view of the hazards and perils through which they have passed and which have been incident to the field service of the Coast and Geodetic Survey.

There is, however, another class of employees in the Coast and Geodetic Survey, in common with many other branches of the Government service, for whom retirement for those who have become superannuated on some sort of civil pension should be provided, and this class comprises the different civil employees of the Bureau. Consequent on the fact that the Coast and Geodetic Survey is a very old branch of the Government service (it having recently rounded out a century of activity) it has on its rolls civil employees who have reached the ages when they should be retired on account of superannuation.

The matter of retirement of civil employees in the Government service has been agitated for years in this country, and while retire-

ment of superannuated employees under varying conditions and at various rates of pay is in effect in many foreign countries, the principle has not been acted upon in this country except to a limited extent in a few services. It is not urged that the Coast and Geodetic Survey is on any different status from other governmental branches in this respect so as to entitle its employees to special consideration, but from the fact that it is such an old service it has on its rolls a considerable number of employees who have reached such ages that their abilitities are impaired and they should be retired. Their pay has been so small and the cost of living has been such that if their salaries ceased they become dependent. The work of the Bureau would be greatly accelerated if there were some general provision for the retirement of the employees of the Coast and Geodetic Survey who have reached ages when they can not keep pace with the needs of the Government.

PROPER HOUSING FOR THE EFFICIENT OPERATION OF THE BUREAU.

Year by year mention has been made of the fact that the operation of the Bureau is fettered and restrained because of the handicap of quarters that restrict at every turn the fullest accomplishments. It is not feasible and practicable to try to make an old hotel building into an office where employees can be grouped under proper supervision and where machinery for printing charts, manufacturing and repairing surveying instruments, electrotyping copper plates, etc., can be properly installed. The limitations in size of rooms, rooms supplying proper light, sufficient number of rooms, communication between employees who have work in common and must consult common records and yet can not be grouped in one part of the building or even on the same floor of the building are restrictions that seriously retard the output of the Bureau. Too noisy machinery must be installed in rooms contiguous to those in which are specialists engaged on work requiring the closest concentration, and the best of results can never be obtained.

However, it is recognized that with the immense burden of expense which the Government is bearing now it is no time to insist upon the expansion of these expenditures in the construction of a new building. Yet, these are conditions that in the interest of ultimate economy should be remedied at the earliest feasible moment.

CHAPTER III.

WAR WORK OF THE COAST AND GEODETIC SURVEY.

On May 22, 1917, an act was approved "to temporarily increase the commissioned and warrant and enlisted strength of the Navy and Marine Corps, and for other purposes." By section 16 of this act the field officers of the Coast and Geodetic Survey, then under the designation of assistants and aids, were directed, by and with the advice and consent of the Senate, to be commissioned as officers in the Coast and Geodetic Survey under designations therein specified.

By this same act the President was authorized "whenever in his judgment a sufficient national emergency exists to transfer to the service and jurisdiction of the War Department and the Navy Department such vessels, equipment, stations, and personnel of the Coast and Geodetic Survey as he may deem to the best interest of the country." Provision is also made for the return to the Coast and Geodetic Survey of such vessels, equipment, stations, and personnel when such emergency ceases in the opinion of the President.

In the exercise of this authority, the President issued an Executive order on September 24, 1917, by which the following vessels and the personnel thereon were transferred to the service and jurisdiction of the Navy Department: *Surveyor*, *Bache*, and *Isis*.

And on May 16, 1918, another Executive order was issued transferring the following vessels and the personnel thereon to the service and jurisdiction of the Navy Department: *Patterson* (temporarily renamed U. S. S. *Forward*) and *Explorer*.

On March 16, 1918, at the request of the Secretary of War, the Superintendent of the Coast and Geodetic Survey was granted "leave of absence" from his duties in the Coast and Geodetic Survey, and commissioned in the War Department.

OFFICERS OF THE SURVEY ON MILITARY DUTY IN THE WAR AND NAVY DEPARTMENTS.

By Executive order of September 24, 1917, and others of subsequent dates, officers and employees of this Bureau were transferred to and commissioned in the War Department and the Navy Department. Members of the Coast and Geodetic Survey are now commissioned in the War Department and the Navy Department as follows:

In the War Department:
Col. E. Lester Jones.
Maj. William Bowie.
Capt. E. P. Ellis.
Capt. C. V. Hodgson.
Capt. E. H. Pagenhart.
First Lieut Rowland K. Bennett.
First Lieut. Frank S. Borden.
First Lieut. P. B. Castles.
First Lieut. E. F. Church.
First Lieut. W. H. Clark.
First Lieut. George D. Cowie.
First Lieut. I. M. Dailey.
First Lieut. Ernest W. Eickelberg.
First Lieut. Bert C. Freeman.
First Lieut. Harry T. Kelsh, jr.
First Lieut W. D. Lambert.
First Lieut. W. J. McKenzie, jr.
First Lieut. C. F. Mourhess.
First Lieut. Harold W. Pease.
First Lieut. Payson A. Perrin.
First Lieut. Howard S. Rappleye.
First Lieut. Ernest E. Reese.
First Lieut. Max O. Witherbee.
First Lieut. Andrew C. Witherspoon.
Second Lieut. J. W. Cox.
Second Lieut. Benj Galos.
Second Lieut. Herbert H. Grummann.
Second Lieut. George R. Hartley.
Second Lieut. Robert J. Hole.
Second Lieut. R. D. Horne.
Second Lieut. Fred E. Joekel.
Second Lieut. R. A. Wheeler.

In the Navy Department:
Lieut. Commander Arthur Joachims,
Lieut. Commander W. S. P. Keyes.
Lieut. Commander Robert F. Luce.
Lieut. Commander W. E. Parker.
Lieut. Commander J. H. Peters.
Lieut. H. R. Bartlett.
Lieut. Leo. O. Colbert.
Lieut. Francis G. Engle.
Lieut. Nicholas H. Heck.
Lieut. A. S. Hallberg.
Lieut. Francis H. Hardy.
Lieut. Wilmer O. Hinkley.
Lieut. Thomas Jamieson.
Lieut. Paul V. Lane.
Lieut. Gardiner Luce.
Lieut. R R. Lukens.
Lieut. Thos. J. Maher.
Lieut. Jas. E. Marsh.
Lieut. K. E. Nelson.
Lieut Raymond S. Patton.
Lieut. Clifford G. Quillian.
Lieut. Leroy P. Raynor.
Lieut. Gilbert T. Rude.
Lieut. H. A. Seran.
Lieut. Roscoe P. Strough.
Lieut. Paul M. Trueblood.
Lieut. Eustace S. Walker.
Lieut. J. T. Watkins.
Lieut. Paul C. Whitney.
Lieut. Leo C. Wilder.
Lieut (j. g.) Kenneth T. Adams.
Lieut. (j. g.) Stanley T. Barker.
Lieut. (j. g.) C. T. Bussell.
Lieut. (j. g.) C. N. Conover.
Lieut. (j. g.) Harold A. Cotton.
Lieut. (j. g.) Arthur J. Ela.
Lieut. (j. g.) A. L. Giacomini.
Lieut. (j. g.) L. D. Graham.
Lieut. (j. g.) Chas. K. Green.
Lieut. (j. g.) M. E. Levy.
Lieut. (j. g.) Geo. C. Mattison.
Lieut. (j. g.) Raymond V. Miller.
Lieut. (j. g.) O. H. Paddison.
Lieut. (j. g.) F. L. Peacock.
Lieut. (j. g.) Ray L. Schoppe.
Lieut. (j. g.) Wm. Weidlich.
Ensign Geo. L. Bean.
Ensign Geo. H. Durgin.
Ensign Fritz C. Nyland.
Ensign R. C. Overton.
Asst. Surg. G. E. Marchand.

The total personnel from the Coast and Geodetic Survey in the War Department and the Navy Department is as follows:

In the War Department:	
Commissioned officers (Coast and Geodetic Survey commissions)	25
Other officers	26
Men	58
Total	109
In the Navy Department:	
Commissioned officers (Coast and Geodetic Survey commissions)	42
Other officers	10
Men	79
Total	131

This total of 240 members from the Coast and Geodetic Survey in the military branches is 30 per cent of the entire personnel of the Coast and Geodetic Survey.

The energies of the personnel remaining with the Coast and Geodetic Survey have been directed almost wholly to the assistance of the military branches of the Government. Practically all the parties in the field on geodetic work have been for the purpose of securing results requested by the War Department, and many special confidential surveys have been made by the hydrographic parties for the Navy Department.

In the Washington office of the Bureau attention has been given to the needs of the military branches for which special computations have been made and special maps and charts produced. Much of the time of the instrument shops has been devoted to repairing sextants and instruments needed by the Navy Department and to the designing and perfection of new instruments and devices for the military authorities. A notable production by the Bureau for the military authorities is a treatise on the Lambert Conformal Projection. This is the projection on which the battle maps in France are based. There was no satisfactory treatise in existence, not even in French,

with which to meet the large and constant demand for information concerning it for Army officers and others interested in war maps, and to supply this need the treatise was prepared in this office. The demand for it has been large, especially from the Army.

The officers of the Coast and Geodetic Survey who have remained with the Bureau have acted in an advisory capacity on many military commissions, boards, etc.

The officers who have not been transferred and the other employees who have not become identified with the Army or Navy, remaining with the Coast and Geodetic Survey, both at the Washington office and in the field, are performing duties that are identical, as far as importance is concerned, with the military forces that are both on land and sea.

From the fact that the Coast and Geodetic Survey is an arm of the Government which is now contributing its entire efforts in war activities, it will be readily appreciated that it is as necessary to have a sufficient number of the personnel remaining with this Bureau, so as to keep it efficiently active.

There are men in this Bureau who feel that they should be at the front. It has been most difficult to discriminate in transferring some to the Army and some to the Navy, and others having to remain at home. However, it should be clearly understood and certainly bring a large amount of satisfaction of mind to those who have remained in the Bureau and have simply been held here because their services are indispensable and their work bears exactly the same importance in connection with the war as those services are literally utilized at the front.

RECENT LEGISLATION ENACTED AFFECTING THE COAST AND GEODETIC SURVEY.

The following is a summary of legislation contained in the sundry civil act of July 1, 1918, affecting the Coast and Geodetic Survey:

Among the important pieces of enabling legislation for the Bureau is the authorization of the payment of not to exceed $1 a day as extra compensation to employees of the different stations of the Lighthouse Service while observing tides or currents. Lightships are peculiarly well situated in positions where it is desirable to collect tide and current data, but such observations are not part of the duty of the Bureau of Lighthouses and in the past could not justly be imposed on the light keepers of that Bureau without some additional compensation, and the appropriations for the Coast and Geodetic Survey could not be expended to recompense them for such additional duties without this authorization. From the results of data collected by lightships it is expected that predictions can be made which will be of direct benefit to navigators and go far toward saving many vessels from loss through inadequate knowledge of the direction and strength of the ocean currents.

This act also authorized the Bureau to purchase supplies or procure services in the open market in the manner common among business men where the amount of the purchase does not exceed $50. Instances are numerous in the past where the necessity of securing competitive bids for small items have materially delayed the progress of

field work, and such required procedure has actually cost the Government more than the value of the article purchased.

Other items are the authorization of the running of lines of precise levels in the interior of Alaska; the employment of draftsmen in the preparation of plans and specifications for vessels; and the reimbursement under rules prescribed by the Secretary of Commerce of officers of the Bureau for food, clothing, medicines, and other supplies furnished for the temporary relief of distressed persons in remote localities and to shipwrecked persons temporarily provided for by them.

Three important items of additional appropriation for the Bureau are contained in the act. One is an appropriation of $50,000 for a new vessel to cost not exceeding $354,000. Another is the appropriation of $50,000 for a new motor-driven vessel, including equipment, to replace the *Taku*. The *Taku* was condemned as unseaworthy and sold. The third is for four or more new launches, including their equipment, $62,500. The two new vessels are for much-needed surveys of the waters of Alaska, and the launches are for use in wire-drag surveys. In the past launches for these surveys have been procured at a necessarily excessive rental, owing to the fact that they were taken from other industries, and they have been generally unsatisfactory for wire-drag work because they were not especially designed for the purpose.

Provision is made for some additional technical employees of the Bureau whose services are used in the preparation and production of charts issued by the Bureau, and which are so largely used by the Navy Department, vessels of the War Department, merchant marine, and the new vessels being built by the Shipping Board.

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

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 field stations, 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 the progress of the field and office work. Detailed statements of the work are given in the reports of the chiefs of sections and parties:

MILITARY WORK

During the fiscal year 1918 practically all of the topographic, hydrographic, and wire-drag work of the Bureau was done at the request of the Navy Department to meet urgent military needs. Work not done at the request of the Navy Department was undertaken only when its urgent need and importance were determined.

The Bureau and its field parties cooperated closely with the Navy Department. At Washington, D. C., frequent consultation and correspondence with the various bureaus of the Navy Department were had relative to the work that was requested. In the field, the parties cooperated closely with the local naval commandants, the commanding officer of the fleet, or other naval authority.

Five of the larger vessels of the Bureau, together with their personnel, were transferred to the Navy Department by Executive order. These vessels required but little work to fit them to meet the needs of the Navy Department after the transfer.

FIELD WORK, ATLANTIC COAST.

The steamer *Bache* was at Norfolk repairing and outfitting for field work during July, 1917. At the request of the commandant of the naval base, Hampton Roads, Va., confirmed by the Secretary of the Navy, the *Bache* was employed from July 24 to September 23, 1917, on a detailed hydrographic and topographic survey of the

naval base, on which should be based very extensive improvements intended at that point.

The steamer *Isis* was repairing at Baltimore, Md., during July and August, 1917. During September the vessel made an inspection trip on the New England coast, by direction of the Secretary of Commerce.

On July 1, 1917, the steamer *Surveyer* was at Portsmouth, N. H., arranging for receiving certain launches and fittings that had been built for that vessel. The vessel then proceeded to Tompkinsville, Norfolk, and Washington, arriving at the last-named place on July 24. At Washington, the vessel was inspected by the naval authorities, the surveying instrumental outfit was placed on board, and arrangements were made for transferring the vessel to the Navy Department.

On September 24, 1917, the steamers *Surveyor*, *Isis*, and *Bache*, with their complements of officers and men, supplies, and equipment, were transferred to the Navy by Executive order, in conformity with law.

The steamer *Hydrographer* completed the comprehensive survey begun the previous year of the entire seacoast of Mississippi and Alabama, including during the present fiscal year Mississippi Sound, Mobile Bay, and the seaward approaches. Detached shore parties were organized for this work as soon as practicable after the funds for the fiscal year became available, and these parties were continued while the work was in progress. Repairs, including the installation of a new boiler, were made to the vessel at Mobile, Ala., for about one month during the latter part of March and first part of April.

This survey developed extensive changes from the published charts, which were based on surveys made about 70 years before. The survey of Mobile Bay was made at the request of the Navy Department and commercial interests, and enables the Bureau to publish an up-to-date chart showing the very extensive commercial development now in progress.

The survey of Mobile Bay was completed at the end of May and the vessel proceeded to Norfolk, Va., arriving on June 13. After a consultation with the commanding officer, instructions were issued for the work in the lower part of Chesapeake Bay, embracing the main channel of the bay and approaches to Hampton Roads, to meet the needs of the Navy Department. At the end of the month signals and tide staffs had been erected and sounding work has been begun.

The schooner *Matchless* completed a comprehensive resurvey of the easterly side of Pamlico Sound from the vicinity of Cape Hatteras to the south end of Roanoke Island. The topography of the inner and outer shore lines of the outer beach was completed; also the hydrography, with the exception of a strip of the sound about 8 miles long between New River Inlet and Oregon Inlet.

The vessel also completed certain surveys previously done by the same vessel in Croatan and Roanoke Sounds. These surveys were made to bring our charts up to date and also to meet the needs of the Lighthouse Service. The previous general surveys of the region had been made about 70 years before.

Owing to the very severe winter the *Matchless* en route from Roanoke Island to Elizabeth City was caught in the ice and held

from about December 24 to January 17, and was then towed to Elizabeth City. On the 29th she was taken to Norfolk. During February, March, and April the vessel was repaired at Norfolk and outfitted for field work.

Soundings were made by the vessel to meet the needs of the Navy Department around the coal piers at Newport News and in the Newport News dredged channel in Hampton Roads.

During May and June the *Matchless* was employed in York River on surveys requested by the Navy Department. These surveys included a complete survey of the Mattaponi River from the bar at its entrance to the shipyard at Yorktown; also a verification of the hydrography of the river from Gum Point to York Spit Lighthouse.

Wire-drag party No. 1 completed the wire-drag survey of the approaches to Portsmouth Harbor, N. H., to meet the needs of the Navy Department. This party cooperated closely with the local naval authorities, and performed certain special surveys requested by them. The work was continued to September 24, 1917, when certain officers of the party were transferred by Executive order to the Navy Department.

In the spring of 1918 the party outfitted at Kittery Point, Me., and on May 6 began a survey on the west coast of Block Island to meet the needs of the Navy Department. This special work was undertaken to develop and make safe a submarine trial course, and the work included current observations and soundings over a very considerable area on either side of the trial course and a wire-drag survey for a distance of 2½ miles westward from the 10-foot curve on the west side of the island.

Along the west side of the south half of the island wire-drag work was extended from the 10-foot curve to a junction with the wire-drag work previously completed there. Many uncharted bowlders and dangers to navigation were located by this party, and the results of this work were furnished to the Navy Department. The work of this party was delayed by reason of the inability to secure efficient launches for the purpose.

Wire-drag party No. 2 surveyed Block Island Sound and the approaches to Narragansett Bay to meet the needs of the Navy Department. While employed on this work the party executed a number of special surveys at the request of the Navy Department, including a comprehensive survey of Sakonnet River and a wire-drag survey of certain areas between Bartlett Reef and The Race. The party was disbanded on December 4, 1917.

In the spring of 1918 the party was organized and the launches equipped at Wickford, R. I., and on April 15 began wire-drag work in Long Island Sound requested by the Navy Department. The first work done by this party was a comprehensive survey of the trial course off Port Jefferson, L. I., including triangulation lead-line hydrography, and a wire-drag survey.

From May 7 to 24, inclusive, the party was employed from Stonington, Conn., as headquarters, on a wire-drag survey in the east end of Long Island Sound. This party was then transferred to the coast of Maine and arrived on June 1.

From July 1 to September 23, wire-drag party No. 5 was engaged on a wire-drag survey of the passage across the Florida Reefs

between Rebecca Shoal Lighthouse and Dry Tortugas, Fla. Frequent high winds and strong currents, together with inadequately powered launches, interfered seriously with the progress of the work.

It having been found impracticable to secure launches for wire-drag work in Porto Rico, wire-drag party No. 5 was organized during the month of June for the work in Block Island Sound requested by the Navy Department. At the close of the month the necessary launches had been secured and the party was ready to begin work early in the next fiscal year.

A shore party was employed from July 23 to September 24, 1917, on a revision of the triangulation and topography of the north shore of Long Island from Northport to Kings Park.

A party using chartered launches revised the hydrography in the south approaches to Cape Cod Canal from August 1 to September 30, 1917. The party was then transferred to Plymouth Harbor, Mass., to complete the revision of the hydrography in that vicinity. This work was completed on November 15.

A party using chartered launches continued a comprehensive tide and current survey, begun the previous fiscal year, of the easterly half of Long Island Sound eastward from New Haven. Currents were observed for 51 hours each at important stations in the sound and the principal tributaries. Automatic tide gauges were maintained at selected stations during the work, staff gauges were operated for short periods at numerous other stations, and approved bench marks were established for all stations and connected up with all previous work of this character which embraced a number of years' observations. This work was continued until November 3, when the party was disbanded.

The field revision of Atlantic Coast Pilot, Section A, which covers the coast from the northeast boundary to Cape Cod, was done between July 13 and October 27, 1917; and that of Atlantic Coast Pilot, Section B, which covers the coast from Cape Cod to New York, was done between July 14 and September 24, 1917.

For use as a trial course for naval vessels, a course 1 mile long was laid out at Alexandria, Va., in November, 1917.

A survey of the Virgin Islands having been requested by the Navy Department, a party left the office on January 31, 1918, and was employed on triangulation and topographic surveys of the islands for the balance of the fiscal year. This party is cooperating with the naval officials at St. Thomas, and, in addition to the general survey requested by the Navy Department, has made a number of small surveys especially requested by the local naval officials.

Field stations, each in charge of an inspector who is a field officer of the Bureau, were maintained at Boston from January 7 to June 30, 1918; at New York City during the fiscal year; at Galveston from July 1, 1917, to January 14, 1918, when the office space was taken over by the District Court; and at New Orleans from March 1 to June 30, 1918.

At each field station there is maintained a stock of charts and other publications of the Survey for consultation and for sale. The officer in charge has for his principal duties an inspection of the navigable waters within his district, for the purpose of keeping the charts and other nautical publications of the Coast and Geodetic Survey cor-

rected to date and the furnishing of information relative to our coasts to the public.

The routine duties of the field station are handled by a clerk. In addition to the inspection duties of the field station, the following special assignments were made to the inspectors during the year:

The inspector at Boston is a member of the Mississippi River Commission and attended several meetings of the commission during the year. The inspector also made a field examination of the coast between Gloucester and Boston, preparatory to undertaking the field work of making a revision of the triangulation and topography of this locality for use on a large scale chart of this area which is urgently needed, especially of the important harbor of Lynn, Mass.

The inspector at New York had charge of the exhibit for the Bureau at the meeting of the Southern Commercial Congress from October 15 to 17, 1917; also at the National Motor Boat Show held at New York city during the week beginning January 20, 1918.

To meet the needs of the Navy Department for the location of certain stations in connection with the Proving Grounds at Sandy Hook, the inspector at New York executed triangulation along the coast of New Jersey during April and May, 1918.

At the request of the United States Engineer's office at Galveston, Tex., the inspector of the Bureau at Galveston executed a survey of Brazos Santiago for purposes of improvement. The work comprised triangulation, topography, and hydrography, and was executed from August 7 to 31, 1917.

FIELD WORK, PACIFIC COAST.

A shore party was employed from July to October, 1917, on a survey begun the previous fiscal year of the triangulation, topography, and hydrography of the important Lake Washington Ship Canal and Duwamish Waterway, which had been recently completed at Seattle Harbor.

Field stations of the Survey, each in charge of an inspector who is a field officer of the Bureau, were maintained at San Francisco and Seattle during the year.

Each field station maintained one of the regular tide stations of the Bureau throughout the year, obtaining a continuous record of the time and height of the tide with an automatic tide gauge.

The field station at Seattle served as headquarters for the field parties operating in Washington and Alaska, and rendered valuable assistance to the field parties in the purchase of outfit and supplies, repairing the vessels, and securing men.

A field officer of the Bureau began an inspection trip during June along the west coast of the United States, to enable the Bureau to keep in close touch with the conditions of the surveys on that coast, so that steps can be taken to meet the immediate needs under present conditions. This officer also inspected the chart agencies of the Bureau on that coast.

FIELD WORK, ALASKA.

The steamer *Patterson* during the summer of 1917 was employed in southeast Alaska on surveys in the approaches to Cross Sound. The triangulation was extended from Cross Sound southward

through Lisianski Inlet, Lisianski Strait, and the outer coast, to Portlock Harbor, forming an important closure in the loop of triangulation around Chichagof Island. The topography and hydrography of Lisianski Strait and Inlet were completed.

The ship executed offshore hydrography in the westerly approach to Cross Sound for a distance of 27 miles off the coast and extending about 60 miles along the coast. It was not possible to complete this work as fully as intended, but the information thus obtained is an important addition to our information for the use of navigators in this important approach from westward to southeast Alaska.

Trouble was had in holding an efficient crew on the vessels for the entire season, and only by shifting a part of the crew from the *Explorer* to the *Patterson* was it possible to keep the work going. The work was closed on September 23, and after storing the *Cosmos* and launches at Metlakatla the ship returned to Seattle on October 13. The vessels were laid up in Lake Union with a reduced crew where repairs were made to the vessel. On May 16, 1918, the vessel was transferred to the Navy Department by Executive order.

The steamer *Explorer* during the summer of 1917 was employed in southeast Alaska on a comprehensive survey of the outer coast from Cape Muzon to Meares Passage. Owing to the difficulty of securing and holding a crew for the vessel this work could not be economically prosecuted.

The vessel therefore closed work on July 19, and a part of the officers and crew were transferred to the steamer *Patterson*. The vessel then returned to Seattle on August 18, and was then laid up in Lake Union, after certain minor repairs had been made. The *Explorer* was transferred to the Navy Department on May 16, 1918, by Executive order.

The steamer *Taku* was assigned to survey the northwesterly end of Prince William Sound in regions where commercial development was most active. Owing to the difficulty of securing and holding an efficient crew and the constant trouble with the engine of the vessel, it was impracticable to continue work throughout the summer. The vessel surveyed the entrance to Port Nellie Juan and all of McClure Bay. Work was closed on August 22 and the party returned to Cordova. The vessel was then inspected by United States steamboat inspectors and was condemned as no longer economically fit for the survey work of the Bureau. The vessel was therefore sold to the highest bidder on December 13, 1917.

The steamer *Yukon* was laid up at King Cove, Alaska, during the entire year. In the summer of 1917 a party of the Bureau repaired the vessel and made her secure while laid up and housed over for the winter. Owing to the difficulty of securing and holding an efficient crew for the vessel no field work could be done.

During the summer of 1917 two wire-drag parties were employed on a survey of the main passages forming the principal inside route through southeast Alaska. Difficulty was had in obtaining and holding efficient parties, but a satisfactory season's work was accomplished; in addition to the wire-drag work, the parties carried out a revision of the topography of the passages covered by the wire-drag survey. The triangulation for the same areas was mostly done by separate parties.

Wire-drag party No. 3 extended the work in Frederick Sound from its easterly end in the vicinity of Dry Strait to Turnabout Island and thence northward to the north side of the entrance to Fort Houghton. The work was continued until September 27 and the party returned to Seattle on October 6. A number of the officers of the party were then transferred to the Army and Navy.

Wire-drag party No. 4 completed the survey of the principal route through Stephens Passage, Saginaw Channel, Favorite Channel, and Lynn Canal from Point Hilda to Point Bridget. The work was continued until September 12, and the party returned to Seattle on September 19. A number of the officers of the party were then transferred to the Army and Navy.

In the spring of 1918 four officers of the Bureau, using the equipment of wire-drag party No. 3, were sent to Anchorage, Alaska, to make a survey of Knik Arm in the approaches to the railroad terminal at Anchorage, at the head of Cook Inlet. This survey had been requested by the Alaskan Engineering Commission to insure safety for vessels carrying supplies to and from Anchorage. The party arrived at Anchorage on May 3, but the equipment did not arrive until May 19.

The Alaskan Engineering Commission actively cooperated in the organization of the party, and enabled it to secure hands and launches sufficient to prosecute the work satisfactorily.

A comprehensive wire-drag and hydrographic survey was then begun and was in progress at the close of the fiscal year. A survey of the town site of Anchorage was also made. In connection with this survey an automatic tide gauge was installed at Anchorage, and tidal observations will be continued throughout the summer and fall until the formation of ice, in order to furnish data to enable the Bureau to publish full tidal prediction in the Tide Tables for the use of mariners for this important terminal.

When the *Patterson* and *Explorer* were transferred to the Navy Department on May 16, 1918, the commanding officer of those vessels withheld those men from the complement of the vessels who were not available for enlistment in the Naval Reserve to form a nucleus for a crew for the launch *Cosmos*. At the close of the fiscal year arrangements had been made for the repairing and placing of the *Cosmos* in commission and the party was en route to southeast Alaska.

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 field station at Manila. The expenses of the work are met partly from the appropriations 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.

One of these, the small steamer *Research* of 96 tons register, was returned by the Bureau to the Philippine government, it having determined that the vessel is not sufficiently seaworthy to continue on the surveys of the exposed localities remaining to be done in the islands.

On March 19, 1918, the steamer *Marinduque* was temporarily transferred to the insular government for use as a transport among the islands. This vessel will be returned to the Coast and Geodetic Survey as soon as full complement of officers of the Survey can be sent to the Philippine Islands.

The steamer *Pathfinder* continued inshore and offshore topographic and hydrographic surveys in the vicinity of Polillo Island until October 18, when the weather conditions through the change of monsoons became unfit for further work in that exposed locality. The vessel then returned to Manila for extensive repairs. These repairs were done at the naval station at Olongapo from December 12, 1917, to April 20, 1918. After obtaining the necessary supplies at Manila the vessel then proceeded to the field of work on the east coast of Palawan Island where the field work was continued to the end of the fiscal year.

The steamer *Fathomer* was at Manila from July 1 to 12 for supplies. Inshore and offshore hydrographic work was then taken up in the vicinity of Polillo Island in conjunction with the steamer *Pathfinder*. The field work was discontinued about the middle of October due to the change of monsoons, making it impracticable to work in that locality for a longer time. The vessel was at Manila repairing from October 19 to November 26 and from March 2 to March 11, and otherwise was employed on offshore hydrographic surveys around Busuanga and Cuyo Islands in the northerly part of the Sulu Sea until the end of the fiscal year.

The steamer *Romblon* was at Manila from July 7 to August 1, from October 14 to November 16, and from January 19 to April 18, outfitting and receiving the necessary repairs. Otherwise the vessel was employed during the fiscal year on combined surveys of the southeast coast of Palawan Island.

The steamer *Marinduque* was employed on combined surveys on the east coast of Palawan from July 16 to September 22 and from October 18 to December 19. The vessel was repaired and outfitted at Manila as necessary, and on March 19 was temporarily transferred to the insular government and the officers of the Coast and Geodetic Survey were assigned to other duties.

The steamer *Research* completed from July 1 to August 24 the survey of Manila Bay begun the previous fiscal year. The vessel was then laid up and on January 4, 1918, was transferred back to the insular government.

A very gratifying result of the field work in the Philippine Islands for the fiscal year is the completion of the secondary triangulation extending throughout the island of Palawan. This will enable the Bureau to prosecute its surveys around that island in a systematic manner so that all work will be on the same datum, and further insures that all work executed in that locality will be done in a permanent manner. The hydrographic and topographic surveys on

the east side of the island based on this triangulation have made excellent progress.

An exhibit consisting of maps, charts, and illustrations, showing the work accomplished by the Coast and Geodetic Survey in the Philippine Islands, was made at the annual carnival at Manila from February 2 to 10, 1918.

SECTION OF FIELD WORK.

This section is a part of the division of hydrography and topography. Its principal duties are to supervise the topographic and hydrographic surveys, and to coordinate and standardize the work of the various field parties with a view to having a complete and continuous survey of the coast.

When general surveys of the coast are in progress, new surveys in remote localities are to be made, or revision surveys contemplated, all data pertaining to the locality in which the work is to be done are assembled. From a careful review or these data, the best methods of accomplishing the work are determined and the memoranda for instructions prepared accordingly. General supervision is given to the topographic and hydrographic work as it progresses, and, through reports and sketches received monthly from each party, close touch is kept with the field work.

During the year there were data collected and itemized memoranda prepared for 20 sets of instructions for field work. These embraced a careful study of the existing surveys, the nature of the bottom, the reviewing of reports upon previous work, and the required closeness of the work needed to obtain a comprehensive survey of the locality in question.

Original field sheets covering areas where changes frequently occur and where preliminary surveys only have been made were reviewed, in order to formulate plans for performing the field work necessary to bring the charts up to date.

As time permitted, completed field sheets were reviewed in the section preparatory to recommending them for the Superintendent's approval. There were 90 hydrographic sheets closely inspected, and memoranda bearing on the work were prepared for insertion in the descriptive report accompanying each sheet.

SECTION OF FIELD RECORDS.

The principal duty assigned to the section of field records is the inspection of the data submitted by the field parties, and their completion for publication and the files. This inspection of the field results has been extended to cover preliminary studies of miscellaneous reports and records for use in formulating detailed plans for the conduct of the work in the field, and takes into consideration both the means available and the general program of operations.

In connection with the review and analysis of the results submitted by the field parties, there are noted the imperfections of present means and methods of conducting our operations, with a view of correcting these shortcomings in subsequent work. There are also developed and reported methods and treatment and suggestions for use in publishing the collected field data.

In addition to the final review of the field results, examination of the work as it progresses is made, and preliminary instructions modified to meet the changing requirements of the work as it is developed.

The section has handled many miscellaneous requisitions and assignments.

During the months of April and May, 53 original hydrographic sheets were examined and memoranda prepared for insertion in the descriptive reports of the sheets.

As a part of his duties as a member of the personnel board, the chief of the section prepares examination papers for promotion of such officers as may be recommended by the board.

On June 11, 1918, the chief of the section was detached and assigned to duty as inspector of construction of the proposed new vessels for the Bureau, authorized in the sundry civil act of July 1, 1918, and no officers were available to carry on the routine work of the section after that date.

SECTION OF VESSELS AND EQUIPMENT.

The section of vessels and equipment has charge of the maintenance of the vessels of the Survey, and supervision is given to all estimates for repairs and the purchase of new equipment. Careful analysis is made of all estimates with a view to standardizing the equipment and supplying each vessel with an outfit adapted for the class of work upon which the vessel is to be engaged.

Inspection of each vessel of the Survey is made once a year by the chief of section when conditions will permit, except vessels in Alaska and the Philippine Islands. Inspections of the vessels in Alaska and the Philippine Islands are made by officers of the Bureau in those localities, and reports forwarded to the office for consideration.

In connection with the supervision of repairs, equipment, etc., of the vessels of the Survey, consideration was given to the preparation of plans and specifications for new vessels and wire-drag launches. The types of launches best suited for the survey work were decided upon, but final plans and specifications were not completed, owing to a lack of an appropriation for the work.

Contracts for repairs and the charter of all launches hired for the season's work were inspected and prepared for the approval of the Superintendent.

Owing to the transfer of the chief of the section of vessels and equipment to duty with the Navy, on September 24, 1917, the work of this section was done after that date under the direction of the chief of the section of field work.

On July 1, 1917, there were 13 vessels used by the Coast and Geodetic Survey for surveying duty. During the year 5 of these have been transferred by Executive order to the jurisdiction of the Navy Department for the period of the war, one being unfit for further service in the Bureau was condemned and sold, and two were returned to the jurisdiction of the insular government in the Philippine Islands, one of them temporarily for duty as a civil transport.

COAST PILOT SECTION.

During the year this section carried on field work on the North Atlantic coast, and as a result of the field work two coast pilots.

Atlantic Coast Pilot, section A, from Eastport, Me., to Cape Cod, and Atlantic Coast Pilot section B, from Cape Cod to Sandy Hook, were compiled. Both volumes are at present in the hands of the printer. Numerous chart corrections collected during the course of the field work were submitted.

These volumes when received will complete the issue of all coast pilots on the Atlantic and Pacific coasts of the United States and of Alaska in the new octavo form.

Reprints were obtained during the year of Atlantic Coast Pilots, parts 1, 2, 3, and 4, section C and section D. Supplements for five volumes and such correction sheets as were necessary to keep the information in all volumes up to date were issued.

The record of the issue of coast pilots in recent years is interesting as indicating the usefulness of these publications. As these volumes are sold at a price sufficient to defray the cost of printing (50 cents), it is obvious that the number sold furnishes an accurate measure of the public demand. The following is the record of the issue for the fiscal years from 1911 to date:

1911	2,720
1912	3,792
1913	3,797
1914	4,148
1915	4,016
1916	5,502
1917	7,952
1918	12,913

SECTION OF TIDES AND CURRENTS.

Tidal observations were made throughout the year at 7 permanent tidal stations along the Atlantic coast, 3 on the Gulf of Mexico, 3 on the Pacific coast, and 1 in Alaska. In addition to these, observations were made in connection with all hydrographic surveys in the United States, Alaska, and the Philippines. Tides were observed at 119 stations during the year, the total combined length of observations being 38 years, 7 months, 4 days.

During the year all permanent tidal stations were inspected at least once, the inspection in all cases including the connection of the tide staffs of the station with the permanent bench mark by spirit levels.

The work of making a comprehensive tidal and current survey of our coasts, which was begun in the summer of 1916, was continued during the fiscal year 1918. A party in eastern Long Island Sound occupied 15 tidal stations and 46 current stations. Other parties were occupied on such work in Mississippi Sound and Mobile Bay, Gulf of Mexico, in connection with hydrographic surveys.

The purpose of the tidal survey is to obtain tidal information at important points along the coast, and the establishment of permanent tidal bench marks at all principal points along the coast, which will serve the public in all cases where a knowledge of tidal planes is required, such as for engineering operations, city and land surveys, surveys of oyster areas, and many other purposes; which will furnish hydrographic parties with standard datums; and which will afford starting and checking points for lines of precise levels.

The purpose of the current survey is to obtain definite information concerning currents in navigable channels, entrances to bays, rivers, passages, and at points along the coast, for the benefit of navigators.

The tidal survey is carried on by means of two automatic tide gauges and several subsidiary staffs; current measurements are made by means of current meters, the velocity being obtained at various depths at each station, and also by means of a vertical pole float.

At the instance of the Navy Department, current observations were made at the following places: The Race, between Little Gull Island and Fishers Island, N. Y., where the velocity was measured at various depths from near the surface nearly to the bottom of the channel; at Port Jefferson, N. Y.; and on the west side of Block Island, R. I.

The two tide staffs which were erected in Wrangell Strait, Alaska, for the benefit of navigation, were visited and repainted. These staffs were set with their zeros at the plane of reference used on the charts, so that navigators can read directly from the staff what correction should be applied to the soundings on the chart to give the depth of water at that time.

A special effort has been made to have newspapers in the principal seacoast cities of the country publish official tidal and related data, and a number of newspapers in Washington, Baltimore, New York, San Francisco, Seattle, and many other cities have responded.

The Tide Tables for 1918 were received from the printer in September, 1917. These tables are similar to those of the preceding year, but full predictions are given for four additional ports, namely, Savannah, Ga.; Anchorage, Cook Inlet, Alaska; Cebu, P. I., and Port Hedland, Australia. The standard port of Amoy, China, has been discontinued, leaving 81 stations for which full predictions are given. Some other minor changes were made to make the volumes more useful to navigators. The following table issues shows the increased demand for these tide tables in recent years:

Tide Tables for—	General Tide Tables.	Atlantic Coast Tide Tables.	Pacific Coast Tide Tables.	Total issue.
1913	1,008	1,607	9,655	12,170
1914	1,126	1,634	10,882	13,692
1915	1,665	1,994	10,481	14,140
1916	1,166	2,367	10,034	13,567
1917	1,548	3,526	12,704	17,778
1918	2,818	3,496	13,635	19,949

The manuscript of the Tide Tables for 1919 was prepared and submitted for printing in three separate parts as follows:

The manuscript of the Atlantic Coast Tide Tables was prepared and submitted in advance, before the other portions of the General Tide Tables had been predicted; then the Pacific Coast Tide Tables were prepared and submitted for printing; and last of all what remained of the General Tide Tables was prepared and submitted. This arrangement is convenient to the Bureau, and under ordinary peace conditions will greatly expedite the early receipt of the volumes for issue.

The Italian Government requested this Survey to furnish predicted tides for Venice, Italy, for the two years, 1918 and 1919, which was complied with. The Government of Western Australia was furnished with copies of the proof sheets of the predicted tides for Port Hedland, Australia, for the two years, 1918 and 1919.

The computation for the graduation of the scales of the United States Coast and Geodetic Survey sounding tubes was completed in this section, and also the corrections to be applied for variations in the height of the barometer and for changes in the temperature of air and water.

The daylight saving law, which was approved on March 29, 1918, required the preparation and printing of an explanatory note to be inserted in the 1918 Tide Tables, as they were issued before the act became a law.

In addition to the extensive use by the military bureaus and Shipping Board of the tide and current tables published by the Bureau, the following data were prepared at the special request of bureaus engaged in war work.

Descriptions of 558 bench marks, currents at 84 stations, predicted tides for Hog Island, Pa., predicted tide curves for two stations, tables of sunrise and sunset, highest and lowest stages of the river at Portland, Oreg., and temperatures of the water for each month of the year at Norfolk, Va.

DIVISION OF GEODESY.

Almost the complete output of field work during the year was in the nature of war work, for the various projects were called for by the Corps of Engineers, United States Army.

Just before war was declared on Germany, in the spring of 1917, a committee on mapping was formed by the Corps of Engineers, United States Army, for the purpose of coordinating the various surveying work of the Government with a view toward having the mapping bureaus assist in the preparation of military maps in this country.

The chief of the division of geodesy of the Coast and Geodetic Survey was appointed a member of this committee to represent the Department of Commerce. This committee had several meetings, at which it was decided that the Geological Survey and the Coast and Geodetic Survey should assist the Corps of Engineers, in every way possible, in their military mapping. Accordingly, it was arranged that the geodetic field parties of the Coast and Geodetic Survey should, as far as possible, be engaged exclusively on war work. After July 1, 1917, until the end of the fiscal year the only geodetic work done which was not of immediate military value was in southeastern Alaska, where two parties were engaged on primary triangulation for several months.

The work which has been done in the past by the Coast and Geodetic Survey and the work now being done in the interior of the country in furnishing control for maps and surveys have proved of very great value to the military authorities. Without the triangulation along the coasts of the United States it would have been most difficult to have made maps of extensive regions which are to be used for defensive purposes.

It is evident, from the fact that the control work of the Coast and Geodetic Survey now in existence has been of great military value that such control should be extended rapidly into those areas of the United States which are now totally lacking geodetic surveys. There are some areas that are tens of thousands of square miles in extent

but which do not have a single triangulation station or precise level station. If topographic maps are made in such areas ahead of the control work, there will be endless confusion when an attempt is ever made to coordinate and join surveys made in various parts of a large area; there will be gaps and overlaps and offsets where any two maps join, unless the control has been carried ahead of the detailed surveying.

Aside from the desirability of having control in order to eliminate discrepancies in the maps of a large area, it is most essential that such control be prepared in advance of its needs, in order that serious delays may not result when it has been found necessary to cover unmapped areas for military purposes. This country has had very serious losses as a result of unpreparedness in military work. We should profit by the experience of the past and provide that no serious embarrassment to the Government and the country shall occur as the result of lack of maps and surveys. That the country will have to be mapped is evident to anyone who has taken any part in the commercial, industrial, and military affairs of the Nation. Not only will it be necessary to have up-to-date maps where there are large centers of population, but the mountains and plains where the population is sparse will have to be mapped for military purposes, for they may be the areas within which important military preparations may be conducted. The presence or absence of proper maps may decide the fate of a battle and it seems to be good business, as well as patriotism, to have all areas that may be of military value mapped in the near future. In fact, such mapping should be rushed. The cost of the mapping of the whole country, in such a way as to furnish results that would be of infinite value to the military establishments, would be less than the cost of a single battleship and much less than the expense of a division of soldiers for one year in time of war.

What has been said above emphasizes the need of topographic maps for military purposes. They are needed just as much for the purpose of commerce and the industries of the Nation. A nation depends for its strength not on military forces alone, but on the industries which make war materials available and the means of transportation which carry those materials to the armies of seaports where they are needed. Without maps industries are at a great disadvantage. It would be foolish to start a power plant on a river if topographic maps were not available to show the extent of a watershed feeding the river. It would also be unwise to put up a plant, or to attempt to do so, if the difficulties of road building would be such as to make the plant inaccessible, except at an enormous expense of transportation. There are many places in the United States where timber, ores of various kinds, building materials, etc., would become available if there were topographic maps by which roads for transporting such supplies could be laid out.

There is an instance of a topographic map having been made by the Geological Survey, in the State of Michigan, in cooperation with a certain railroad. As a result of the survey, a gap or pass was found among some hills which permitted the railroad to join two places at a very great reduction of cost over what the expense would have been if it had been necessary to skirt the hilly country or build the road through some pass that was much higher in elevation. It was stated by officials of the railroad that the saving to the company

in finding that one pass was much greater than the total cost of the topographic survey.

The chief engineer of one of the western railroads, several years ago, stated that the topographic surveys, as published by the Geological Survey, were of the greatest value to the railroad in question, for it was frequently possible to choose a route between terminal points by reference to the Geological Survey maps that would be far better than could possibly have been selected had those maps not been in existence.

The maps of the country to-day, published by the Geological Survey, are used also to a very great extent in the extension of the electric transportation lines in extending the network of telegraph and telephone lines as well as those carrying electrical power throughout the country.

The development of the good-roads system of the United States, which must be carried on in the very near future with the expenditure of hundreds of millions per annum, requires the rapid completion of topographic surveys in the areas not now mapped in order that the work may be done quickly and economically. The saving to the good-roads movement alone, in the period of five or ten years, will far more than pay for the topographic mapping of all unmapped areas in the United States.

This country is becoming a nation of map users and, after the war, the demand for maps is going to be far greater than ever before. Therefore it behooves the Government to provide means for rapidly mapping the unmapped areas of the country. It is hardly probable that this can be taken up to any very great extent, or at least the present effort can not be made much greater until the war is over.

A most important part of the mapping of the country is the preliminary work called geodetic control. It would be just as improvident to try to build a house without drawing up a general plan and having the framework erected first as to make a topographic survey of a large area of the country without having established numerous points in the area whose latitude, longitude, and elevation were previously determined. A map is a poor one that does not have the proper control to enable one to refer the topographic features accurately to the universally adopted system of coordinates; that is, the plane of the Equator, the plane of the meridian through Greenwich, and mean sea level. Those three coordinates are used, respectively, for latitude, longitude, and elevation.

It will be impracticable to extend greatly the geodetic work of the Coast and Geodetic Survey during the war, and, therefore, no increase in the State survey item of the appropriation bill that is asked for the year 1920 is recommended. As soon as the war ends this policy will be changed, and a material increase in the State survey item will be asked in order that a rapid extension of the geodetic control may be made.

It is impossible to predict how much geodetic control is needed in this country. This will depend on the evolution of maps. It is known, however, that as a minimum requirement there should be a point or points whose latitude, longitude, and accurate elevation are known within about 50 or 100 miles of every place in the United States. We are far from having this minimum amount, and it

should be planned to have it as soon as practicable after the close of the war. If we have the network of triangulation and traverse lines and also a network of precise leveling lines spread over the country in such a way that no place is more than a moderate distance from primary control, then it would be very easy to furnish any Government bureau, or any State or city with primary control upon request in a very short time. It is believed that it would be economical to complete this minimum control at an early date and the fill in intermediate areas as the demands should arise.

The amount of precise leveling remaining to be done in order to meet this minimum requirement is about 12,000 miles. There are now in existence in the United States about 39,400 miles of this class of leveling. There should be about 9,000 linear miles of arcs of primary triangulation in order to furnish the latitudes and longitudes necessary to supplement the existing work to provide what may be called the minimum amount of control. There are now in existence about 15,000 miles of primary triangulation and primary traverse in this country. It should have been stated that the primary triangulation should be supplemented at times with primary traverse. Each is equally strong in furnishing primary control, but the primary traverse is only used when the country is very flat and heavily wooded, which conditions make primary triangulation very expensive.

The new horizontal and vertical control which is necessary to supplement the present work and to meet the minimum requirements will cost about $600,000. This is a very small amount in comparison with the benefits which would accrue to the Nation. If all of the geodetic funds were expended for 10 years, we should be able to complete the control up to what we call the minimum requirements. But that work should be done sooner than in 10 years, and besides a portion of the geodetic funds are spent each year in what may be called the intermediate areas to furnish horizontal and vertical control for surveys and maps in response to requests from the Corps of Engineers, the United States Geological Survey, and other competent authorities. We may, therefore, assume that not more than $35,000 can be spent toward completing the general project each year. Consequently it would be between 15 and 20 years before the general project could be completed. This is a condition which must be remedied, and the remedy should be provided in the form of increased appropriations for geodetic work immediately after the war.

What has been said above in regard to the need for geodetic control for surveys and maps in the United States applies equally to the territory of Alaska. There we have a large area of very valuable mineral, timber, and other classes of land which are being surveyed by the General Land Office and the topographic branch of the United States Geological Survey. Those organizations are making maps in those areas which are being developed earliest. Eventually the various maps will be joined, and then the trouble occasioned by gaps, overlaps, and offsets will present itself. Again, we may refer to the absurdity of trying to build a house without first erecting the frame. The frame for the maps and surveys in Alaska should undoubtedly be done ahead of the detailed work and funds should be provided in sufficient quantities immediately after the war to extend certain lines over the area which should have been done in the past. These lines

of primary triangulation and precise leveling are shown in two illustrations which have accompanied several reports of the Superintendent in past years. They show the sad lack of geodetic control in Alaska.

FIELD WORK.

At the end of the fiscal year 1917 a party was being organized at Harlingen, Tex., to carry on reconnoissance and signal building along the Rio Grande to the westward of Harlingen. Early in the fiscal year 1918 this party, which consisted of a reconnoissance party, under the immediate charge of the chief of party and two building parties to be engaged in the erection of signals, was completely organized. This combined party continued operations until November when the work was connected with that being carried eastward from the vicinity of Van Horn, Tex., by another party.

Automobile trucks were used as a means of transportation, several of which were borrowed from the Quartermaster, United States Army. These automobile trucks have proved conclusively to be far more efficient as a means of transportation for geodetic parties than horses and wagons, which were used for many years.

A slightly different type of triangulation signal from that usually employed in primary triangulation was used. It was somewhat along the general plan of the older signals, but very much lighter lumber was used. Considerable time and money were saved by cutting down the amount of lumber in each of the signals as the transportation was very difficult and expensive along the Rio Grande, most of the places at which signals were built being far removed from lumberyards.

Early in August, 1917, a primary triangulation party was organized which began observations immediately to the west of Harlingen and occupied stations which were provided by the reconnoissance and signal-building party. This work was continued to the westward until it joined that of another party which was working eastward from the vicinity of Van Horn, Tex.

Early in September, 1917, a reconnoissance was made to the eastward of Van Horn, Tex., along the Rio Grande, to a junction with the work of a party in the vicinity of Del Rio, Tex.

When the two observing parties on the Rio Grande completed their work, a primary base-line party was organized for the purpose of measuring bases along the arc of triangulation. This work was completed late in May, 1918.

Both observing parties and the base-line party on the Rio Grande arc used automobile trucks as the means of transportation. As in the case of the building and reconnoissance work, they proved to be the ideal means of communication over the country traversed because of the difficulty of securing water and supplies. With horses and wagons as a means of triangulation the work would have cost several times more than it did.

The Rio Grande arc was done at the request of the office of the Chief of Engineers, for the purpose of furnishing control for military topographic surveys and maps which were being made at the time the triangulation was begun.

The Chief of Engineers also requested the following lines of precise leveling in Texas: Sierra Blanca to San Antonio and New

Braunfels; Spofford to Eagle Pass; San Antonio to Laredo; San Antonio to Point Isabel, by way of Sinton, Robstown, and Brownsville; a spur line from Robstown to Corpus Christi; Sinton to Beaumont, thence to New Orleans, La.

The line from Sierra Blanca eastward had been begun by two parties during the latter part of the fiscal year 1917. These two parties continued operations until the line had been completed from Sierra Blanca to New Braunfels, by way of San Antonio. A spur line had been run from Spofford to Eagle Pass and levels had been begun on the line running southward from San Antonio toward Laredo and southward from San Antonio toward Point Isabel.

Work was continued along the San Antonio–Laredo line until it reached the latter place. The party then proceeded to Sinton, Tex., and began running a line eastward from that place toward New Orleans.

The line of levels was carried to Point Isabel by way of Robstown and Brownsville. From Robstown a spur line was run to Corpus Christi, where a connection was made with a number of tidal bench marks which had previously been established at that place.

After the completion of the measurements of the bases along the Rio Grande, a line of check levels was run over a portion of the line between Robstown and Point Isabel in order to discover an error of 1 meter which had been made in the original running of the line. When this error had been found, which proved to be an even meter, in the vicinity of San Benito, the work of this party was closed for the year.

The line of levels running from the vicinity of Sinton northeastward toward New Orleans was carried to the vicinity of Lafayette, La., and several spur lines were run from the main line to bench marks on the Gulf coast.

Work on the line running toward New Orleans was in progress at the close of the fiscal year.

The parties working in Texas on leveling used motor velocipedes as the means of transporting their parties, with the exception of one party working along the Southern Pacific Railroad, to the eastward of Houston, Tex., which used an automobile truck, supplemented by railroad trains.

The Chief of Engineers requested horizontal and vertical control in Georgia, South Carolina, North Carolina, Florida, Mississippi, and Alabama. This work had been begun in the latter part of the fiscal year 1917, when parties were organized to extend primary traverse and precise leveling northwestward from Jacksonville, Fla., and Brunswick, Ga. These parties were at work during the early part of the fiscal year 1918 and continued throughout the year, with some modifications which will be indicated below.

The work called for by the Chief of Engineers included the following lines:

(1) Primary traverse and precise leveling, Jacksonville, Fla., to Columbus, Ga.; (2) primary traverse and precise leveling, Brunswick to Columbus, by way of Macon, Ga.; (3) primary traverse and precise leveling from Albany, Ga., to Callahan, Fla., by way of Valdosta, Ga.; (4) primary traverse and precise leveling from Macon to Griffin, Ga.; (5) primary triangulation from Griffin to Atlanta, Ga.; (6) primary traverse and precise leveling from Macon

to Savannah, Ga.; (7) precise leveling from Macon to McDonough, Ga.; (8) primary traverse and precise leveling Savannah to Everett City, Ga.; (9) precise leveling, Everett City, Ga., to Yulee City, Fla.; (10) primary traverse and precise leveling from Savannah, Ga., to Norfolk, Va., by way of Columbia, S. C., and Raleigh, N. C.; (11) precise leveling, Biloxi, Miss., to River Junction, Fla.

As mentioned above, the work on the first two lines was begun during the fiscal year 1917. Those two lines and the work on lines numbered from 3 to 9, both inclusive, were completed by the end of the fiscal year 1918. The work on line No. 10 had been extended northward to the vicinity of Pontiac, S. C., and southwestward from Norfolk, Va., to the vicinity of Vaughan, N. C. The work on line No. 11 had been carried to a point a little to the eastward of Pensacola, Fla. Two combined parties operated on the Savannah–Norfolk line and one leveling party on the line No. 11.

There are given below details in regard to the organization of the parties carrying on the work in the Eastern States.

At the beginning of the fiscal year a primary traverse party was operating northwestward along the line from Jacksonville toward Columbus. A precise leveling party was operating along the same line and cooperating with the traverse party.

The work accomplished by these two parties consisted of primary traverse and precise leveling from Jacksonville to Columbus; from Albany to Callahan, by way of Valdosta; from Savannah to Everett City, and from Savannah northward to Pontiac, S. C.; also a line of precise leveling from Everett City to Yulee, Fla.

The primary traverse party that was working northwestward from Brunswick, Ga., carried the primary traverse to the vicinity of Columbus, Ga., where a connection was made with similar work done by another party and a traverse and triangulation were begun between Macon and Atlanta, Ga.

The precise leveling party operating to the northwestward of Brunswick, Ga., at the beginning of the fiscal year 1918 completed the line to the vicinity of Fort Valley, where a connection was made with a line of levels run by the party working from Jacksonville to Columbus. After making this connection a line of precise levels was run from Macon northward to McDonough.

This party completed a line of primary traverse and precise leveling from Macon to Savannah, and then moved to Norfolk, Va., and carried similar work southwestward to the vicinity of Vaughan, N. C., by the end of the fiscal year.

Early in April, 1918, field work was begun on a short arc of primary triangulation between Griffin and Atlanta for the purpose of connecting several lines of primary traverse in Georgia with the primary triangulation of the oblique arc. This work was finished about the middle of May.

In February, 1918, after the completion of the line of precise leveling from San Antonio to Point Isabel, Tex., a line was begun running eastward from Biloxi, Miss., toward River Junction, Fla. At the close of the fiscal year the line had been extended to a point about 15 miles to the eastward of Pensacola.

For the first few months of the fiscal year 1918 two primary triangulation parties carried on primary triangulation in southeast Alaska. This work had been started during the latter part of the

fiscal year 1917. The work of these parties was part of a general arc of primary triangulation which will eventually extend from Tacoma, Wash., to the crossing of the Yukon River by the one hundred and forty-first meridian. A portion of the arc in Canadian territory will be done by the geodetic survey of Canada. This is a remarkable example of geodetic cooperation between the geodetic surveys of two nations, and the results of the work will be of immense value to each of them in furnishing final control for the surveys and maps that will be made in western Canada and in Alaska.

In July, 1917, a topographic survey was made for the military authorities at Camp Meigs, D. C.

Certain surveys were also made of the grounds of the rifle range at Congress Heights, Md. This work was requested by Brig. Gen. R. D. Sims, of the District of Columbia National Guard.

A survey was made in the vicinity of Lewes, Del., for the purpose of locating a range mark of the Delaware Breakwater Trial Course. The work was done at the request of the Cramp Ship Building Co., and all expenses incident to the work, except the salary of the Coast Survey field officer, were paid by that company. The work was done in May, 1918.

Late in October and early in November a geographic position and azimuth were determined in the Aberdeen Proving Ground, Md., in response to a request from the Army officials connected with the proving ground.

A tertiary triangulation was made in upper Chesapeake Bay late in January and early in February to determine the geographic positions of a number of range towers used by the Aberdeen Proving Ground. The request for this work was also made by the officials of the proving ground.

Late in May, 1918, additional triangulation was begun in the upper Chesapeake Bay for the purpose of determining the geographic positions of a number of range towers erected by the officials of the proving ground at Aberdeen. The request was made for this work by those officials. This work at the proving ground was in progress at the end of the fiscal year.

SUMMARY OF GEODETIC WORK ACCOMPLISHED.

The total amount of geodetic work accomplished in the United States and Alaska, during the fiscal year 1918, is as follows:

	Miles.
Primary triangulation along axis	639
Primary traverse	940
Tertiary triangulation along axis of scheme	70
Precise leveling	2,367

The above does not include triangulation done by any hydrographic parties, nor any work in the Philippine Islands. No precise leveling or traverse was done except that indicated above.

The geodetic work of the Survey was not done at as low cost as usual for two reasons: One is that many of the experienced officers who had been doing that work in the past were transferred to the Army and Navy and the field operations had to be done to a large extent by new engineers. This statement does not apply, of course,

to those engineers on geodetic work who had had large experience and who had not been transferred to the Army or Navy. Another cause for the higher cost of the work was the greater cost of material and the higher wages paid to the temporary employees.

Several records were made during the year on geodetic work. The most notable one was in March, 1918, when 165.4 miles of precise leveling were run in one month. This is 6 miles greater progress in a calendar month than that previously made in October, 1916. It goes without saying that this is a world's record for a single month of precise leveling. In no other country is such rapid work done on precise leveling as in the United States.

In one day of February, 1918, 22 miles of single line of leveling were completed. The previous record for a single day's work was between 20 and 21 miles.

Observations were completed at 79 primary triangulation stations on the Rio Grande arc, at an average rate of 16 stations per month, with a maximum number of 18 per month. This record is slightly greater than that made several years ago on the southern end of the ninety-eighth meridian in Texas.

Seven differences of longitude were observed in Georgia and Florida between Atlanta, Ga., and Fernandina, Fla. The sum of the seven differences agrees with the previously determined difference between Fernandina and Atlanta within 0.009 second. The correction to each of the new differences to make them fit the old results was either 0.001 or 0.002 second. This is a remarkably close agreement, and is an indication of excellent observing and instruments.

DIVISION OF TERRESTRIAL MAGNETISM.

The duties of the chief of division include 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.

MAGNETIC SURVEY.

In the continuation of the magnetic survey of the United States, observations were made during the year at 275 stations in 21 States, of which 118 were new primary stations, 114 auxiliary stations, 34 repeat stations for the determination of secular change, and 9 new stations in old localities. Meridian lines were established when they were requested by the local authorities. The number of county seats at which magnetic observations have not been made was reduced from 163 to 138.

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 in the Survey.

In cooperation with the department of terrestrial magnetism of the Carnegie Institution of Washington, special observations were made at the time of the solar eclipse on June 8. Eye readings of declination were made at one-minute intervals for a period of six hours at three stations in the belt of totality, namely: Orlando, Fla.,

Mena, Ark., and Green River, Wyo. Eye readings of declination were also made for the same period at the five magnetic observatories, and values of declination, horizontal intensity, and vertical intensity at five-minute intervals were computed from the records of the magnetographs.

In further cooperation with the department of terrestrial magnetism of the Carnegie Institution of Washington, two magnetic observers of this Bureau took part in a series of observations in the vicinity of Pikes Peak, Colo., for the purpose of determining, if possible, the variation in the earth's magnetism with change of altitude. Nearly simultaneous observations were made at stations on the mountain and at numerous stations around the base at much lower altitudes. Provision was made for insuring a homogeneous series of observations by having all the observers make observations at a common station at Manitou.

MAGNETIC OBSERVATORIES.

The observatories at Cheltenham, Md., Vieques, P. R., Tucson, Ariz., Sitka, Alaska, and near Honolulu, Hawaii, were in operation throughout the year. Continuous photographic records were secured of the variations of declination, horizontal intensity, and vertical intensity. Absolute observations were made at least once a week and scale-value determinations once a month. Beginning with January, 1918, horizontal-intensity observations, as well as dip and declination, were made both in the morning and in the afternoon on the same day to secure additional data regarding the relation between the variation and absolute instruments.

All of the magnetic instruments used in the field work were standardized at Cheltenham. In addition, comparisons were made between the extra magnetometer No. 40 at Cheltenham and the standard magnetometer of the department of terrestrial magnetism of the Carnegie Institution of Washington. This magnetometer No. 40 was subsequently sent to Tucson for comparison, in order to verify the change in the relation of the Cheltenham and the Tucson magnetometers which had been indicated by the observations made at Tucson with one of the field magnetometers in October, 1917. A comparison between the Cheltenham and Sitka observatory instruments was also secured from the instruments sent to Sitka for use in the field work in the interior of Alaska. At Cheltenham the investigation of the relation between the absolute instruments and the two magnetographs was continued, but no satisfactory explanation of the outstanding differences was determined.

In October, 1917, the absolute building at Sitka was moved from the old site on the Swanson property to the lot on which the variation building stands, near the site of the old Russian blockhouse, and the necessary observations were made for determining the relation between the two sites. The erection of a new building for office quarters at Cheltenham was deferred because of conditions regarding material and labor arising out of the war.

A seismograph was operated continuously at each observatory. Considerable difficulty was experienced at Honolulu in April because of the excessive moisture in the seismograph house, and it became necessary to tear up the floor in order to remove the water which had accumulated underneath.

APPROPRIATIONS AND DISBURSEMENTS.

The appropriation made by Congress for the United States Coast and Geodetic Survey in the sundry civil act for the fiscal year ended June 30, 1918, was $1,379,970, divided as follows:

Field expenses	$487,600
Repairs and maintenance of vessels	56,000
Officers and men, vessels	320,000
Pay of field officers	223,500
Pay of office force	220,770
Office expenses	67,500
Offset attchment for lithographic press	3,000
Paper-cutting machine	1,600
Total	1,379,970

For the fiscal year ending June 30, 1919, the total amount appropriated is $1,367,960, and the items of appropriation are as follows:

Field expenses	$382,600
Repairs and maintenance of vessels	36,000
Officers and men, vessels	225,000
Pay of field officers	223,500
Pay of office force	253,860
Office expenses	80,000
Offset attachment for lithographic press (reappropriated)	3,000
Two motor-driven lathes, at $750	1,500
One new vessel to cost $354,000	50,000
One new motor vessel	50,000
Four or more new launches	62,500
Total	1,367,960

DETAILS OF FIELD OPERATIONS.

HYDROGRAPHIC AND TOPOGRAPHIC WORK, ATLANTIC COAST.

MAINE AND NEW HAMPSHIRE.

[J. H. PETERS.]

SUMMARY OF RESULTS.—Hydrography: 83 square miles of area dragged, 149.3 miles run while dragging, 168 soundings retained.

Wire-drag party No. 1 was organized at Portsmouth, N. H., in April, 1917, for wire-drag work in Portsmouth Harbor and in the area between the entrance of the harbor and the Isles of Shoals, coast of Maine; continued work after July 1 with headquarters at Kittery Point. A subparty was engaged in tidal and current work in the same vicinity. Work was closed September 27, the party disbanded, and the records sent to the office.

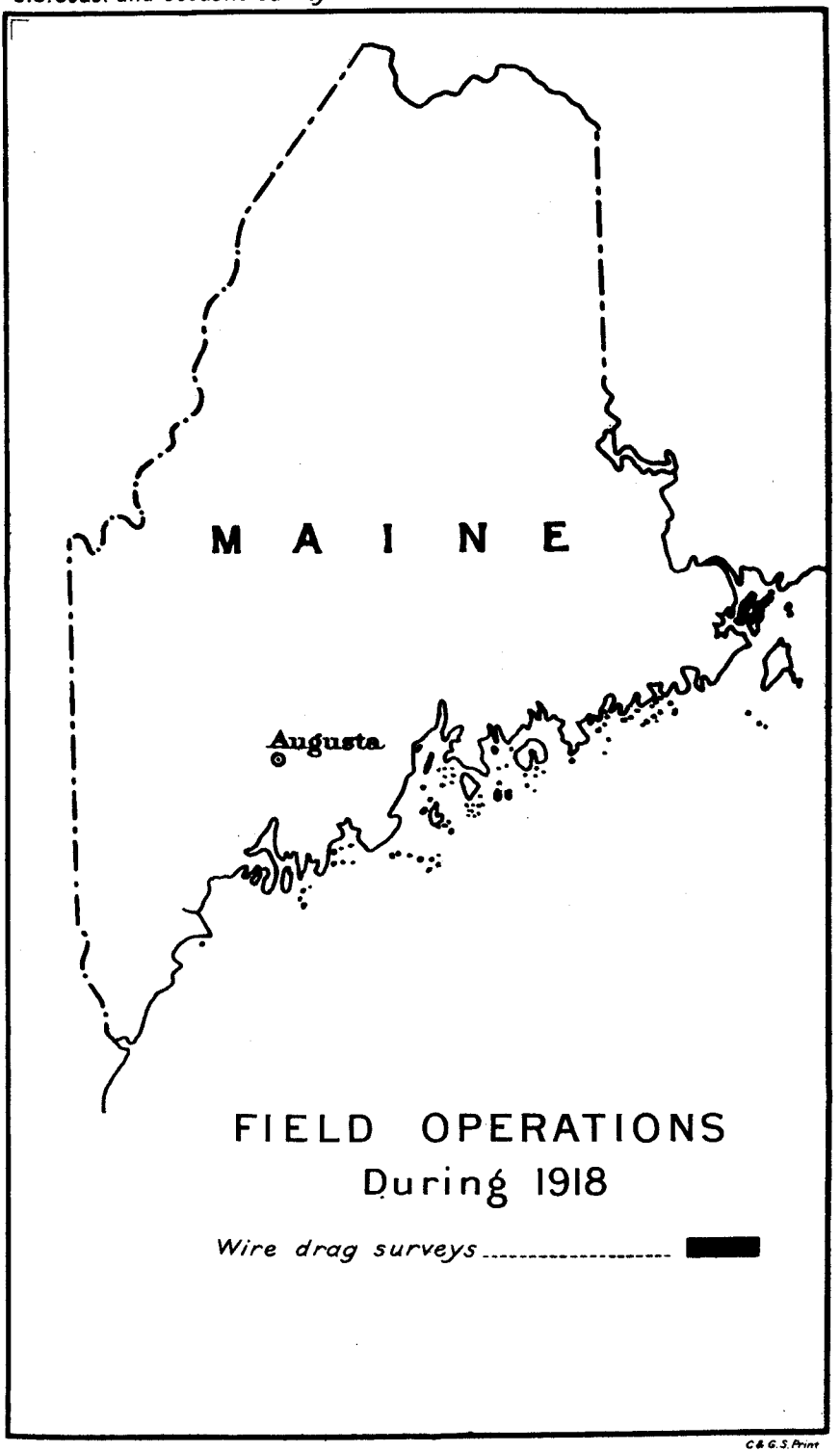
MAINE, RHODE ISLAND, CONNECTICUT, AND NEW YORK.

[J. H. HAWLEY.]

SUMMARY OF RESULTS.—Triangulation: 18 square miles of area covered, 9 signal poles erected, 7 stations in supplemental schemes occupied for horizontal measures, 8 geographic positions determined. Leveling: 7 miles of levels run, 9 permanent bench marks established. Hydrography: 7.5 square miles of area covered, 41 miles run while sounding, 946 positions determined (double angles), 394 soundings made. Hydrography (wire-drag work): 27.4 miles of area dragged, 858 miles run while dragging, 10 retained soundings taken, 4 tide stations established, 3 current stations established, 4 hydrographic sheets (unfinished), scales 1:10,000 and 1:20,000.

Preparations were begun in March, 1918, for wire-drag work in Long Island Sound. A party was organized at Wickford, R. I., on April 15, and launches were chartered and equipped.

Immediately after outfitting at Wickford, R. I., wide-drag party No. 2 proceeded to Port Jefferson, N. Y., in order to take up the survey of the trial course


MAINE
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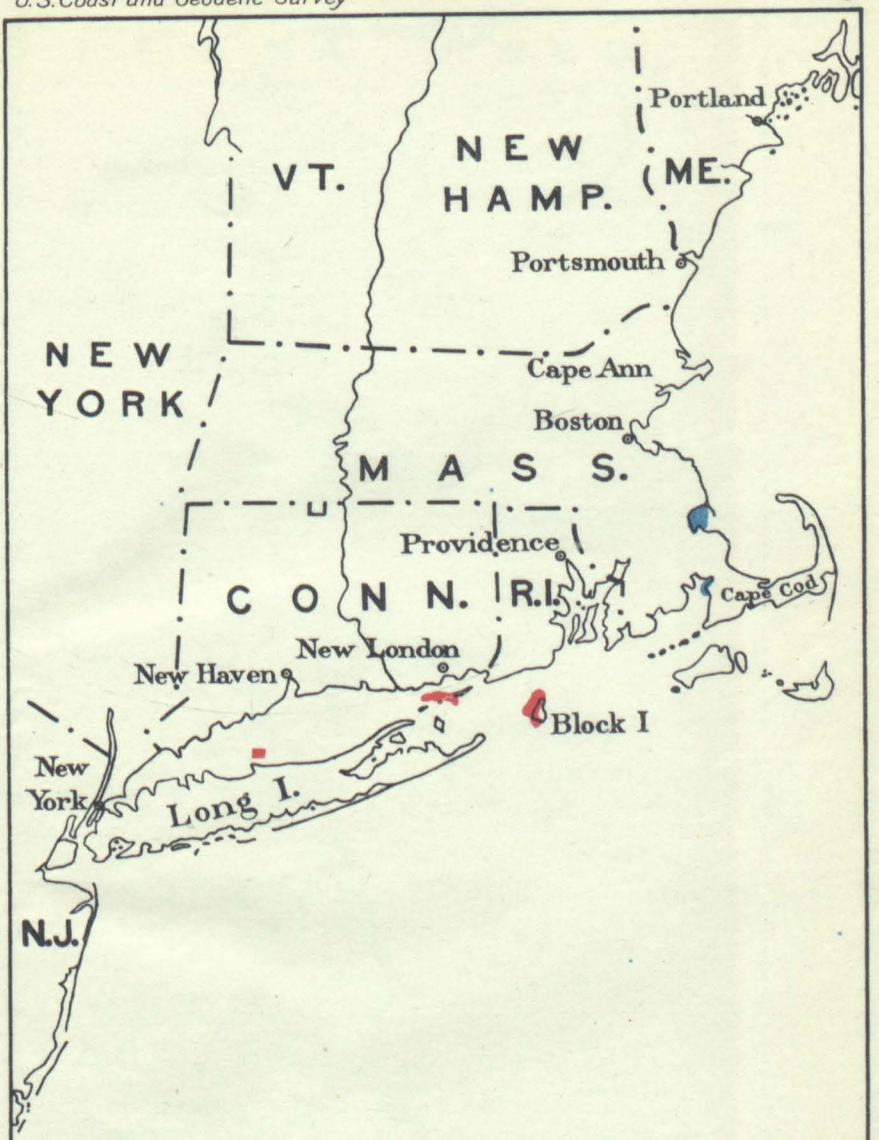
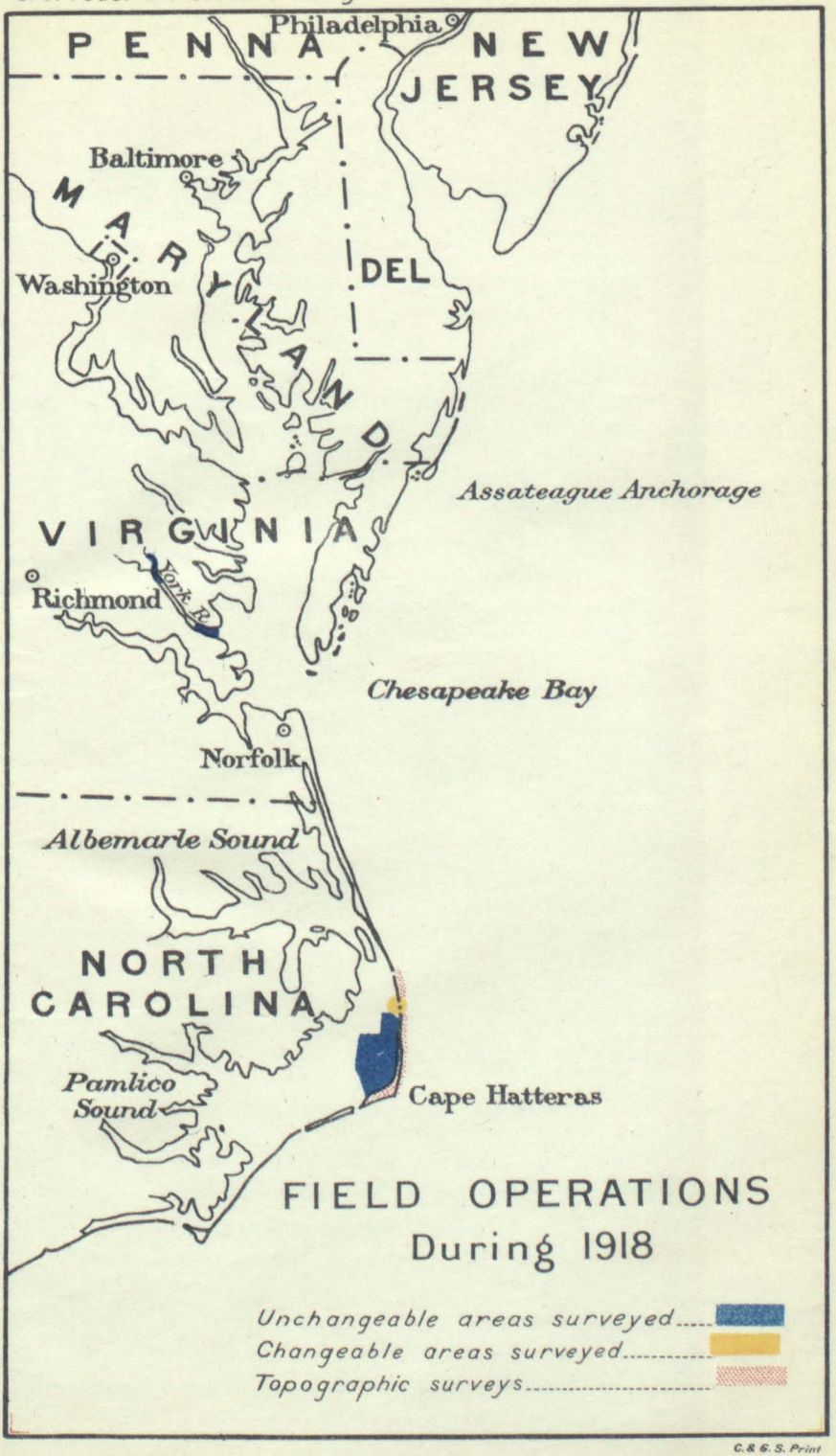
FIELD OPERATIONS
During 1918
Wire drag surveys



FIELD OPERATIONS
During 1918

Wire drag surveys.....
Unchangeable areas surveyed.....


Philadelphia
PENNA.
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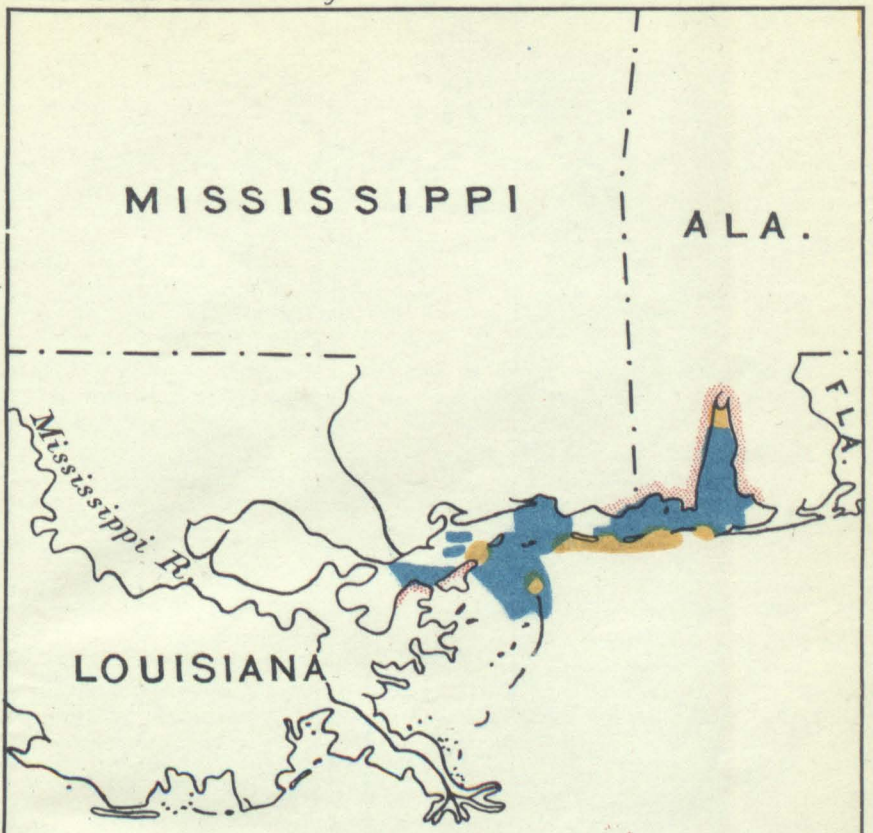
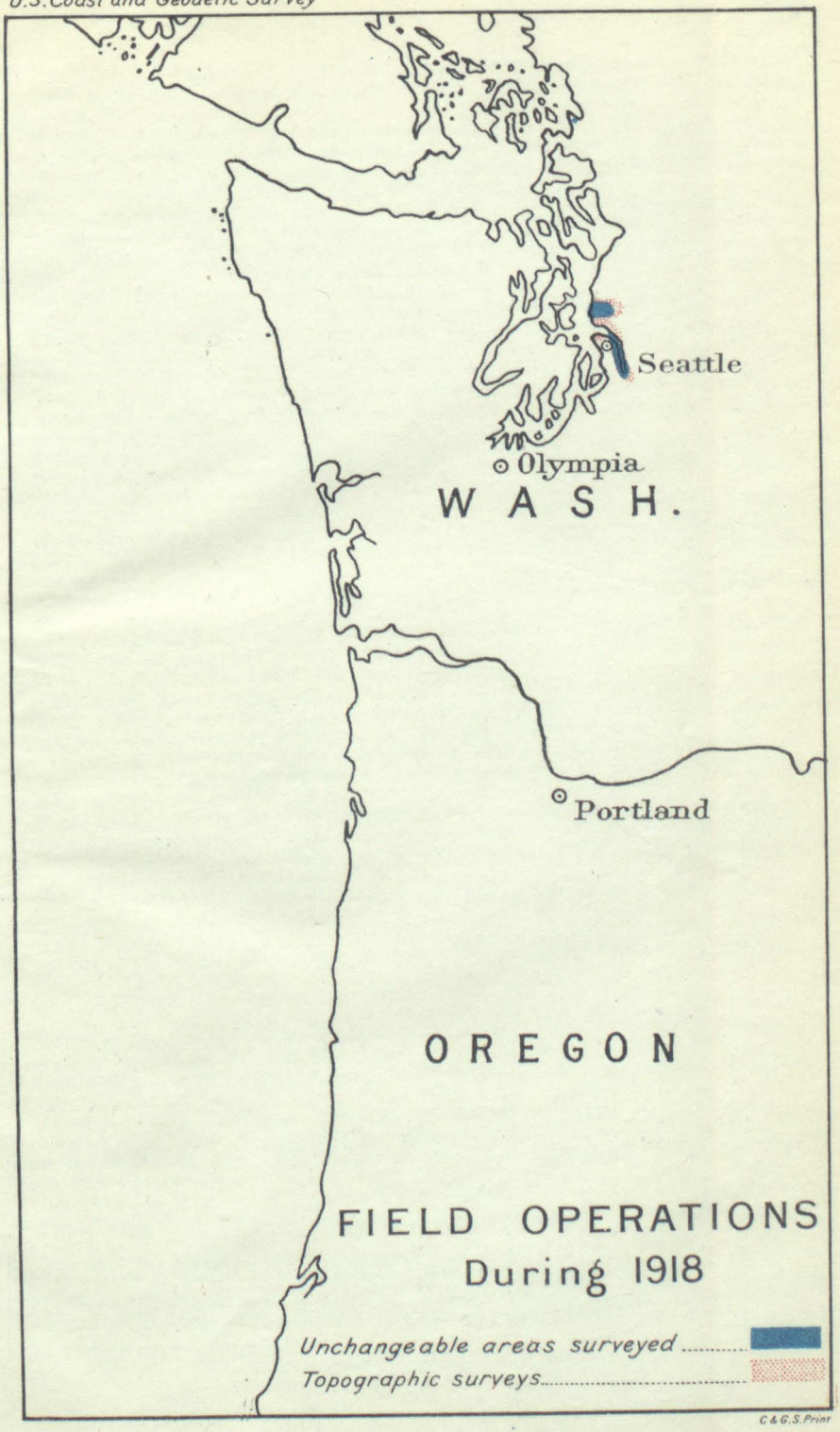
Richmond
York R.
Chesapeake Bay
Norfolk
Albemarle Sound
NORTH CAROLINA
Pamlico Sound
Cape Hatteras
FIELD OPERATIONS
During 1918
Unchangeable areas surveyed
Changeable areas surveyed
Topographic surveys



FIELD OPERATIONS
During 1918

Unchangeable areas surveyed
Changeable areas surveyed
Topographic surveys


Seattle
Olympia
WASH.
Portland
OREGON
FIELD OPERATIONS
During 1918
Unchangeable areas surveyed
Topographic surveys

off that port in conformity with instructions dated April 13, 1918. The party arrived at Port Jefferson at 5 p. m. on April 25, 1918, and field work was begun on April 26.

It was found that the two buoys mentioned in the data furnished with the instructions as marking the approximate ends of the trial course were not in place, and current stations were accordingly located at about the points where these buoys would be placed, judging by the data furnished.

The main-current station was located at the western end of the course, and currents were observed at this station at hourly intervals for 52½ consecutive hours, beginning at 8.30 a. m. on April 26, 1918. For the greater part of this period the weather conditions were exceptionally favorable for current observations. During the daytime on April 26 and 27 simultaneous observations were obtained at a second station located near the eastern end of the course.

While current observations were being obtained, triangulation was carried on to locate the trial-course range beacons and prominent objects in the vicinity of the field of work. The beacons were found as described in the data furnished. The two westerly beacons have rectangular center poles about 4 by 10 inches in cross section. The easterly beacons have round center poles about 10 inches in diameter.

A tide gauge was established on the east breakwater at the entrance to Port Jefferson Harbor and connected with bench marks at Port Jefferson by levels. Hydrographic work was begun on April 30 and completed on May 2.

Wire-drag work was begun on May 3 and completed on May 6. As it is evident that submarines using this course must navigate waters westward of meridian 73° 06′, the western limit of the work requested by the Navy Department, the work was extended to meridian 73° 07′.

The work was somewhat delayed by smoke, haze, and fog, especially in the forenoons.

After completing the survey the party proceeded to Stonington, Conn., May 7, 1918, and at once began the wire-drag survey of the area in Long Island Sound, in the vicinity of Bartlett Reef Light Vessel.

This work was in progress on May 24, when instructions, dated May 23, 1918, to transfer the party to the coast of Maine were received. The equipment was loaded on the launches on May 25 and on May 26 the party left Stonington in the launches for the coast of Maine. It was necessary to stop at some harbor each night en route in order to secure accommodations for the party.

From June 3 until June 13 the party was engaged in signal building, triangulation, establishing a tidal station, and miscellaneous work. During this period the weather was mostly stormy, with fog and rain, and consequently unfavorable for wire-drag work.

Wire-drag work was started on June 14, and the survey was continued under very favorable weather conditions.

MAINE, NEW YORK, NEW JERSEY, PENNSYLVANIA, MARYLAND, AND FLORIDA.

[J. S. S. JONES.]

Between May 9 and June 22 an inspection was made of tide stations at the following places on the Atlantic coast: Portland, Me.; Fort Hamilton, N. Y.; Atlantic City, N. J.; Philadelphia, Pa.; Fort McHenry, Md.; Fernandina, St. Augustine, Key West, and Cedar Keys, Fla.

At each station the apparatus was overhauled, adjusted, and repaired when necessary, the gauges connected by spirit leveling with the bench marks, and new bench marks were established at some stations where the old ones had been destroyed.

MASSACHUSETTS.

[E. B. LATHAM.]

SUMMARY OF RESULTS.—Triangulation: 5 square miles of area covered, 16 signal poles erected, 1 station in supplemental scheme occupied for horizontal measures, 33 geographic positions determined. Hydrography: 8 square miles of area covered, 395 miles run while sounding, 3,058 positions determined (double angles), 24,883 soundings made, 4 hydrographic sheets finished, scales 1 : 5,000 and 1 : 10,000.

A supplementary survey of the approaches to the Cape Cod Canal in Buzzards Bay, Mass., was made between August 1 and September 28, 1917.

In this work the triangulation done by the Cape Cod Canal Co. was utilized and also the results of a survey made in 1917 by Corps of Engineers, United

States Army, covering a portion of the area to be examined. Points in the latter survey were connected with the work by the Coast and Geodetic Survey.

The triangulation for the control of the work and the connection with the triangulation of the United States Engineers and the Cape Cod Canal Co. was completed August 24, and the hydrography was taken up on September 4 and continued until September 28, when work was closed in this locality, and a survey was begun in the vicinity of Plymouth, Mass.

Between October 2 and November 15 a supplemental survey was made in Plymouth Harbor, Mass., to furnish additional lines of soundings required to complete the hydrographic surveys of that harbor, with the object of more clearly defining the sloughs through the mud flats. Sounding operations were begun October 15 and closed November 15.

RHODE ISLAND.

[F. B. T. SIEMS.]

SUMMARY OF RESULTS.—Triangulation: 4 stations in main schemes occupied for horizontal measures, 8 geographic positions determined. Wire-drag work: 14 square miles of area dragged, 50 miles run while dragging, 35 retained soundings, 1 wire-drag sheet partly finished, scale 1 : 20,000. Hydrography: 6 square miles of area covered, 50 miles run while sounding, 391 positions determined (double angles), 1,106 soundings made, 1 tide station occupied, 5 current stations occupied, 1 hydrographic sheet finished, scale 1 : 20,000.

Wire-drag party was organized in April, 1918, at Kittery Point, Me., by J. A. Daniels, pending the arrival of F. B. T. Siems, who took charge of the party on May 3. On May 4 the party and launches proceeded to the working grounds at Block Island, arriving there on May 6.

The launches accepted for charter by this party for wire-drag surveys, consisted of the *Gladys* as tender, the *Bernard F.* as end launch, and the *Wisdom*, which was building at the time of acceptance at Broad Channel, L. I., as guide launch. The *Wisdom* was intended to be delivered to the party on April 15, 1918. The launch, however, was still in an incomplete state by the latter part of June, when steps were taken to charter another launch to replace the *Wisdom*. The *Bernard F.* proved unserviceable for towing a wire-drag outfit over 3,000 feet in length, due to insufficient power; also, being of poor design, the launch rolled heavily in the seaway. Provisions for replacing the *Bernard F.* with a suitable launch were also made.

During May and June the *Lillian B.* was temporarily hired as a guide launch and was used with the *Bernard F.* for short wire-drag work off the west shore of Block Island.

Surveys requested by the Navy Department, consisting of a hydrographic and wire-drag survey of the 3-mile standardization course for submarines along the west shore of Block Island, extending from Sandy Point to Grace Point, were made during May and June. The hydrography covered an area five-eighths of a mile on either side of the trial course and extending about 5 statute miles in the direction of the trial course. The area swept by the wire drag extends westward from the 10-foot curve along the west shore of Block Island between Sandy Point and Southwest Point to a junction with the wire-drag work previously completed south of Grace Point and about 2½ miles offshore north of Grace Point. Currents were observed at five stations on the trial course, the analyses of which show that the currents at these points are irregular, of small velocity, and influenced appreciably by winds.

The important bowlders and obstructions found by the wire drag are located within 1 mile of the shore. A wreck with 51 feet of water over it was found in a depth of about 75 feet, a 9-foot bowlder was found in a depth of 18 feet about one fourth mile offshore, and a bowlder with 15 feet of water over it was found three-eighths of a mile offshore near Southwest Point, the general depth here being 30 feet.

The ranges ashore marking 1 nautical mile distances on the trial course were located by triangulation.

[R. P. STROUGH.]

SUMMARY OF RESULTS.—Triangulation: 2 single poles erected, 4 stations in main scheme occupied for horizontal measures, 12 geographic positions determined. Leveling: 4 permanent bench marks established, 0.5 mile of levels run. Topography: 41.3 square miles of area surveyed, 41.3 miles of shore line of rivers surveyed, 2 miles of creeks surveyed, 21.2 miles of ponds surveyed, 55.6 miles of roads surveyed, 3 topographic sheets finished, scale

1:10,000. Hydrography (wire drags): 139.7 square miles of area dragged, 217.1 miles run while dragging, 85 soundings made on shoals, 1 tidal station established, 2 hydrographic sheets finished. Hydrography: 6 square miles of area covered, 146.9 miles run while sounding, 1,012 positions determined (double angles), 5,541 soundings made, 1 tide station established, 1 hydrographic sheet finished, scale 1:10,000.

At the beginning of the fiscal year wire-drag work was in progress in Block Island Sound in the approaches to Narragansett Bay, R. I. Progress made in this work prior to July 1 is stated in the annual report for 1917.

On Sunday, July 1, the chief of party, with one launch, proceeded to Cerebus Shoal, Block Island Sound, and located the position of the U. S. S. *Olympia* and the buoys marking the shoal.

On July 23 assistance was rendered to the 98-ton, two-masted schooner *Emma F. Potter*, of Annapolis, Nova Scotia, which had gone ashore in a fog on the east bank of Sakonnet River about one-half mile north of Sakonnet, R. I. Some difficulty was experienced in finding the vessel in the fog, but she was finally located, and with the *Pilot*, one of the wire-drag launches used by the party, was towed off the shore and into Sakonnet Harbor.

On August 23 the party was visited by Lieut. Commander Frank Stewart, of the Argentine Navy, naval attaché to the Argentine Embassy, for the purpose of observing the operation of the wire drag.

The field work which could be economically carried on from Sakonnet was completed early in September, and on September 6 the headquarters of the party were moved to Saunderstown, R. I., on the shore of the west passage of Narragansett Bay.

On November 9 Commander Julio Dittborn, of the Chilean Navy, naval attaché to the Chilean Embassy, visited the party, and was given the opportunity to witness the drag in operation.

Supplemental instructions were issued September 19, October 3, and November 10 for wire-drag work between Bartlett Reef and the vicinity of The Race, Long Island Sound entrance, and this work, with the exception of a small area near Valiant Rock, was completed before the close of the season. On November 27 wire-drag work was discontinued in the vicinity of The Race, and the party returned to Saunderstown, R. I., where, on December 4, the party was discharged.

A scheme of triangulation was carried up Sakonnet River for the control of the hydrography and topography from two old recovered stations, Telegraph 2 and East Rock, and was connected with the old station, Anthonys Rock, at the entrance to Mount Hope Bay. This scheme included 14 occupied stations and 36 intersection stations, which were used for control of the hydrography and topography.

The entire shore line of both banks of Sakonnet River was traversed with the plane table.

A complete new hydrographic survey of the river was made and plotted on two sheets on a scale of 1:10,000. Lines were run at intervals of about 200 meters, and the shoal areas were closely developed.

In the operations from Sakonnet considerable delay was experienced at the beginning of the season in getting the drag work well underway on account of the prevailing southwest winds and the foggy weather. At the east end the work was joined to that done by J. H. Hawley in 1914 and was carried offshore south from Browns Ledge to the 20-fathom curve. Few shoals were found with less depths than 60 feet. Owing to the great depth to which the drag was set, the wooden floats with which the party was equipped water-logged very rapidly, and it soon became evident that metal floats were essential for this deep work. After July 1 metal floats similar to those used in Alaska were constructed and used during the remainder of the season.

In all an area of 145 square miles was dragged, using Sakonnet as a base, and in this area more than 50 shoals were discovered. The highest pinnacle found with the drag was a small rock about 15 feet in diameter at the top with 36 feet of water over it and surrounded by a depth of 72 feet. It was only after considerable search that the leadsman succeeded in getting the sounding.

After changing the headquarters of the party to Saunderstown the drag work was carried on from that base, joining that which had been done from Sakonnet.

When the weather conditions would not permit of dragging in this area, work was done in the protected waters of the west passage of Narragansett Bay and Newport Entrance, but neither was completed. All the inside work was done with a short drag set very close to the bottom. An area of about 45 square

miles was dragged, using Saunderstown as a base, and in this area about 16 shoals were found, the most important of these being the 28-foot spot south of Brenton Reef buoy and the 31-foot spot at the entrance to the west passage.

Due to the strong currents and the great depth to which the area in the vicinity of Bartlett Reef and The Race was dragged, many difficulties were encountered which materially retarded the progress of the work.

The ordinary routine with the drag aground, which consists of sounding at the indicated location until a depth less than that at which the drag is set is found, was impracticable in The Race. In this strong current the entire drag, large and small buoys and all, was swept under and out of sight as soon as it touched bottom, and unless the tender was near the shoal when this happened there was no indicated location, and all efforts to find the shoal were fruitless. The proceeding in this case was immediately to begin to take up the drag and to endeavor to locate the shoal when the wire was seen to be caught on the shoal. This procedure was often prevented by the breaking of the wire.

Around shoal spots the strong currents caused whirlpools, by which the drag was drawn beneath the surface so as to catch at a depth below that at which the drag was set.

In all, in this locality an area of about 18.5 square statute miles was completed and about 21 shoals were found, the most important shoal being the 38-foot spot which lies about one-half mile west-southwest from Bartlett Reef Light Vessel, where the chart showed a depth of 14 to 20 fathoms. This region is a treacherous one on account of the numerous bowlders and ledges.

A plane table survey was made of the street system of Jamestown, R. I., and the roads on Conanicut Island. The control for this work was obtained from the existing triangulation. In this survey a new determination was made of the position of the Jamestown standpipe.

A total of 32.5 statute miles of public roads was mapped, and brief notes as to the construction and condition of the roads were prepared.

The hired launches, *Pilot*, *Standard*, and *Edna M.*, were used in this work. These boats were the best that could be obtained, but they were not well suited to the purpose of a wire-drag survey.

The entire season's work was done at the request of the Navy Department.

RHODE ISLAND, CONNECTICUT, AND NEW YORK.

[P. M. TRUEBLOOD, July 1 to Sept. 28, 1917; H. P. RITTER, Sept. 29, to Nov. 6, 1917.]

SUMMARY OF RESULTS.—Physical hydrography: 40 current stations occupied, 18 tidal stations occupied.

The current and tidal survey of Long Island Sound, begun in May, 1917, was in progress on July 1 and was continued by the same chief of party until September 29, when he was relieved by Homer P. Ritter. Field was closed November 5. Two hired launches were used in this work.

Current stations were occupied at selected points in Long Island Sound and tributaries between New Haven and The Race and including Fishers Island Sound.

Automatic tide gauges were in operation at New London from the beginning of the season until November 3, at New Haven until October 2, and at New Suffolk, N. Y., from October 6 to 26.

Temporary tide stations were occupied at Herod Point, Long Island, Milford, New London, Clinton, Guilford, Cornfield Point, Orient Shoal, New Suffolk, Jamesport, Sag Harbor, Southold, Greenport, Niantic, and Two Tree Island Channel.

NEW YORK.

[I. M. DAILEY.]

SUMMARY OF RESULTS.—Triangulation: 11 stations occupied for horizontal measures. Topography: 34 miles of shore line surveyed, 27½ miles of railroads and other roads surveyed.

Field work was begun July 21, 1917, on the revision of the triangulation and topography on the south side of Long Island Sound between Eatons Neck and longitude 73° 13′ and from Matinicock Point around Hempstead Harbor to Sands Point.

Work was closed for the season on September 24, 1917.

[ISAAC WINSTON.]

Inspection duty for the region between Narragansett and Dela are Bays was continued by an officer who is in charge of a field station of the Survey, with an office in the Customhouse, New York City.

The demand upon the field station for nautical information and publications has greatly increased and its usefulness has been extended.

Copies of tide tables for 1918 and tables giving the time of sunrise and sunset and moonrise and moonset were prepared and furnished to persons desiring to publish them in local calendars, and in some instances the proof of these was read for the publishers. Similar tables were furnished to a number of newspapers and journals.

The inspector had charge of the Bureau exhibit at the Southern Commercial Congress held in New York October 15 to 17, and of an exhibit illustrative of the work of the Survey at the National Motor Boat Show, New York, January 19 to 26.

A triangulation station at the eastern end of Long Island was transferred to a new position, the change having become necessary on account of building operations.

The tide stations at Sandy Hook, N. J., Fort Hamilton, N. Y., and St. George, Staten Island, N. Y., were inspected in company with an officer of the Corps of Engineers, United States Army.

The inspector has voluntarily given one evening in each week to teaching nautical astronomy in the Hudson River Power Squadron Free School at the High School of Commerce and has distributed a number of canceled charts and tide tables, for purposes of instruction only, in these classes and also to the Naval School at Pelham Bay Park.

Attention was given to the inspection and shipment of material and supplies intended for the use of field parties of the Survey.

In May the inspector was engaged in certain field work on the coast of New Jersey, which had been requested by the Navy Department.

Information and publications were furnished to various officials and a stock of charts and nautical publications was maintained for reference, distribution, and sale to the public.

The privilege of obtaining charts and publications of the Survey from the field station without delay as emergencies arise is appreciated by officers of the Army and Navy, who have frequently expressed their gratification at the convenience.

The inspector was called upon to testify as a witness in court on two occasions where expert testimony was required on questions relating to surveys.

VIRGINIA.

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

SUMMARY OF RESULTS.—Triangulation: 5 square miles of area covered, 6 stations occupied for horizontal measures, 24 geographic positions determined. Topography: 1 square mile of area surveyed, 5.5 miles of shore line surveyed, 3 miles of creeks and sloughs surveyed, 4 miles of roads surveyed, 3 miles of railroads surveyed. Hydrography: 3 square miles of area surveyed, 258 miles run while sounding, 2,821 positions determined (double angles), 23,000 soundings made, 1 tidal station established, 3 tidal bench marks established.

On July 1 the steamer *Bache* was lying at Norfolk, Va., preparing for field work, repairing and outfitting. Office work in connection with the previous field season was in progress during the month of July.

During the latter part of the month a request was made by the naval authorities at Norfolk and confirmed by the Navy Department at Washington, D. C., for a detailed topographic and hydrographic survey of Sewall Point and vicinity, at which locality extensive improvements were to be made in connection with the new naval operating base.

This survey was required on account of large improvements along the water front. The plans were for building some 18,000 feet of bulkhead, reclaiming about 350 acres, and dredging 7,000,000 cubic yards of material. To obtain the necessary data to compute the yardage moved and to locate the bulkhead and piers a close hydrographic survey was needed, together with the establishment of numerous triangulation points.

This work was started during the last few days of July and was practically completed at the time the vessel was transferred to the Navy.

A triangulation scheme was observed resting on Newport News Middle Ground Light and Old Point Comfort Light as a base. This scheme served to

cut in all the hydrographic signals as well as objects located on the topographic sheet. An azimuth was observed to verify the triangulation.

The hydrography was executed on a scale of 1:5,000. Sounding lines were run on located ranges at distances approximately 100 feet apart. It was essential that these lines be run as nearly straight and parallel as possible, and great care was exercised to meet these conditions.

A tide staff was established along the north shore of Sewall Point in the small lagoon. This staff was connected with the United States Army Engineers' bench mark on the Virginian Railway's pier.

A topographic survey was made on a scale of 1:5,000 and showed the shore line and the old culture and improvements of the base at the time the survey was being carried out, but since the survey this area has been so improved that the topographic features have been entirely changed.

In connection with the development of the naval base the results of the triangulation, topography, and hydrography from this survey were used constantly and were a great aid in laying out the extensive water-front improvements and in the proper orientation of the streets and building lines.

In conformity with an Executive order dated September 24, 1918, the steamer *Bache*, with the complement, supplies, and equipment, was transferred to the Navy Department on that date and the commanding officer reported to the commandant of the Norfolk Navy Yard.

[E. B. LATHAM, Commanding Schooner *Matchless*.]

SUMMARY OF RESULTS.—Triangulation: 4 square miles of area covered, 9 signal poles erected, 5 stations in main scheme occupied for horizontal measures, 7 geographic positions determined. Hydrography: 25.5 square miles of area covered, 205 miles run while sounding, 1,864 positions determined (double angles), 9,891 soundings made, 1 tide station established, 1 current station occupied, 3 hydrographic sheets finished, scales of hydrographic sheets 1:20,000 and 1:10,000. Leveling: 3 miles of levels run, 2 permanent bench marks established.

On February 8, 1918, when the command of the *Matchless* was transferred, the vessel was undergoing general repairs at Norfolk, Va. These repairs were completed March 14. The work of outfitting the ship, taking stores on board, and securing a crew occupied the time until May 3, when the *Matchless* left Old Point Comfort for Westpoint, Va., arriving May 5. The hydrographic work required at Westpoint was completed May 25, and the vessel then sailed for Gloucester Point. Work in that vicinity was taken up on arrival May 28, and was in progress at the close of the fiscal year.

Under instructions issued in December an officer was sent to Columbia, N. C., to investigate the existence of a number of sunken logs obstructing navigation in the Scuppernong River. A special report was made on this subject.

At the request of the Navy Department surveys were made to determine the depths around the coal piers at Newport News and a 29-foot spot which had been reported in the dredged channel in Hampton Roads leading to Newport News. These surveys were completed between April 15 and 30, and copies of the results were furnished to local naval authorities.

As directed in supplemental instructions, a hydrographic investigation was made of the York and Mattaponi Rivers near Westpoint, Va., and in the Mattaponi River from deep water in York River to the shipyard of the York River Ship Building Corporation. Old triangulation stations were recovered, and several objects and signals were determined by triangulation.

This survey was done to enable the York River Ship Building Corporation to take vessels under construction for the United States Shipping Board from the Mattaponi River to deep water in the York River, and to determine what dredging was needed to effect that end. Advance information of the results of this work was furnished the York River Ship Building Corporation.

The hydrographic survey of York River from Gum Point to York Spit Light, made at the request of the Navy Department, and of the inshore area from York Spit Light to a junction with recently completed work south of Thimble Shoal Light, was begun May 28 and was in progress at the close of the fiscal year.

The location of signals and objects requested by the naval authorities was given precedence over other work. The signals below Gloucester Point were erected by the naval authorities and determined by the party on the *Matchless*. Above Gloucester Point the signals were erected and determined by the Coast and Geodetic Survey party, and the hydrography was begun. Lines of soundings 400 meters apart run at an angle of approximately 45 degrees with the

channel were completed below Pages Rock Light, and signals were erected and determined to carry the work to Tue Marshes Light.

[HARRY LEYPOLDT, Commanding Steamer *Hydrographer*.]

SUMMARY OF RESULTS.—Hydrography: 35 miles run while sounding, 970 soundings made, 1 tide station occupied.

On June 25, 1918, the party on the steamer *Hydrographer* began a survey of the lower part of Chesapeake Bay. Signals were built, two tide gauges were erected, and the work was in progress at the close of the fiscal year.

NORTH CAROLINA.

[N. H. HECK, Commanding Schooner *Matchless*.]

SUMMARY OF RESULTS.—Triangulation: 2 stations occupied for horizontal measures. Topography: 15 miles of shore line surveyed, 2½ miles of roads and railroads surveyed. Hydrography: 56.5 miles of area covered, 379.2 miles run while sounding, 13,121 soundings made, 2 tide stations established.

On July 1, 1917, the schooner *Matchless* was engaged in the hydrography of Pamlico Sound, N. C., and most of the preliminary work of signal building and triangulation had been completed.

During July the hydrography and topography were actively carried on. The hydrography was of three classes: Offshore, that is at a distance from the low-lying islands on the eastern side of the sound; shoal water, in depths from 2 to 10 feet, the aim of which work was to develop sloughs or narrow channels through the shoals; and over flats with less than 2 feet of water, where depths were obtained by wading.

All of the work was retarded in the early part of July by the failure of the launches. The progress of the work was found to depend largely upon the use of suitable launches.

As the result of recommendations made at that time a new motor sailing launch was ordered and an excellent 32-foot, flat-bottomed launch was leased. An observing platform was constructed on the latter launch for the purpose of bringing the eye of the observer high enough for the offshore work. Other boats of the vessel were used as signals for the work farthest from land.

On July 25 the charge of the party was transferred to R. F. Luce.

[R. F. LUCE, Commanding Schooner *Matchless*.]

SUMMARY OF RESULTS.—Topography: 7.5 square miles of area surveyed, 12 miles of shore line surveyed, 16 miles of roads and railroads surveyed. Hydrography: 183 square miles of area covered, 546 miles run while sounding, 20,670 soundings made, 5 tide stations occupied.

During August and September the party on the schooner *Matchless* was engaged on the survey of Pamlico Sound, as elsewhere mentioned in this report. The survey was in progress at the close of September. The continuation of this work is reported in another abstract.

[E. E. SMITH, Commanding Schooner *Matchless*.]

SUMMARY OF RESULTS.—Triangulation: 4 stations occupied for horizontal measures. Topography: 15 square miles of area surveyed, 44 miles of shore line surveyed. Hydrography: 94 square miles of area covered, 600.9 miles run while sounding, 23,546 soundings made, 2 tide stations established.

During the month of October the survey of Pamlico Sound was continued. The headquarters of the vessel was at Manteo, N. C.

The command of the *Matchless* was transferred to E. E. Smith on October 18.

The instructions under which the party was operating had in view the continuation of the work in Pamlico Sound to a junction with the completed work at the south end of Roanoke and Croatan Sounds.

By instructions issued November 19 the completion of the hydrographic survey of Pamlico Sound from Long Shoal to Croatan and Roanoke Sounds was postponed, and the party was directed to complete the topography of the ocean shore line of the outer beach from New Inlet to Oregon Inlet, to complete certain additional work in Croatan Sound, and then to discontinue work in Pamlico Sound and vicinity and proceed with the *Matchless* to Elizabeth City, N. C., for repairs.

Surveys in Croatan and Roanoke Sounds were completed on December 27. Then followed a series of gales with snow and freezing weather, and the vessel

was held in the ice until January 17, when the ice was broken up and the schooner was towed to Elizabeth City, N. C. After much delay in securing a tug, vessel left Elizabeth City on the 29th, and was taken to Norfolk, Va., the same day for repairs.

On February 8, E. B. Latham relieved E. E. Smith of the command of the *Matchless*.

FLORIDA.

[J. H. HAWLEY.]

SUMMARY OF RESULTS.—Hydrography (wire drag): 140 square miles of area dragged, 231.1 miles run while dragging, 1,121 positions determined (double angles), 10 soundings taken (on shoals), 520 supplemental soundings made, 1 hydrographic sheet completed, scale, 1 : 40,000.

Wire-drag work in the vicinity of the westerly Florida reefs was in progress at the beginning of the fiscal year. Fort Jefferson, on Dry Tortugas, was used as the base of operations throughout the season.

Whenever weather conditions permitted, work was done in the vicinity and southward of Rebecca Shoal until the easterly limit of the work was from 15 to 18 nautical miles distant from Dry Tortugas. Because of the slow speed of the launches used by the party it was found impracticable to extend the work beyond this limit.

The southern limit of the work was then extended well beyond the line of shoal soundings shown on the chart, and the work southward and eastward of Dry Tortugas was continued to a junction with the work in Rebecca Shoal Channel. This resulted in the completion of a continuous area extending from Rebecca Shoal to Dry Tortugas and southward to the general locality of the 20-fathom curve.

Eighteen shoals were found in this area, all but one being in the vicinity of Rebecca Shoal.

To supplement the hydrographic data in this region, soundings were obtained during the course of dragging operations from the large tender. While the drag was underway the tender ran back and forth across the drag, and soundings were obtained at certain drag buoys as directed. Each sounding was recorded, together with the time and buoy at which it was taken, so that all soundings could be plotted on a tracing of the smooth drag sheet. About 800 soundings were obtained in this manner.

A tide staff was maintained at Garden Key during the season and tidal bench marks were recovered and established on the Key.

From one-half hour to one hour's time was saved each day on the runs to and from the working grounds by the discovery and use of a 4-foot channel across the reefs opposite Port Jefferson.

On several days in September the wire-drag launches and their crews were used by the naval authorities at Dry Tortugas.

The weather conditions during the season were generally favorable. This was an important factor affecting the work in Rebecca Shoal Channel. It required from five to six hours per day to run to and from the working grounds, and good weather throughout the entire day was essential for the successful prosecution of this work.

The chartered launches *Twilight*, *Standard*, and *Starlight* were used in this work. While they were the best boats available, they were not well suited for the work.

Four floating signals made up of navigational buoys with superstructures were used in this work, and gave satisfactory service. A 60-foot hydrographic signal was erected on East Key and located by triangulation.

To carry the work beyond the limit of visibility of these signals, a special type of floating signal was devised and constructed by the party.

This signal was easily handled and found to be of ample size for the work, and during the latter part of the season was used in preference to the larger buoy signal with satisfactory results. They were securely anchored and located by sextant angles observed at the signal.

The semaphore signaling machine constructed in 1916 was used during the season with satisfactory results.

Work was closed for the season on September 29.

ALABAMA.

[HARRY LEYPOLDT, Commanding Steamer *Hydrographer*.]

SUMMARY OF RESULTS.—Hydrography: 175 square miles of area covered, 891 miles run while sounding, 3,118 positions determined (double angles), 32,437 soundings made.

On April 22, 1918, the command of the steamer *Hydrographer* was transferred by F. B. T. Siems to Harry Leypoldt. The ship was then at Mobile, Ala., completing repairs. The topographic survey of upper Mobile Bay was in progress at the time.

On April 25 the *Hydrographer* and hired launch *Acacia* left for the working grounds and hydrographic work was resumed. On the following day it became necessary to return to Mobile for further repairs to the engine.

On April 30 a two weeks' series of current observations was begun abreast Fort Morgan. High winds prevailed for three days, greatly influencing the currents. When the wind and sea subsided hydrography was begun in the entrance and carried westward to a junction with previous work near the western end of Dauphin Island. The topography of the southern shore of Dauphin Island was also completed.

When current observations were completed the ship commenced signal building and hydrography of the outer coast from Mobile Bay entrance to the eastern limit of the topographic sheet.

There was no triangulation control for this region, so resort was had to a plane table traverse from Fort Morgan to triangulation station ALA, at the western side of Perdido Bay. This station had been destroyed, but a reference mark (blazed tree) was recovered. The traverse checked remarkably well, there being an error of about 25 meters in distance. The ship or launch parties kept ahead of the topographer with signals and then commenced sounding without a boat sheet, the signals being as yet undetermined. The lines were fairly straight and evenly spaced. The instructions called for hydrography to the 6-fathom curve, but in places this was close to the beach, with shoaler water offshore, so that an irregular system of lines finally resulted, as some of the earlier lines did not go offshore far enough to go beyond the outer 6-fathom curve.

The shoals at the eastern side of the Mobile Bay entrance channel were well developed and they appear to have undergone little change. Those to the westward apparently shift with every storm, and the islands as charted have been washed away to a large extent, so that only a few small sand keys remain, with shoal water between them.

On May 23 the outer hydrography and topography were completed, and the unfinished work remaining was the topography of Bon Secours Bay and a few small stretches in the vicinity of the rivers at the head of Mobile Bay.

The launch *Acacia* had during this time completed the hydrography of Bon Secours Bay and part of the topography of this bay, together with several areas of hydrography near the head of the bay.

From May 25 to May 28 the ship was being made ready for the trip to Chesapeake Bay, while the *Acacia* finished the work at the head of Mobile Bay.

On May 29 the shore party was disbanded, and at 6 p. m. the *Hydrographer* cast off and sailed for Key West, Fla., arriving there in the late afternoon on June 1 after an uneventful trip, having made a landfall at Tampa.

On June 3 the *Hydrographer* sailed from Tampa for Norfolk, Va., stopping at Savannah, Charleston, and Beaufort. The vessel arrived at Norfolk June 14.

LOUISIANA AND MISSISSIPPI.

[H. A. SERAN, Commanding Steamer *Hydrographer*.]

SUMMARY OF RESULTS.—Topography: 98 miles of general coast line run, 2 topographic sheets finished, scale 1 : 40,000. Hydrography: 575 square miles of area covered, 1,075 miles run while sounding, 30,159 soundings made, 3 tide stations established, 2 hydrographic sheets finished, scale 1 : 40,000. Leveling: 2 miles of levels run, 3 permanent bench marks established.

On July 1, 1917, the steamer was temporarily laid up at New Orleans on account of lack of funds. On July 2 instructions were received and an allotment made, and on July 7 the vessel left New Orleans to continue work in Mississippi Sound from Gulfport as headquarters. A shore party was established at Pascagoula on July 16, and continued the work begun at this point in May, 1917.

The hydrography of Mississippi Sound was extended from the eastern limit reached at the end of June eastward to the limits of hydrographic sheet C, north of Ship Island. The hydrography between Ship Island and Chandeleur Islands was completed, except for a small portion lying immediately east of Chandeleur Islands.

The shore party working from Pascagoula extended the hydrography from a line connection, Belle Fontaine Point, and the west end of Horn Island eastward to a line connecting the western shore of the bay immediately west of Grand Bay and a point due south of this shore on Petit Bois Island. No hydrography outside of Horn or Petit Islands was done.

The topography was extended from Belle Fontaine Point to the western shore of the bay lying immediately west of Grand Bay on the north shore, and also the topography was completed of Horn Island, Petit Bois Island, Round Island, Ship Island, and that portion of Chandeleur Islands within the limits of hydrographic sheet C.

An automatic tide gauge was continued in operation at St. Louis Bay, and tide-staff readings were taken at Pascagoula and the quarantine station at Ship Island.

Records were also obtained from the automatic tide gauge maintained by the Mississippi River Commission at Biloxi, Miss.

Some additional offshore work was done east of South Pass, Mississippi River. Shoal soundings had been reported in this vicinity, but nothing was found to justify such reports.

The command of the vessel was transferred to F. B. T. Siems on September 16, 1917.

[F. B. T. SIEMS, Commanding Steamer *Hydrographer*.]

SUMMARY OF RESULTS.—Triangulation: 182 square miles of area covered, 13 signal poles erected, 1 water signal erected, 16 stations in supplemented schemes occupied for horizontal measures, 52 geographic positions determined. Leveling: 3 miles of levels run, 15 permanent bench marks established. Topography: 140 square miles of area surveyed, 298 miles of general coast line surveyed, 162 miles of roads surveyed, 2 topographic sheets finished, scales 1:40,000 and 1:10,000. Hydrography: 950 square miles of area sounded, 2,918 miles run while sounding, 8,864 positions determined (double angles), 111,436 soundings made, 9 tide stations established, 5 current stations occupied, 3 hydrographic sheets finished, scale 1:40,000.

This report covers the period from September 16, 1917, to April 21, 1918, while the steamer *Hydrographer* was in command of F. B. T. Siems.

The central part of Mississippi Sound, the inlets between Ship Island and Horn Island, together with the adjoining gulf coast, and the hydrography of the gulf coast southward of Horn Island were surveyed by the party of the steamer *Hydrographer* from September 18 to October 11, 1917. A small area of hydrography northeast of Chandeleur Islands was also completed during this period.

The weather during September and October was generally fair, and enabled the party to work outside of Ship Island, Horn Island, and Dog Key and develop the passages between these islands under very favorable circumstances. A hurricane, the center of which traversed the working grounds during the latter part of September, blew down several signals which had to be rebuilt later and the storm itself caused a suspension of field work for three days.

The *Hydrographer* called at Gulfort, Miss., for coal, mail, and supplies while operating in the central part of Mississippi Sound, and after the completion of this work on October 12 the ship proceeded to Mobile, Ala., which was used as a base for operations in eastern Mississippi Sound and Mobile Bay.

About the middle of October the surveys in the eastern end of Mississippi Sound were taken up by the ship's party. Some time was necessary to recover old triangulation stations, build signals, and perform additional triangulation for determining the positions of supplementary stations and the aids to navigation marking the dredged cut through Pass aux Heron. Topographic work was begun at Cedar Point and on Dauphin Island, and was extended westward to form a junction with the completed topography. At the same time hydrographic work was begun in Pass aux Heron Channel and surrounding locality and then extended westward. A tide station was established at Beacon 8, Pass aux Heron, for the hydrography in that locality. Currents were observed at the west end of the pass for 72 consecutive hours and again for 42 consecutive hours.

Combined operations in the eastern part of Mississippi Sound between Horn Island Pass and Pass aux Heron were continued during November and December, 1917, and during part of January, 1918, and included the hydrographic

development of the new inlet between Petit Bois Island and Dauphin Island, Horn Island Pass, and the hydrography of the adjoining Gulf coast out to the 6-fathom curve. Continuous hazy and stormy weather during the winter months retarded the progress of the surveys considerably; also the field work was delayed on account of boiler trouble. The progress of the topography was slow on account of the intricate and muddy marsh areas, which make up the greater part of the north shore of Mississippi Sound. Considerable time was spent in strengthening the marking of the numerous triangulation stations in this locality, while other field work was impossible. Tides were observed at Bayou la Batre, Horn Island Pass light, and the west end of Dauphin Island.

A shore party equipped with a chartered launch and composed of four officers and eight hands, under the direction of the commanding officer of the steamer *Hydrographer*, executed certain portions of the survey of Mississippi Sound, Lake Borgne, and Mobile Bay. At the beginning of the period covered by this report the shore party continued operations in Mississippi Sound near Pascagoula, at which town the party was quartered. Horn Island Pass, the channel paralleling Horn Island, and the surrounding shoals were developed by this party during September and October. On October 21 the shore party was transferred to Bayou la Batre to assist the ship's party in the surveys of the eastern part of the sound.

During the latter part of December the shore party was transferred to Bay St. Louis for surveys in the western part of Mississippi Sound and in Lake Borgne, covered by the Superintendent's supplemental instructions of November 30, 1917. Two new launches were chartered for this work and two additional hands were employed in the party. These surveys included the topography from Isle au Pitre to Point aux Marchettes, the hydrography northward of these shores and extending to the previously completed hydrography of the fiscal year 1917, and the redevelopment of Pass Christian and Pass Marianne Channels. On account of the exposed locality, with the prevailing north winds occurring at that time of the year, the progress of this work was necessarily slow. Sufficient triangulation stations were recovered for the necessary control of the detailed surveys. Tides were observed at Malheureux Point and at Bay St. Louis. During January, February, and part of March, 1918, the shore party was engaged in the surveys outlined above.

The survey of Mississippi Sound (with the exception of its western portion not then completed by the shore party) and the adjoining Gulf coast to the 6-fathom curve, was completed early in January, 1918. The *Hydrographer* then took up the survey of Mobile Bay, under the Superintendent's instructions dated December 8, 1917.

The numerous channel beacons in Mobile Bay were readily located by triangulation from recovered United States Army Engineer triangulation stations. These beacons served as excellent hydrographic signals for the greater part of Mobile Bay, and were also very useful for the control of the topography. Considerable progress was made in the hydrography of the bay by the ship during the latter half of January. The combined operations in the central part of Mobile Bay were undertaken at that time, the plan being to leave the work at the head of the bay for the time while the ship would be repairing at Mobile during April, and the entrance and Gulf coast during the favorable weather conditions which could be expected after the repairs had been completed.

During February field work in general was delayed by frequent fogs and rains. A short spell of good weather, however, enabled the party to execute the triangulation scheme of Bon Secours Bay. In order to avoid long lines of sight a central point figure was used by building a signal in 11 feet of water. This triangulation was extended from the line Mobile Bay Light–Fort Morgan. Natural objects, principally trees, and supplementary signals were located by triangulation for hydrographic signals and topographic control.

The topography of the east and west shores of Mobile Bay was progressing favorably while the ship was engaged in hydrography and triangulation in the proximity of the topographic party. Particular attention was given to the mapping of roads and settlements located not more than 1 mile inland.

The *Hydrographer* was at Mobile, Ala., from March 7 to 9 for inspection by prospective bidders for repairs to the vessel. The contract for the repairs, consisting principally of the installation of a new boiler, was awarded to the Alabama Dry Dock & Shipbuilding Co. on March 19, and the vessel was delivered to the contractors on the following day. Repairs by the contractors were completed on April 16. Considerable work of cleaning and painting the

ship and adjustments in the engine room were necessary, and the ship remained at Mobile until after the date of the transfer of the command to another officer on April 22, 1918.

While the ship was undergoing the repairs, field parties were engaged in combined operations at the head of Mobile Bay and in the vicinity of Mobile. The triangulation of Mobile Bay was extended by a central point figure for the control of the detailed surveys of the rivers at the head of the bay. Marked changes in the bars at the entrances of these rivers necessitated considerable development of these areas. The topography was made difficult by the tall marsh reeds and unstable ground. In most places a plane table could not be used, and it was necessary to resort to a sextant for topographic work. A detailed survey of the water front of Mobile was made on a 1:10,000 scale projection.

The shore party completed the surveys in the western part of Mississippi Sound and in Lake Borgne, and on March 14 proceeded to Mobile Bay for assignment to work in that locality. This party was engaged in observing currents and on inshore hydrography in the central portion of Mobile Bay and on combined operations at the head of the bay during the last two weeks of March and the first three weeks of April.

Automatic tide gauges were established at Fort Morgan and Mobile, and subsidiary tide staffs at Great Point Clear, Weeks Bay, and Alabama Port.

On April 22, the date of the transfer of the command of the steamer *Hydrographer* to another officer, the survey of the head of Mobile Bay, including Mobile, and of the greater portion of the bay itself was completed. The principal work remaining to be completed consisted of the hydrography and topography of the greater part of Bon Secours Bay, the development of the entrance of Mobile Bay, and the survey of the Gulf Coast.

LOUISIANA.

[J. B. BOUTELLE.]

A field station was opened at New Orleans, La., on February 27 with an office in room 503, Godchaux Building. Notice of the establishment of this office was published in local newspapers, and was brought directly to the attention of Government officials, shipping companies, and firms connected with maritime business.

Since the establishment of the office many requests for publications and information from the Army and Navy and other branches of the public service have been received and complied with. An inspection has been made of the agencies for the sale of publications of the Survey in New Orleans, and they have been supplied with charts from time to time to meet requests for such as they had not in stock.

Monthly tide tables and tables of the time of sunrise and moonrise and sunset and moonset were supplied to the local newspapers for publication.

Information was supplied to the office of the Survey at Washington in regard to reported dangers to navigation, changes in shore line and depths, copies of recent surveys by the United States Engineers, descriptions of inland waterways, and other matters necessary for the correction of the charts, coast pilots, and tide tables.

TEXAS.

[J. B. BOUTELLE.]

During the first half of the fiscal year an officer was engaged on inspection duty for the coasts of Texas and Louisiana, with headquarters at Galveston, Tex.

Information in regard to surveys, geographic positions, elevations, tides, currents, changes in aids to navigation, etc., was furnished to the Coast and Geodetic Survey Office, to officials of the Government, and others applying therefor.

A stock of charts and nautical publications was maintained for distribution, reference, and sale.

From August 7 to 31 the inspector, at the request of the United States Engineers, executed a resurvey of Brazos Santiago Pass and Harbor to obtain data for estimates for improving that port by dredging a harbor and channel and building jetties.

HYDROGRAPHIC AND TOPOGRAPHIC WORK, PACIFIC COAST.

CALIFORNIA.

[E. F. DICKINS.]

An officer of the Survey has continued on duty as inspector of the Bureau for the coast of California and in charge of the field station at San Francisco, Cal.

The principal duty of the inspector in charge of the field station is the inspection of the navigable waters within his district, to assist in keeping the charts, coast pilots, and tide tables of the Survey corrected to date, and to furnish information relating to our coasts to the public.

Under the supervision of the inspector an automatic tide gauge was maintained throughout the year at the Presidio station, San Francisco, obtaining a continuous record of the time and height of the tide.

Arrangements were made by the inspector to install apparatus for current observations on the light vessels within his district, an authorization for which is contained in the sundry civil act for 1919.

The inspector has kept on hand a stock of charts and nautical publications for sale and reference. He has obtained information for the correction of the charts and coast pilots; furnished information in regard to surveys to Government officials and others applying therefor; has supplied tidal information and advance notices to mariners, to the public, and for publication in the newspapers; attended to forwarding instruments and supplies to the field station of the Survey at Manila; and furnished transportation to officers of the Survey upon request.

WASHINGTON.

[J. F. PRATT.]

An officer of the Survey has continued on duty as inspector of the Bureau for the coast of Alaska, Washington, and Oregon and in charge of the field station at Seattle, Wash.

This field station has continued to prove very helpful to the Alaska parties, to the public, and Government officials within the district, and to the Bureau at Washington in keeping it informed of the condition of the surveys on the western coast. Special consideration was given to surveys that are urgently needed in Puget Sound waters, and the revision of the survey of the Lake Washington Canal and Seattle waterways.

The field station cooperated with the United States Steamboat-Inspection Service by examining seamen for certification as lifeboat men.

Self-registering tide gauges were kept in operation at Seattle and Olympia. Information in regard to the tides was furnished for publication in the newspapers.

Designs and specifications were prepared for wire-drag apparatus for purchase for the field parties of the Bureau in Alaska.

Assistance was rendered in laying up the vessels of the Survey at Seattle in the fall of 1917, and the inspector was placed in charge and handled the accounts of all the vessels and parties at Seattle, the commanding officers and other chiefs of parties having been transferred to the Navy.

Arrangements were made to secure plans and specifications for a vessel to replace the *Taku*, provision for which is made in the sundry civil act for 1919.

The inspector furnished information and publications to Government officials applying therefor, and kept on hand a stock of charts and nautical publications for sale and reference. He attended to the enlistment of seamen, the purchase of supplies, and the forwarding of instruments and supplies to the parties of the Survey in Alaska and furnished transportation to officers passing through Seattle on their way to and from the field.

[JOHN A. DANIELS.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 2 miles, 5 points selected for scheme. Base lines: 1 secondary, 2,045.6 meters in length. Triangulation: 3 stations in main scheme occupied for horizontal measures, 49 geographic positions determined. Leveling: 1 mile of levels run, 7 permanent bench marks established. Topography: 14½ square miles of area surveyed, 30 miles of general coast line (river and canal) surveyed, 86½ miles of roads surveyed, 3 topographic sheets finished, scale 1 : 5,000. Hydrography: 3.75 square miles of area covered, 97 miles run while sounding, 2,094 positions determined (double angles), 4,645 soundings made, 3 tide stations established, 5 hydrographic sheets finished, scale 1 : 5,000.

Chart-revision work in the vicinity of Seattle, Wash., including triangulation, topography, and hydrography, was in progress at the beginning of the fiscal year.

This work was done in order to show changes due to the construction by the United States Army Engineers of the Lake Washington Ship Canal connecting Puget Sound and Lake Washington through Salmon Bay and Lake Union and the construction of a lock at the narrow part of Salmon Bay, the improvements making these waters a part of Seattle Harbor.

The completion of this project lowered the level of Lake Washington 8 feet and raised the level of Lake Union about 10 feet. The entire waterway from Lake Washington to the lock at the western end of Salmon Bay is now continuous, and the water level is controlled by gates at the dam alongside the lock.

A resurvey of Smith Cove was necessary because of the recent construction of a large terminal and dock.

In the southern part of Seattle the Duwamish Waterway Commission, in cooperation with the city of Seattle and King County, have straightened and deepened the Duwamish River from the head of the East and West Waterways for a distance southeastward of about 4 miles. The material dredged from the straightened river was used to fill the old river bed and other near-by depressions. Street and railroad facilities have been built along the eastern shore of the waterway, with the consequent addition of many shipyards and industrial plants.

Topographic revision in the vicinity of Alki Point and West Seattle was necessary to show the various improvements along the water front and also the addition and extension of several roads and streets that improve considerably the grades in the approaches to West Seattle.

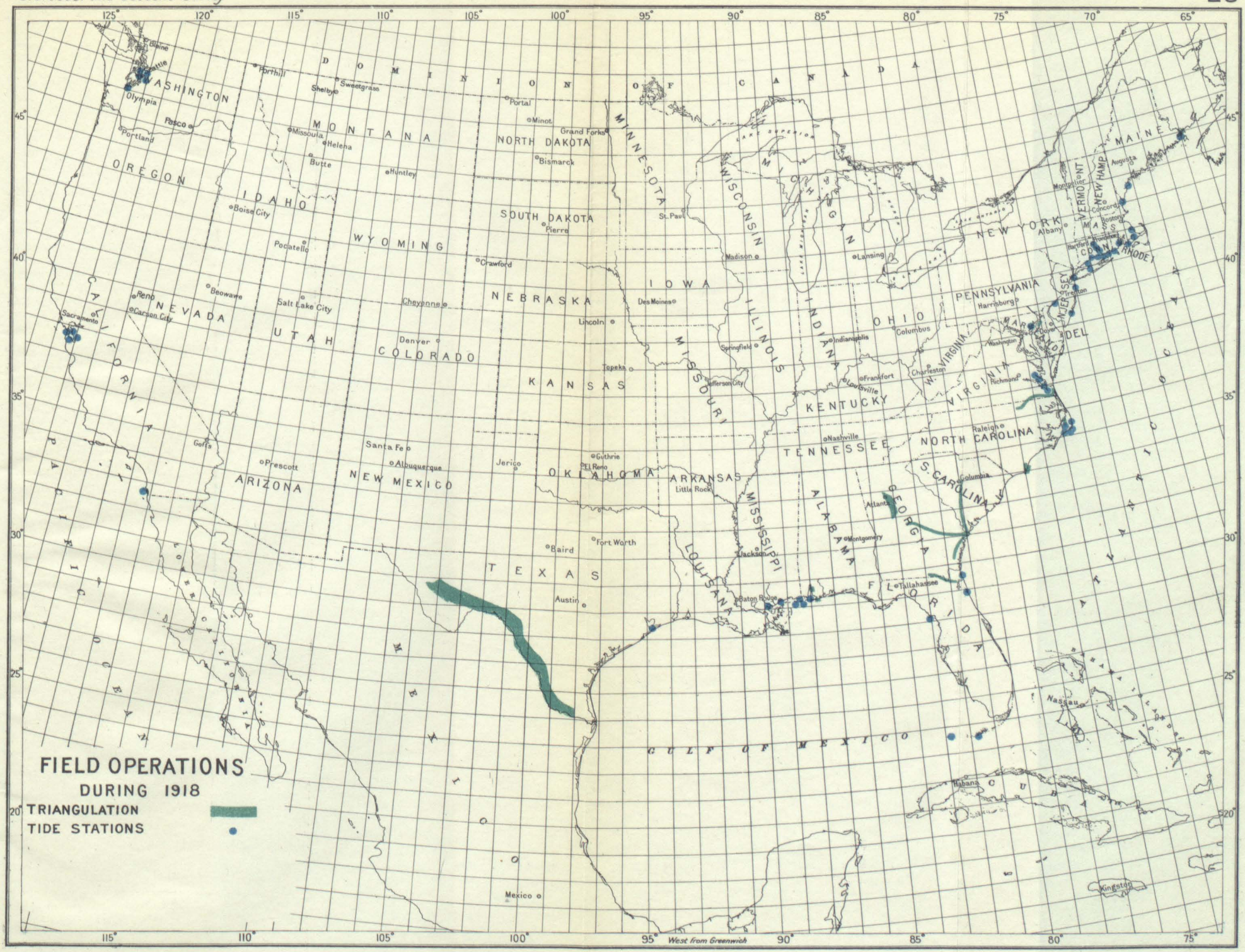
The necessary triangulation consisted of a tertiary scheme from Salmon Bay to the southern end of the Duwamish Waterway, crossing Smith Cove and Elliott Bay, a distance of approximately 10 statute miles. A base line was measured along the eastern side of the Duwamish River upon a new paved roadway.

The connection between points in the vicinity of Salmon Bay with those in Smith Cove was begun by the party of the steamer *Patterson*, C. G. Quillian commanding. All of the seven signals necessary to reach Smith Cove without connecting to known points across Elliott Bay were built, one of the stations was completely occupied, and two partially observed by the *Patterson* party. In order to complete this connection with triangulation points recovered in Elliott Bay it was necessary to build 2 signals, occupy 7 complete stations, and partially observe 2 others. The complete scheme from Salmon Bay to South Park, Seattle, contains 23 main-scheme stations, of which 15 were occupied. There are 18 closed triangles, with an average closure of 2.1 seconds. The length of the scheme is about 10 statute miles, and its area 16 square statute miles.

Advantage was taken of an excellent opportunity to measure a secondary base along the newly built brick pavement situated on the eastern side of the new Duwamish Waterway. The pavement is level and straight, except for one slight bend for over a mile, and as yet very few buildings have been erected to obscure lines of sight. The base was completely measured forward and back in two sections in two forenoons.

When the work was taken over one or two days' work had been done upon the topographic sheet of Shilshole Bay. The topography of the water front and shore line of the new canal was completed through Union Bay to Lake Washington proper. The low land between Salmon Bay and Smith Cove was surveyed, together with the shore line and water front of Smith Cove. In the western and southern part of Seattle the shore line was run from 1 mile southward from Alki Point around Duwamish Head, including East and West Waterways and the new Duwamish Waterway to its head, about 4 statute miles from the junction of the East and West Waterways. The industrial section between the East Waterway and the high land to the eastward was concluded.

The topography was all done upon a scale of 1 : 5,000, and was included upon six sheets. Much care was taken throughout the work to avoid errors due to distortion of the sheets, and all details were accurately located. No elevations were determined or contours drawn, but new roads and streets, showing changes from the previous surveys, were run in. The greater part of the topography was done by Douglas Karr, junior hydrographic and geodetic engineer, with a


FIELD OPERATIONS
DURING 1918
TRIANGULATION
TIDE 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.
N. JERSEY
MARYLAND
DEL.
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
LOWER CALIFORNIA
CUBA
BAHAMA ISLANDS
Blaine
Seattle
Olympia
Pasco
Portland
Porthill
Sweetgrass
Shelby
Missoula
Helena
Butte
Huntley
Boise City
Pocatello
Beowawe
Reno
Carson City
Sacramento
Salt Lake City
Cheyenne
Denver
Goffs
Prescott
Santa Fe
Albuquerque
Portal
Minot
Grand Forks
Bismarck
Pierre
Crawford
Lincoln
Topeka
Jerico
Guthrie
El Reno
Baird
Fort Worth
Austin
Mexico
St. Paul
Des Moines
Madison
Springfield
Jefferson City
Little Rock
Jackson
Baton Rouge
Lansing
Indianapolis
Columbus
Frankfort
Louisville
Nashville
Charleston
Richmond
Raleigh
Columbia
Atlanta
Montgomery
Tallahassee
Albany
Montpelier
Concord
Boston
Augusta
Hartford
Trenton
Harrisburg
Washington
Dover
Nassau
Habana
Kingston
West from Greenwich
125°
120°
115°
110°
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40°
35°
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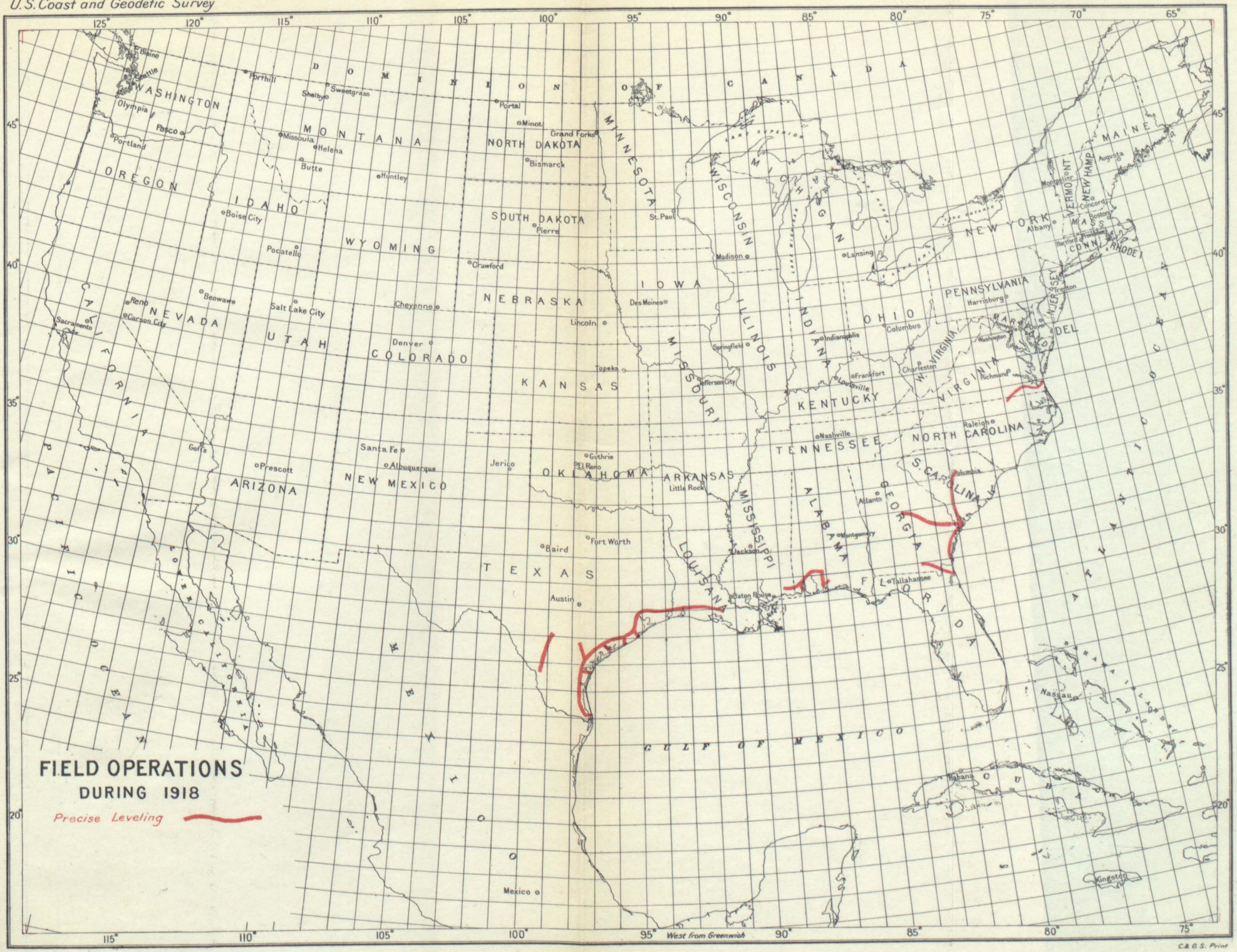
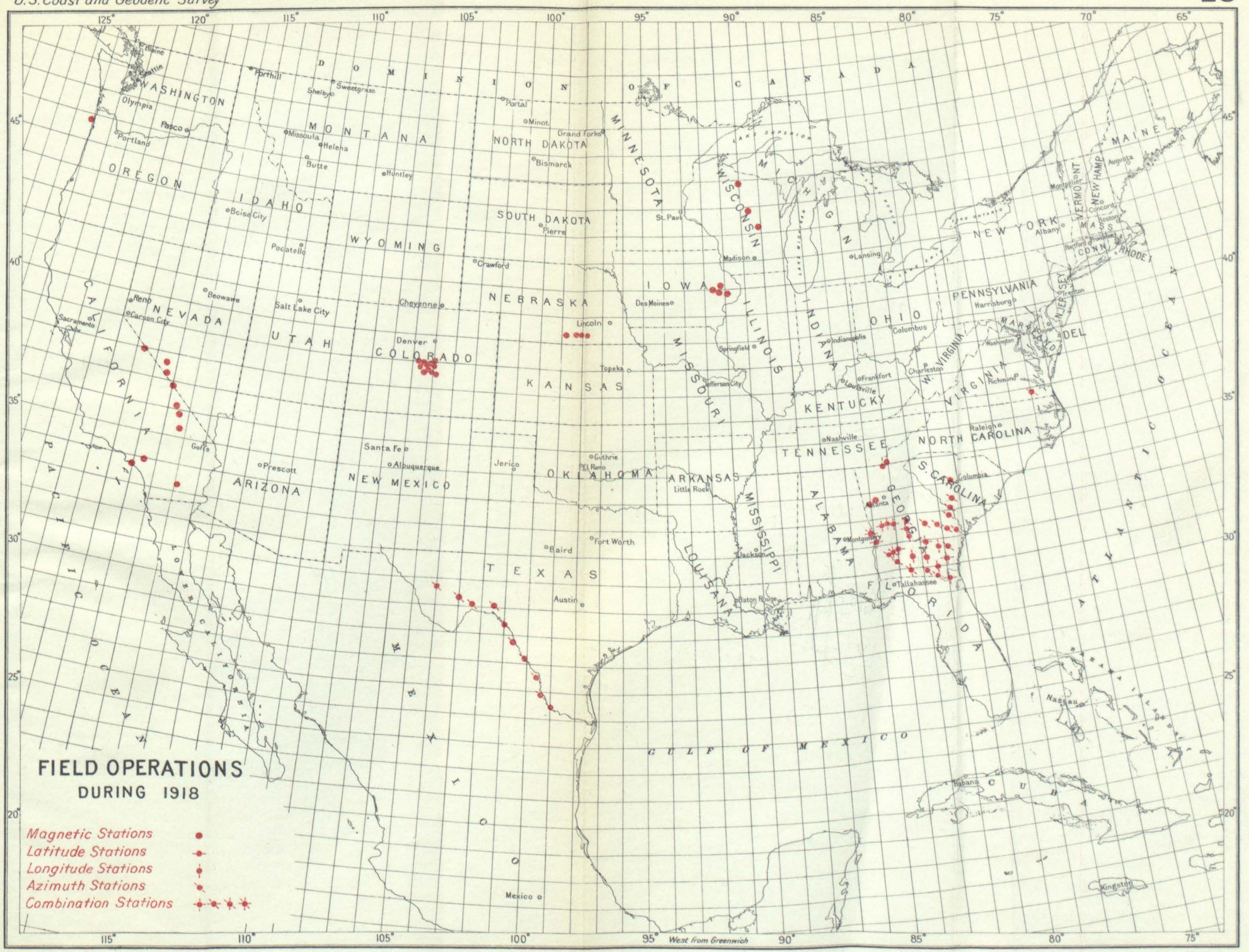
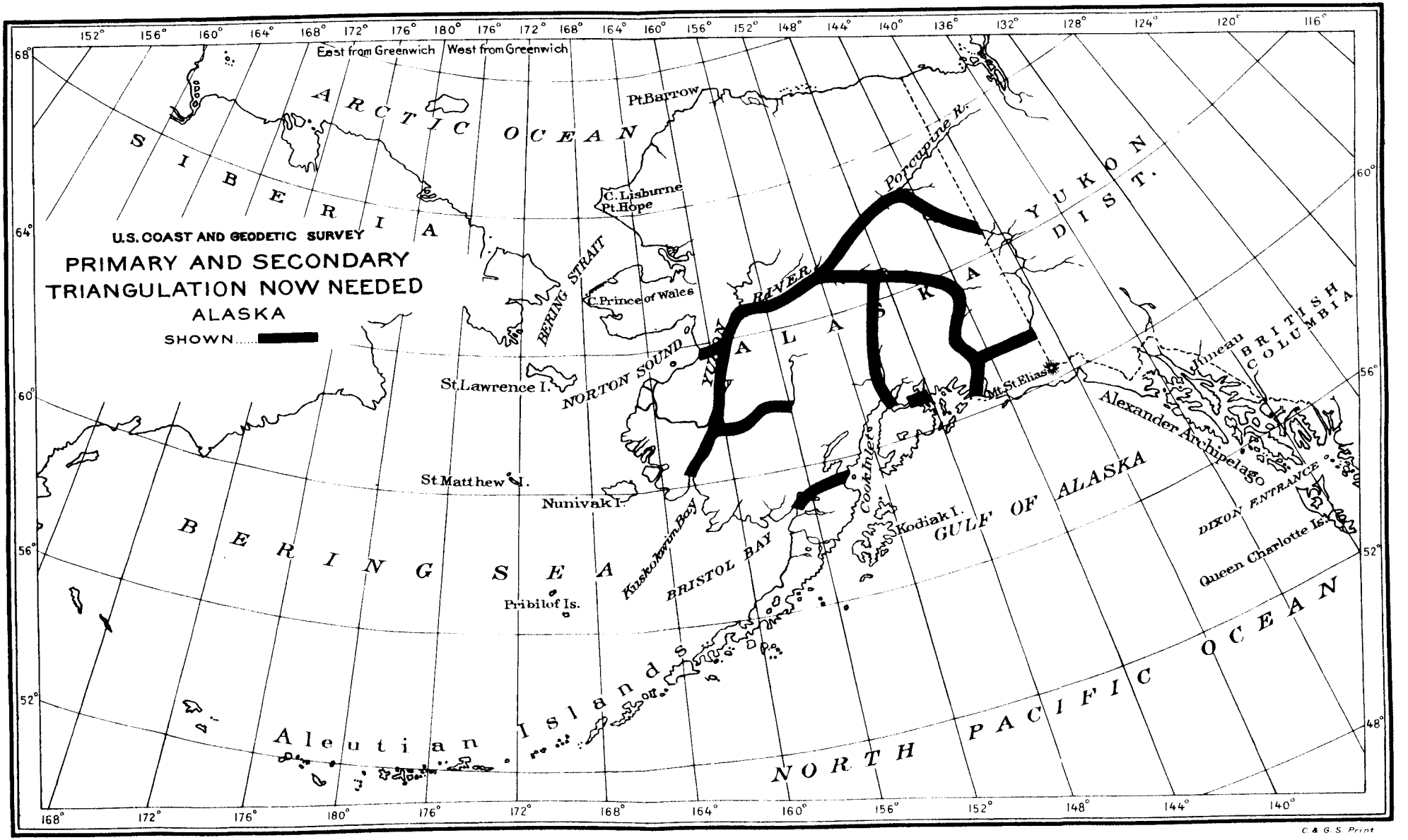
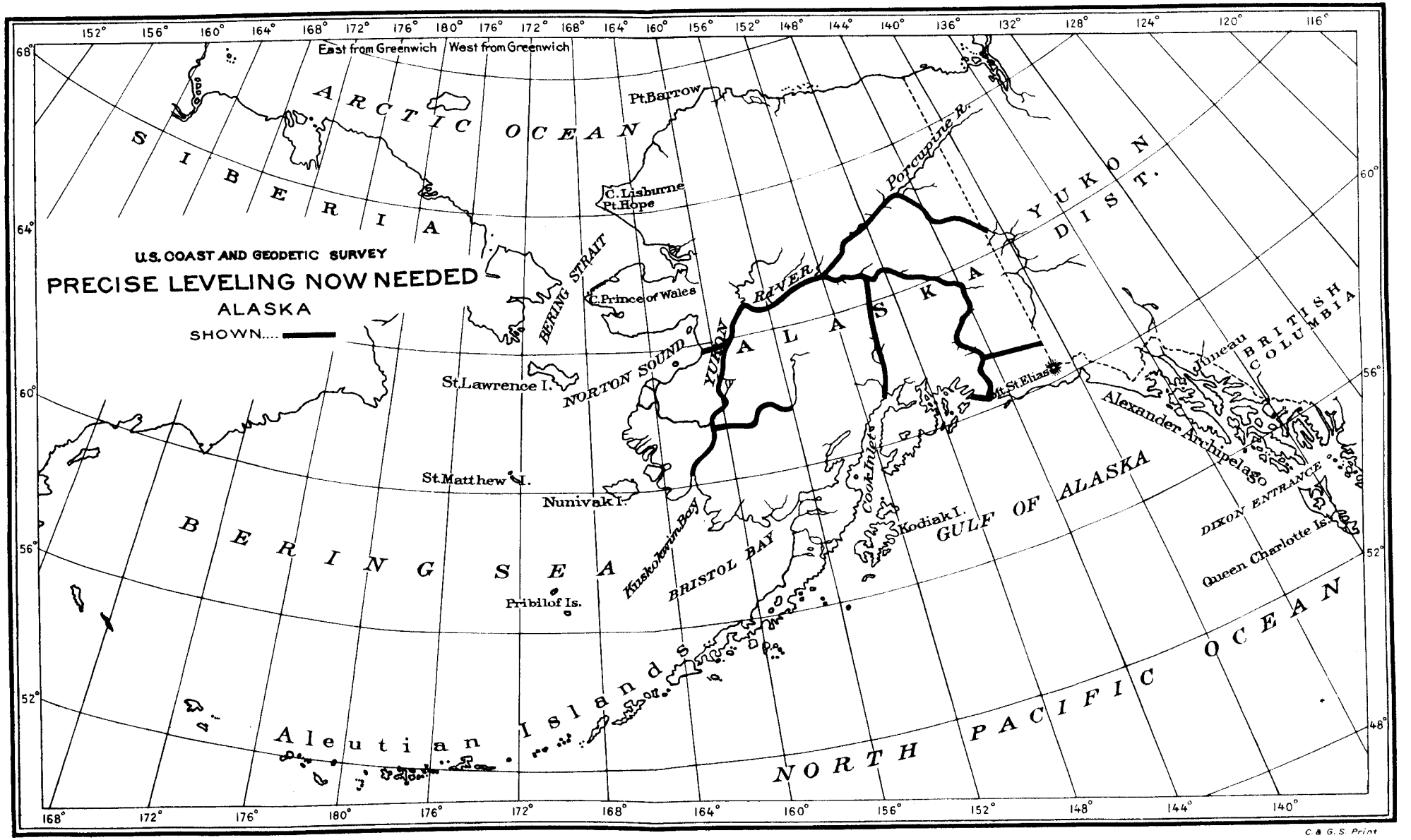
20°


FIELD OPERATIONS
DURING 1918
Precise Leveling
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.
N. JERSEY
MARYLAND
DEL.
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
LOWER CALIFORNIA
BAHAMA ISLANDS
CUBA
Blaine
Seattle
Olympia
Pasco
Portland
Porthill
Sweetgrass
Shelby
Missoula
Helena
Butte
Huntley
Portal
Minot
Grand Forks
Bismarck
Boise City
Pocatello
Pierre
Crawford
Beowawe
Reno
Carson City
Sacramento
Salt Lake City
Cheyenne
Denver
Lincoln
Des Moines
St. Paul
Madison
Lansing
Springfield
Jefferson City
Topeka
Indianapolis
Columbus
Frankfort
Louisville
Charleston
Washington
Richmond
Harrisburg
Trenton
Albany
Montpelier
Concord
Boston
Augusta
Hartford
Dover
Raleigh
Nashville
Columbia
Atlanta
Montgomery
Tallahassee
Baton Rouge
Jackson
Little Rock
Guthrie
El Reno
Jerico
Santa Fe
Albuquerque
Prescott
Goffs
Baird
Fort Worth
Austin
Mexico
Nassau
Habana
Kingston
West from Greenwich
C.&G.S. Print


FIELD OPERATIONS
DURING 1918
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.
N. JERSEY
MARYLAND
DEL.
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
LOWER CALIFORNIA
BAHAMA ISLANDS
CUBA
Bloine
Seattle
Olympia
Pasco
Portland
Porthill
Sweetgrass
Shelby
Missoula
Helena
Butte
Huntley
Boise City
Pocatello
Beowawe
Reno
Carson City
Sacramento
Salt Lake City
Cheyenne
Denver
Goffs
Prescott
Santa Fe
Albuquerque
Portal
Minot
Grand Forks
Bismarck
Pierre
Crawford
Lincoln
Topeka
Jerico
Guthrie
El Reno
Baird
Fort Worth
Austin
Mexico
St. Paul
Des Moines
Madison
Springfield
Jefferson City
Little Rock
Jackson
Baton Rouge
Lansing
Indianapolis
Columbus
Frankfort
Louisville
Charleston
Nashville
Atlanta
Montgomery
Tallahassee
Columbia
Raleigh
Richmond
Washington
Dover
Harrisburg
Trenton
Albany
Montpelier
Concord
Boston
Augusta
Hartford
Providence
Nassau
Habana
Kingston
125°
120°
115°
110°
105°
100°
95°
90°
85°
80°
75°
70°
65°
45°
40°
35°
30°
25°
20°
West from Greenwich


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
NORTON SOUND
St. Lawrence I.
St. Matthew I.
Nunivak I.
BERING SEA
Pribilof Is.
Kuskokwim Bay
BRISTOL BAY
Aleutian Islands
NORTH PACIFIC OCEAN
Porcupine R.
YUKON RIVER
ALASKA
YUKON DIST.
Cook Inlet
Kodiak I.
GULF OF ALASKA
Mt. St. Elias
Juneau
BRITISH COLUMBIA
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
C. & G. S. Print

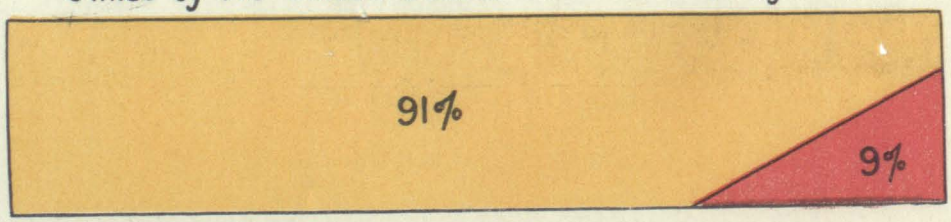

U.S. COAST AND GEODETIC SURVEY
PRECISE LEVELING NOW NEEDED
ALASKA
SHOWN....
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
NORTON SOUND
St. Lawrence I.
YUKON RIVER
Porcupine R.
ALASKA
YUKON DIST.
BRITISH COLUMBIA
Juneau
Mt.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

Condition of water surveys, Pacific Coast and Alaska, 1918, as compared to the Philippine Islands

United States Coast and Geodetic Survey

Alaska

Owned by the United States since 1867 (51 years)

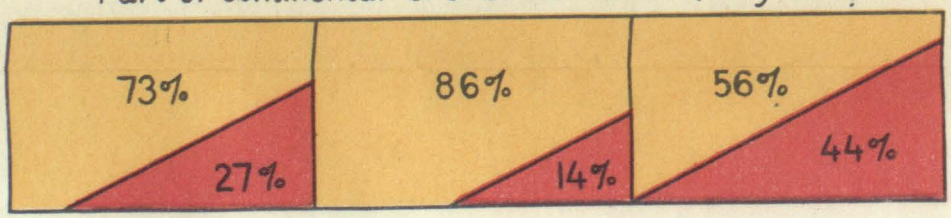


Yellow (91%) - represents unsurveyed water areas.
Red (9%) - represents water areas surveyed in past 32 years.

One vessel of the Surveyor type will require 118 years to complete a first survey of Alaska's exposed navigable waters, by which time all surveys in sheltered waters can also be completed by a continuation of the present rate of progress.

California Oregon Washington

Part of continental U. S. since 1848 (70 years)



Yellow (73%, 86% and 56%) - represents unsurveyed water areas.
Red (27%, 14%, and 44%) - represents water areas surveyed in past 68 years.

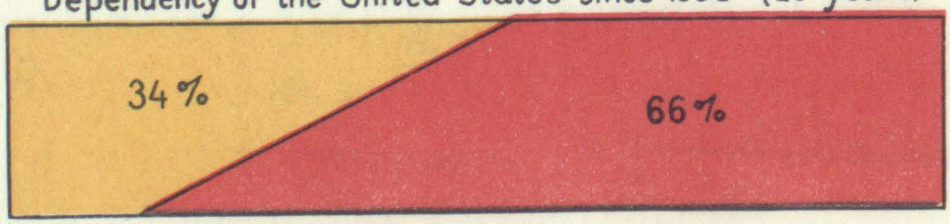
One vessel of the Surveyor type will require 20 years to complete a first survey of the navigable waters of this coast.

For 21 years no systematic survey of water areas has been made on account of lack of vessels.

Now compare work done in the

Philippine Islands

Dependency of the United States since 1898 (20 years)



Yellow (34%) - represents unsurveyed water areas.
Red (66%) - represents water areas surveyed in past 18 years.

Philippine surveys have progressed more rapidly in 18 years than in the other regions shown on this sheet due to the funds and four (4) ships supplied by the Philippine Government.

C.&G.S. Prnt

party of two rodmen. Street cars were used for transportation, except at a few inaccessible points, where a light auto truck was hired to carry the instruments and party. The weather conditions were very favorable for topography throughout the summer.

The hydrography was done upon five sheets upon a scale of 1:5,000. Two of the sheets include the Lake Washington Canal and adjacent waters, except Lake Washington; another taken in Smith Cove and vicinity; and the other two embrace the Duwamish River section. In general the sounding was done on lines 50 meters apart. The boats used were loaned to the party by the steamer *Explorer*. In the more open waters the steam launch was used, and in other localities the small whaleboat was more efficient. The commanding officer of the *Explorer* cooperated in the hydrographic work by furnishing boats and men.

Inshore sounding was done in Shilshole Bay and in the entire water area in and bordering the ship canal from the above bay to the cut between Portage Bay and Lake Washington. One day's work was done to locate definitely the entrance to the dredged channel of the canal from Lake Washington.

Large tows of logs were found moored along the banks of the canal all the way from the lock to Lake Union. The area covered by the logs was considerable, and was sounded out by walking over the rafts and dropping the lead between the logs. Lines about 60 meters apart were run throughout the work. In the southern part of Seattle the East and West Waterways were sounded with their approaches and the new Duwamish Waterway, with its accessible tributaries and slips, was developed to the southern limit of the dredging. In Smith Cove the approaches to the docks were carefully sounded out. The hydrography was done upon a scale of 1:5,000 and includes five sheets. The Lake Washington Canal, Smith Canal, and Smith Cove work was done under the immediate direction of the chief of party and the remainder was done by a party in charge of Henry Bernhardt, mate.

While work was in progress in Shilshole Bay outside of the lock, tides were observed upon a staff near the northwest abutment of the Great Northern Railroad bridge. Inside of the lock the lake levels were determined by the Army Engineers at the lock by readings taken twice each day. By obtaining copies of their records it was possible to reduce the soundings to mean lake level, the datum adopted by the Army Engineers and the United States Coast and Geodetic Survey for depths in the canal and the lakes. Two tidal stations were established upon the Duwamish River and readings taken on staffs while work was in progress. Comparisons with the values obtained from the automatic gauge maintained at Madison Street, Seattle, showed very little difference in time or range.

GEODETIC WORK.

NEW JERSEY.

[ISAAC WINSTON.]

SUMMARY OF RESULTS.—Triangulation: 40 square miles of area covered, 17 stations occupied for horizontal measures, 24 geographic positions determined.

In the latter part of April, 1918, after consultation with the naval authorities at Sandy Hook, N. J., the Coast Guard stations Long Branch, Deal Beach, Shark River, Spring Lake, and Squan Beach were visited in company with an engineer, who indicated the objects used as reference points in measuring angles to determine the positions of shells falling in the water in sight of the stations.

On April 30 the field work of triangulation for determining the positions of the necessary points was begun at Asbury Park, N. J.

Old stations Rumson, Wright, Ferris, Como, and Beach House were recovered, and observations were made at these and at the following stations: Long Branch Coast Guard station, Tower Hill 2, Takanassee, Windmill (Shadow Lawn), Windmill (U. S. E.), Shark River Coast Guard station, Squan Beach Coast Guard station, Observatory 2, Monterey Hotel, Spring Lake Coast Guard station, Deal Beach Coast Guard station, High School (Asbury Park).

In addition to the angles necessarily measured a large number of directions were measured to determine the positions of prominent objects.

The field work was completed on May 17.

The positions of the Coast Guard stations were afterwards computed and the geographic positions sent to the Washington office on June 26 for transmission to the naval authorities.

MARYLAND.

[J. A. DANIELS.]

SUMMARY OF RESULTS.—Triangulation: 42 square miles of area covered, 7 signal poles erected, 9 stations occupied for horizontal measures, 10 geographic positions determined.

Between March 22 and 29 and April 3 and 6 the positions of the fire-control towers upon the United States Ordnance Department Proving Ground on the east and west shores of Chesapeake Bay from Plum Point to Wortons Point were determined by triangulation.

The cupola of the Rod and Gun Club at Spesutie Island was used with Turkey Island as a base. To clear the line of sight it was necessary to cut a number of trees on the reservation near Mulberry Point.

All points located were marked by substantial stakes, which will be replaced by concrete monuments by the military authorities.

VIRGINIA.

[J. S. BILBY.]

SUMMARY OF RESULTS.—Reconnoissance (for primary traverse): Length of scheme 55 miles, 27 lines of intervisibility determined, 27 points selected for scheme. Primary traverse: 50 miles of primary traverse run, 27 observing tripods and scaffolds built, average height 16 to 20 feet, 27 stations in main scheme occupied for horizontal measures, 4 stations in supplemental schemes occupied for horizontal measures, 30 geographic positions determined. Leveling: 40 miles of levels run, 37 permanent bench marks established. Azimuth: 1 station occupied for determination of azimuth.

On May 2, 1918, preparations were begun at Portsmouth, Va., for running a line of precise leveling and primary traverse from the vicinity of Norfolk, Va., toward Savannah by way of Weldon and Raleigh, N. C., and Columbia, S. C.

During the early part of May triangulation stations were recovered in the vicinity of Norfolk, Va., signals built, stations occupied, and a connection made with a traverse station on the Virginian Railway. Traverse stations were also selected along the Virginian Railway, signals built, and the stations occupied. During the latter part of the month a traverse tape party and a leveling party were organized. During the latter part of May and early in June the work was much interfered with on account of labor problems. Wages paid by the Norfolk Naval Station for skilled workmen were very much higher than those paid by the Survey, and as a result many of the men left the Survey with the intention of securing work at Portsmouth and Norfolk. Nearly all of the positions in the Survey party were filled with new men, and by June 6 work was making satisfactory progress.

The work was begun from the triangulation stations to the southward of Portsmouth, and connected with the first traverse station which was selected near the Virginian Railway west of the Elizabeth River. Precise leveling was started from bench marks which had been established at the naval station at Portsmouth. Primary traverse and precise leveling were run along the Virginian Railway to a point about 3 miles east of Suffolk; then along the Seaboard Air Line Railway to Suffolk; then along the Virginian Railway to a point 3 miles west of Suffolk; and then continued along the Seaboard Air Line. By June 15 the levels were completed to a point about 5 miles to the westward of Franklin, the signal building had been completed about 15 miles to the westward of Franklin, and the tape measurement and observing party had completed work about 10 miles to the westward of Franklin. On June 16 the charge of the work was transferred to Max Steinberg.

VIRGINIA AND NORTH CAROLINA.

[MAX STEINBERG.]

SUMMARY OF RESULTS.—Primary traverse: Length of traverse 30 miles, 27 observing tripods and scaffolds built, average height of tripods and scaffolds 10 feet, 13 stations in main scheme occupied for horizontal measures. Precise leveling: 30 miles of precise levels run, 30 permanent bench marks established. Azimuth: 1 azimuth station occupied.

On June 16, 1918, the primary traverse party operating on the tracks of the Seaboard Air Line Railway between Norfolk, Va., and Savannah, Ga., was transferred to Max Steinberg by J. S. Bilby. At that time the work was completed to a point 3 miles south of Franklin, Va. By the end of the month, the work had been carried to Seaboard, N. C. Work was still in progress at the close of the fiscal year.

The entire party, consisting of four subparties, worked within a limited distance of 10 to 15 miles, and it was planned to continue this method. One railroad conductor was employed with the party.

NORTH CAROLINA.

[W. C. HODGKINS.]

SUMMARY OF RESULTS.—Triangulation: 20 square miles of area covered, 60 signal poles erected, 6 observing tripods and scaffolds built, height 15 feet, 54 stations in supplemental schemes occupied for horizontal measures, 180 geographic positions determined, 26 positions of floating objects determined.

The tertiary triangulation of the Cape Fear River was begun July 9, 1917. A preliminary examination was made for the purpose of obtaining a knowledge of the topography of the country to be traversed and the facilities available as to transportation, obtaining supplies, and assistance required in the work.

Useful information and aid were obtained from the officer of the Corps of Engineers, United States Army, in charge of the improvement of the Cape Fear River and from the officer of the United States Naval Reserve in command of the Wilmington section of the sixth naval district, and from other Government officials.

A suitable power launch was hired for the transportation of the party.

After recovering as many of the stations of the old triangulation as possible, a connected scheme of new stations was laid out, joined by suitable triangles to the bases furnished by the lines between the old stations. Considerable difficulty was experienced in this part of the work in Wilmington and its immediate vicinity because of the changes which have occurred since the date of the former work there and also because of the extreme narrowness of the river at that point, which has the effect of making the lines very short and of correspondingly increasing the necessary number of figures.

Seven stations of the triangulation of 1908 were recovered and three of the stations established in 1913. Twenty-two stations established and marked by the Unted States Engineers were recovered and used in the triangulation, either as regular stations or as intersection points.

Before the extension of the triangulation down the river, it was carried to the northward as far as Point Peter, at the junction of the northeast and northwest branches of the Cape Fear River, where connection was made with a permanent station of the United States Engineers.

The shores of the river are generally low, frequently swampy, and for the most part wooded, so that considerable difficulties were had in the matter of finding suitable sites for stations. Considerable clearing of trees and brush was required and several scaffold signals were found necessary.

Many of the stations were under water at high tide, and only three below Wilmington were much above the river level.

A reconnoissance for connection by a line of traverse between the triangulation of the Cape Fear River and the coast triangulation and for an extension of the coast triangulation was made.

An examination was made of tidal bench marks at Wilmington which had been connected with an automatic tide gauge established there in 1908.

Five of the seven bench marks were found to be in existence in apparently good condition.

Five new bench marks were establishd and marked with brass disk markers set in the walls of permanent buildings, and their elevations were determined by a double line of levels.

On account of unfavorable weather, work was closed for the season on January 16, 1918.

[CLEM L. GARNER.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 20 miles, 25 square miles of area covered, 74 lines of intervisibility determined, 32 points selected for scheme. Base lines: 2 secondary, 3 kilometers in length. Triangulation: 25 square miles of area covered, 29 signal poles erected. 2 observing tripods and scaffolds built, average height 10 feet; 34 stations in main scheme occupied for horizontal measures, 40 geographic positions determined. Leveling: 3 miles of wye levels run. Azimuth: 1 azimuth station occupied.

Between May 23 and June 30, 1918, a scheme of tertiary triangulation was completed connecting with the coast triangulation of 1914 south of Beaufort, N. C., and extending through Masonboro and Myrtle Sounds to the Cape Fear

River. The connection with the southern end of the triangulation in the Cape Fear River was made by a traverse from the south end of Myrtle Sound across the peninsula to the river.

A party was organized for establishing and marking stations and erecting signal poles. This party also staked out the base and traverse lines and prepared them for the measurements.

A second party was trained for observing horizontal angles and the chief of party, when time and other conditions permitted, also took part in this work.

The work was carried on in this manner until the last few days, when the bases and traverse were measured and azimuth observed, and leveling done over the base and traverse lines.

One small power boat and three small skiffs were used in the sounds for transporting the party. Some difficulties were encountered on account of the very shallow water in the sounds, and this was especially true at low water when there are many of the main channels which go dry. To avoid this the work was arranged to suit the tides as nearly as possible, and, except for a few days in Wrightsville Sound, there were only a few delays.

With 34 stations occupied in the main scheme, which close 58 triangles, the average closure was 3.6 seconds with 9 seconds the maximum. All observations, including the azimuth, were made with the 7-inch theodolite, following the field instructions for tertiary triangulation. The time observations for the azimuth were made with a vertical circle.

GEORGIA.

[C. V. HODGSON.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 52 miles, 89 points selected for scheme. Triangulation: Length of traverse 41.1 miles, 89 observing tripods and scaffolds built, 53 stations in main scheme occupied for horizontal measures and their geographic positions determined. Leveling: 18.6 miles of levels run (over stakes of traverse). Azimuth: 1 station occupied for observation of azimuth.

Work on the primary traverse from Brunswick to Columbus, Ga., via Macon, was in progress at the beginning of the fiscal year, having been carried to within 15 miles of Macon at the end of June. Progress made to that time is stated in the annual report for 1917, in which the methods followed are also briefly mentioned.

Motor velocipede cars were used for the transportation of the party.

During the season Lieut. Francisco Stewart, of the Argentine Naval Commission, visited the party for the purpose of inspecting the work with invar tapes.

On July 31 the charge of the party was transferred to George D. Cowie, the work having then reached the vicinity of Fort Valley, Ga.

[GEORGE D. COWIE.]

SUMMARY OF RESULTS.—Primary reconnoissance (traverse): 8 stations selected for main scheme. Primary traverse: 89 miles of traverse run, 87 stations occupied for horizontal measures. Azimuth: 2 azimuth stations occupied. Leveling: 23 miles of levels run.

The primary traverse party which had been under the charge of C. V. Hodgson operating between Brunswick and Fort Valley, Ga., was on August 1 transferred to George D. Cowie, who continued the work in the same manner as before.

Five motor cars were used for transportation of the party, instruments, and equipment on this work. These did not give satisfactory service, owing to frequent breakdowns and overloads.

The primary traverse line from Fort Valley to Upatoi, Ga., was in a hilly country, and many curves delayed the work, on account of many short tangents and frequent scaling of high banks to reach the traverse stations.

At Upatoi the traverse was changed to triangulation, and a connection was made with the triangulation stations of the party under charge of E. H. Pagenhart.

While this triangulation and signal building was being completed, a preliminary reconnoissance from Macon to Atlanta was made by R. V. Miller, which indicated that the line should follow the Central of Georgia Railway tracks from Macon toward Atlanta and change to triangulation when ground was favorable.

At Upatoi a connection was made with a traverse station of the United States Geological Survey.

Azimuth was observed at Station "Fort" near Fort Valley and at a station near Butler, Ga.

On completing the work toward Columbus the party returned to Macon and started from some of the traverse stations, previously determined, traversing to a hill near the city reservoir, and then by secondary triangulation carried the line across the city to points north of Macon near Vineville Station, thereby avoiding a very crooked track, short tangents, and numerous signals. The points occupied in Macon were college towers.

By the end of September the line was carried to a point near Forsyth, Ga., and reconnoissance for primary triangulation from this point to stations on the eastern oblique arc of triangulation near Atlanta was practically completed.

As G. D. Cowie was transferred to the Coast Artillery Corps on the 24th of September, the work was placed in shape to turn over to O. W. Ferguson on the 30th.

Forked stakes were used to stretch the tape and later a form of stake designed by Mr. Pagenhart, which was an improvement.

The progress when the party was not engaged in triangulation was at the rate of approximately 70 miles per month.

[O. W. FERGUSON.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 101 miles, 1,474 square miles of area covered, 19 points selected for scheme, 152 points selected for traverse line. Triangulation: 735 square miles of area covered, 87 signal poles erected, 18 observing scaffolds and tripods built (average height 28.77 feet), 11 stations in main scheme occupied for horizontal angles, 49 traverse stations occupied, 79 geographic positions determined. Leveling: 226 miles of levels run, 205 permanent bench marks established.

By July 1, 1917, the line of precise levels from Brunswick, Ga., toward Macon, Ga., had been completed to 5 miles eastward of Eastman, Ga., and by July 26 the line was completed to Macon. Between July 27 and August 10 leveling was completed on a line from Macon to near Fort Valley; between August 17 and September 20 a line was completed between Macon and McDonough, Ga.; and between September 26 and October 22 a line from Macon to Griffin, Ga., was completed.

Motor cars were used for the transportation of the party and equipment, permission to use them having been obtained from the Southern Railroad Co., on condition of the employment of a conductor.

Adding machines were used for recording level readings.

The highest points at centers of the rails were at first used for rod supports. After reaching Macon the spikes were used for rod supports.

Standard bench marks were placed about every fourth mile. The traverse station marks were all determined as bench marks, and disk bench marks were set in railroad stations and other suitable places in every town, so that the average distance between bench marks is not more than 1 mile.

On September 26 charge of the party previously under the direction of G. D. Cowie engaged in traverse and triangulation work between Macon and Atlanta, Ga., was transferred to Mr. Ferguson.

It had been planned to run a line of traverse from Macon to Forsyth and another, for a base, from Barnesville to Griffin, and to execute a scheme of triangulation from Forsyth to Atlanta.

As soon as the precise leveling had been done and stations had been selected observations were begun on the triangulation.

On December 13 in accordance with instructions most of the party was transferred to Macon to work on the traverse from Macon to Savannah. Part of the force had been detached about a month before to begin this traverse work.

On January 16, 1918, the party was transferred to Jasper S. Bilby.

[J. S. BILBY.]

SUMMARY OF RESULTS.—Reconnoissance (for primary traverse): Length of scheme 176 miles, 210 lines of intervisibility determined, 210 points selected for scheme. Primary traverse: 210 observing scaffolds and tripods built (heights 8 to 20 feet), 210 stations in main scheme occupied for horizontal measures, 210 geographic positions determined. Leveling: 176 miles of levels run, 242 permanent bench marks, and 180 reference bench marks established. Azimuth: Azimuth observed at 3 stations on six nights.

On January 16, 1918, the charge of the party engaged in running a line of primary traverse from Macon to Savannah, Ga., was transferred by O. W. Ferguson to J. S. Bilby.

At that time a small scheme of reconnoissance had been completed for triangulation, a few signals built and stations made ready for observation, about 6 miles

of traverse line had been prepared, and tape measurements made over the prepared portion of the line. About 30 per cent of the measured line was on stakes, and as no stake levels had been run and most of the stakes had been removed by persons living in the vicinity, it was necessary to restake and remeasure that part of the line.

An inspection of the line of work showed that it would be necessary to have two parties to keep up the observing, and on account of car shortage it was not practicable to carry on the building, taping, stake leveling, keep two observing parties at work, and have cars for the precise leveling work. It was therefore necessary to postpone the leveling and to purchase new cars.

As the cars which had been in use were not suitable for the work, cars of a new type were obtained, and these were found satisfactory in every way.

During the month of February there were five subparties at work, as follows: One building party of 1 foreman-hand and 2 men, taping party of 7 men, stake-leveling party of observer and 1 man, and two observing parties, each consisting of 1 observer and 3 men. Early in March a precise leveling party was organized, which consisted of the observer and 4 men.

On March 22 the building, tape measurements, and stake leveling were completed to Savannah, and soon afterwards a second leveling party was organized, the leveling and observing was carried on, and by April 20 the observing had been completed. All field records were brought up to date and forwarded to the office. On May 1 the two leveling parties were left to complete the levels to Savannah and other members of the party moved to Portsmouth, Va., to take up work in that vicinity. By May 20 the levels were completed to Savannah, the records were forwarded to the office, and the leveling parties moved to Virginia.

The line of traverse and precise leveling between Macon and Savannah was run over the following-named railroads: Macon to Dublin, Macon, Dublin & Savannah Ry.; Dublin to Brewton, Wrightsville& Tennille Ry.; Brewton to Statesboro, Central of Georgia Ry.; Statesboro to Cuyler, Savannah & Statesboro Ry.; and Cuyler to Savannah, Seaboard Air Line Railway. The length of the line is about 175 miles. There are 205 primary stations, and nearly all stations of the primary traverse were made precise level bench marks. In addition to the traverse station bench marks, a precise level mark was established in each town along the line of work.

[E. H. PAGENHART.]

SUMMARY OF RESULTS.—Primary traverse: 97 miles of traverse line measured with tapes. 60 signal poles erected, 83 observing tripods and scaffolds built (average height 3.6 feet). Leveling: 18 miles of levels run.

The traverse work in progress on June 30 in the vicinity of Willingham, Ga., was continued to Albany along the Atlantic Coast Line Railway, a distance of about 12 miles, and from Albany to Columbus over the Seaboard Air Line tracks.

The tape work was finished to Columbus on August 25, and construction work was completed August 31. On September 1 the party was turned over to another officer. On the date of transfer all of the work on the line had been completed with the exception of the observing, which was finished to the vicinity of Richland, leaving about 80 stations to be observed.

From Kimbrough to Columbus, the last 45 miles of the line, there is almost an entire separate scheme carried along the hills near the track to control the azimuth of the track stations. At Albany, Dawson, and Parrott the controlling azimuth was carried through lines by omitting some of the track stations.

Triangulation stations Cusseta and Columbus, which are situated on commanding hills near the railway to control the azimuth, will be connected with triangulation station Rich, near Upatoi, a station on the Brunswick line. At Columbus the traverse expands into a five-point figure. Two of these stations were needed for control. The three additional ones were located on bare hills where only instrument stands were needed. This gave convenient points for later work.

[CLEM L. GARNER.]

SUMMARY OF RESULTS.—Reconnoissance (for traverse): Length of scheme 35 miles, 39 lines of intervisibility determined, 65 points selected for scheme. Primary traverse: Length of traverse, 25 miles, 39 signal poles erected, 33 observing tripods and scaffolds built (average height 12 feet), 11 stations in main scheme occupied for horizontal measures, 37 stations in supplemental schemes occupied for horizontal measures, 56 geographic positions determined. Leveling: 6 miles of levels run. Azimuth: 1 azimuth station occupied.

The party under charge of E. H. Pagenhart, engaged in running a line of primary traverse from Jacksonville, Fla., to Columbus, Ga., was, on September 1, 1917, transferred to Clem L. Garner, with instructions to run a line of primary traverse from Albany, Ga., toward Callahan, Fla., where connection was to be made with the Jacksonville–Columbus line of primary traverse completed earlier in the year. The party was taken to Albany, the starting point of the work, where the motor cars to be used in the work were repaired.

The traverse was begun September 4 and was continued to the south over the Georgia Northern Railway. This railroad is very crooked and contains on an average 1½ curves to the mile, some of which are very long. The country is heavily wooded in patches and, being only slightly rolling, triangulation was not practicable. On September 29, 1917, the party was transferred to M. E. Lutz, at Doerun, Ga. The progress to that time was 25 miles.

The character of country and the very crooked road caused the lines between subsidiary stations to be slightly shorter than the average and also made necessary a great deal of clearing and staking in order to get around the curves. The azimuths for control, however, were always on lines more than a mile long, and the stations for these azimuths were strongly tied into the subsidiary stations, thus forming a very strong system of control.

[MAX STEINBERG.]

SUMMARY OF RESULTS.—Precise leveling: 208.3 miles of levels run, 130 permanent bench marks established.

On July 12, 1917, the charge of the precise-leveling party previously under charge of C. L. Garner at work on the line between Jacksonville, Fla., and Columbus, Ga., was transferred to Max Steinberg, at Columbus, Ga. The line was then continued along the Central of Georgia Railway to Bliss, Ga., to connect with the line run by O. W. Ferguson from Brunswick, Ga. On August 10, after connection had been made with the line from Brunswick, Ga., the party was moved to Albany, Ga., a distance of 80 miles. On August 11 work was begun on the Albany–Callahan line. The route lay along the Georgia Northern, Valdosta, Moultrie & Western and the Georgia Southern & Florida Railroads by way of Albany, Moultrie, and Valdosta, Ga., to Callahan, Fla. The line was carried as far as Council, Ga., on October 5. The party was then transferred to M. E. Lutz, to be continued by him in connection with the traverse over the same line.

In order to furnish the required information for the traverse party it was necessary to determine the elevation of the top of the rail at each point of curve, point of tangent, and opposite all permanent and temporary bench marks. Certain sections of the line were found to be a continuous series of curves. Between Albany and Moultrie, a distance of 38 miles, there were 68 curves. The progress of the party was necessarily retarded. Throughout the entire season conductors furnished by the railroads were employed in the party.

Permanent bench marks were set on the average about 1.6 miles apart.

[CLEM L. GARNER.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 55 miles, 1,000 square miles of area covered, 25 miles of intervisibility determined, 12 points selected for scheme. Triangulation: 1,000 square miles of area covered, 13 observing tripods and scaffolds built (average height 32 feet, with greatest height 57 feet), 13 stations in main scheme occupied for horizontal measures, 13 stations occupied for vertical measures, 32 geographic positions determined, 20 elevations determined trigonometrically.

Between April 1 and May 22, 1918, connection was made by primary triangulation between the primary traverse at Griffin, Ga., and the oblique arc of primary triangulation in the vicinity of Atlanta, Ga.

This work began on the line Wise–Jackson, which was a line of the first quadrilateral projected from the traverse between stations Hog Mountain and Wise as a base.

The country in this vicinity is rolling, with few hills of any prominence and heavily wooded in patches, which often occur on the tops of the hills, and necessitated the building of structures in order to bridge over them.

Some stations for the continuation of this scheme had been established and structures built over them. It was found, however, that several of the stands and scaffolds were blown down and that several of the proposed lines were not visible. As a result the entire scheme was changed. The length of lines was made to average about 12 miles, which reduced the length considerably from that originally proposd and proved to be a more economical length of line in a

country where haze and poor atmospheric conditions for observing prevail. With this length of line and the large electric lamps, few delays are to be expected on account of haze and bad seeing.

Two building parties of four men each were organized, while the chief of party did the reconnoissance and selected the stations. The work was delayed for about 10 days during the first part of April while there was a dense haze and smoke which made it impossible to determine the visibility of lines more than 6 miles long. Fortunately, the entire party was not delayed this amount of time, for several stations had been selected and the structures were put up during this time.

On the completion of the reconnoissance the building parties were drawn upon for enough men to begin the light keeping and recording, and only two men were left to complete the building. This was very practical, since the structures after this time were mostly small and could be well managed even by one man. Trucks and automobiles secured from local places were used in the transportation.

The equipment for the observing was practically the same as for the ordinary primary triangulation party except for trucks which have generally been used for transporting the party from place to place. On this work the light keepers moved by train, mostly hiring teams or automobiles to take them from station to railway, and vice versa. The observing party, for the most part, used Ford cars for carrying instruments from station to station. In addition to the usual equipment all light keepers were given a large electric lamp and batteries for use during bad haze or other atmospheric conditions which made seeing difficult. The acetylene lamps were used during ordinary conditions, since they were considerably more economical than the electric lamps.

The total number of stations occupied was 13, requiring one month from the time the observations were started until they were completed and the party left for other work in North Carolina.

The average closure for the work consisting of 18 triangles was 1.5 seconds, or a little more than that called for in primary triangulation. Considering, however, that the connection to the south was with a line of traverse over very crooked road where the accuracy could by no means be compared to the triangulation, it seemed inadvisable to reoccupy stations to reduce this mean closure.

GEORGIA AND SOUTH CAROLINA.

[MELVIN E. LUTZ.]

SUMMARY OF RESULTS.—Reconnoissance (for traverse): Length of scheme 227 miles, 174 points selected for scheme. Primary traverse: Length of traverse run 225 miles, 48 signal poles erected, 126 observing tripods and scaffolds built (average height of scaffolds and tripods 16.8 feet), 166 stations in main scheme occupied for horizontal measures, 66 stations in supplemental scheme occupied for horizontal measures. Leveling: 295 miles of precise levels and 28 miles of wye levels run, 149 permanent bench marks established. Azimuth: 10 azimuth stations occupied.

On January 1, 1918, active preparations were in progress for running a primary traverse and precise level line from Savannah, Ga., to Everett City, Ga., in compliance with instructions dated December 11, 1917. The route of this primary traverse and precise level line followed the main line of the Seaboard Air Line Railway from Savannah, Ga., to Everett City, Ga., and the level line was extended from Everett City, Ga., to Yulee, Fla. The latter section of the line was not covered by primary traverse.

This work was through timbered and marshy country, which was practically level. The conditions for traverse and leveling were ideal. The highest signal that it was found necessary to erect on this line was 18 feet in height. This work was pushed to completion rapidly, and on January 28 instructions were received to take up the work of extending primary traverse and precise levels from Savannah, Ga., to Norfolk, Va. On about February 8 the traverse work was completed to Everett City and the construction and traverse parties started working northward on the line toward Norfolk. The leveling party continued on to Yulee.

Permits had not been received for the use of motor cars on the main line northward from Savannah, and the work was carried forward for the first month and one-half by using local passenger trains as much as possible for the transportation of parties to and from the field, while the construction work which involved the transportation of materials of course could not be prosecuted in this manner. A 1½-ton truck was rented in Savannah, and the construction work was pushed to a point 80 miles north of Savannah by this means.

The observing party had progressed on the Albany–Callahan line to Moultrie, Ga., at the first of the year. During the early part of January two observers were put on this work, so that this branch of the work would not lag so far behind. By the first of April the observing had been completed on the Albany–Callahan line, and was nearing completion on the Savannah–Everett line.

As it became necessary to secure more transportation of some kind in order to prosecute the work on the line north, the question was taken up with the superintendent of the Seaboard Air Line Railway system of getting permission for the use of motor cars. After some delay the desired permission to operate cars was granted. The motor truck was returned from Olar, S. C., to Savannah, and the motor cars, which had been laid up for two months, were put into use again.

The country over which this truck was used was decidedly unfavorable for its use, and it was put to a severe test. The roads were poor, the main difficulty being sand hub deep which would slow up and stall anything but the strongest car. It was necessary to run in low gear the greater portion of the time. Even with all these obstacles in the way of efficient transportation, it can be said for the truck that it is a feasible method of carrying on the work, but slower and more costly than by using motor velocipedes on the railway. The conditions were unfavorable for the truck in that the highways did not parallel the railway, and it was frequently necessary to make long detours to where the road crossed the railway in an effort to get material for signal building to the proper location.

The route of the primary-traverse and precise-level line northward from Savannah followed the main line of the Seaboard Air Line Railway. Of the work covered to the end of the fiscal year, that section lying between Savannah, Ga., and Norway, S. C., was ideal for traverse and levels. The country throughout this belt is level, fairly heavily timbered, and there are but few curves. From Norway, S. C., to Blaney, S. C., where the work had progressed at the end of the fiscal year, the country becomes more hilly and the conditions for traverse work are rather unfavorable—in some places difficult. Numerous long and sharp curves are encountered. It was necessary to carry a main scheme azimuth through this section somewhat independent of the tape work on the track but tied to the tape work at each main scheme station. The main scheme was carried through, however, without excessive building, the highest signal being 36 feet in height: It was necessary, however, to construct a number of signals of this height.

On February 21 instructions were received to make connection between the line of primary traverse passing the city of Savannah and the triangulation existing along the Savannah River. While other work was in progress this connection was made by the establishing of three quadrilaterals. On March 21 instructions were received for making a connection with the primary traverse line extending from Augusta, Ga., to Beaufort, S. C., via Fairfax, S. C. In order to carry out these instructions it was necessary to run a spur line of the primary traverse and precise levels to Allendale, S. C.

At the close of the fiscal year all branches of the work were under way at a point near Blaney, S. C.

GEORGIA AND FLORIDA.

[MELVIN E. LUTZ.]

SUMMARY OF RESULTS.—Reconnoissance (for traverse): Length of scheme, 160 miles; 160 points selected for scheme. Primary traverse: Length of traverse, 160 miles; 65 signal poles erected, 94 observing scaffolds and tripods built (average height of scaffolds and tripods, 18.3 feet), 47 stations in main scheme occupied for horizontal measures, 82 stations in supplemental schemes occupied for horizontal measures. Leveling: 15 miles of wye levels run, 48.8 miles of precise levels run, 22 permanent bench marks established. Azimuth: 2 azimuth stations occupied.

On October 1, 1917, the primary traverse party which had been under the charge of C. L. Garner was transferred to Melvin E. Lutz. The party was then located at Doerun, Ga., on the Georgia Northern Railway, and the invar tape and construction work had advanced to Bridgeboro, Ga.

On October 8 the precise leveling party under charge of Max Steinberg was transferred to Mr. Lutz and the precise leveling operations were suspended for the time being, as the level line had then been carried to the vicinity of Fargo, Ga., about 100 miles in advance of the work of the traverse party.

The route for the primary-traverse and precise-level line followed the Georgia Northern Railway to Moultrie, Ga.; thence via the Valdosta, Moultrie

& Western Railway to Valdosta, Ga.; thence via the Georgia, Southern & Florida Railway to Crawford, Fla.; thence via the Seaboard Air Line to Callahan, Fla., connecting at that point with the Jacksonville-Columbus primary traverse and level line.

The entire work was through timbered country which, in general, was practically level. From Bridgeboro to Moultrie, on the Georgia Northern Railway, conditions for traverse work were only fair, as many sharp curves and rather steep grades were encountered. The main scheme, however, was carried through this section without excessive building, the highest signal being 36 feet in height.

From Moultrie to Valdosta, a distance of 42 miles, conditions for primary-traverse work were also fair, some of the way very good. In some sections, however, numerous sharp curves were encountered. Through this section the main scheme was also carried forward without excessive building, the highest signal again being 36 feet in height.

From Valdosta to Callahan the work was carried forward under almost ideal conditions, the highest signal required being only 10 feet. One tangent 20 miles in length facilitated progress very much.

The best day's work for invar-tape measurements, under the most favorable conditions, was 7 miles of completed line. This distance was measured without working excessive hours and without undue fatigue to the members of the party. It was accomplished by a thorough coordination of each man's work so that there was no lost motion.

As previous experience proved that 2½ to 3 miles gave the most economical length of line for construction and observing, this length was adhered to throughout the progress of the work. It had also been found that very substantial tripods up to 36 feet in height could be built out of 2 by 4 lumber.

Careful attention was paid to the carrying through of a main-scheme azimuth where short lines were encountered, so that this portion of the work would not be weakened. The shortest main-scheme line established is seven-eighths of a mile in length.

When the primary-traverse work was carried forward to Fargo, Ga., the precise-level party was again organized and the levels were carried through to Callahan simultaneously with the primary traverse.

At the time of the transfer of the party, observations on the Jacksonville-Columbus primary-traverse line had not been completed, and the observer was working in the vicinity of Columbus, Ga. It took one month, or until the 1st of November, to complete the observation and azimuth work on that line.

Early in November the observer accordingly started on the Albany–Callahan line, and at the close of the calendar year had advanced as far as Moultrie, Ga.

Motor velocipedes were used throughout as a means of transportation. Altogether the party had eight motor velocipedes.

On December 11 instructions were received to establish primary-traverse and precise-level line between Savannah, Ga., and Everett City, Ga. By December 17 the construction and invar-tape measurements had been completed to Callahan, Fla., on the Albany–Callahan line, and this portion of the party moved to Savannah, Ga., to take up work on the new line. The precise-level line was completed to Callahan, Fla., on December 22.

At the close of the calendar year active preparations and outfitting were under way for the Savannah–Everett City line.

[W. B. FAIRFIELD AND J. E. MCGRATH.]

SUMMARY OF RESULTS.—Latitude and longitude: 11 primary latitude stations established, 20 longitude differences (telegraphic) determined, signals exchanged on 65 nights.

During the period between August 17, 1917, and June 28, 1918, differences of longitude were determined between Atlanta and Hump (Macon), Ga.; Hump (Macon) and Fort Valley, Ga.; Hump (Macon) and Cochran, Ga.; Cochran and Mud (Eastman), Ga.; Mud (Eastman) and Joint (Hazelhurst), Ga.; Joint (Hazelhurst) and Jesup, Ga.; Jesup and Brunswick southeast base, Ga.; Brunswick southeast base, Ga.; and Fernandina, Fla.; Fernandina and Lancaster 2 (Jacksonville), Fla.; Lancaster 2 (Jacksonville), Fla., and Folkston, Ga.; Folkston and Waresboro, Ga.; Waresboro and Willacoochee, Ga.; Willacoochee and Valdosta, Ga.; Valdosta and Jones (Sumner), Ga.; Jones (Sumner) and Sylvester D, Ga.; Sylvester D and Kimbrough, Ga.; Kimbrough and Columbus E, Ga.; Columbus E and Butler, Ga.; Butler and Harmon, Ga.; Harmon and Riley, Ga.

From November 28 to December 31 very unfavorable weather was experienced.

Observations were made and exchange of signals had between Atlanta and Hump (Macon) on August 26 and September 6 and 7, completing the line.

Observations were made and exchange of signals had between Hump (Macon) and Forty Valley on September 18, 19, and 20, completing the line.

Observations were made and exchange of signals had between Hump (Macon) and Cochran on October 1, 3, and 4, completing the line.

Observations were made and exchange of signals had between Cochran and Mud (Eastman) on October 12, 13, and 15, completing the line. Observations for the determination of latitude were made at Cochran on October 15.

Observations were made and exchange signals had between Mud (Eastman) and Joint (Hazelhurst) on October 22, 23, and 24, completing the line. Observations for the determination of latitude were made at Joint (Hazelhurst) on October 30.

Observations were made and exchange of signals had between Joint (Hazelhurst) and Jesup on November 1, 2, 3, and 4, completing the line.

Observations were made and exchange of signals had between Jesup and Brunswick southeast base on November 16, 17, and 18, completing the line. Observations for the determination of latitude were made at Brunswick southeast base on November 24.

Observations were made and exchange of signals had between Brunswick southeast base and Fernandina on November 27 and December 1 and 2, completing the line.

Observations were made and exchange of signals had between Fernandina and Lancaster 2 (Jacksonville) on December 22, 28, and 30, completing the line. Observations for the determination of latitude were made at Lancaster 2 (Jacksonville) on January 15.

Observations were made and exchange of signals had between Lancaster 2 (Jacksonville) and Folkston on January 25, 26, 28, and 29, completing the line.

Observations were made and exchange of signals had between Folkston and Waresboro on February 7, 8, 9, and 10, completing the line.

Observations were made and exchange of signals had between Waresboro and Willacoochee on February 23, 24, and 25, completing the line.

Observations were made and exchange of signals had between Willacoochee and Valdosta on March 12, 13, 14, and 15, completing the line.

Observations were made and exchange of signals had between Willacoochee and Jones (Sumner) on March 25, 26, and 27, completing the line. Observations for the determination of latitude were made at Jones (Sumner) on April 2.

Observations were made and exchange of signals had between Jones (Sumner) and Sylvester D on April 13, 15, and 16, completing the line. Observations for the determination of latitude were made at Sylvester D on April 22.

Observations were made and exchange of signals had between Sylvester D and Kimbrough on April 28 and May 1 and 2, completing the line. Observations for the determination of latitude were made at Kimbrough on May 3.

Observations were made and exchange of signals had between Kimbrough and Columbus E on May 8, 9, 10, and 11, completing the line. Observations for the determination of latitude were made at Columbus E on May 18 and 19.

Observations were made and exchange of signals had between Columbus E and Butler on May 21, 22, and 24, completing the line. Observations for the determination of latitude were made at Butler on May 25.

Observations were made and exchange of signals had between Butler and Harmon on May 31 and June 1 and 13, completing the line. Observations for the determination of latitude were made at Harmon on June 15.

Observations were made and exchange of signals had between Harmon and Riley on June 16, 18, and 19, completing the line. Observations for the determination of latitude were made at Riley on June 22.

The Western Union Telegraph Co. cooperated with the observers in this work, making all the connections when required and seeing that everything necessary was done in a very prompt and efficient manner.

On June 25 arrangements were made to begin observations for the determination of the difference of longitude between Riley and Fort Valley, but on June 27 the work was temporarily suspended in order to make certain measurements on the traverse lines in the vicinity of Macon.

The distances between traverse stations Ira and Amons at Forsyth, Ga., and stations Rock and Martin at Vineville, Ga., were measured with a steel tape. Traverse station Gun at Jeffersonville, Ga., was recovered and the difference of

elevation between it and the reference mark was determined. This work was completed on June 29.

In order to expedite the longitude work the sites of the stations were selected and the observatories built in advance of the arrival of the observers.

FLORIDA, GEORGIA, AND ALABAMA.

[G. D. COWIE.]

SUMMARY OF RESULTS.—318 miles of levels run, 116 permanent bench marks established.

Between January 1 and April 5, 1917, the line of precise leveling between Tallahassee, Fla., and Mobile, Ala., was continued from the vicinity of Birmingham to Mobile, Ala.[a]

Connections were made during the period covered by this abstract with several bench marks of the precise levels of the Tennessee Coal & Iron Co. south of Birmingham and with bench marks of the United States Engineers at the Coosa River, Ala., and at the Tombigbee River, Ala., near Jackson.

The above connections were close and afforded excellent checks on the work.

On this line connections had been made with the United States Geological Survey bench marks at Columbus, Ga., at several places between Columbus and Atlanta, Ga., between Atlanta and Birmingham along the Seaboard Air Line tracks, and between Birmingham and Ashby, Ala.

MISSISSIPPI.

[H. G. AVERS.]

SUMMARY OF RESULTS.—Precise leveling: 22 miles of levels run. 13 permanent bench marks established.

Upon the completion of the lines of levels to Point Isabel, Tex., the observer proceeded, on February 13, 1918, to Biloxi, Miss., arriving there February 16, 1918.

On February 18, 1918, work was begun on a line of precise levels to extend from Biloxi, Miss., to River Junction, Fla., over the tracks of the Louisville & Nashville Railroad. Connections were made with several bench marks of the United States Engineers at Biloxi, and the line was then extended to the tide gauge of the United States Engineers on Biloxi Bay.

At the tide gauge connections were made with the tide staff and with the reference bench marks.

After leaving the tide gauge the level line follows the Louisville & Nashville Railroad through Ocean Springs and Pascagoula, Miss.

In accordance with instructions of February 27, 1918, the chief of party was relieved of this work by Douglas Karr on March 5, 1918, the line having been completed to Pascagoula, Miss., at the time.

MISSISSIPPI, ALABAMA, AND FLORIDA.

[DOUGLAS KARR.]

SUMMARY OF RESULTS.—Precise leveling: 184 miles of precise levels run, 84 permanent bench marks and 149 temporary bench marks established.

On March 5, 1918, Douglas Karr relieved H. G. Avers of the charge of the precise leveling party operating on the line from Biloxi, Miss., to River Junction, Fla. The work had then been completed to Pascagoula, Miss.

The work was afterwards carried along the line of the Louisville & Nashville Railroad, and by June 30 was completed to a point 15 miles east of Pensacola, Fla.

A spur line of levels was run from Theodore, Ala., to Bayou la Batre and Alabama Port, Ala., to connect with the tide staffs established by the party on the U. S. *Hydrographer*. A short spur line was also run at Mobile, Ala., to connect with the tide staff established there by the U. S. *Hydrographer*.

For practically all permanent bench marks the regulation United States Coast and Geodetic Survey disk was used. Care was taken to always set these disks in substantial structures. Reinforced concrete posts, with the disk set

[a] In the annual report for 1917 the abstract of the portion of this work done between Jan. 1, 1917, and Apr. 5, 1917, was accidentally omitted. It is here inserted, although belonging to another fiscal year, in order that the record may be complete.

in the top, were also used as bench marks. In placing these posts care was taken to select good ground, and they were well tamped in place.

Temporary bench marks were lag screws driven in mileposts, rail-rack posts, or telegraph poles, whichever appeared more solid and enduring. Ordinary railroad-track spikes driven in structures and tie bolts on bridges were also used.

The equipment consisted originally of two velocipede motor cars, on one of which the instrument was mounted and upon the other the adding machine. These cars were new and gave good service. A motor car of different make was afterwards received from another party and gave good service.

LOUISIANA AND TEXAS.

[MAX STEINBERG.]

SUMMARY OF RESULTS: Precise leveling: 498 miles of levels run, 306 permanent bench marks established.

The line of levels completed by this party between January 18 and June 1, 1918, extends from Sinton, Tex., by way of the St. Louis, Brownsville & Mexico Railroad to Houston, Tex.; then continues eastward over the Southern Pacific Railroad to New Orleans. Spur lines were run to the Gulf coast from Placedo to Port Lavaca, Tex., over the Galveston, Harrisburg & San Antonio Railway; Bay City to Matagorda, Tex., over the Gulf, Colorado & Santa Fe Railway; Angleton to Freeport, Tex., over the Houston & Brazos Valley Railroad; Beaumont to Sabine Pass, Tex., over the Southern Pacific Railroad.

On June 1 the party was transferred to Casper M. Durgin. At that time the line was completed to Estherwood, La. The above work, as well as that previously reported upon during this year, was done at the request of the Chief of Engineers of the United States Army to furnish vertical control for topographic surveys.

At Sinton the line was started from three Coast and Geodetic Survey bench marks established several months earlier. Connection was made with three Coast and Geodetic Survey bench marks at Houston, Tex. Connections were also made with one tidal bench mark at Quintana, Tex., several United States Geological Survey bench marks on the Southern Pacific Railroad east of Houston, one United States Army Engineer bench mark on the west abutment of the Texas & New Orleans Railroad bridge at Beaumont, Tex., and with the line of United States Geological Survey bench marks on the Southern Pacific Railroad east of Jennings, La. A careful search was made for the old tidal bench marks established by the Survey at Matagorda and Velasco, but only one, the top of an iron pipe of an artesian well at Quintana, near Velasco, could be found. The terminals of the spur lines to the coast were well marked with plates in permanent structures and will doubtless be easily recovered for use in connection with future hydrographic work.

The officials of the Southern Pacific Railroad having refused permission for the operation of our motor cars over that road between Houston and New Orleans, on account of the heavy traffic and frequent fogs, the motor cars were shipped to C. L. Garner, at Wilmington, N. C. The party then proceeded to level on foot. A motor truck was secured for use in carrying the observing party to and from work. This was found to be very convenient as long as the highway paralled the railroad.

Permanent bench marks were placed on the average of 1½ miles apart. Many of the temporary marks on the Southern Pacific line, such as corners of concrete bases of fairly massive block signals, are of a permanent character and can be readily recovered, but are not marked. The total number of permanent and temporary bench marks were placed on the average of one bench mark to eight-tenths of a mile. Of the permanent marks, 122 are square concrete posts with the standard metal disk set flush with the top. One hundred and eighty-four standard metal plates were set in buildings, bridge abutments, and concrete culverts.

[CASPER M. DURGIN.]

SUMMARY OF RESULTS.—Precise leveling: 61.6 miles of levels run, 48 permanent bench marks established.

On June 1, 1918, when the charge of the work was transferred to Casper M. Durgin, the line of precise levels extending from Sinton, Tex., to New Orleans, La., begun by Max Steinberg on January 18, 1918, had been carried from Sinton,

Tex., to Estherwood, La., 28 miles west of Lafayette, La., with spur lines from the main line to the following places: Port Lavaca, Tex.; Matagorda, Tex.; Velasco, Tex.; and to Sabine Pass, Tex.

During the month of June, 1918, this line of levels was continued along the main line of the Southern Pacific Railroad from Estherwood, La., to Jeanerette, La., a distance of 61.6 miles.

A motor truck was used for the transportation of the party, and, although not so well adapted to the work as the motor-velocipede cars, was found to be very efficient, except for the 10 miles between Rayne, La., and Scott, La., where the highway left the railroad and was in poor condition as a result of heavy rains. The truck was laid up on two occasions for repairs, once for a period of 12 days. At these times it was necessary to make use of railroad trains or hired automobiles. In a few cases the railroad trains were the only recourse, as the roads were unfit for travel. During the latter part of the month, however, there was very little rain and a good highway followed very closely to the railroad.

The number of permanent bench marks established during the month of June was 48, making an average of 1 permanent bench mark to every $1\frac{3}{10}$ miles. Of these bench marks 22 were plates set either in brick buildings or in concrete abutments of railroad or highway culverts. Seven concrete posts were set and 2 bench marks were established on the concrete bases of block signals. A line of precise levels made by the United States Geological Survey in 1906 followed the Southern Pacific Railroad throughout the entire section of the line run during the month of June, and 15 of the permanent bench marks set at that time were recovered and connected with.

TEXAS.

[J. S. BILBY.]

SUMMARY OF RESULTS.—Reconnoissance. Length of scheme, 420 miles, 3,630 miles of area covered, 350 lines of intervisibility determined, 119 points selected for scheme. Base lines: 5 sites for base lines selected. 1 base line site (primary) prepared. Triangulation: 81 observing tripods and scaffolds built, 38 tripods built, without scaffolds (average height to tripod head above mark, 14.72 feet).

At the close of the fiscal year June 30 a party had been organized and equipped at Harlingen, Tex., to make a reconnoissance and build signals and instrument stands in preparation for an observing party on the Rio Grande arc of primary triangulation.

On July 2 the party moved to station Donna near the town of Donna, Tex., where a 60-foot signal was erected and work begun.

The building party was divided into two subparties, each consisting of one foreman and three hands. Each of the subparties was provided with one Packard 1½-ton truck, one team of mules and wagon, one White 1-ton truck, and the necessary tools and miscellaneous outfit. This organization was maintained during the month of July while engaged in building large signals in the Rio Grande Valley between Donna and Rio Grande City.

The trucks were used for hauling all material, lumber, and supplies, no extra transportation being supplied. The men employed on the actual building work also drove the trucks and team.

Early in August the number of hands was reduced on account of the changed conditions and character of the country, which made it impracticable to continue the use of large tripod and scaffold signals. One Packard truck and one White truck were turned over to the chief of the observing party.

The reconnoissance was executed by the chief of party alone, using a one-half ton truck for transportation of himself and of the necessary instruments, tools, bedding, and cooking utensils. The chief of party also had personal charge of all transportation of material and supplies for the two subparties.

The work was begun from stations Donna–Rio. The character of the country east of the Pecos River was such that only a small scheme was practicable.

Connection was made with reconnoissance stations located by E. H. Pagenhart in the vicinity of Sanderson, Tex.

The length of the scheme from Donna–Rio to the stations with which connection was made near Sanderson is 420 miles, and there are 119 stations in the scheme. The actual work was begun July 2 and was completed December 1. The actual time occupied in field work was five months, the stations occupied averaging 23.8 per month. The necessary building was done at all stations and the stations were marked and made ready for the observing party.

After closing work arrangements were made for preparing base lines for measurement.

[C. V. HODGSON.]

SUMMARY OF RESULTS.—Triangulation: Length of scheme 61 miles, 370 square miles of area covered, 7 observing tripods and scaffolds built (heights averaging 12 feet), 19 stations in main scheme occupied for horizontal measures, 19 stations occupied for vertical measures, 56 geographic positions determined, 56 elevations determined trigonometrically, 1 azimuth (Laplace) station established.

Reconnoissance and signal building having been sufficiently advanced and necessary repairs having been made to the automobile trucks used for the transportation of the party, observations were begun August 23 in the vicinity of Harlingen, Tex., on the arc of primary triangulation westward along the Rio Grande River.

The reconnoissance provided a very small scheme of triangulation with lines about 10 or 12 miles long at the beginning and decreasing to half that length after five or six figures. At first the country traversed was partly irrigated, with considerable native mesquite growth 30 or 40 feet high, but farther west the height of the vegetation was not more than 20 or 30 feet. The towers were a corresponding height, varying from 60-foot tripods with a 20-foot superstructure at the beginning to stands and 35-foot tripods with 20-foot superstructure farther west. Owing to the difficulty of obtaining lumber and the cost of transportation, the towers were very lightly constructed, the 35-foot tripods having legs made up of only two by four pieces spliced together. This method of building was found to give insufficient stability in azimuth to the tripod in high winds.

Three automobile trucks were used for the transportation of the party.

The party left Harlingen for the first station on August 28 and closed observations to prepare for the transfer of the party on September 28. During that period 19 primary stations were completed and 61 miles of progress were made through the center of the scheme.

In this work an 8-inch Wanschaff direction theodolite belonging to Columbia University was used, instead of the usual 12-inch theodolite, with satisfactory results.

Thirty-three triangles gave an average closure of 0.91 second and a maximum of 2.51 seconds with one reoccupation for closure. The azimuth station, a Laplace station with two night observations, gave a probable error for the station of 0.17 second.

Field work was closed September 28, and arrangements were made for the transfer of the party to C. L. Garner.

[E. H. PAGENHART.]

RECONNOISSANCE.—Length of scheme 140 miles, 4,000 square miles of area covered, 16 primary and 3 supplementary points selected for scheme. Base lines, 1 primary selected. Primary triangulation: Length of scheme 250 miles, 5,500 square miles of area covered, 34 stations occupied for horizontal measures, 34 stations occupied for vertical measures, 46 geographic positions determined, 45 elevations determined trigonometrically. Azimuth: 4 azimuth stations occupied. Base lines: 5 primary base lines measured. Precise leveling: 145 miles of single line of levels run.

After transferring the traverse party in Georgia to C. L. Garner, E. H. Pagenhart proceeded to Brownsville, Tex., where he organized and outfitted a party for reconnoissance and primary triangulation along the Rio Grande arc. The party then moved by motor truck to Marfa, Tex., at the western end of the Rio Grande arc. The reconnoissance work was started at Marfa on October 15, and was continued toward the southeast to a point near the Dryden base line, where the work was joined later to that of J. S. Bilby.

About November 4 the party returned to Marfa and started work on the triangulation. On March 2 the triangulation was completed to a point near Del Rio, Tex., where it joined the work of the other party under C. L. Garner, who had been working westward on the eastern end of this same arc.

Mr. Pagenhart then reorganized his party into a base-line party and started work on the measurement of five base lines along the Rio Grande arc. These were completed about April 20, and Mr. Pagenhart, with a part of his party, proceeded to Harlingen, Tex., to do precise leveling.

Between April 26 and May 17 check levels were run from a bench mark near Robstown to a bench mark near San Benito to locate an error of 1 meter in the precise-level line between Sinton and Brownsville, Tex.

[CLEM L. GARNER.]

SUMMARY OF RESULTS.—Triangulation: 3,500 square miles of area covered, 4 signal poles erected, 4 observing scaffolds and tripods built, 79 stations in main scheme occupied for horizontal measures, 79 stations occupied for vertical measures, 215 geographic positions determined, 200 elevations determined trigonometrically, length of scheme 275 miles. Azimuth: 5 azimuth stations occupied.

Between October 3, 1917, and March 2, 1918, observations were made in the primary triangulation along the Rio Grande arc from a point 5 miles west of Riogrande to the vicinity of Del Rio, Tex., a total distance along the line of progress of 275 miles. Seventy-nine stations in the main scheme were occupied for horizontal and vertical measures, five of which were azimuth stations. The work of this party closed about 20 miles northwest of Del Rio, Tex., where the observations were joined to those of E. H. Pagenhart, who made the reconnoissance and observations for the western end of the arc.

Intersections were measured on many objects in the usual manner for the purpose of locating them geographically, and when at all possible a third intersection was taken to act as a check. With the exception of objects in the towns and the few mountain peaks in Mexico, practically all of these objects were windmills. For that reason they were very difficult to identify, and this could only be done by plotting them on a progress sketch. It is believed, however, that enough of these can be sufficiently well identified to give very good control for any future work in that country.

Several mountain ranges in Mexico were visible from the vicinity of the work and as many of these peaks were determined as possible. They were long distances away and were rarely sufficiently visible for definite pointings, and never clearly enough seen for vertical measures, except at the very worst hour of the day, viz, about dusk. For that reason very few vertical measures were made on them.

All of the instruments used were of the same character as those previously used on primary triangulation, excepting the theodolite, which was an 8-inch Wanschaff direction theodolite with an exposed circle 2 micrometers 180 degrees apart and a stride level with a value of slightly more than 9 seconds for each division of the bubble.

White trucks Nos. 3 and 4 and a 1½-ton Packard truck loaned the Coast and Geodetic Survey by the quartermaster at Fort Sam Houston were used for transportation of the party and equipment from the beginning of the work until January 5, 1918, when the Packard truck was called for by the quartermaster. This was immediately delivered to the proper authorities and in its place a light three-fourths ton Republic truck was loaned by the department engineer at Fort Sam Houston, Tex. This was returned to the department engineer at the close of the work during the first of March, 1918.

The use of three trucks was made necessary on account of the character of the country, and proved a very economical and efficient method. It has been the custom in the past to use two trucks to move the observing party, while the light keepers traveled by train and wagon or other conveyance, as the conditions afforded. This was when the scheme of triangulation was large and a third truck could not make the moves as quickly as they could be made by other travel. In this work, however, the scheme was small, with the average length of line about 10 miles across a country where the railroad facilities were of little use and where very few people live. The use of a third truck in this case was about the only solution and worked very satisfactorily. This method was started by Mr. Hodgson and was continued to the end of the season.

During the season of five months 79 stations in the main scheme were occupied, with an average of 16 stations per month. There were 175 triangles closed, with an average closure at the end of the season of 0.995 second. For the first three and one-half months of the season the average closure was 4.93 seconds, but it was increased at the end of the work on account of unfavorable weather and poor conditions for observing in general.

[J. D. POWELL.]

SUMMARY OF RESULTS.—Precise leveling: 108½ miles of levels run, 54 permanent bench marks established.

The work of precise leveling between Sierra Blanca and San Antonio, Tex., undertaken at the request of the War Department in the previous fiscal year, was in progress on July 1, two parties being engaged in the work.

The party under charge of J. D. Powell was working from Del Rio to the eastward, and had made about 100 miles of progress by June 30, 1917.

On July 18 instructions were issued to Mr. Powell, then at Del Rio, after finishing the work contemplated by his original instructions, to continue alone the line of levels to San Antonio, Tex., and run a spur line of precise levels from Spofford to Eagle Pass.

On September 26 Mr. Powell, who had then moved to San Antonio, was directed to transfer the charge of the precise-leveling party and outfit to Douglas Karr, who assumed charge of the party on October 13. The headquarters of the party was then at Pearsall, Tex.

The party was operating along the line of the International & Great Northern Railway between San Antonio and Laredo, and the work had progressed to a point about 1 mile south of Natalie, Tex.

[DOUGLAS KARR.]

SUMMARY OF RESULTS.—Precise leveling: 127 miles of levels run, 81 permanent bench marks established.

On October 6, 1917, the charge of the prceise-leveling party under J. D. Powell, at work between San Antonio and Laredo, Tex., along the line of the International & Great Northern Railroad, was transferred to Douglas Karr.

The work, which had then progressed to a point about a mile south of Natalie, Tex., was continued toward Laredo, and the line was completed about December 31.

Two motor cars were used in this work, to which they were well adapted. The level tripod was mounted on one of these cars and the adding machine on the other.

Standard Coast and Geodetic Survey bench-mark disks were set in numerous substantial stone or concrete structures along the line, and limestone posts were used as additional bench marks and set approximately every 2 miles along the line, and as nearly as practicable at the even mileposts. These posts were set so as to project about 6 inches out of the ground. For temporary bench mark railroad-track spikes were driven in telegraph poles at or near the odd-numbered mileposts.

[O. W. SWAINSON.]

SUMMARY OF RESULTS.—Precise leveling: 215 miles of levels run, 110 permanent bench marks established.

At the beginning of July, 1917, a line of precise levels was being run along the Southern Pacific Railroad eastward from Tesnus, Tex. The work was continued during July until it joined the line run by John D. Powell at Meyers Canon No. 2 Bridge on July 27.

In accordance with instructions the party was then moved to San Antonio, Tex., and began a line of precise levels from New Braunfels southward toward Brownsville, Tex.

The line from New Braunfels to San Antonio was carried over the Missouri, Kansas & Texas Railway. From San Antonio to Sinton it was carried over the San Antonio & Aransas Pass Railway.

Permanent bench marks were established in all of the principal railroad stations in San Antonio. They were also placed at or near every even-numbered milepost along the railroads and in the buildings in the principal cities. These bench marks consisted of a standard United States Coast and Geodetic Survey brass bench mark set in 6-inch diameter concrete posts about 6 inches above the ground, or in the outcropping country rock, or in stone or concrete bridges, culverts, etc., or in the foundations of the buildings.

Temporary bench marks were established at or near every odd-numbered milepost. These consisted of railroad spikes driven in the telegraph poles, bridges, culverts, etc. Sometimes only one spike was driven in the pole and sometimes three, two to serve as a protection for the one used as a bench mark.

On October 5 O. W. Swainson received orders from the War Department to report at the Coast Artillery School at Fort Monroe, Va., and on that date the charge of the party was turned over to H. G. Avers.

[H. G. AVERS.]

SUMMARY OF RESULTS.—Precise leveling.—225 miles of levels run, 90 permanent bench marks established.

On October 5, 1917, the charge of the party engaged in extending a line of precise levels from New Braunfels to Brownsville, Tex., was transferred by O. W. Swainson to H. G. Avers.

The level line at that time had been completed to a point 15 miles north of Sinton, Tex., on the San Antonio & Aransas Pass Railroad. Upon completing the line to Sinton work was begun on the line south of Sinton toward Brownsville, Tex.

From Sinton to Brownsville, Tex., 162 miles, the line follows the St. Louis, Brownsville & Mexico Railway through a perfectly level and unbroken country. The principal towns along the railway are Robstown, Kingsville, Riviera, Raymondville, Harlingen, and San Benito.

At Robstown, Tex., a 25-mile spur was run to Corpus Christi over the Texas & Mexico Railway to connect with the United States Engineer bench marks at that place.

From Brownsville, Tex., the line was extended 22 miles to Point Isabel, Tex., over the tracks of the Rio Grande Railway and connection was made with the Coast and Geodetic Survey and the United States Geological Survey bench marks at that place.

A cylindrical cement post weighing about 75 pounds, with a disk in the top, was used for a permanent bench mark where there were no buildings or other structures available for placing the disk. The condition of recovered bench marks showed very plainly that a stone or cement bench mark having sharp corners should not be used. Any corner or projection invites mutilation.

Spikes in telegraph poles were used almost entirely as temporary bench marks.

MAGNETIC WORK.

MARYLAND.

CHELTENHAM MAGNETIC OBSERVATORY.

[GEORGE HARTNELL.]

During the year the work of the Cheltenham Magnetic Observatory was continued as outlined in previous annual reports.

All of the observatory instruments were in satisfactory operation.

Thirty-four earthquakes were recorded during the year.

On September 27 and 28 the periods of both components of the seismograph were reduced to 15 seconds, which is as short a period as can be obtained with the present mounting and range of adjustment.

Styluses constructed from the indices of minimum thermometers suitably mounted have proven a great improvement over styluses having wire for the recording points in that the friction is materially reduced. It is understood that some seismological stations are using satisfactorily metal styluses with rounded points.

In March, 1918, it was found necessary to forward the large earth inductor No. 26 to the office for repairs to the commutator. Since its replacement at Cheltenham, the inductor has performed very satisfactorily.

Magnetometer No. 26 and Cooke magnetometer No. 40 were compared by means of 10 sets of observations during February. The relationship between these magnetometers appears not to have changed since No. 40 was purchased in 1915.

During April a series of observations was made with the D and Z variometers of magnetograph No. 5 to redetermine the Z distribution factor and to determine the effect of the slight eccentricity of the deflector with reference to its carriage. Of the four distances used, three gave perfectly consistent scale values, while the distance 26 centimeters gave an abnormally high value. This effect has been attributed to a roughness or an irregularity of the pivots of the Z magnet in the position corresponding to the deflections at that distance. No change in the distribution factor was indicated. As regards the slight differences between the distances of the magnets due to carriage, the deflections did not always confirm the measurements. To avoid any error from this cause the magnet carriage is used in direct and reversed positions during deflections.

Beginning with November, 1917, the values of H derived from both magnetographs on the days of absolute observations have been plotted, thus providing a correct idea of the behavior of the two variometers.

On May 15, 18 sets of dip were made with earth inductor No. 26 at half-hour intervals during the day. From these observations and the mean Z base line a diurnal curve of H was derived. The fact that the curve thus derived fitted in between the H curves plotted from the variometers would indicate that earth inductor No. 26 is capable of determining the dip with a high degree of accuracy.

Earth inductor No. 22 was compared with No. 26 on May 7 and 21, the mean correction of No. 22 being 0.8 foot on both days.

Beginning with the month of March, 1918, the temperature coefficient of Z variometer No. 1 has been regarded as zero, a value which much better satisfies the trend of the base lines over a considerable interval of time.

FLORIDA.

[J. R. BENTON.]

On June 8, 1918, observations were made at the time of the solar eclipse at Orlando, Fla., in the belt of totality. The usual magnetic observations (declination, dip, intensity) were made in the morning, and in the afternoon observations of the declination were made every minute for about five hours, during which the totality took place. The end of this last set of observations was interfered with by rain.

NORTH CAROLINA AND SOUTH CAROLINA.

[J. R. BENTON.]

STATIONS OCCUPIED.—North Carolina: Aberdeen,* Goldsboro,* Raleigh,* Rockingham, and Wadesboro. South Carolina: McBee, Cheraw, Laurens, and Chester.*

Observations of the three magnetic elements were made at the stations named above in July, 1917.

Old stations were reoccupied at the places marked by asterisks (*). The old stations at Laurens, Wadesboro, and Rockingham were no longer suitable, so new stations were established and permanently marked. The other stations on the list, except Aberdeen, were not marked.

At Chester, Wadesboro, and Rockingham auxiliary stations were occupied to determine the extent of the local magnetic disturbance. At Chester eight points were occupied, at several of which the declination seemed to be normal, while at others it was widely disturbed; and at Wadesboro and Rockingham four auxiliary stations each were occupied, each about 7 miles from the center of the disturbance, in the directions east, south, west, and north.

ARIZONA, CALIFORNIA, NEVADA, OREGON, AND WASHINGTON.

[H. E. MCCOMB.]

STATIONS OCCUPIED.—Arizona: Yuma † and Tucson.† California: Alderpoint,* Barstow,† Brown,* Cartago,* Cloverdale,* Crescent City, Death Valley,* Dos Rios,* Eureka, Fort Bragg,* Hanford, Independence, Indio,† Lakeport, Laws,* Montrio,* Niland,* Orick,* Point Reyes,* Riverside, San Bernardino,† Santa Ana, Scotia,* Silver Lake,* Stockton,† and Tecopa.* Nevada: Beatty,* Bonnie Clare,* Goldfield, and Mt. Montgomery.* Oregon: Bend, Coquille, Culver, Dallas, Elkton,* Eugene † and 7 auxiliaries, Gold Beach, Hood River and 6 auxiliaries, Langlois,* Mohler,* Oakridge,* Oregon City, Pacific City,* Portland,† Reedsport,* St. Helena and 7 auxiliaries, and Tillsmock. Washington: Berlin,* Cathlaimet and 5 auxiliaries, Cle Elum,* Eagle Gorge,* Pateros,* Prosser, Seattle,† Waterville, and Wenatches.

During the time from July 1 to November 1, 1917, observations of the three magnetic elements were made at the stations named.

The stations indicated by an asterisk (*) were not permanently marked. Old stations were reoccupied at the places indicated by a dagger (†). All other stations were permanently marked.

At Tucson four sets of magnetic observations were made in order that the instruments might be compared with those of the observatory. For this purpose simultaneous observations were made.

ALABAMA, ARKANSAS, COLORADO, GEORGIA, LOUISIANA, MISSISSIPPI, NORTH CAROLINA, AND TEXAS.

[WILLIAM W. MERRYMON.]

STATIONS OCCUPIED.—Alabama: Mobile * and Selma.* Arkansas: Mena.* Colorado: Colorado Springs, Edgerton, Fountain, Glen Eyrie, Manitou, Manitou Junction, Pikeview station, and Rosemont. Georgia: Blairsville, Hiawassee, Lagrange,* Palmetto, and Red Oak. Louisiana: Alexandria * and Shreveport.* Mississippi: Brookhaven.* North Carolina: Marion * and Murphy.* Texas: Fort Worth, Greenville,* Sherman, and Texarkana.*

Old stations were reoccupied at the stations indicated by an asterisk (*).

Between March 23 and June 30, 1918, the three magnetic elements were observed at each of the stations mentioned in the foregoing list.

Special observations were made at the time of the solar eclipse of June 8, 1918, at Mena, Ark., in connection with similar observations made at a number of other places in the belt of totality. They included observations of declination every minute for a period of six hours, with observations every half minute during the 20-minute period about totality. The observations at Colorado Springs and vicinity were made in cooperation with the department of terrestrial magnetism of the Carnegie Institution of Washington to determine whether there is any change of the earth's magnetic field due to changes of elevation.

Four auxiliary stations were occupied in the country around Marion, N. C.

A meridian line was established at the new magnetic station at Sherman, Tex., at the request of the city manager.

Requests for magnetic data were made by local surveyors and engineers or local authorities at most of the stations occupied.

The new stations occupied at Red Oak and Palmetto, Ga., and at Fountain, Manitou Junction, Manitou, Glen Eyrie, Pikeview station, Edgerton, and Rosemont, Colo., were not permanently marked.

ARIZONA.

TUCSON MAGNETIC OBSERVATORY.

[F. P. ULRICH, July 1, 1917, to Mar. 27, 1918; H. E. MCCOMB, Mar. 28, 1918, to June 30, 1918.]

At the Tucson Magnetic Observatory the usual observations were recorded.

The magnetograph recording variations in declination and horizontal intensity and vertical intensity was in continuous operation with the exception of short breaks that occurred on November 10 and 13 in adjusting the instruments. Scale-value observations were made at least once a month, and more often when made necessary by instrumental adjustments. Absolute observations were made usually twice each week.

Chronometer corrections were obtained from telegraphic time signals at Tucson by telephone until November and then by comparison of chronometers.

Both components of the Bosch-Omori seismograph were kept in continuous operation except during November and the first part of December, when the driving clock of the E–W component was sent to the office for repairs. Thirty-three earthquake shocks were recorded.

The usual meteorological observations were made.

Special magnetic observations were made from noon until 6 p. m. on June 8, at the time of the total solar eclipse.

In May, 1918, six complete sets of declination and horizontal intensity observations were made with magnetometer No. 40 for the purpose of making comparisons between the instruments here and at other observatories.

IOWA, KANSAS, AND MISSOURI.

[W. M. HILL.]

STATIONS OCCUPIED.—Iowa: Cascade, Clinton,* Columbus Junction, Davis City, Dewitt, Farley, Green Island, Humeston, Lamotte, Lineville, Mediapolis, Monmouth, Oxford Junction, Princeton, Tipton,* Stanwood, Wapello,* West Liberty, Wheatland, and Wilton Junction. Kansas: Herington. Missouri: Bethany, Bucklin, Kingston, Kirksville, Lawson, Linneus, Princeton, Trenton, and Unionville.

Between July 1 and October 5, 1917, the three magnetic elements were determined at the places named. Old stations were reoccupied at the places marked by an asterisk (*).

Auxiliary stations were occupied as follows: Six in the vicinity of Salina, Kans.; 9 in the vicinity of Wapello, Iowa; 4 in the vicinity of Tipton, Iowa; and 3 in the vicinity of Clinton, Iowa.

A meridian line was established at Unionville, Mo.

At many of the stations permanent marks were not required, since they were in thinly populated regions, where the results obtained were mainly for the purpose of developing local magnetic disturbances.

ILLINOIS AND WISCONSIN.

[W. W. MERRYMON.]

STATIONS OCCUPIED.—Illinois: Chatsworth, Rochelle, Rockford, and Streator. Wisconsin: Delavan and 6 auxiliary stations, Drummond,† Eland, Fairchild, Hudson * and 6 auxiliary stations, Hudson (new station), Marengo,† Mercer,† Milwaukee, Mondovi, Moore,† New London, Pecks station * and 5 auxiliary stations, Port Washington * and 5 auxiliary stations, Rhinelander * and 4 auxiliary stations, Spooner and 8 auxiliary stations, Valley Junction, West Bend * and 4 auxiliary stations, Woodruff, and Woodville.

Between July 1 and November 10, 1917, observations of the three magnetic elements were made at the places named. Stations marked with an asterisk (*) were old stations reoccupied; those marked with a dagger (†) were new stations occupied but not permanently marked. Others were new stations established and permanently marked.

During the season a number of applications for magnetic data were received and forwarded to the office.

ALASKA.

[L. O. COLBERT.]

SUMMARY OF RESULTS.—Triangulation: 72 square miles of area covered, 9 stations in main scheme occupied for horizontal measures, 1 station in supplemental scheme occupied for horizontal measures, 35 geographic positions determined. Leveling: 0.2 mile of levels run. Topography: 14.9 square miles of area surveyed, 98 miles of general coast line surveyed, 0.2 mile of roads surveyed, 2 topographic sheets finished, scale 1:20,000. Hydrography: 73.7 square miles of area dragged, 1,768 positions determined (double angles), 77 retained soundings, 3 hydrographic sheets finished, scale 1:20,000.

Wire-drag party No. 4 began work in Alaska on May 3, 1917, and the work done to June 30 is reported in the annual report for 1917.

The location of the work was in Stephens Passage, Lynn Canal, and the two straits which connect those bodies of water, namely, Favorite Channel and Saginaw Channel. The northern limit extends across Lynn Canal from Point Bridget to the opposite shore. The eastern limit follows closely the indentations of the shore line, and is close to low-water mark in most places. In Lynn Canal the western limit is marked by a line from Point Whidbey to Little Island; in Saginaw Channel by a line between Point Retreat and Hump Island and also by the shore line of Lincoln and Admiralty Islands. The water areas within the above limits were completed as far south as Young Point. In addition a dragged strip three-fourths of a mile wide extends in mid-channel about 7 miles farther southeastward.

The hydrography consisted of a wire-drag examination of the area outlined above. The effective depth dragged was 85 feet at mean lower low water, except where less water was known to exist, as shown by previous surveys. When dragging close inshore no attempt was made to maintain this depth on account of the great loss of time, without adequate return, which would have been involved. Instead a depth of 45 feet was usually set as a maximum.

During the season 19 shoals with depths of 10 fathoms or less were located by the drag. Only one shoal in the track of steamers and dangerous to navigation was found. A number of soundings were secured in mid-channel where the depths were less than those shown on the chart, but these spots were not less than 10 fathoms in depth.

In addition to the above shoals a number of uncharted rocks and reefs lying close inshore were found either by the topographic party or by a launch party on a special investigation of suspicious localities where submerged rocks were reported by local fishermen. These rocks were located in the narrow strip which was left between the dragged area and the high-water mark on the beaches. Many of them were in the path of launches and cannery tenders, but out of the track of larger vessels.

Tides were recorded by an automatic gauge at Auke Bay, and an almost continuous record was obtained from May 15 to September 11.

Topographic surveys were made of the shore line contiguous to the dragged areas. On the mainland the shore line only was delineated in order to show several of the off-lying rocks and reefs not shown on previous charts or geological maps. The limits of the shore line surveys are a point opposite North Island on the north and the end of the peninsula extending into Fritz Cove on the south.

The western shore line of Douglas Island from Fritz Cove to a point 5½ miles southeast of Point Hilda was surveyed. On the west side of Stephens Passage a survey was made of the shore line of Admiralty Island from Horse Island to Point Retreat, including the shore line in Barlow Cove and the smaller islands adjacent to this stretch. The entire shore line of Shelter and Lincoln Islands was run. All of the smaller islands lying within the limits of the above work were included in the topographic survey.

The control for the main part of this work was furnished by the primary triangulation party under F. S. Borden. A tertiary scheme was observed in advance of this work, when the progress of the drag preceded the observations of that party. It was necessary to run a tertiary scheme into Saginaw Channel for the determination of the signals in that channel.

The chartered steamer *Roscoe* and the launch *Wanick* were used in this work.

Field work was closed for the season on September 11, and the party returned to Seattle.

[A. JOACHIMS.]

SUMMARY OF RESULTS.—Triangulation: 7.7 square miles of area covered, 23 signal poles erected, 13 stations in main scheme occupied for horizontal measures, 3 stations occupied for vertical measures, 6 geographic positions determined. Topography: 126.25 square miles of area surveyed, 136 miles of general shore line surveyed, 2.9 miles of shore line of creeks surveyed, 6 topographic sheets finished, scale 1 : 20,000. Hydrography (wire drag): 216.2 square miles of area dragged, 1 tide station established, 3 current stations established, 5 hydrographic sheets finished, scale 1 : 20,000.

Progress made by wire-drag party No. 3 in the survey of Frederick Sound, Alaska, to June 30, 1917, was stated in the last annual report.

By the close of the season, September 28, 1917, the main ship channel of Frederick Sound had been dragged within the limits defined below, and the topography had been carried through the whole of the region covered by the drag. Two separate schemes of triangulation were run in order to establish the necessary control. Lines of soundings were run in the vicinity of buoys 17 and 24 and buoys 19 and 26 in Wrangell Strait in order to determine whether or not shoaling had taken place since the last survey in 1910. Tides were observed at Petersburg and Cleveland Passage, with an automatic tide gauge at the former place and by observers during 36 consecutive hours at the latter place. Current observations were taken at three current stations in the main ship channel, and additional notes were taken during the course of other operations. Coast-pilot notes were taken during the entire season. A topographic reconnoissance was made in the vicinity of Patterson Bay, Baranof Island.

The area dragged in Frederick Sound is bounded by Mitkof and Kupreanof Islands and Dry Strait on the south, approximately by a line from Port Houghton through the Sail Islands and the mainland on the north and by the mainland on the east. This area was completely dragged, except that the sudden ending of the season's work prevented certain small areas from being completed.

As much topography was done as was possible without interfering with the drag work. Current observations were made at three stations, one in mid-channel south of Cape Fanshaw, one in mid-channel between Portage and Farragut Bays, and one in mid-channel near the entrance to Thomas Bay.

Two schemes of tertiary triangulation were run in order to obtain the necessary control. At current stations and at various times while running to and from anchorages, cuts to mountain peaks were taken in order to aid in contouring the topographic sheets.

A tide staff was erected in Cleveland Passage, and tidal observations were taken during 36 consecutive hours.

An effective depth of 85 feet was dragged in most cases, except close inshore and over known shoals, where the prevailing depths were less.

The first trials with the drag at that depth were necessarily experimental, because this was the first occasion of such deep dragging. The metal floats in the equipment were designed to withstand the hydrostatic pressure at a depth of 72 feet, but they were not wholly satisfactory when used at the increased depth. The increased pressure caused a number of the floats to collapse the first time the drag was set out. Accordingly wooden floats were used during the greater part of the season.

The maximum length of a section permissible was found to be 400 feet with the type of buoys used. Long drags ranging from 10,000 to 12,000 feet in length were used, with both launches taking independent positions. For inshore work a somewhat shorter drag sufficed, although in this case also independent positions were taken. To insure an effective depth of 85 feet at all stages of tide, the length of the upright had to be 100 feet. In order to increase the buoyancy of the drag so as to guard against its sinking, two large buoys were substituted for two of the small buoys, one midway between the near and middle buoys and one midway between the middle and far buoys.

The chief difficulties encountered were due to tidal currents and floating glacial ice.

The entire area dragged during the season from April 27 to September 28 was slightly in excess of 400 square miles. This area was covered by five sheets, slightly overlapping.

On sheet 4, from Cape Fanshaw to the north end of Whitney Island, a small area remains unfinished.

The survey of the shore line on the south side of Frederick Sound is complete from a point about 3 miles southeast of Cosmos Point, near Dry Strait, to a point approximately south of Point Fanshaw. A little more than half of the shore line on either side of Portage Bay was run. The survey of the shore line on the north side of Frederick Sound is complete from the entrance to LeConte Bay, near Dry Strait, to Point Houghton, except for about 1.5 miles in the vicinity of Brown Cove. No attempt was made to survey Thomas Bay, and in Farragut Bay only those portions close to Frederick Sound were run. The Sukoi Islands, the Five Fingers, and the Brothers were run in, as well as other small islands. About one day's work was done in the vicinity of False Point Pybus.

Particular attention was paid by the topographers to the delineation of the low-water line, offshore rocks, and the kelp line, as well as to the high-water line.

Ten shoals, with depths varying from 43 to 85 feet, were located and reported during the season.

The immediate control for the greater part of the wire-drag hydrography and the topography was furnished by two separate small schemes of tertiary triangulation developed in advance of the other work. The first scheme extends from the Sukoi Islands to Portage and Farragut Bays. A subordinate scheme was extended from the above scheme into Farragut Bay for plane-table control.

The second scheme is in the vicinity of the Five Finger and Brother Islands.

The chartered launches *Equator*, *Roosevelt*, and *Freyea* were used in this work.

Lines of soundings were run in the vicinity of buoys 17 and 24, at the entrance to Wrangell Strait, to determine whether or not shoaling had taken place, as reported, since the survey of 1910. Similar lines were run at buoys 19 and 26 for the same purpose. No material difference was found when the results were compared with the chart.

Before dragging operations were begun an automatic tide gauge was installed at the end of the old unused sawmill dock at Petersburg. Continuous records were obtained from April 25 to September 28. Lines of leveling were run connecting the tide gauge with previously established bench marks.

A tide staff was erected at an unused dock in Cleveland Passage. Observations were taken during 36 consecutive hours. Lines of level were run from a recovered tidal bench mark on Whitney Island.

An effort was made during the season to obtain as much current data in Frederick Sound as was practicable without interfering with the drag work. In addition to the three current stations established and the data taken therefrom, notes were taken at various times during other operations.

In accordance with instructions a subparty was sent out to determine the heights of Mount Cecil and Mount Elizabeth, which are on the east side of Baranof Island, just north of Patterson Bay, and to determine whether or not there were any lakes of considerable size in the same vicinity.

Three triangulation stations were recovered, and directions and vertical angles were observed on the principal peaks in the vicinity of Mount Cecil and Mount Elizabeth. From these observations the geographic positions and the heights of Mount Cecil and Mount Elizabeth were computed.

In order to determine whether or not there was a large body of fresh water in the vicinity of the above-mentioned peaks, an attempt was made to climb one of the ridges near the head of Patterson Bay. At the elevation reached one lake could be seen across the valley at the head of the bay. The height of this lake above sea level was determined approximately. Another lake was discovered at the head of a stream flowing into the upper part of the bay.

Coast-pilot notes were gathered in regard to all important localities visited.

[FRANK S. BORDEN.]

SUMMARY OF RESULTS.—Triangulation: 55 square miles of area covered, length of scheme 25 miles, 23 signal poles erected, 22 stations in main scheme occupied for horizontal measures, 22 geographic positions determined.

At the beginning of the fiscal year work was in progress on a scheme of primary triangulation in Stephens Passage, southeastern Alaska, to extend southeastward from the vicinity of Lincoln Island to Grand Island.

The object of this triangulation was to furnish control for a wire-drag party operating in this locality, and also to establish a strong scheme of triangulation through this section of southeastern Alaska.

Previous to June 30 the triangulation had been carried from Young Bay northward to the line Sentinel–Little on Sentinel and Little Islands in Lynn Canal.

Work was then taken up in Young Bay. A base line was measured at the head of Young Bay, after which the triangulation was carried southeastward. Work was closed for the season on September 25, the triangulation at that time having been carried to a base, Rock–Grave, 2 miles south of Grand Island. From the main-scheme stations of the triangulation, all banners, whitewashed rocks, etc., established by the wire-drag parties, were cut in, as well as many prominent peaks, lighthouses, etc.

Two subsidiary stations, Marmion and Entrance, were established at the entrance to Gastimeau Channel as a base for carrying the triangulation up the channel. The positions of these stations were computed through the quadrilateral Corner, Oliver, Marmion and Entrance. The stations Corner and Oliver are main-scheme stations. The subsidiary stations Marmion and Entrance were occupied.

From the base Sentinel–Little, the north end of the season's work, the lines are clear to the next pair of stations northward, while from Rock–Grave, the south end of the work, the lines are clear to Lime–Stone, the next pair of stations southward. Signals Lime, Rock, and South had been built, and were ready for occupation at the close of the season.

[E. W. EICKELBERG.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 48 miles, 172 square miles of area covered, 49 lines of intervisibility determined, 23 points selected for scheme. Base lines: 1 primary, 4,800 meters in length. Triangulation: Length of completed scheme 80 miles, 92 square miles of area covered, 18 signal poles erected, 1 observing tripod and scaffold built (height 20 feet), 15 stations in main scheme occupied for horizontal measures, 1 station in supplemental scheme occupied for horizontal measures, 4 stations occupied for vertical measures, 25 geographic positions determined, 4 positions determined trigonometrically.

The party engaged in the primary triangulation of Frederick Sound, southeastern Alaska, was in the field at the beginning of the fiscal year. Progress made to July 1 is reported in the annual report for 1917.

The primary object of this work was to furnish control for the wire-drag party operating in Frederick Sound.

The launch *Marguerite* was chartered for the use of the party.

On account of numerous rounding points and also to peculiar turns in the channel, the reconnoissance had to be very thorough before any signal building could be done. In some cases mountain peaks might have been used to advantage, but would have caused considerable delay on account of rain and overhanging clouds.

It was at first thought from previous experience that the observations would be made in the daytime, but it was found that the necessary accuracy could not be obtained by sighting on the signals, and both carbide and electric lights were used, the latter proving most satisfactory.

The signals consisted of a tripod with center pole. The signal was used mainly as a day mark for the wire-drag parties and for sighting on before the lights or heliotropes were showing.

The instrument support and light stand consisted of a four-legged stand, suitably branced and weighted down with stones, or cemented to the rock. A platform for the observer was built around the stand. At Turnabout Island a 50-foot scaffold had to be built and at North Base it was necessary to build a 20-foot scaffold.

A base line was located on the same ground as the old base of 1887, except that it lay farther inshore on ground above high water and was much shorter. No ready method presented itself for connecting with the main scheme from this base, and the question of getting by Point Agassiz and the Sukoi Islands without considerable overlapping of figures presented a difficult problem.

A site was found where by clearing about 500 yards of woods and utilizing a beach which bares at low water the base was made a main-scheme line so as to overcome the difficulty mentioned. The base is 4,800 meters in length.

At the close of the season 20 miles of triangulation remained to be done to connect with the work of 1916 in Dry Strait. Signals Creek, Bluff, Pershing, and Camp had been erected, when orders were received to close work, and owing to unfavorable weather in the latter half of September were not occupied. Work was closed for the season on September 25.

[T. J. MAHER, Commanding Steamer *Explorer*.]

SUMMARY OF RESULTS.—Topography: 10.5 miles of shore line surveyed. Hydrography: 8.8 square miles of area covered, 133.4 miles run while sounding, 1,137 positions determined (double angles), 1,239 soundings made, 1 tide station established.

At the beginning of the fiscal year the steamer *Explorer* was engaged in general surveys on the outer coast of southeastern Alaska northward of Cape Muzon. The work of the party was seriously handicapped by the desertion of a number of the crew and the resignation of the chief engineer.

Owing to these hindrances to field work the commanding officer was ordered by telegraph on July 12 to close work, transfer the steamer *Cosmos*, launch *117*, and certain officers and men to the *Patterson*, and return with the *Explorer* to Seattle. The vessel arrived at Seattle August 19.

[C. G. QUILLIAN, Commanding Steamer *Patterson*.]

SUMMARY OF RESULTS.—Triangulation: 83 square miles of area covered, 139 signals erected, 43 stations in main scheme occupied for horizontal measures, 3 stations in supplemental scheme occupied for horizontal measures, 62 geographic positions determined. Magnetic work: 2 land stations occupied for magnetic declination. Topography: 32 square miles of area surveyed, 71 miles of coast line surveyed, 4 topographic sheets finished, scale 1:20,000. Hydrography: 42 square miles of area covered (inshore), 2,275 square miles of area covered (offshore), 976 miles run while sounding, 3,850 positions determined (double angles), 8,092 soundings made, 3 tidal stations established, 1 current station established, 4 hydrographic sheets finished, scales one 1:200,000, two 1:20,000, and one 1:10,000.

At the beginning of the fiscal year the steamer *Patterson* was engaged in general surveys in the approaches to Cross Sound, including Lisianski Inlet and Strait, Alaska. Progress to June 30, 1917, is detailed in the last annual report.

By that date the triangulation had been completed from Cross Sound to below Stag Bay and signals built to Point Urey. Reconnoissance had been made and some of the signals built for several figures into Lisianski Inlet below Junction Island, and the topography completed to Stag Bay. No offshore soundings had been made, but the hydrography of the narrow portions of Lisianski Strait had been completed for the use of the *Patterson*, and in anticipation of vessels being sent to the cannery under construction in Stag Bay.

Work was continued after July 1, 1917, the vessel sounding outside and offshore on favorable days. These soundings will be useful on the charts, although the work was not completed. Soundings were made only when points on shore were visible for determining the position of the vessel. For continuing this work peaks are located or available along the Yakobi and Chichagof shores.

Inshore the triangulation was extended to the head of Lisianski Inlet, through Lisianski Strait, and thence southward to Khaz Bay, where a connection was made with the work of E. F. Dickins, 1906. Further observations are desired in this triangulation.

The topography and hydrography of Lisianski Inlet and Strait were completed. No work was done on the west shore of Yakobi Island.

A topographic survey of the vicinity of Nickel was made, and a hydrographic reconnoissance of the approach also made. The topographic survey does not join the Lisianski Strait work by about 2 miles, and there is a larger gap between the hydrographic work off Nickel and the entrance of Lisianski Strait.

The *Cosmos* and crew were assigned to the *Patterson* from the *Explorer* on August 1, and the addition of this launch, on which the party could live, made possible the connection of the triangulation with Khaz Bay and the topographic work in vicinity of Nickel.

The west coast of Yakobi Island and Chichagof Island are extremely irregular and foul, and a vessel of any size or draft can not approach the shores. There are numerous small bays and inlets into which small gas launches can find shelter. Many of these have only a few feet at low water and contracted entrances. Nickel, for example, is in a small bay called Mirror Harbor, which is landlocked. The approach is narrow and foul, and at the narrowest point, about 20 yards wide, are two rocks, and a sharp turn must be made. It was all the *Cosmos* could do to make this shelter.

On September 20 orders were received to close work at once, store the outfit, and return to Seattle. The camp party was picked up September 22 and the party proceeded to Juneau.

From Juneau the *Patterson* proceeded to Metlakatla, having to anchor over several days because of too heavy weather to tow the *Delta*. Both the *Delta* and *Cosmos* were sent by way of Zimovia Strait and Ernest Sound from Wrangell Narrows.

At Ketchikan the power-boat equipment of wire-drag party No. 3 was taken aboard, and the vessel then proceeded to Metlakatla. At Metlakatla the various boats were stored. The ship left Metlakatla on October 8, obtained mail and provisions at Ketchikan, and sailed for Seattle at midnight, reaching Seattle October 13.

As a number of the officers had been transferred to the Army and Navy, and all Army officers had orders detaching them on arrival, these officers continued office work on sheets and records until detached, and completed the inking of the topographic sheets.

On October 16 three of the officers left under orders to report at Fort Monroe for Army duty. The same day the *Patterson* was taken into Lake Union through the Lake Washington Canal and Locks and moored at the county dock built for the Survey.

Three additional officers were enrolled in the United States Naval Reserve Force on October 15, and directed to continue duty on the *Patterson*, pending orders from the Bureau of Navigation. The commanding officer and one other officer were not enrolled until the end of the year and also continued on duty on board the vessel. On enrollment they were assigned to continue duty on the *Patterson*, pending orders of the Bureau of Navigation.

During the season the following work was accomplished: The triangulation control was extended through Lisianski Inlet, Lisianski Strait, and southward along Chichagof Island to Khaz Bay, thus connecting Cross Sound triangulation, by J. F. Pratt, 1901, with Khaz Bay triangulation, by E. F. Dickins, 1905. Triangulation was also extended to the head of Lisianski Inlet.

The topographic survey covered all of Lisianski Inlet, Lisianski Strait, and Stag Bay. The control was furnished by triangulation above mentioned. Topography covered contours of hills adjacent to the shore line. The topographic survey extends southward to Ilin Bay, then there is a gap of about 2 miles, and then a further topographic survey in the vicinity of Nickel and the northern part of Portlock Harbor.

A complete hydrographic survey was made of Lisianski Inlet and Lisianski Strait, a hydrographic reconnoissance of Davison Bay, and the hydrographic offshore development extends 27 miles offshore and 60 miles along the coast.

[E. E. SMITH, Commanding Steamer *Taku*.]

SUMMARY OF RESULTS.—Triangulation: 54 square miles of area covered, 13 signal poles erected, 13 stations in main scheme occupied for horizontal measures, 11 geographic positions determined. Leveling: 3 permanent bench marks established. Magnetic work: 1 land station occupied for magnetic declination. Topography: 40 square miles of area surveyed, 476 miles of general coast line surveyed, 1 topographic sheet finished, scale 1:20,000. Hydrography: 32 square miles of area covered, 163 miles run while sounding, 818 positions determined (double angles), 1,328 soundings made, 1 tide station established, 1 hydrographic sheet finished, scale 1:20,000.

The party for the steamer *Taku*, under instructions to continue the survey of Prince William Sound, arrived at Cordova on May 10, and was employed until the end of June in making needed repairs to the vessel.

On July 7 the vessel proceeded to Port Nellie Juan, arriving on July 8, and the next day began building signals.

The engines and boiler of the *Taku* were in bad condition and even after being repaired were constantly breaking down. An engine which had been ordered for launch *No. 39* did not arrive in time to be of service, and was not installed.

The signal building, observing and topographic parties were obliged to go to work and return in pulling boats.

The cannery of the Copper River Packing Co. in the small bay on the east side of McClure Bay gave the use of their dock as a berth for the *Taku* and supplied water and storage for coal without charge.

A storehouse for the Survey was built at the head of the bay where the cannery is situated.

An automatic tide gauge was set up at the cannery dock, and bench marks were established. The greatest range observed was 16.9 feet.

No current observations were made, as there were no facilities for anchoring in the deeper parts of the channel. The currents appear to set with the channels and are usually weak, not exceeding probably from one-fourth to three-fourths knot in Port Nellie Juan.

The triangulation was extended from the base First-Catch, the most available line. Thence three quadrilaterals were extended through the first reach of Port Nellie Juan.

The topography was extended from the triangulation stations Wire and End at the entrance to Port Nellie Juan through the first reach to the turn at stations Land and Fini, including McClure Bay. The work was done with the plane table, a traverse being run from station Port down the east side of McClure Bay and thence to station Land. The remainder of the shore line and the contours were done after the triangulation was completed. The woods covering the lower slopes dwindle away at about the thousand-foot curve. Soundings were made over the area of McClure Bay and the outer reach of Port Nellie Juan.

Observations for magnetic deviation were made with the compass-declinometer at station Port.

At the request of the mayor of Cordova a military registration of eligibles for the draft was made by the chief of party at Port Nellie Juan.

Field work was closed for the season on August 22, and the party arrived at Seattle September 5.

At Cordova the *Taku* was inspected by officers of the Steamboat-Inspection Service, who recommended that she be condemned and sold.

The equipment to be retained for use was stored at Cordova, and the instruments were shipped to Seattle.

The chart agency at Cordova was inspected while the vessel was being held up, and a member of the party was sent to inspect the agency at Valdez.

[E. R. HAND.]

SUMMARY OF RESULTS.—Leveling: 3 miles of levels run, 4 permanent bench marks established. Topography: 2 square miles of area surveyed, 10 miles of coast line surveyed, 5 miles of roads surveyed, 1 topographic sheet finished, scale 1:10,000. Hydrography: 15 square miles of area covered, 151 miles run while sounding, 1,200 positions determined (double angles), 2,140 soundings made, 1 tide station established, 1 hydrographic sheet finished, scale 1:10,000. Wire-drag work: 14 square miles of area dragged, 3.5 linear miles dragged, 466 angles measured.

Preparations were made and a party organized at Seattle, Wash., in March and April, 1918, for wire-drag work at Knik Harbor, Anchorage, Alaska, and on April 21 the party sailed for Alaska on the S. S. *Admiral Farragut*.

On the way up the *Farragut* struck an obstruction in Wrangell Narrows, but was able to proceed to Juneau, where the freight was landed and the passengers and mail transshipped to the *Alameda*, which landed the party at Anchorage on May 3, but without gear or instruments, which were not received until May 17. The intervening time was spent in building signals, erecting a tide gauge, arranging for the necessary boats, and other preparatory operations.

The work contemplated by the instructions included a wire-drag survey of Knik Arm between Point Woronzof and Cairn Point, with wire-drag set at an effective depth of not less than 40 feet at mean lower low water, and to within 3 feet of the bottom at less depth, and on all separate or detached shoals of less than 40 feet depth the minimum depth to be determined. It was also directed that a hydrographic survey with lines 200 meters apart and a closer development where needed be made over the same area.

An automatic tide gauge was put in operation June 1, four permanent bench marks were established and connected by leveling with each other with the staff and with a bench of 1914.

A topographic revision was made in order to show certain improvements. Hydrographic signals were located with the plane table, and the rocks seen at lowest tides were cut in. The only ones considered dangerous were found off Cairn Point.

Triangulation stations at points Woronzof and Mackenzie were found in danger of slipping over the bluff and so were re-marked with bronze plates in concrete, set farther back, and in such a way as to preserve the azimuth of the line.

The entire harbor from Cairn Point to Point Woronzof was sounded, and the greater part of the navigable area was dragged. This work, which was not completed, was in progress at the close of the fiscal year.

The work of sounding was accomplished under unusual difficulties. There is an extreme tidal range of 40 feet, and in consequence the tidal currents are very strong, attaining at times a velocity of almost 7 knots.

For this reason it was impossible to run lines crosswise of the channels, and the following plan was adopted: Out to about 10 fathoms the lines were run normal to shore, and beyond that they were run lengthwise of the Arm. Advantage was taken of slack water for the first, but when the current set in, lines were run with it the length of the harbor.

Inshore there was found mud bottom of even slope, but a short distance outside of the low water the bottom drops off abruptly and the lead develops great inequalities, showing deep holes and all rocky, with traces here and there of clean sand. The strong currents continually scouring out the bottom cause the silt brought down from the upper Arm to be held in suspension until it reaches the shoals just outside the points.

The drag work in deep water was quickly finished, but when it became necessary to operate the drag close to the bottom, much difficulty was experienced, owing to the irregular bottom and the strong currents. It was impossible to operate the drag, except about the time of slack water and by drifting with the current.

A number of shoal spots surrounded by deeper water was found, but it was impossible to decide whether they were menaces to navigation until the least depths over them were more accurately determined.

Launches for the sounding and wire drag were furnished by the Alaskan Engineering Commission, which otherwise cooperated in the work in every way practicable.

[A. J. ELA, Commanding Steamer *Yukon*.]

In June, 1917, a party was organized at Seattle for work during the summer season of 1917 on the south coast of the Alaska Peninsula.

The party left Seattle July 10 and arrived at King Cove, Alaska, July 20.

On July 24 and 27 orders were issued directing the chief of party to repair the steamer *Yukon* and return to Seattle as soon as practicable, without attempting to do any field work. As it was apparent from the first that it was impossible to get the *Yukon* in commission in time to do any field work during the season, it had been determined to repair the launch *Alpha* and do field work with her when the weather conditions were favorable, reserving for less favorable weather the completion of the repairs to the *Yukon*.

At the time the instructions to return to Seattle were received the repairs to the *Alpha* were nearly completed, but the *Yukon* had been taken apart and the material which it was thought could be used again was piled up under canvas on the ground around her. It was impossible to replace this material in time to have taken the September mail boat to Seattle, but an extra effort was made to get the better part of it back in time to take the mail boat on its October trip, a carpenter and helper being left to complete the replacing of some of the interior woodwork and to attempt to complete the new pilot house. Toward the close of the season the vessel was entirely roofed over as a protection from the elements.

No survey work was done during the season other than a hasty reconnoissance of Morzhovoi Bay and the establishment and operation of an automatic tide gauge at King Cove from July 31 to October 17, 1917.

[J. W. GREEN.]

STATIONS OCCUPIED.—Alaska: Eagle and Circle.

Between June 16 and 30 observations of the three magnetic elements were made at the above-named stations on the Yukon River, in the interior of Alaska, small boats being used for transportation between stations.

Before leaving Sitka the instruments were compared with the absolute instruments at that observatory.

SITKA MAGNETIC OBSERVATORY.

[J. W. GREEN, July 1, 1917, to June 9, 1918; F. P. ULRICH, June 10, 1918, to June 30, 1918.]

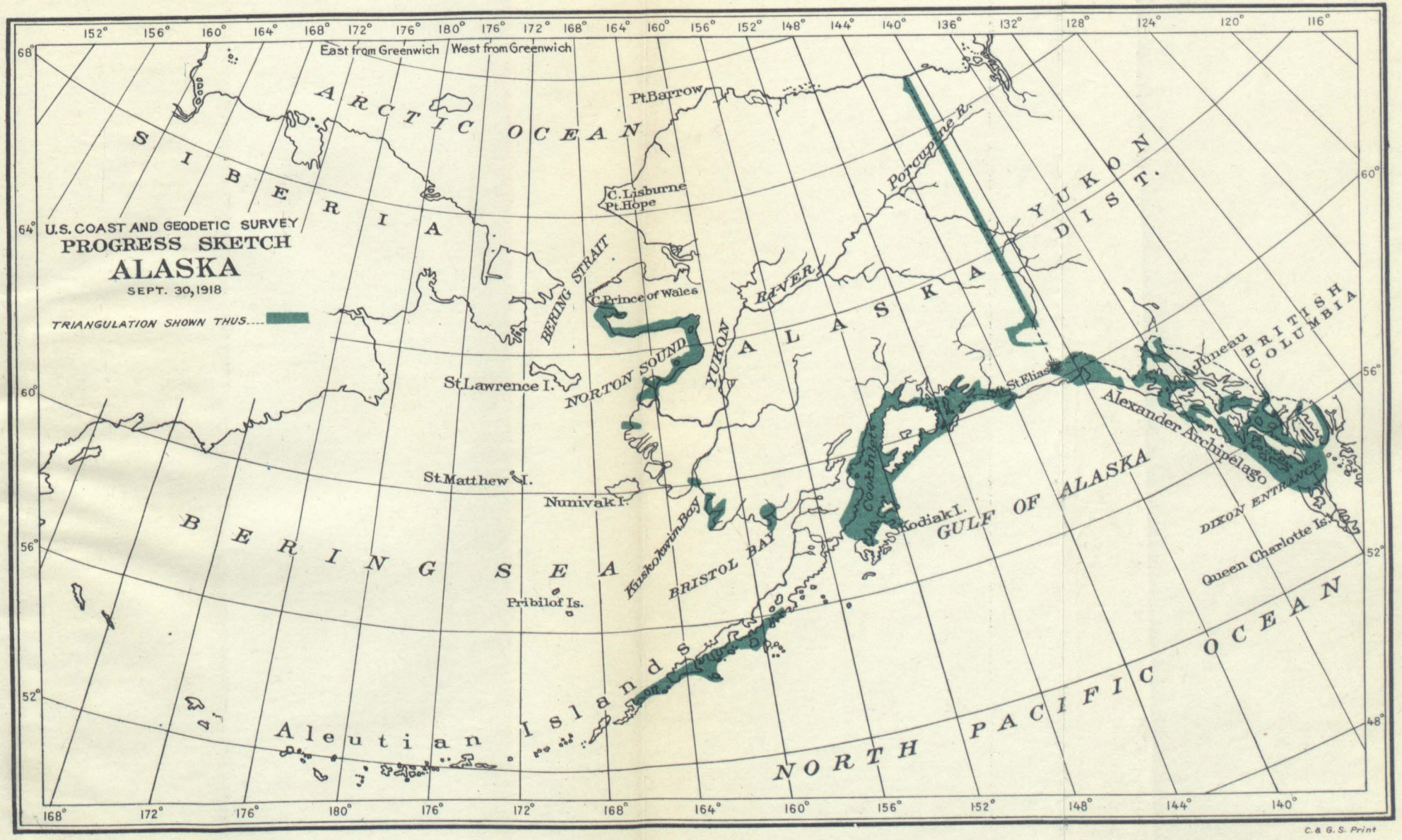
The usual observations were recorded at the Sitka Magnetic Observatory during the year with practically no interruption.

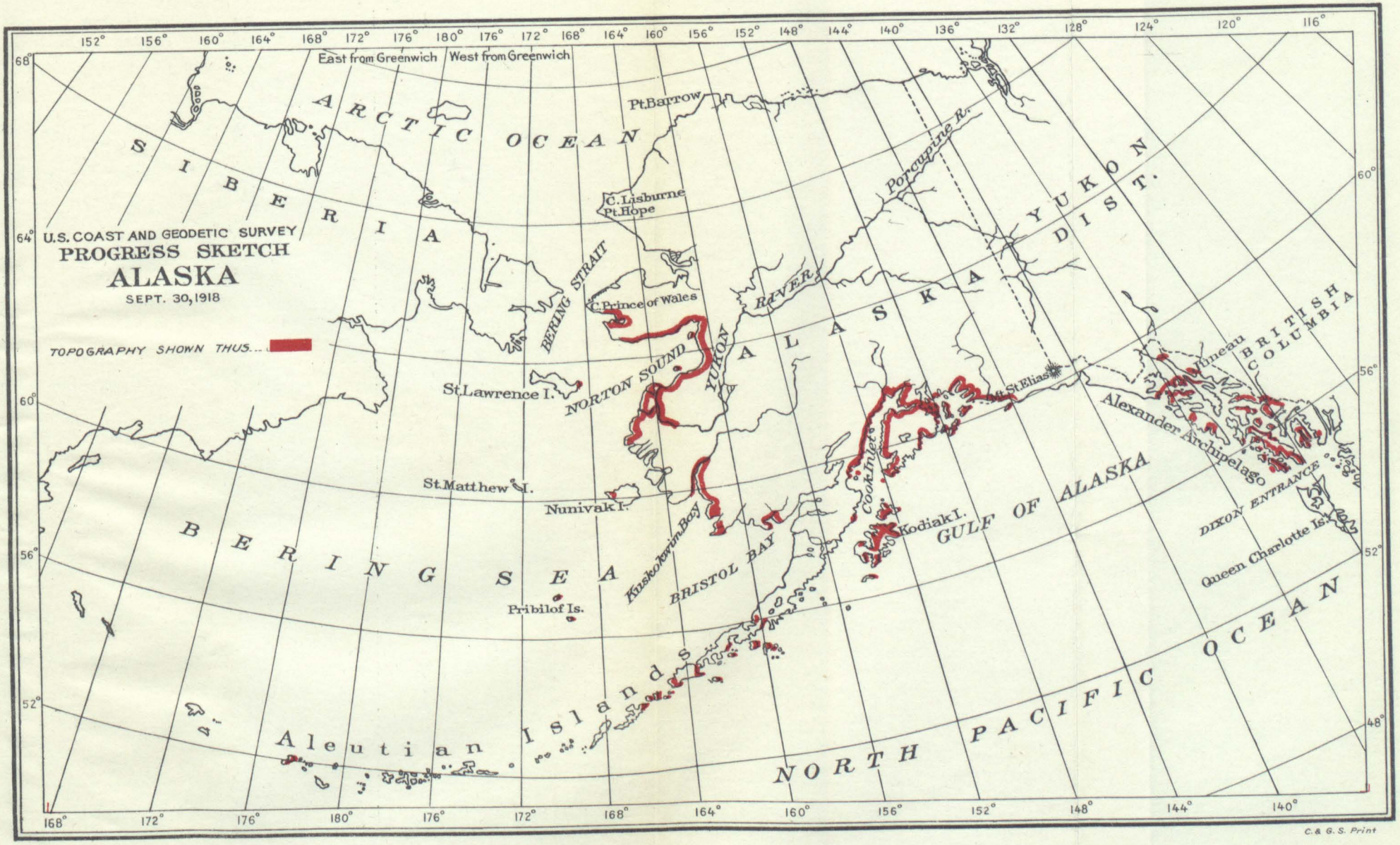
The magnetic variation instruments have continued in satisfactory operation.

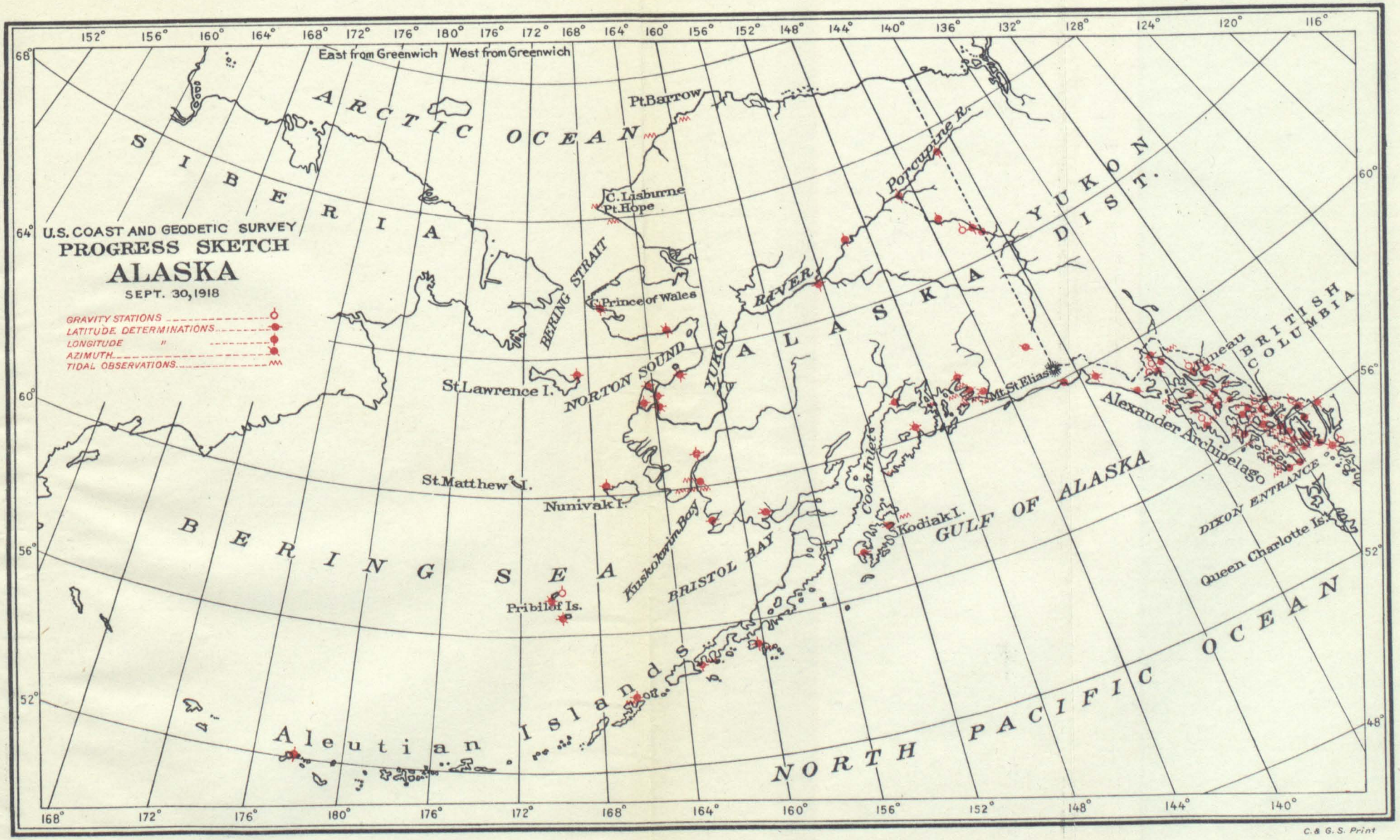
Absolute observations, consisting of three sets of declination, two sets of dip, and the regular double set of horizontal intensity observations, were obtained twice each week, with the exception of one week in October, when the absolute observation building was being moved to a new site.

Time observations from noon transits of the sun were obtained when practicable.

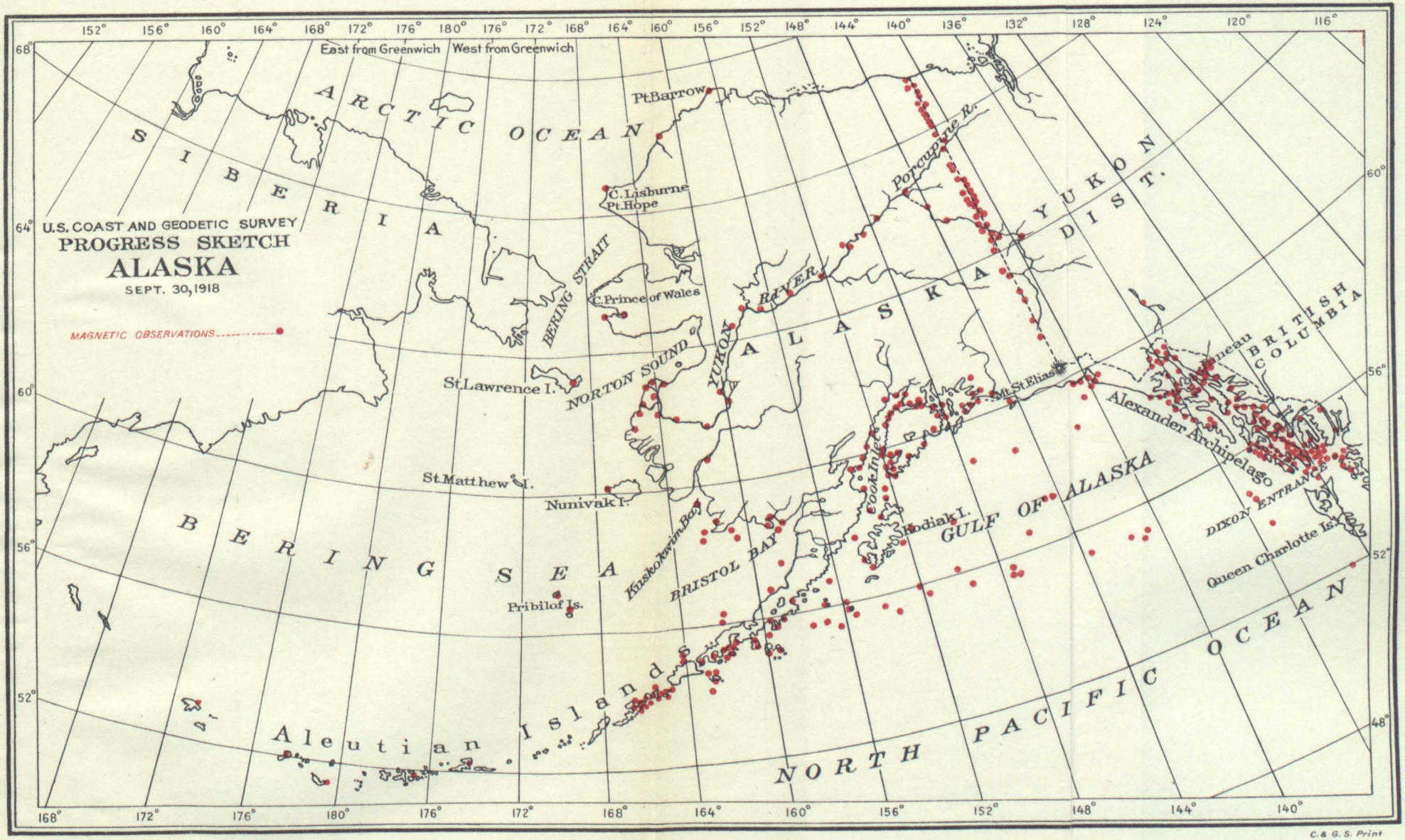
The seismograph was kept in operation and a total of 21 earthquakes, nearly all of small magnitude, were recorded during the year. During April and May the record was partly interrupted, owing to the failure of the driving clock.


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
SEPT. 30, 1918
TRIANGULATION SHOWN THUS....
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
NORTON SOUND
YUKON RIVER
Porcupine R.
YUKON DIST.
ALASKA
BRITISH COLUMBIA
Juneau
Mt. St. Elias
Alexander Archipelago
St. Lawrence I.
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BRISTOL BAY
Cook Inlet
Kodiak I.
GULF OF ALASKA
DIXON ENTRANCE
Queen Charlotte Is.
BERING SEA
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN
C. & G. S. Print


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
SEPT. 30, 1918
TOPOGRAPHY SHOWN THUS...
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
NORTON SOUND
St. Lawrence I.
YUKON
RIVER
Porcupine R.
YUKON DIST.
ALASKA
Mt. St. Elias
Juneau
BRITISH COLUMBIA
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
Cook Inlet
Kodiak I.
GULF OF ALASKA
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BRISTOL BAY
BERING SEA
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN
C. & G. S. Print


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
SEPT. 30, 1918
GRAVITY STATIONS
LATITUDE DETERMINATIONS
LONGITUDE "
AZIMUTH "
TIDAL OBSERVATIONS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
St. Lawrence I.
NORTON SOUND
YUKON RIVER
Porcupine R.
YUKON DIST.
ALASKA
Mt. St. Elias
Alexander Archipelago
Juneau
BRITISH COLUMBIA
DIXON ENTRANCE
Queen Charlotte Is.
GULF OF ALASKA
Cook Inlet
Kodiak I.
Kuskokwim Bay
BRISTOL BAY
Nunivak I.
St. Matthew I.
BERING SEA
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN

C. & G. S. Print


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
SEPT. 30, 1918
MAGNETIC OBSERVATIONS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
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.
Cook Inlet
Kodiak I.
GULF OF ALASKA
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BRISTOL BAY
BERING SEA
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN

C. & G. S. Print

Immediately after securing the absolute observations on October 1 the work of moving the absolute-observation building from the Swanson property to the new site was begun. This work occupied two weeks. From the new site the former azimuth mark is not visible, and consequently it was necessary to transfer the azimuth and use a new mark. Comparative observations were made to determine the relation between the old and the new sites.

PORTO RICO.

[F. L. ADAMS, July 1, 1917, to Apr. 12, 1918; WALLACE M. HILL, Apr. 13 to June 30, 1918.]

At the magnetic observatory at Vieques, P. R., the usual absolute observations of the three magnetic elements—declination, dip, and horizontal intensity—were made.

The magnetograph and seismograph have been in practically continuous operation. Twenty-eight earthquakes were recorded during the year.

The buildings at the station are in good condition of repair.

About 2 acres of waste land surrounding the station were cultivated, and a fair crop of corn, beans, sweet potatoes, and other vegetables was raised.

VIRGIN ISLANDS.

[O. W. SWAINSON.]

SUMMARY OF RESULTS.—Reconnoissance: 5 lines of intervisibility determined, 2 points selected for scheme. Base lines: 1 secondary 1,848.38 meters in length. Triangulation: 198 square miles of area covered, 98 signal poles erected, 3 observing scaffolds and tripods built (heights 30 to 40 feet), 15 stations in main scheme occupied for horizontal measures, 7 stations in supplemental scheme occupied for horizontal measures, 18 stations occupied for vertical measures, 68 geographic positions determined, 3 elevations determined trigonometrically. Leveling: 2 miles of levels run. Topography: 10 square miles of area surveyed, 37.5 miles of general coast line surveyed, 1 mile of shore line of ponds surveyed, 13 miles of roads surveyed, 1 topographic sheet finished, scales 1:900 and 1:10,000.

In January, 1918, a party was organized for surveys in the Virgin Islands. This party left New York for San Juan, P. R., on February 2, arriving at San Juan on February 7. While waiting for transportation to St. Thomas a search was made for launches suitable for wire-drag work.

The party arrived in Charlotte Amalie, St. Thomas, on February 19, and the chief of party immediately reported to the governor of the islands. With the assistance of the Engineering and Pay Departments of the Navy on the following day, the party was organized and bids for supplies sent out.

A site for a base line was selected, and, as soon as the supplies were received and the party organized, work was begun on it. A subparty was put to work building signals.

The best site for a base line was found to be 1 mile east of the town, starting on a small knoll just east of the West Indian Co.'s Dock and running in a northeasterly direction to the base of the hills. The base site rose gradually on an average of $2\frac{4}{10}$ per cent after a steep decline of a 16 per cent slope in getting away from south base. North base was 103 feet higher than south base, the elevation of the lowest stake being 40 feet lower than either base. The length of the base was 1,848.3865 meters.

Four by 4 inch stakes were driven 25 meters apart and lined in with a theodolite. Brass strips were fastened on top of the stakes on which the zeros of the tape fell. The elevation of the top of the stakes was determined with a wye level. A standardized invar tape was used for measuring. The regular method of base measurement with the use of this type of tape was employed.

The triangulation was carried from the established line East End on Vieques Island, Savana. Heliotropes were used on both ends of the three lines from East End. Three parties, one in charge of each officer, were in continuous operation.

It was necessary to build a tower at East End in order to see Buck Island, The height of this tower was computed, and accordingly enough lumber was taken there from Fajardo for the purpose. Buck Island Light could be seen from the top of this tower at night, but the heliotrope could not be seen in the daytime, although of equal elevation. It was necessary to build a tower alongside of Buck Island Light and 15 feet higher to overcome the difficulty.

Central-point figures were decided upon to give the best bases for cutting in topographic control stations with the least amount of main-scheme observing. Intersection stations were established about every mile along the shore line for

topographic control. These were cut in from at least three stations wherever possible. The triangulation was rushed in order to get one topographic party started on the most difficult topographic sheet.

One topographic party was started on the sheet embracing the town and harbor on April 22. The other party was started on the western sheet May 1. Both continued with only short interruptions for signal building and triangulation the balance of the fiscal year.

Extreme care was taken to obtain accuracy on the sheet covering the town. An elaborate control was furnished. The contours were determined with more than ordinary precision, due to the fact that the local government is contemplating installing a water system in the vicinity, and the Coast Survey chart would be studied for a waterworks site.

At the request of the Navy Department particular stress was given the locating of old ruins, stone walls, boundary monuments, etc. All of this topography was done on a 1:10,000 scale. Twenty-foot contours were determined.

At the request of the local authorities a special topographic survey was made of a piece of alien property which it was contemplated to seize for military purposes. This survey consisted in locating the shore line, docks, houses, and contours. It was on a scale of approximately 1:900. Assistance was rendered the naval civil engineer by checking his results in laying out the foundation for a wireless tower. The commanding officer of the Marines supplied a launch whenever it could be spared.

HAWAIIAN ISLANDS.

[FRANK NEUMANN.]

At the magnetic observatory near Honolulu a continuous record was obtained with the variation instruments.

Absolute observations were made weekly to determine base-line values. Scale-value observations were made monthly.

The Milne seismograph was in operation with only slight interruptions, and 107 earthquakes were recorded.

In order to obtain chronometer corrections, time observations with sextant and artificial horizon were made three or four times each month.

Meteorological observations were made as usual and reported monthly to the United States Weather Bureau office at Honolulu.

PHILIPPINE ISLANDS.

[FREMONT MORSE, Director of Coast Surveys.]

The work of the Survey vessels was somewhat handicapped by the greatly increased cost of all supplies and particularly of coal. The difficulty in regard to coal was greatly relieved by the purchase from the Navy of a supply for the *Pathfinder* and *Fathomer* at a cost of about half the prevailing local price.

In August when it became apparent that the Philippine appropriation was insufficient to meet the expenses of the surveying parties to the close of the year, a request was made to the Philippine Emergency Board for an allotment which was granted. Later it became necessary on account of the shortage of officers and delays in repairing to withdraw the *Fathomer* and *Research* from active service, so that the whole of the extra allowance was not needed, and a portion of it was returned to the insular treasury.

As it was not practicable to replace the officers sent back to the United States and those transferred to the Army and Navy the steamers *Research* and *Marinduque* were laid up and the *Research* was finally transferred back to the insular government.

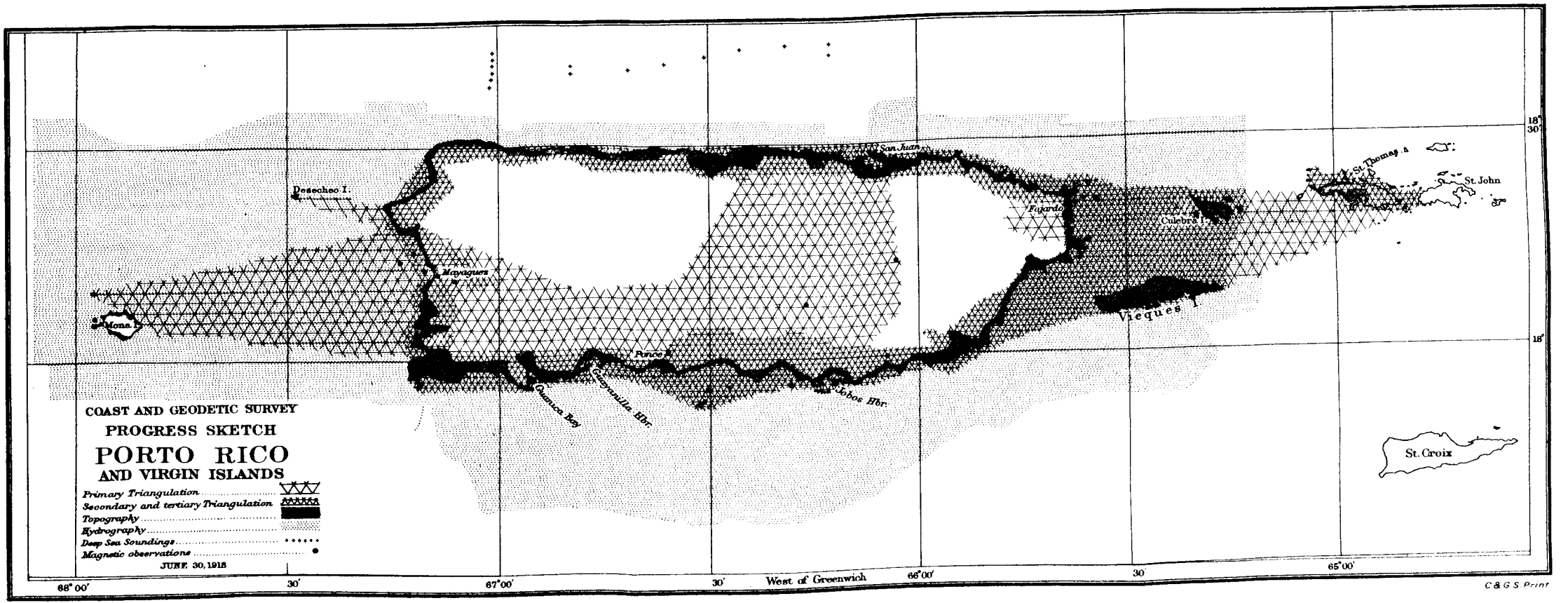
On December 31 the steamer *Pathfinder* was taken to the Olongapo Naval Station for extensive repairs.

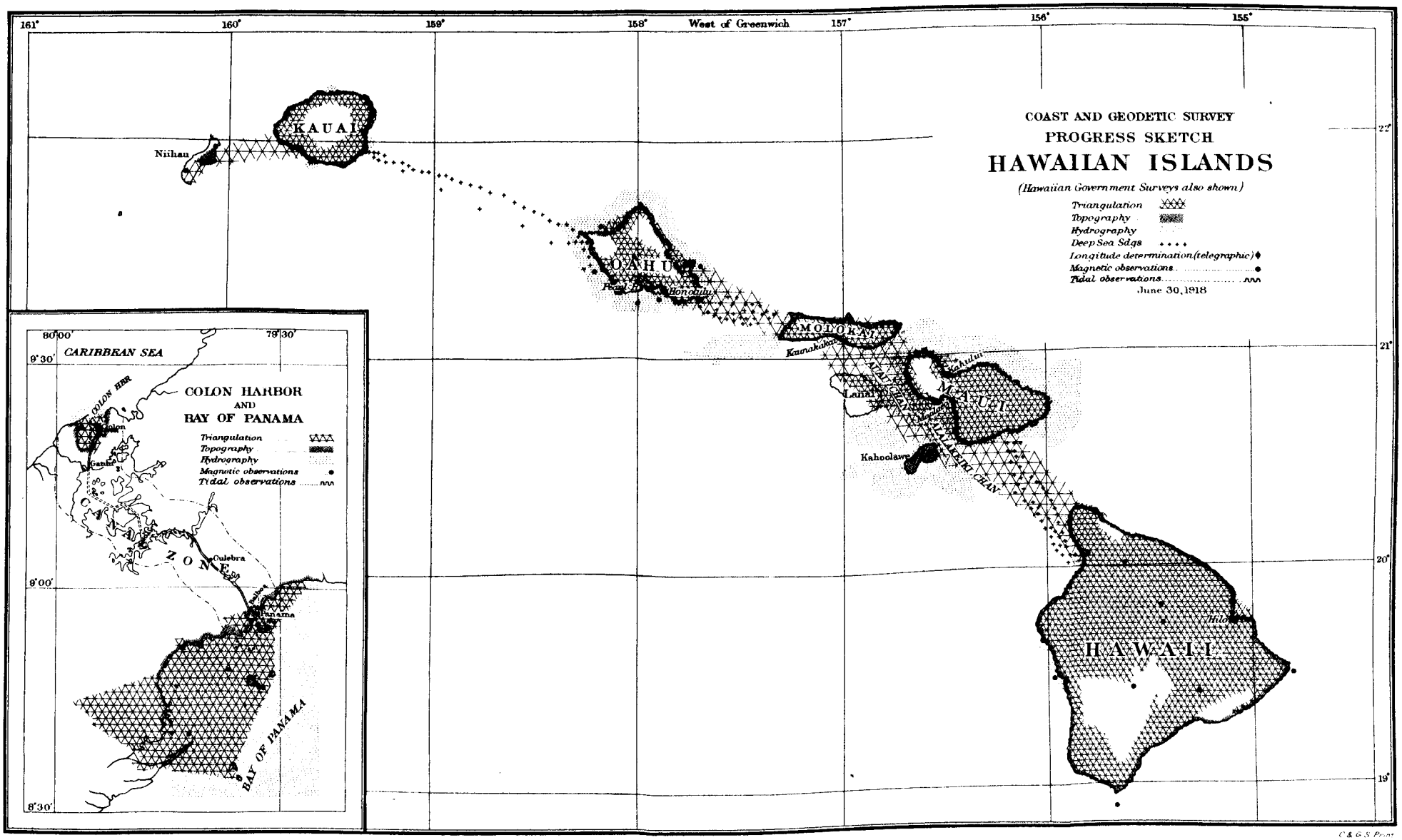
The Philippine Committee on Geographic Names was reorganized June, 1917, and, after a preliminary meeting on August 30, meetings were held monthly beginning on October 3. The names of barrios are being considered province by province, and good progress had been made.

The Harbor Line Commission was reorganized November 6, 1917, and the Director of Coast Surveys was continued as a member.

Extensive repairs to the steamer *Pathfinder* begun in December were greatly delayed by the pressure of Navy work at the Olongapo Naval Station, so that the ship did not get away from the yard until April 20.

The steamer *Marinduque* was temporarily turned over to the bureau of labor of the Philippine government on March 19, 1918.


COAST AND GEODETIC SURVEY
PROGRESS SKETCH
PORTO RICO
AND VIRGIN ISLANDS
Primary Triangulation
Secondary and tertiary Triangulation
Topography
Hydrography
Deep Sea Soundings
Magnetic observations
JUNE 30, 1918
Desecheo I.
Mona
Mayaguez
San Juan
Ponce
Guanica Bay
Guayanilla Hbr.
Tobos Hbr.
Fajardo
Culebra I.
Vieques I.
St. Thomas
St. John
St. Croix
18° 30′
18°
68° 00′
30′
67° 00′
30′
West of Greenwich
66° 00′
30′
65° 00′
C & G S Print


COAST AND GEODETIC SURVEY
PROGRESS SKETCH
HAWAIIAN ISLANDS
(Hawaiian Government Surveys also shown)
Triangulation
Topography
Hydrography
Deep Sea Sdgs
Longitude determination (telegraphic)
Magnetic observations
Tidal observations
June 30, 1918
West of Greenwich
161°
160°
159°
158°
157°
156°
155°
22°
21°
20°
19°
KAUAI
Niihau
OAHU
Honolulu
MOLOKAI
Kaunakakai
Lanai
MAUI
Kahului
Kahoolawe
HAWAII
Hilo
CARIBBEAN SEA
COLON HARBOR
AND
BAY OF PANAMA
Triangulation
Topography
Hydrography
Magnetic observations
Tidal observations
COLON HBR
Colon
Gatun
CANAL ZONE
Culebra
Panama
BAY OF PANAMA
80°00'
79°30'
9°30'
9°00'
8°30'
C & G S Print

OFFICE WORK.

In the computing division the office work on reductions of tides and soundings was carried on as usual. In the triangulation no main scheme adjustment was undertaken, as all work was on minor schemes in regions previously covered by main scheme adjustments. The computation of geodetic positions and the preparation of final abstracts of positions were prosecuted to such an extent that final positions are available for all stations in adjusted work throughout the Visayas and Northern Mindanao, except along the east coasts of Mindanao, Leyte, and Samar.

In the drafting and geographic divisions, 22 hydrographic and 9 topographic sheets, besides 2 supplemental hydrographic sheets and 1 supplemental topographic sheet, were received, making a total of 1,388 survey sheets received since the commencement of the surveys in the islands. The number of survey sheets on hand at the Manila office on December 31, 1917, was 399.

Seven chart tracings were completed and forwarded to Washington for printing, consisting of 3 new charts, 1 new edition, and 3 correction pieces. Seven chart drawings were in progress on December 31, 1917.

Tracings were made of 10 topographic and 3 hydrographic sheets.

The necessary field projections and other data were furnished to hydrographic parties and the regular plotting and verification of hydrographic sheets and inking of topographic sheets were attended to.

Blue prints of topographic sheets were furnished to other Bureaus and individuals.

A large progress map of work of the Coast and Geodetic Survey in the Philippine Islands was prepared for exhibit during the Philippine Carnival in February, 1918.

In the geographic division the tracings for the map of the Philippine Islands on a scale of 1 : 1,000,000, size 1.33 by 2.09 meters, were sent to the United States for publication. This map was constructed in accordance with the plans for a map of the earth on a uniform scale adopted by the International Geographic Congress.

Progress was made on drawings for five other maps of the Philippine Islands, viz: No. 50, Mindanao Island, scale 1 : 600,000; No. 13, Samar; No. 3, Northern Luzon, scale 1 : 200,000; No. 6, Central Luzon, Eastern Part, scale 1 : 200,000; No. 9, Southeastern Luzon, scale 1 : 200,000.

The sales of maps and blue prints were attended to by the chief clerk of the Manila suboffice.

A list of names of municipalities, barrios, and sitios is being compiled in the geographic division.

An alphabetical card index was begun to include all Philippine geographic names.

[H. C. DENSON Commanding Steamer *Pathfinder*.]

SUMMARY OF RESULTS.—Topography: 32.5 square miles of area surveyed, 54 miles of general coast line surveyed, 7.5 miles of rivers surveyed, 1 topographic sheet finished, scale 1 : 20,000. Hydrography: 1,058.4 square miles of area surveyed, 2,866.7 miles run while sounding, 6,939 positions determined (double angles), 21,755 soundings made, 1 tide station established, 4 hydrographic sheets finished, scales one 1 : 60,000 and three 1 : 20,000. Traverse: Length 25.1 miles, 8.1 square miles of area covered, 23 signal poles erected, 21 stations in main scheme occupied for horizontal measures, 16 stations in supplementary scheme occupied for horizontal measures, 21 geographic positions determined.

At the beginning of the fiscal year the steamer *Pathfinder* was engaged in the survey of the approaches to Burdeus Bay, Polillo Island.

The control for this work was obtained from supplementary tertiary triangulation from four recovered stations. Eight stations were occupied. Additional hydrographic signals were determined by plane-table cuts and traverses. Launch hydrography in this locality, which had been interrupted from June 28 to August 28, was completed September 28. The extremely irregular bottom necessitated lines at 100 meters intervals and very close development of important shoals and channels. As the bottom is visible in a good light at 5 fathoms, it is quite certain that the channels, where no indications of shoals were found, are quite clear.

As discrepancies were found in the shore line, the previous work in this locality done in 1908 was disregarded, and a complete examination was made.

The examination did not reveal any new dangers in the 1906 deep channel, though less water was found on most of the known shoals. A new deep chan-

nel was found north and east of Pacabalo Reef. A very complicated 9-fathom channel was developed between Polillo Island and Cataoyan Reef. Numerous rocks and shoals were found which practically close navigation for about 3 miles south of Patnanongan Island, to the eastward of Minasawa Island.

The work on the southern approaches to Burdeus Bay was interrupted at the end of June in order to take up work on an offshore hydrographic sheet extending some 24 miles north and east of Polillo and the Uala Islands and to survey the north coast of Polillo Island.

The area to the north of Polillo Island completed this season includes in addition to the offshore sheet a topographic and an inshore hydrographic sheet covering the unsurveyed north and northwest coasts of Polillo Island. Owing to flat thickly wooded ridges, triangulation was impracticable, and the control for the Polillo Island work was obtained by theodolite-stadia traverse around the north coasts between triangulation stations established in 1906 and 1916. This 24-mile traverse was made with due regard to accuracy and time, no sights in excess of 400 meters being taken, the distances across bays and rivers being obtained by triangulation and the distances checked by an improvised tape of stranded sounding wire whenever practicable. The closing error was 0.72 meter per mile of traverse, or 1:2,540.

The traverse was started in the second week in July and the topography and inshore hydrography completed by the third week in August. The coast line indicated on the existing chart was found to be considerably in error in appearance and 3 to 4 miles south or inside the true position.

An anchorage with gray mud bottom, about one-half square mile in area and protected in all directions except from the north, was found in Pinavisagan Bay, on the northeast coast of Polillo Island.

An excellent landlocked anchorage with depth of 3 fathoms mud bottom for small vessels with a swinging radius of 150 feet was found in the south bight of the Pinagagan River, on the northwest coast.

No ship watering places were found. The small surface streams are practically dry from May to October, and the rivers are salt for several miles from their mouths.

The signals used for offshore hydrography were, with but two exceptions, natural objects located by the few practicable triangulation directions and by sextant angles from the ship.

Work on the offshore sheet was commenced on June 27 and continued at intervals until it was completed on October 17. The only detached shoal indications found and developed were the 15-fathom banks lying about 5 miles northwest of Polillo Island and an 8-fathom spot about 4 miles east of Kalongkooan Island.

On the afternoon of October 17 and morning of October 18 the ship partially developed a shoal spot lying one-third mile east of the small islet which lies due north of the eastern end of Palasan Island. Further work is required in this locality, as it was impracticable to complete the development on account of heavy seas.

There is little remarkable in the appearance of the areas examined. The low islands in front of the higher wooded ridges of Polillo afford numerous natural ranges through the channels into Burdeus Bay, but since they usually consist of slight variations in the sky line over clumps of trees it is impracticable to so describe them in print as to preclude mistakes in identfying them.

The north coast of Polillo is thickly wooded with several flat-topped ridges, rising very gradually to a height of 690 feet. As the different ridges can be distinguished only in misty weather and from offshore, the contours which have been sketched may be very inaccurate. Except in the heads of the bays and in the rivers, the entire coast is fringed by a coral reef, which extends out for distances ranging from 100 meters to almost a mile from the high-water line. On the northwest side a small barrier reef extends about 2 miles offshore. There is only a complicated small-boat passage between it and the shore reef. Landing on the open coast in a heavy swell would be very dangerous. One of the numerous bays should be made if possible. Notwithstanding the protection of the reef, the high-water line exposed to the northeast everywhere shows evidence of strong wave action. The rock outcrops are always undercut and very irregular, while the coral sand is driven up in a dike from 15 to 20 feet high.

The commercial possibilities of this coast are limited, at least in the near future. There is no great amount of large accessible timber. The land is probably fertile, but it requires considerable labor to clear it. Coconuts and

other plants cultivated by the inhabitants do well. The present inhabitants consist of Tagalogs and a number of scattered families of Dumagats.

The season's work was brought to a close on October 18, and the *Pathfinder* proceeded to Manila, at which port the vessel arrived on October 22. From this date to December 1 the vessel was anchored in Manila Bay, the party being engaged in making out specifications for repairs to vessel and preparing field data to submit to the Manila office; also in preparing inventories, etc., necessary to effect transfer of command. From December 2 to December 31 the *Pathfinder* was undergoing repairs at the Olongapo Naval Station. On December 31 the command of the steamer *Pathfinder* was transferred from H. C. Denson to H. B. Campbell.

[A. M. SOBIERALSKI, Commanding Steamer *Pathfinder*.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 10 miles, 29 square miles of area covered, 5 lines of intervisibility determined, 2 points selected for scheme. Base line: 1 secondary, 4,706 meters in length. Triangulation: 52 square miles of area covered, 14 signal poles erected, 2 stations in main scheme and 3 stations in supplemental schemes occupied for horizontal measures, 2 stations occupied for vertical measures, 5 geographic positions determined, 2 elevations determined trigonometrically. Topography: 59.6 square miles of area surveyed, 58.5 miles of general coast line surveyed, 17.5 miles of shore line of rivers and creeks surveyed, 34 miles of roads surveyed, 8 topographic sheets finished, scale of topographic sheets 1 : 10,000 and 1 : 20,000. Hydrography: 305 square miles of area covered, 1,771.9 miles run while sounding, 5,820 positions determined (double angles), 25,210 soundings made, 2 tide stations established, 1 hydrographic sheet finished, scale of hydrographic sheets 1 : 20,000 and 1 : 40,000.

While repairs to the steamer *Pathfinder* were in progress at Olongapo, a detached party completed the survey of Mariveles Harbor. The topography was carefully rerun and a close development on a 1 : 10,000 made of the harbor.

The *Pathfinder* sailed from Manila for the working ground on the east coast of Palawan on May 7. En route a small patch of hydrography south of Dumaran Island was completed and some deep soundings off Bold Point were taken. Upon arrival at Puerto Princesa the final reconnoissance for the base line was made and a party left at Iwahig to prepare the base for measurement. On May 31 the base line was ready for measurement. The base line is only 4,700 meters long, but a good scheme of expansion makes it possible to use this length.

Besides the areas off Dumaran and off Bold Point the inshore hydrography was completed from Table Head to Trading Bay. The ship and one launch worked on the offshore hydrography, completing all the work outside of a line 1 mile east of Malanao and Sombrero Islands, down to latitude 9° 20′ N. A large part of this work was hand-lead work.

The topography was completed from Table Head to Malanao Island. The work in Puerto Princesa was held up on account of unfavorable tides. All the head of the bay is a mangrove swamp and can be done only at low tides. Only some supplementary stations for the control of hydrography and topography were located. The ship was swung for compass deviations off Malanao Island.

The automatic tide gauge at Puerto Princesa was kept in continuous operation. A tide staff at Village Rocks was observed while hydrography was in progress in the vicinity. A tide staff was established at Aborlan and read while hydrography was in progress in the vicinity.

Puerto Princesa was used as headquarters. Sandakan, British North Borneo, was the coaling station.

During the month of June the following work was executed by this party:

Two triangulation stations in base expansion were established and occupied. Supplementary triangulation was extended to Panacan.

The hydrography was extended southward and two 65-foot hydrographic signals built. Two lines of deep soundings were run from latitude 9° 05′ to Bancoran Island.

About 19.6 miles of topography was executed.

Two of the stations, Mount Beaufort and Stavely Shoulder, were occupied, although the party had not returned from the latter on June 30. Mount Beaufort is about 3,800 feet high, while Stavely Shoulder is about 3,000 feet high. It takes about 10 days to occupy one of these stations.

Five signals were built for extending the supplementary triangulation south from the line Arena-Native Point. It will be possible to extend this scheme to Bivouac Point, but it will not be possible to join up with a local scheme in Island Bay.

The ship and two launches were sounding when weather was favorable. The completed hydrography was extended to latitude 9° 16′ N., outside of the line between Sombrero and Arena Islands. The coral reef south of Imagauan extends to this latitude, requiring close development. As the hills in this vicinity are fronted by an extensive plain, it would be necessary to use a scale of 1:80,000 for the development of this bank, but by building some tall signals on Malanao, Sombrero, Arena, and Rasa Islands, it was possible to work on a scale of 1:40,000.

The peaks around Sultan Peak and Victoria Peak are so indefinite and so often in the clouds that it will be difficult to obtain good positions in the vicinity of Altnacraig and Marabout Shoals, except in the early morning.

The anchorage at Aborlan was developed, but the shoal water between Malanao Island and the mainland has not yet been surveyed.

The hydrography in Puerto Princesa was extended to a line west of Tidepole Point. This work was done while the base line was being measured.

On the run to and from Sandakan, lines of sounding were run between Bancoran Island and Palawan. The soundings were spaced closely in the latitude of Rosalia Reef, but no indication was found. Sextant positions were obtained in this vicinity, while dead reckoning was used for the rest of the run, with good bearings on Bancoran Island for determination of the southern ends of the lines.

The topography of Malanao Island and the shore line from Aborlan to Calver Point was completed. As the hills back of Aborlan do not come on a 1:20,000 topographic sheet, a sheet was laid out on a scale of 1:40,000 on which the contours only will be shown.

While the ship went to Sandakan for coal, a party was left at Puerto Princesa to continue the topography of the bay. Low tides occurred during the daytime during this week, and the worst part of the work was completed. Even at low tide the party had to wade continuously in mud and water up to the waist.

A typhoon passing to the northward during the week June 24 to 30, caused very rough weather. It was rough two days before the barometer fell.

[J. W. MAUPIN, Commanding Steamer *Fathomer*.]

SUMMARY OF RESULTS.—Triangulation: 18.4 miles of area covered, 3 signal poles erected, 3 stations in supplemental schemes occupied for horizontal measures, 2 geographic positions determined. Leveling: 2 permanent bench marks established. Topography: 7 square miles of area surveyed, 20.2 miles of general coast line surveyed, 1 topographic sheet finished, scale 1:20,000. Hydrography: 458.1 square miles of area covered, 1,602.2 miles run while sounding, 5,211 positions determined (double angles), 15,393 soundings made, 1 tide station established, 2 hydrographic sheets finished, scales 1:20,000 and 1:60,000.

From July 1 to 14 the steamer *Fathomer* was repairing and outfitting at Manila. After coaling at Cavite on July 14, the vessel sailed the same day for the working grounds, arriving at Burdeus Bay, Polillo Island, on July 20.

The work of the season included topography and hydrography on the east coast of Luzon in the vicinity of Polillo Island, and was done in cooperation with the party on the steamer *Pathfinder*.

On July 23 a camp was established on one of the Uala Islands for the launch hydrographic, topographic, and signal-building parties. The vessel then proceeded to Dahikan Bay, where a tide gauge and camp were established. This was used as the ships' headquarters throughout the season.

Considerable progress was made in the work during August, but in the latter part of the season the weather was unfavorable. Most of the work was in localities exposed to the open Pacific, where heavy swells made surveying operations on the outlying shoals hazardous and difficult.

In consequence of unfavorable weather conditions, work closed for the season on October 15. The *Fathomer* sailed direct for Manila on that date, arriving on October 18. From this date until the close of the month the vessel was at Engineer Island undergoing repairs and outfitting for the continuation of the work off Busuanga Island.

[S. D. WINSHIP, Commanding Steamer *Fathomer*.]

SUMMARY OF RESULTS.—Triangulation: 418.8 square miles of area covered, 27 signal poles erected, 1 observing tripod and scaffold built (20 feet in height), 9 stations in main scheme occupied for horizontal measures, 6 stations in supplemental schemes occupied for horizontal measures, 10 geographic positions determined. Leveling: 3 permanent bench marks established. Magnetic work: Ship swung at one sea station. Topography: 4.8 square miles of area surveyed, 13.4 miles of general coast line surveyed, 1 topographic

sheet finished, scale 1:20,000. Hydrography: 2,432.6 square miles of area covered, 4,109.1 miles run while sounding, 5,240 positions determined (double angles), 21,864 soundings made, 1 tide station established, 5 hydrographic sheets finished, scale of hydrographic sheets 1:80,000, 1:20,000, 1:40,000, and 1:100,000.

The command of the *Fathomer* was transfered on November 26, while she was undergoing repairs, which were completed December 26. Supplies and coal had been taken on in the meanwhile, and on the same day the vessel sailed for the working ground on the west coast of Busuanga Island, Calamian Group, arriving December 27.

Bench marks were established and connected with the tide gauge by leveling, a camp was established on shore, buoys and ranges for entering the harbor were repaired, and a general study was made of the work to be done. On December 29 hydrographic work was begun by the ship, heavy seas preventing any launch work.

The work of the party consisted of the completion of five hydrographic sheets in the vicinity of the northwest coast of Busuanga Island, which had been begun under the party in charge of John W. Maupin the year previous.

The greater part of this work was confined to development of shoals reconnoitered by the previous party and to work outside the 100-fathom curve.

The first of the year found the party on the working grounds with everything ready to prosecute the work diligently, all preliminaries, such as setting tide staff and establishing tide observer's camp, having been attended to in the last few days of the preceding year.

The center of the operations for the first six weeks was Illuituk Bay, on the west coast of Busuanga Island, but the ship rarely put in there except over Sunday, it being more convenient to anchor behind islands or on shoals nearer the work.

The weather at first was very discouraging. One northeast blow following hard on another made it necessary to work in the deep water fully exposed to the heavy seas, which swept the decks continuously. On two days it was necessary to seek shelter.

When these gales, which lasted about 10 days, had subsided, the northeast monsoon appeared to have blown itself out, for the following weeks brought excellent weather for hydrography, with very fair seeing conditions.

On February 18 the base of operations was transferred to Pangauaran River, Port Caltom, on the north coast of Busuanga, and from there the work around Hunter and Merope Rocks was carried on under generally excellent conditions.

Coal was obtained once from Manila and once from the coal pile at Uson Island. On January 5 a trip was taken to San Jose, Mindoro, to send a telegram to Manila.

During the period from March 2 to June 30, 1918, the *Fathomer* was employed in the unsurveyed portion of Cuyo West Pass and the Sulu Sea south to latitude 10° 21.5′ N. The greater part of this was ship hydrography, the only triangulation involved being the tying in of a few small islands, the topography of which was to be done.

The week following March 2 was spent making minor repairs and getting the supplies necessary for a season's work. On March 10 the ship left for the working grounds in Cuyo West Pass, stopping two days, en route, at Coron for coal, and arriving at Cuyo on the 15th.

A single quadrilateral of secondary triangulation was extended off the base Patunga–Capnoyan, which was tied in to station Tabac Rock to strengthen the general scheme. Another quadrilateral of tertiary triangulation was extended to the south and east to tie in the three small islands there, and a filled triangle was formed on the base Capnoyan–Imalaguan to locate Piedra Blanca. All of this was completed.

To the westward a quadrilateral was extended from the base Norte–Dalanganem to determine the base Dalanganem–Carandaga, from which a small scheme can be extended to control the local topography. This work was in progress at the close of the year.

Observing was greatly hindered by the haze until the end of the northeast monsoon in the early part of May. Aside from this there were no difficulties to overcome.

One sheet of topography, on 1:20,000 scale, was completed, covering the small islands southwest of Cuyo Island with Paya Rock, Tabac Rock, and Piedra Blanca shown in subplans.

Another 1:20,000 sheet covering the Dalanganem Islands was partially done.

A tide staff was erected at Bisucay Island in approximately the same location as the former gauges and tied in to the bench marks there. The small amount

of inshore hydrography about Capnoyan Island and the islands southward was done by a launch party camped on Capnoyan Island. While waiting a favorable day for observing triangulation in the Dalanganem group a small amount of launch work was done there. The shoal westward of Piedra Blanca was developed by the launch, and the work plotted on the ship sheet, and on a favorable day the shoal in the vicinity of Elax Rock and Queen of the Sea Bank, which was reconnoitered by the ship, was developed by a launch party, using as a center signal a small boat anchored with wire in 50 fathoms.

All the remainder of the hydrography was done by the ship. The general plan of work has been to clean up from the eastward, doing the off-shore work whenever weather was favorable, saving the work nearer shore for weather when the seeing was poor, or the sea so rough as to make it necessary to seek shelter at night.

The work in the vicinity of the Dalanganem Islands was incidental to the triangulation there and to the development of the shoals reported as Queen of the Sea Bank and Elax Rock, which were the objects of a special effort requiring good seeing and smooth sea.

While working east and southeast of Piedra Blanca, the weather being favorable, the ship was allowed to drift during the night to determine the set of the current. In addition to this data, careful record of the set on trips to and from Iloilo was kept and plotted on the boat sheet. A very uniform set of 1 knot in a direction slightly south of east seems to prevail.

The only magnetic work was one ship swing on the sun azimuth.

Stopping off for a day en route to Iloilo, a reconnoissance was made of the Cagayan Islands. Particular effort was made to find an entrance to the inclosed area between the islands to be used as a ship anchorage, but without any results.

There was not sufficient time to make a comprehensive reconnoissance for triangulation, but enough was done to determine a favorable location for the base and the general trend of the progress of the scheme.

In addition to the prescribed work, an investigation was made and report transmitted on the shoals in the mouth of the Iloilo River. At the request of the presidente of Cuyo, the engineer of the bureau of lands, and the observer of the Weather Bureau, three bench marks were established at Cuyo and connected by four days' simultaneous readings with Bisucay.

[R. R. LUKENS, Commanding Steamer *Romblon*.]

SUMMARY OF RESULTS.—Reconnoissance: 300 square miles of area covered, 9 lines of intervisibility determined, 5 points selected for scheme, length of scheme 30 miles. Triangulation (secondary): 1 signal pole erected, 3 observing tripods built (height 75, 68, and 25 feet), 6 stations in main scheme occupied for horizontal measures, 1 station in secondary scheme occupied for horizontal measures, 6 stations occupied for vertical measures, 15 geographic positions determined. Leveling: 0.5 mile of levels run, 3 permanent bench marks erected. Topography: 38 square miles of area surveyed, 38 miles of general coast line surveyed, 1 topographic sheet finished, scale 1:20,000. Hydrography: 125 square miles of area covered, 1,060.4 miles run while sounding, 4,072 positions determined (double angles), 18,378 soundings made, 1 tidal station established, 1 hydrographic sheet finished, scale of hydrographic sheets, two 1:20,000 one 1:60,000.

The work of this party was the continuation of general surveys along the southeastern coast of Palawan Island with the special object of extending the secondary triangulation to a junction with the work of the steamer *Marinduque*, which was being brought down from the northward.

From July 7 to 31 the vessel was at Manila undergoing repairs. On August 1 she sailed for the Palawan coast.

Upon arrival at the working grounds a camp was put out on Pirate Island, and the officer in charge was given instructions to carry on the topography and hydrography as he saw fit, but to make a finished survey as he went along. The ship then took up triangulation, building high signals along the beach and shifting parties around for trips into the interior stations. This caused a great deal of running with the ship, as the triangulation was 30 to 40 miles ahead of the hydrography, and therefore but little ship hydrography could be accomplished. Even when a day was available for sounding, the squalls and low-hanging clouds would usually stop work in the early afternoon.

The *Romblon* made trips to Sandakan for coal and water about every 24 days, leaving one or two parties in camp to carry on work in her absence.

From about September 20 the efforts of the whole party were concentrated on the triangulation, and a plan was laid out which, if successful, would insure the completion of the work by the time the ship went to Manila in October. The

success of this plan hinged on the ability to establish and occupy a station on Mount Gantung, one of the most difficult of all the Palawan peaks. The officer assigned to this task started out on September 25.

The ship proceeded to Sandakan for coal on October 3, and upon returning the officer sent to occupy Mount Gantung was picked up on October 8. His trip had been unsuccessful. The weather was bad and on the eighth day out his Tagbanua cargadores deliberately deserted him, and he was left no alternative except to return as best he could with his two sailors.

This unfortunate incident broke up all hope of finishing the work, and, owing to the continued bad weather, it was decided to return to Manila at once for supplies and cleaning boilers and to get back as soon as possible, in the hopes of encountering better weather during the change of monsoon. Accordingly the ship arrived in Manila on October 14 and plans were made to sail again on October 22.

On October 19, however, the matter of the transfer of the commanding officer of the *Romblon* to the Naval Reserve came to the attention of the commander in chief of the Asiatic Fleet, and he issued verbal orders that the vessel remain in port while he communicated with the Navy Department in Washington in regard to this assignment. Answer to this cable was not received until November 15, and as it was favorable, this officer was ordered into the Naval Service. In the meantime the ship had been held in Manila.

In accordance with instructions received from the Director of Coast Surveys, the command of the *Romblon* was turned over to another officer on November 17.

The launch was kept busy at inshore hydrography during all the time that the ship was on the working grounds. This work was carried from Iglesia Point to a point about 2 miles northeast of San Antonio Bay. The area covered is very full of shoals and reefs, and much development work was necessary. The offshore work was taken up by the ship when opportunity offered, but the prevalence of low-hanging clouds made it very difficult; indeed, 8 or 9 miles offshore seemed to be about the limit at the northern end of the work. The area of shoals seems to extend many miles offshore, and close work will be required to find all the dangers.

In development work a bright day was utilized, and the ship anchored on the shoalest part of the bank in question; then a small boat was put out to search the area thoroughly for coral heads and pinnacles. Enough lines were run to delineate the depth curves, but the great effort was to find the least depths.

Tanner-Bliss pressure tubes were used in the ship work, and they gave very good results. The ship's work joins that of the launch for a distance of about 15 miles and the soundings cross very well. Numerous up-and-down soundings were taken during the work to verify the tubes. Hand lead was used on all shoals and banks.

The topography was completed from Iglesia Point to Tami Point, the most of the work being done by a party in camp. Care was taken to establish many triangulation stations along the shore, so that the work is well controlled. Around Iglesia Point and part of San Antonio Bay the shore line is mangrove and mud, making the work very tedious. This section was done during low-water periods. The northern part of the work consists, in the main, of a fine sand beach.

The main mountain range does not come on the topographic sheets; therefore a 1:100,000 prejection was made for the purpose of cutting in the mountain topography. Cuts were taken for this sheet when an opportunity offered itself, but it was not completed.

The triangulation was the most important part of the season's work, the object being to effect a junction with the work of the steamer *Marinduque* as brought down from the north. The reconnoissance was finished and all signals except one were up when the ship returned to Manila. The conditions governing this work were hard. One line of stations was on the central range, from 3,000 to 7,000 feet high, while the other line was on a wooded beach where high scaffolds were necessary. Continued bad weather and the prevalence of malaria were the features that prevented the completion of the work during this season.

In this work the officers have displayed some very fine qualities of courage and tenacity. To spend day after day in those mountains, cutting every foot of the trail, not knowing when all the cargadores may leave, chilled by the daily cold rain and unable to sleep much nights because of the cold, is a task that requires some nerve and determination. Added to this, one is being constantly preyed upon by leeches and the hands and feet get badly cut up by the thorns and briars.

The following is quoted from the report of the chief of party:

"The writer made one five-day trip to one of the easy stations, and he appreciates thoroughly what the other officers have gone through. When Mr. Egner's men left him at the 4,700-foot level en route to Gantung, it took himself and his two men six days to double-pack the equipment back to the nearest barrio. Both Mr. Egner and Mr. Shaw have contracted the malaria from these trips, but it is hoped that they will soon recover from the effects of it."

It was absolutely essential that the station be located on Gantung, for it is the only peak that shows from the station on Mantalingajan.

Day and night readings were made on the tide staff at Sir J. Brooke Point while the ship was on the working grounds. A subsidiary staff on Pirate Island was used while hydrography was in progress in the vicinity. Both staffs are referred to standard bench marks. No protected place suitable for an automatic gauge could be found. In southwest storms a very heavy sea rolls into the landing at Brooke Point, and it was necessary to rebuild the plain staff after nearly every storm.

No systematic current survey was made, but it was noted that there is a set to the northeast along the Palawan coast. This current no doubt is caused by prevailing winds, for in the height of the northeast monsoon, a current setting to the southwest was also encountered. In the run from Bugsuk Island to Cagayan Sulu Islands, a moderate set to the north was always found. In making this run the ship steered N. 49° W. and S. 40° E. with good results.

[LEONARD H. ZEMAN, Commanding Steamer *Romblon*.]

SUMMARY OF RESULTS.—Triangulation: 296 square miles of area covered, 1 signal pole erected, 7 stations in main scheme occupied for horizontal measures, 6 stations occupied for vertical measures, 7 geographic positions determined, 11 elevations determined trigonometrically. Topography: 7 square miles of area surveyed, 16.4 miles of general coast line surveyed, 1 topographic sheet finished, scale 1:20,000. Hydrography: 81.6 square miles of area covered, 695.4 miles run while sounding, 2,260 positions determined (double angles), 8,792 soundings made, 1 tide station established, 1 hydrographic sheet finished, scale of hydrographic sheets, 1:20,000 and 1:60,000.

On November 17, 1917, the command of the steamer *Romblon* was transferred from R. R. Lukens to Leonard H. Zeman.

On November 20 the *Romblon* proceeded to the working grounds on the southeast coast of Palawan, arriving there on November 23. On November 24 the field work commenced. The field work consisted in a continuation of the ship hydrography, launch hydrography, topography, and main-scheme triangulation as brought up the southeast coast of Palawan by R. R. Lukens and party.

Coal was purchased at Sandakan, British North Borneo, a distance of about 200 miles from the working grounds. During runs for coal, parties were left in camps ashore to be engaged in triangulation, hydrography, and topography.

The inshore hydrography completed by the launch extended offshore a distance of about 3½ miles from a point 2 miles northeast of San Antonio Bay to Sir J. Brooke Point. The area surveyed disclosed many shoals which were subsequently developed. When the ship was not engaged on triangulation work, it took up the offshore hydrography from the point where the launch left off and extended the lines to the limit of visibility of shore signals. Tanner-Blish pressure tubes were used for the ship work, and they gave very satisfactory results.

The topography was completed from Tami Point to Filantropia Point. Traverses were run between the main-scheme triangulation points on the beach.

The gap of 25 miles between the main-scheme triangulation, as brought down the island of Palawan from the northward and that brought up from the assumed datum at Balabac, was completed. Field computations yielded the following results at the junction: Length of line checks about 1:50,000; discrepancy in azimuth about 50 seconds; discrepancy in latitude about 20 seconds, and discrepancy in longitude about 27 seconds.

A tide staff was read every day at Sir J. Brooke Point between the hours of 6 a. m. and 6 p. m. No observations for currents were made.

The weather during the period covered by this report was excellent for all the branches of the field work.

On January 16, 1918, the ship sailed for Manila under orders received from the Director of Coast Surveys. A short stop was made at Puerto Princesa in order to obtain mail. On January 19, 1918, the ship tied up alongside the dolphins at Engineer Island, and on January 21 repairs to the vessel were commenced.

On March 13, 1918, the command of the steamer *Romblon* was transferred from L. H. Zeman to H. B. Campbell. The ship was still undergoing repairs on that date.

Owing to the fact that the lignum-vitæ of the stern bearing of the starboard propellor shaft had entirely worn away or dropped out, it was deemed necessary to use only the port engine of the ship in order to avoid possibility of bending the shaft or breaking the bearings. This faulty condition of the stern bearing was first noticed on the trip from Sandakan to the working grounds on January 2–3, 1918.

Several attempts were made to do ship hydrography, using only one engine, but owing to the prevalence of strong northeast monsoon weather this branch of the work was stopped.

The launch was engaged whenever the weather permitted in shoal development just southward of Brooke Point.

Additional work was done on the topographic sheet extending from Brooke Point to Nariz Point The sheet was left unfinished, however, on account of orders to proceed to Manila. During the month of February while the ship was undergoing repairs at Engineer Island a line of levels was run from the automatic tide guage at Pier 5 to the Intendencia Building. The tide staff at Pier 5 was also replaced.

[H. B. CAMPBELL, Commanding Steamer *Romblon*.]

SUMMARY OF RESULTS.—Triangulation: 7 signal poles erected. Leveling: 0.2 mile of levels run. Magnetic work: Ship swung at one sea station. Topography: 0.1 square mile of area surveyed, 10 miles of general coast line run, 2 topographic sheets finished, scale 1:20,000. Hydrography: 581.9 miles of area covered, 252,512 miles run while sounding, 6,704 positions determined (double angles), 24,707 soundings made, 1 tide station established, 1 hydrographic sheet finished, scales of hydrographic sheets 1:20,000 and 1:60,000.

On March 13, 1918, the command of the steamer *Romblon* was transferred from Leonard H. Zeman to H. B. Campbell, at which time the *Romblon* was undergoing extensive repairs at Engineer Island, Manila.

The repairs were completed on April 16, and on April 19 the *Romblon* sailed for the working grounds. On April 23 the vessel arrived at Brooke Point, Palawan, and rebuilt the tide staff. On the next day the launch party was put in camp to do hydrography, and the ship started sounding.

Up to June 30 three trips were made to Sandakan, British North Borneo, for coal, a distance of nearly 200 miles. On these trips at least one camp party was left beind to continue field work.

Both the ship and the launch were continuously engaged in sounding. Anticipating, from general reports, that the weather would be the most favorable at this season, every effort was made to do as much sounding offshore with the ship as was practicable. The extent of this work, which is nearly all inside the 100-fathom curve, is shown on the progress sketch.

The launch worked from camp, and besides filling in the gap west of Ursula Island continued the inshore hydrography to Nariz Point, and developed a number of dangerous shoals which had been located by the ship.

Only sufficient topography was done to keep ahead of the launch party, as it was considered best to keep the two kinds of work together. The topography was completed to Nariz Point.

The main scheme in this locality having been completed, no observing was done. Seven intersection stations were built north of Nariz Point for control, three of them, between stations Nariz and Crawford, being built in tree tops. The remainder are in Island Bay. The approximate location of these stations is shown on the progress sketch. No observing was done.

The staff at Brooke Point was read from 6 a. m. to 6 p. m. during this period. No opportunity offered for observing currents without interference with other work, so none were observed.

[A. M. SOBIERALSKI, Commanding Steamer *Marinduque*.]

SUMMARY OF RESULTS.—Reconnoissance: 3 lines of intervisibility determined, 1 point selected for scheme. Triangulation: 1,270 square miles of area covered, 25 signal poles erected, 11 stations in main scheme occupied for horizontal measures, 22 stations in supplemental schemes occupied for horizontal measures, 16 stations occupied for vertical measures, 43 geographic positions determined, 43 elevations determined trigonometrically. Magnetic work: 2 land stations occupied for magnetic declination, 1 sea station occupied for magnetic declination. Topography: 57 square miles of area surveyed, 46.4 square miles of general coast line surveyed, 8 miles of shore line of rivers surveyed,

1 mile of creeks surveyed, 2.6 miles of roads surveyed, 1 topographic sheet finished, scale 1 : 20,000. Hydrography: 528.4 square miles of area surveyed, 2,407.9 miles run while sounding, 7,920 positions determined (double angles), 33,675 soundings made, 5 tide stations established, 3 hydrographic sheets finished, scales one 1 : 40,000 and two 1 : 20,000.

On July 1 the *Marinduque* was at Manila undergoing repairs and outfitting. Upon the completion of these repairs the ship left Manila to resume work on the east coast of Palawan, arriving on the working grounds July 15. The next day a party was started to build and occupy triangulation station Anepahan, a 4,800-foot peak 17 miles inland, while the rest of the party took up hydrography in Honda Bay.

The only men available for the triangulation party were colonists from the Iwahig penal colony and civilized Tagbanuas, poor material, as experience had shown that the uncivilized Tagbanuas living in almost inaccessible villages in the mountains were the best for this kind of work. The difficulties in the way of reaching this station—its great distance in the interior of the island and its height—with such a poor party seemed almost insuperable, and for this reason no work was done on the triangulation pending the results of this expedition.

On July 29 after the party had been gone two weeks, some stragglers reached the ship who reported that the party had lost their way and had run out of provisions. A relief expedition was immediately started. The ship in the meantime had to run to Sandakan for coal. It was not until August 8, after an absence of 24 days, that the party was picked up; the station was occupied and all observations completed. Great credit is due to the officer in charge especially for his persistence after encountering difficulties that might well have discouraged him.

This was a typical experience during the prosecution of this triangulation, for there were stations such as Victoria, Cleopatra, and Stripe Peak that were even more difficult to reach. One can better appreciate the difficulties of those expeditions after reading Mr. Worcester's account, in his book, The Philippine Islands, pp. 115–124, of the difficulties encountered in the ascent of Thumb Peak, one of the "easy" stations in the scheme.

As soon as the party had returned from Anepahan the ship went to Separation Point, and during the rest of the month of August, Sundays and week days, three observing parties were kept continuously at work on the stations at the southern end of the scheme, while a fourth party was engaged clearing at triangulation station Crawford, where some enormous hard wood (ipil) trees had to be cut down. The stations occupied were Sombrero, Arena, Calatugas, Pulute, Crawford, Albion, and Alboaba in the main scheme, and the supplemental stations Tagalinog, Arrecife, Emelina, and Cay.

Most of these stations were either difficult of access or required heavy clearing, or both. Albion Head, on the west coast, was reached by using an almost obliterated trail across the narrow part of the island at Separation Point to Alphonso XIII, where a native boat had to be secured, and then a precipitous cliff 600 feet high had to be climbed. The natives were afraid to make the ascent, as the place is reputed to be infested with snakes, and the rocks are so sharp that their feet are always badly lacerated in making the ascent.

Pulute, a 3,000-foot peak, 11 miles inland, was also reached from Separation Point, the trail passing through a fairly well-settled country. A considerable amount of clearing was done at this station.

Both Aboaba and Crawford required a large amount of heavy cutting.

Calatugas was a steep, hard climb, 2,500 feet, and required much clearing. The other stations were easy to reach.

This work was finished on August 31, and after coaling at Sandakan the ship returned to Puerto Princesa where it was necessary to blow down in order to make some minor repairs to the boiler. The time was utilized in securing men and making preparations for two triangulation parties to occupy triangulation stations Central and Thumb Peak. While these parties were in the field the rest of the party, taking advantage of a spell of fine weather, completed a large area of hydrography from Bold Point to Pasco Point, including the development of a large number of shoals. On September 22 the triangulation parties returned and the ship left for Manila for repairs and supplies.

During this stay at Manila the ship was hauled out, the bottom cleaned, and a new rudder stock installed.

On October 17 the ship returned to the working grounds, and during the rest of the month was engaged on hydrography and topography in Honda Bay. One party completed the observations at triangulation stations Table Head and Sombrero.

During the first half of November the weather was very bad, with an unprecedentedly large rainfall, and work could be carried on only intermittently. However, as in this country a spell of bad weather is almost always followed by a spell of correspondingly fine weather, all preparations were made for prosecuting the work vigorously—ship was coaled, extra hands secured, and parties advantageously distributed—so that when the weather cleared up (about November 19) everything was ready for work. A topographic and three hydrographic parties were kept almost continuously at work until December 19, when the work was closed and the ship returned to Manila.

During this month of fine weather (from November 19 to December 19) over a thousand miles of hydrography (most of it close development or deep-sea sounding, where it is difficult to run up large mileage) and over 50 miles of topography were completed, besides building and occupying 9 triangulation stations in the supplementary scheme.

The rest of the month was spent at Manila repairing and laying up the ship.

The results of the season's work are as follows:

The observations in the main-scheme triangulation were completed as far south as the line Pulute–Crawford, where it joins the work being done by the party on the steamer *Romblon*, thus completing the main scheme down to the Mantangule base. One angle at Albion Head was not observed, the observer mistaking another peak for Anepahan. The station is not very difficult to reach, but exceptionally clear weather is required to observe this long line (67 kilometers).

Besides the supplementary stations already established at Malanao, Inagauan, Emelina, and Cay, stations were placed on Arrecife and Tagalinog Islands. Some fishermen stripped the latter signal of cloth (a valuable article among the natives) and made it impossible to observe this station from Calatugas and Pulute.

All the observing was completed on the supplementary scheme in Puerto Princesa, and a supplementary scheme was carried between Malanao Island and the mainland. This latter scheme can be carried one or two figures farther northward.

Control for topography southward of Sombrero Island can easily be obtained by establishing supplementary stations, observing from main-scheme stations which are easy to reach.

The topography of the shore line from Addison Point to Table Head was completed and contours were shown as far inland as possible. All the work was done on a scale of 1 : 20,000.

The hydrography has been carried down to Table Head, including Binunsalian Bay, the entrance to Puerto Princesa, and all of Honda Bay, and extending out to about 800 fathoms; in some places out to the 1,000-fathom curve. All of Honda Bay, including the complicated area in the northwest part of the bay, was thoroughly developed. All the inshore area was covered with lines not more than 165 meters apart, even in depths of 25 fathoms.

The shoal marked on the chart "10 P. D." in latitude 9° 43′, longitude 119° 03′, was found in approximately the position shown and developed. An immense area in Honda Bay of coral formation extending 10 miles offshore was thoroughly developed.

A line of deep-sea soundings was carried from latitude 9° 13′ N. northward while en route from Sandakan to Puerto Princesa.

Some reconnoissance lines were run by the ship when running between triangulation stations.

Many uncharted shoals were discovered. The office was kept informed so that notices of these shoals could be published.

The same stupendous slopes near the 100-fathom curve as were found around Pasig Shoal were also found along this stretch; a slope of 70 per cent (70 feet in 100 feet) was often encountered.

An automatic tide gauge was kept continuously in operation at Puerto Princesa. Tide staffs were observed at Tinitian, Babuyan, Makesi Island, and Village Rocks during the progress of hydrography in their respective vicinities.

The same remarkable tides mentioned in previous reports were recorded at Puerto Princesa.

No opportunity occurred to take systematic current observations. While occupying triangulation station Tagalinog, located on an island 13 miles offshore, with very deep water around it, the ship anchored in 16 fathoms very

close to shore a single observation of 2½ knots was made, but the anchor would not hold, and the ship was swept away. Strong currents were noticed between this island and the mainland.

Two stations were occupied for magnetic declination.

The ship was swung for compass deviations (16 headings) in latitude 9° 45′ N., longitude 118° 50′ E., using a range of two triangulation stations instead of sun azimuths. The bearing was taken both with the compass and the pelorus.

On account of the high cost of coal in the Philippines, it was necessary to run to Sandakan, British North Borneo, 240 miles distant, for coal. However, it is possible to coal so much faster at Sandakan than at Puerto Princesa that there was not a great loss of time. A deck load of coal was always taken.

[EOLINE R. HAND, Commanding Steamer *Research*.]

SUMMARY OF RESULTS.—Topography: 10 square miles of area surveyed, 25 miles of rivers surveyed, 2 miles of roads surveyed, 1 topographic sheet finished, scale 1 : 20,000. Hydrography: 58.5 square miles of area covered, 556.7 miles run while sounding, 2,189 positions determined (double angles), 8,221 soundings made, 2 tide stations established, 3 hydrographic sheets finished, scales 1 : 5,000, 1 : 20,000, and 1 : 40,000.

The survey of Manila Bay, which was in progress at the beginning of the fiscal year, was completed on August 24.

The work done after June 30, comprised 55 square miles of ship hydrography in the center of the bay and topography and sounding up the Orani and Pasag Rivers to the town of Guagua.

The sounding in the center of the bay was continued on the 1 : 40,000 scale sheet, with lines spaced about 250 meters apart, a somewhat greater interval than that used on the 1 : 20,000 sheets contiguous to the shore. The depths ranged between 9 and 20 fathoms, and the bottom was invariably mud and remarkably even. The survey of the waterways to Guagua was desirable, since they are traversed regularly by the Manila steamers. As these rivers are bordered with swamps for the entire distance, the topography was difficult. It is all stadia traverse with ample control. The soundings were between 2 and 5 fathoms. To determine the difference of time of tide turnings between the upper end, the mouths, and Manila, for reduction data, stations were established both at Sexmoan and Orani for simultaneous readings, the standard being at Manila.

A list of landmarks was furnished to be plotted on the revised issue of the chart of Manila Bay in order that the navigator may be able to accurately determine his position with reference to the plotted soundings.

After the completion of the work of the steamer *Research* in Manila Bay and pending the return of the vessel to the Philippine Government, a small area of about one-half mile immediately behind the North Breakwater, Manila Bay, was closely sounded for the information of the division of port works, presumably as a basis for calculating the extent and cost of dredging operations. The launch was used in this work, and lines of soundings 20 meters apart were run about normal with the sea wall.

SPECIAL DUTY.

NEW YORK.

EXHIBIT OF THE COAST AND GEODETIC SURVEY AT THE SOUTHERN COMMERCIAL CONGRESS.

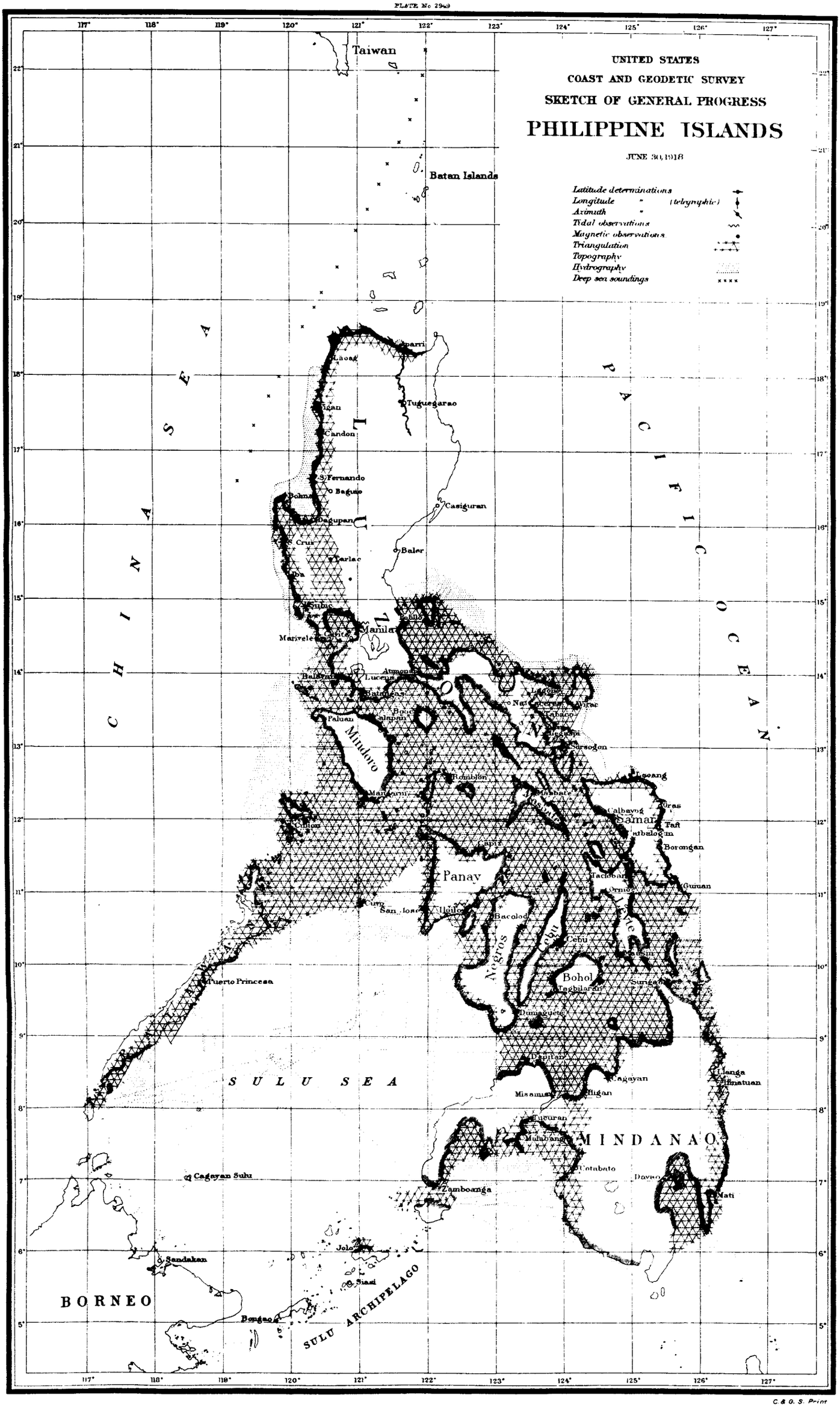
[ISAAC WINSTON.]

An exhibit illustrative of the work and methods of the United States Coast and Geodetic Survey was made at the meeting of the Southern Commercial Congress held in the Hotel Astor, New York City, from October 15 to 17, 1917.

The space occupied was 13 by 29 feet, and the instruments were arranged to show the progress from astronomic work through geodetic work, magnetic work, topographic work, and hydrographic work to the chart as the finished product in the development of commerce. Charts and statistics of the principal southern ports and of New York Harbor and approaches were shown.

Six bureaus of the Department of Commerce, namely, the Steamboat-Inspection Service, the Census, Bureau of Foreign and Domestic Commerce, Bureau of Fisheries, Bureau of Lighthouses, and Coast and Geodetic Survey, participated, and the Chief Clerk of the Department of Commerce was present as the representative of the department in charge of the exhibit.

The greater part of the hall was occupied by exhibits from several States showing their products and resources.


UNITED STATES
COAST AND GEODETIC SURVEY
SKETCH OF GENERAL PROGRESS
PHILIPPINE ISLANDS
JUNE 30, 1918
Latitude determinations
Longitude " (telegraphic)
Azimuth "
Tidal observations
Magnetic observations
Triangulation
Topography
Hydrography
Deep sea soundings
Taiwan
Batan Islands
CHINA SEA
PACIFIC OCEAN
LUZON
Aparri
Laoag
Tuguegarao
Candon
S. Fernando
Baguio
Casiguran
Dagupan
Baler
Tarlac
Manila
Marivele
Lucena
Batangas
Paluan
Mindoro
Romblon
Mangarin
Cuyo
San Jose
Iloilo
Panay
Capiz
Bacolod
Negros
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Cagayan
Misamis
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MINDANAO
Cotabato
Davao
Mati
Llanga
Ilinatuan
Zamboanga
Puerto Princesa
SULU SEA
Cagayan Sulu
Sandakan
Jolo
Siasi
Bongao
SULU ARCHIPELAGO
BORNEO
Calbayog
Samar
Taft
Borongan
Guiuan
Oras
Sorsogon
Tabaco
Legaspi
Tacloban
Ormoc
Lucena
Batangas
Balayan
Cuyo
Mambate
Masbate
Jasper
Lagoon
Virac
Cebu
Masin
Surigao
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C. & G. S. Print

EXHIBIT OF THE UNITED STATES COAST AND GEODETIC SURVEY AT THE NATIONAL MOTOR BOAT SHOW.

[ISAAC WINSTON.]

An exhibit illustrative of the work and methods of the United States Coast and Geodetic Survey was made at the National Motor Boat Show held in the Grand Central Palace, New York City, January 19 to 26, 1918.

A space 12 by 30 feet was assigned to the Survey on the mezzanine floor in the front of the building near the elevators, and a frame with 10 large wings was procured for use in displaying charts and photographs. One hundred and eighty feet of wall space were also available for display purposes.

A collection of charts and publications was prepared at the Coast and Geodetic Survey office to supplement the publications on hand at the field station.

The articles for exhibit were delivered at the Grand Central Palace January 18, and were placed in position on the following day and evening. On January 21 an officer detailed from the Washington office arrived and served until the close of the exhibition.

The charts showing Long Island Sound and the approaches to New York were joined so as to form a continuous whole, and attracted much attention. About 200 different charts fastened together in series were displayed on tables, and they were examined with interest by many persons.

Charts showing the wrecks that have occurred on the coast of Alaska, the relative size of different countries superimposed on the United States, the steamer routes of the world with distances between ports, the magnetic declination in the United States, and the cloud formations as classified for observation purposes were placed on the wings of the chart exhibitor and on the wall space.

All available chart catalogues, light lists, buoy lists, tables of distances between ports, catalogues of publications on nautical subjects, coast pilots, tide tables, inside route pilots, pilot rules, International Rules of the Road, Notices to Mariners, Nautical Almanacs, etc., were displayed on tables for the information of the public. These included publications of the Bureau of Lighthouses, the Hydrographic Office of the Navy Department, and the Coast and Geodetic Survey. Orders were taken for charts, coast pilots, and tide tables.

The chart of New York Harbor, made by the British before the Revolutionary War was taken from the field station to the show and attracted much attention.

One copy of each of the publications referred to above was displayed as a sample of what was available for the use of mariners. The photographs were arranged in series on the wings of the chart exhibitor to illustrate the work of the Survey.

A considerable number of publications describing the work of the Survey and the elements of chart marking were distributed to visitors.

The instruments shown were a sextant, three-arm protractor, parallel rule, and boat compass.

A large national flag, a banner of the Secretary of Commerce, the Bureau service flag, and two Bureau banners were used as decorations and the sign Coast and Geodetic Survey was displayed.

The exhibit was classed as "educational" in catalogue.

No expense in connection with the exhibit was incurred on account of the Government, the incidental expenses being paid by the National Motor Boat Show.

INSPECTION OF CHART AGENCIES.

[H. R. GARLAND.]

In January an inspection was made of the agencies for the sale of Coast and Geodetic Survey charts and nautical publications at Baltimore (Md.), Wilmington (Del.), Philadelphia (Pa.), and New York City (N. Y.) for the purpose of examining their stocks of charts and publications.

At each agency the charts and publications were inventoried, the obsolete charts and publications condemned and destroyed, receipts therefore given, and copies sent to the office at Washington. The value of the charts and publications remaining on hand was computed, and the figures furnished to the agents as a basis for their reports. The methods of caring for the charts and publications and the general interest shown by the agencies in the sale of them were noted.

DELAWARE.

[J. J. GILBERT.]

In April, 1918, at the request of the William Cramp & Sons Ship & Engine Building Co., the location of the north range west beacon of the trial course at Lewes, Del., which had been undermined and blown down by a storm, was redetermined, and the position was marked by surface and underground marks in order that the beacon might be reerected in the proper position.

This work was done at the expense of the Cramp & Sons Co.

VIRGINIA.

TRIAL COURSE IN POTOMAC RIVER FOR THE GENERAL SHIPBUILDING & AERO CO.

[JEAN H. HAWLEY.]

In November, 1917, a trial course 1 nautical mile in length was laid off in the Potomac River at Alexandria at the request of the General Shipbuilding & Aero Co. The work of laying out the trial course was begun November 13 and was concluded November 16.

The spire on the belfry of the new Colored Catholic Church, at the corner of Wythe and Columbus Streets was selected as the rear range at the north end of the course, and the starting point for the traverse was located on the east curb of Fairfax Street, at a point where a line perpendicular to the curb line intersects this spire. A wooden beacon was constructed on the bluff just east of Fairfax Street for the front range on this line.

The traverse was run along the east curb of Fairfax Street for a distance of 1,853.25 meters. A 50-meter steel base tape under a tension of 10 kilograms was used in running this traverse.

At the end of this traverse a line to establish the south end of the course was laid off at right angles to the curb line and marked by two wooden range beacons.

The lines at right angles to the street were measured with a 4-inch theodolite set up over each end of the traverse, the curb line being used as the initial line in each case.

OHIO.

TRIAL COURSE FOR DIRIGIBLES.

[H. P. RITTER.]

In compliance with a request from the Navy Department, a determination was made in August, 1917, of the length of a trial course for dirigibles, located in Portage County eastward of the aviation grounds and about 12 miles southeast of Akron, Ohio.

The course had been laid out by the engineers of the Goodyear Tire & Rubber Co. to be used in connection with their aviation school and for the official trials of the United States naval dirigibles. The course was designed to be 2 nautical miles long, and each end and the middle are marked by a range consisting of two range poles set at right angles to the course. The poles are 50 feet apart and near the top have wires stretched between them for the purpose of observing from the ground the time of transit of the dirigibles across the range.

The direction of the course is north and south and parallels the road passing through the town of Suffield. The ranges are placed just west of the road. The surface of the ground along the course is undulating and ranges between about 1,150 and 1,250 feet above mean sea level.

The measurements for the length of the course were made along the edge of the road on a line parallel to the course and at right angles to the ranges. Hubs 50 meters apart were set along the line and a forward and backward measure made. A line of levels was run over the measured line, and corrections for the slopes of the ground determined. Field work was completed August 24.

CALIFORNIA, OREGON, AND WASHINGTON.

[J .J. GILBERT.]

In June an inspection trip was begun by an officer of the Survey along the Pacific coast of the United States for the purpose of determining the condition

of the surveys on that coast, in order to meet immediate needs for surveys and charts under present conditions.

At the same time an inspection was made of the chart agencies of the Bureau on that coast.

Respectfully,

R. L. FARIS,
Acting Superintendent.

To Hon. WILLIAM C. REDFIELD,
Secretary of Commerce.

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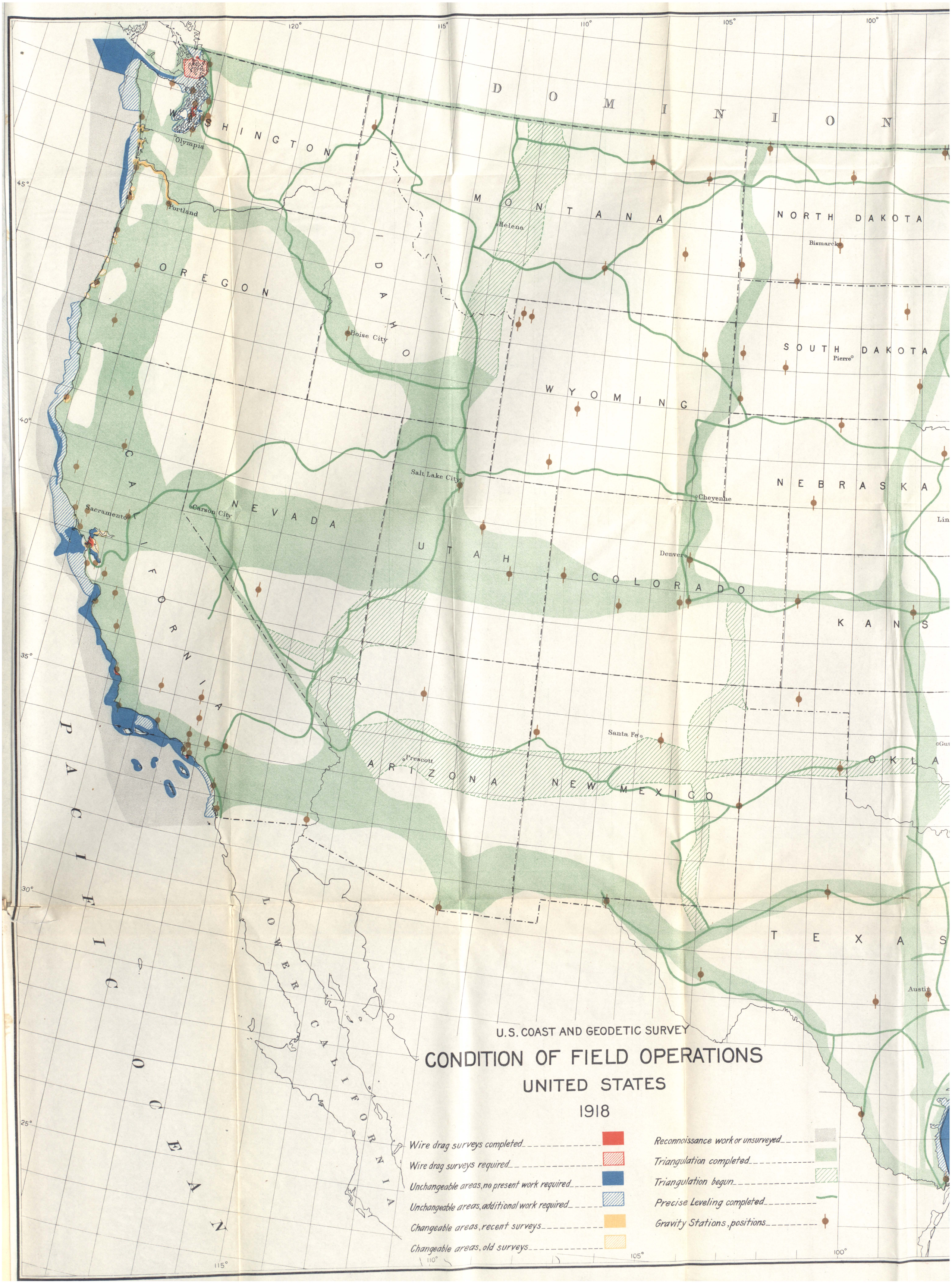
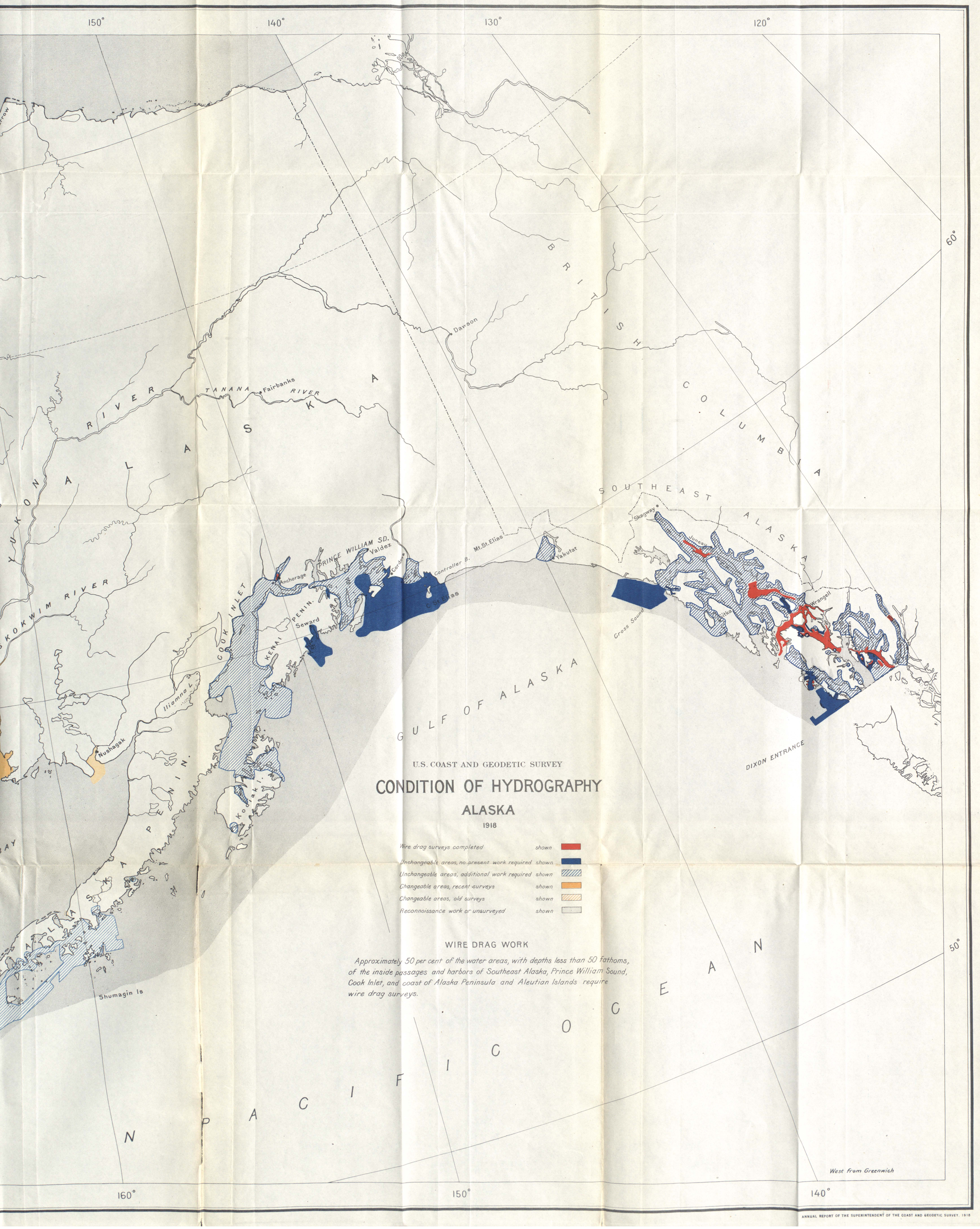

U.S. COAST AND GEODETIC SURVEY
CONDITION OF FIELD OPERATIONS
UNITED STATES
1918
Wire drag surveys completed
Wire drag surveys required
Unchangeable areas, no present work required
Unchangeable areas, additional work required
Changeable areas, recent surveys
Changeable areas, old surveys
Reconnoissance work or unsurveyed
Triangulation completed
Triangulation begun
Precise Leveling completed
Gravity Stations, positions
DOMINION
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
CALIFORNIA
NEVADA
UTAH
COLORADO
KANS
OKLA
ARIZONA
NEW MEXICO
TEXAS
LOWER CALIFORNIA
PACIFIC OCEAN
Olympia
Portland
Boise City
Helena
Bismarck
Pierre
Salt Lake City
Cheyenne
Sacramento
Carson City
Denver
Santa Fe
Prescott
Austin
120°
115°
110°
105°
100°
125°
45°
40°
35°
30°
25°

CANADA
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
MINNESOTA
WISCONSIN
MICHIGAN
IOWA
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA
NEW YORK
VERMONT
NEW HAMP.
MAINE
MASS.
CONN.
R.I.
NEW JERSEY
MARYLAND
DEL.
VIRGINIA
W. VIRGINIA
KENTUCKY
TENNESSEE
NORTH CAROLINA
S. CAROLINA
GEORGIA
ALABAMA
MISSISSIPPI
LOUISIANA
ARKANSAS
MISSOURI
KANSAS
OKLAHOMA
FLORIDA
ATLANTIC OCEAN
GULF OF MEXICO
BAHAMA ISLANDS
St. Paul
Madison
Lansing
Des Moines
Lincoln
Springfield
Indianapolis
Columbus
Topeka
Jefferson City
Frankfort
Charleston
Nashville
Guthrie
Little Rock
Atlanta
Montgomery
Jackson
Tallahassee
Baton Rouge
Austin
Harrisburg
Trenton
Annapolis
Washington
Dover
Richmond
Raleigh
Columbia
Montpelier
Albany
Boston
Concord
Augusta
Providence
Hartford
Nassau
95°
90°
85°
80°
75°
70°
65°
45°
40°
35°
30°
25°

160°
170°
180°
170°
160°
150°
ARCTIC OCEAN
SIBERIA
Pt. Barrow
Icy Cape
Pt. Hope
BERING STR
Nome
YUKON RIVER
ALASKA
St. Michael
St. Lawrence I.
KUSKOKWIM RIVER
60°
St Matthew I
Nunivak I.
Nushagak
Iliamna L.
BRISTOL BAY
Pribilof Is
BERING SEA
ALASKA PENIN
Unimak I.
Shumagin Is
Unalaska I
Umnak I.
Attu I
ALEUTIAN IS
Kiska I
Tanaga I
Atka I
N
East from Greenwich.
180°
170°
160°

C.&G.S. Print


U.S. COAST AND GEODETIC SURVEY
CONDITION OF HYDROGRAPHY
ALASKA
1918
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
BRITISH COLUMBIA
SOUTHEAST ALASKA
YUKON
ALASKA
TANANA RIVER
Fairbanks
KOKWIM RIVER
Nushagak
Iliamna L.
COOK INLET
KENAI PENIN.
Seward
Anchorage
PRINCE WILLIAM SD.
Valdez
Cordova
Controller B.
Mt.St.Elias
C.St.Elias
Yakutat
Cross Sound
Skagway
Juneau
Sitka
Wrangell
DIXON ENTRANCE
GULF OF ALASKA
ALEUTIAN ISLANDS
Kodiak I.
Shumagin Is
NORTH PACIFIC OCEAN