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ANNUAL REPORT

OF THE

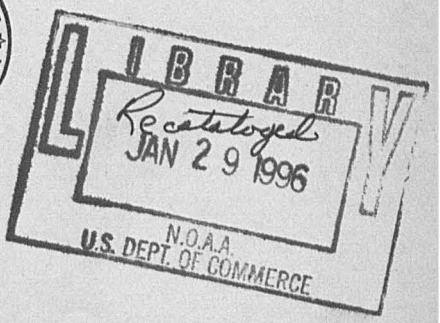
SUPERINTENDENT, UNITED STATES COAST AND GEODETIC SURVEY

TO THE

SECRETARY OF COMMERCE

FOR THE

FISCAL YEAR ENDED JUNE 30, 1915



WASHINGTON
GOVERNMENT PRINTING OFFICE
1915

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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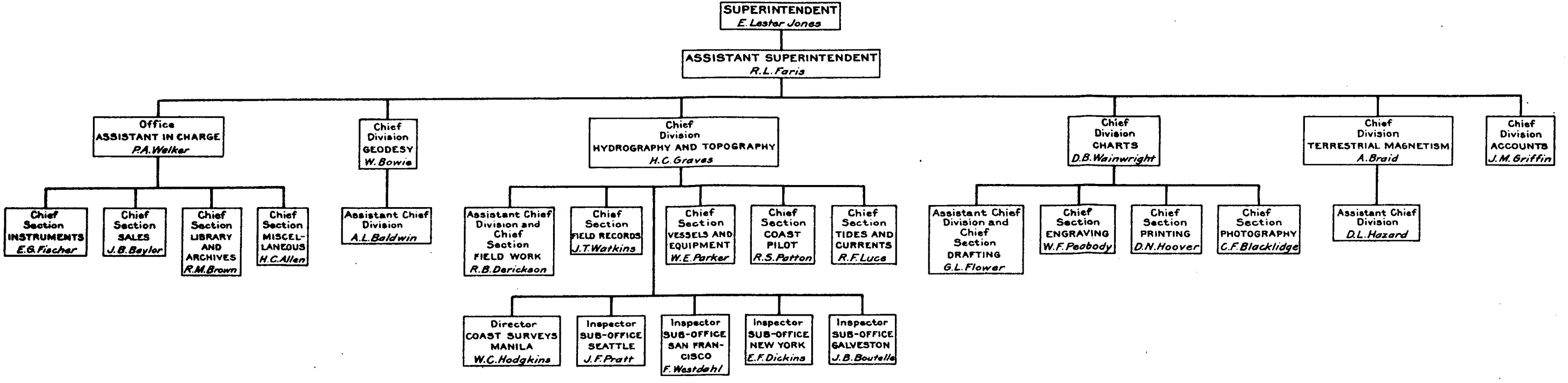
PART I.

PART II.

Effective Oct. 15, 1915

CHART SHOWING ORGANIZATION OF THE U.S.COAST AND GEODETIC SURVEY 1915



ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

House Doc. 31; 64th Cong., 1st Sess.

REPORT

OF THE

SUPERINTENDENT, U. S. COAST AND GEODETIC SURVEY

DEPARTMENT OF COMMERCE,
COAST AND GEODETIC SURVEY,
Washington, D. C., October 9, 1915.

SIR: There is submitted herewith the annual report of the United States Coast and Geodetic Survey for the fiscal year ended June 30, 1915.

PART I.

Part I explains the needs of the Bureau by text and illustrations, and is an appeal for greater recognition of its essential requirements. With the increased work in recent years there has been no corresponding increase in the force and equipment, which is a pertinent cause for the backwardness of much of the work.

PART II.

Part II is a detailed statement of the field and office work of the Bureau. It is accompanied by illustrations showing the progress made in the past year, as required by statute.

Part I.—NEEDS OF THE BUREAU.

NEW BUILDING.

It is an old story to again call attention to the inadequate conditions afforded this Bureau in the buildings at present occupied, which cover 70,000 square feet of floor space, distributed in such a manner that labor is difficult and expensive. One of these buildings was originally built for a hotel, and it is cut up into so many small rooms that the partitions take up much space. Because of this, no division can be properly supervised, with the possible exception of the new printing section. The buildings are five and six stories high, respectively, with 16 different levels in one and 11 in the other, and without any suitable elevator. The buildings are improperly lighted, overcrowded, and reported by the Public Health Service as being insanitary. One of the worst features of the present condition is the fact that they are not fireproof, and records that cost millions of dollars and could not be replaced short of the expenditure of other millions of dollars are constantly in danger. To attempt to remodel these present structures would avail nothing, for actual rebuilding is the only means of providing permanent relief. It is an evident fact that the efficiency of the Bureau is daily disturbed by the incommodious office conditions, and by the inconvenience and loss of time involved in communication between widely separated portions of the buildings.

The foregoing statement can not be overemphasized. The further expenditure of money on these old buildings would be an actual waste, for while they can be made to look fairly well, they are far from proving satisfactory.

It is earnestly hoped that in the near future consideration will be given to the urgent necessity for an up-to-date building that will properly accommodate the officers and workrooms of this Bureau.

CONDITION OF HYDROGRAPHY.

The hydrographic survey of the coast, harbors, and approaches constitutes the most important element of the charts, and is the prime factor in promoting the safety of navigation.

With this report are published four maps to illustrate the condition of the hydrographic surveys of the coasts of the United States and Alaska, all on the same scale in order that correct comparisons may be made at a glance. No. 3 shows the Atlantic coast from Maine to Georgia; No. 4, the coast of Florida and the Gulf; No. 5, the Pacific coast of California, Oregon, and Washington; and No. 6, Alaska.

The colors used on the charts to illustrate the surveys have the following signification: Wire-drag surveys completed, solid red; wire-drag surveys required, hachured red; unchangeable areas, no

No. 2.

LEVELS OF OFFICE BUILDINGS, COAST AND GEODETIC SURVEY.

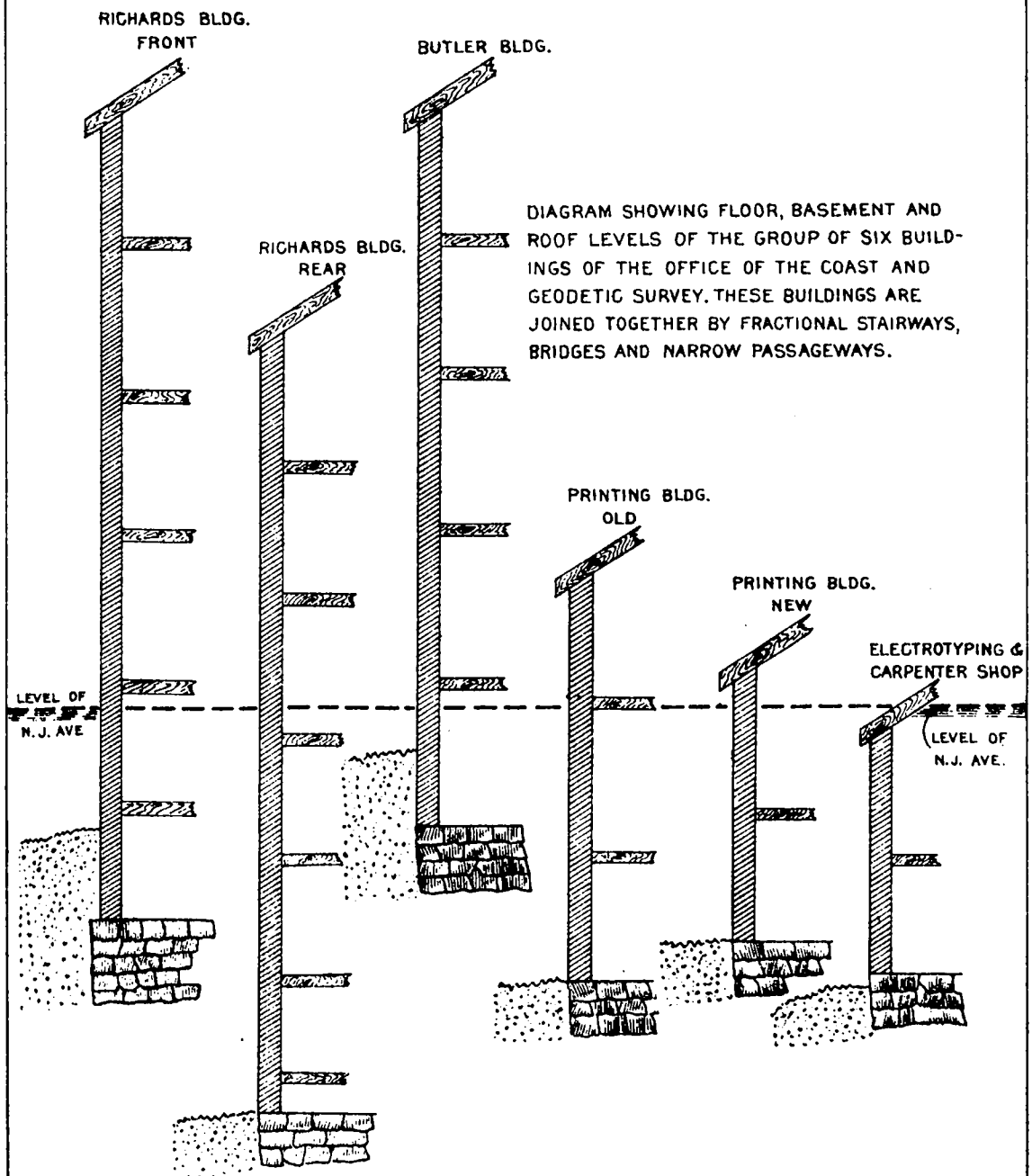
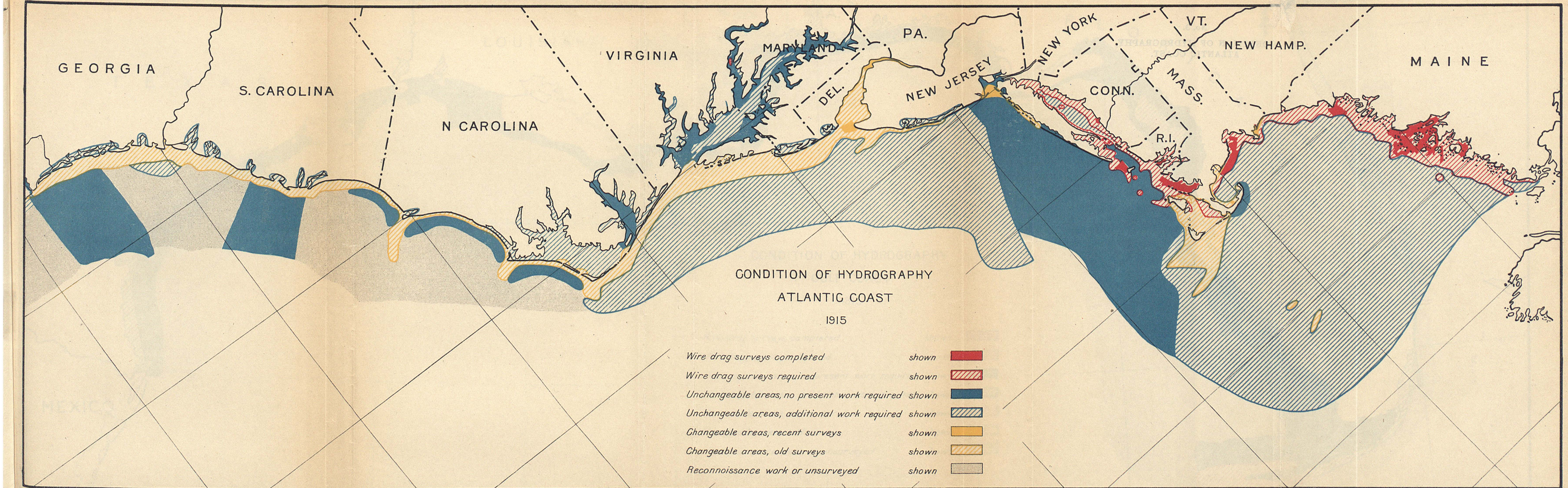


DIAGRAM SHOWING FLOOR, BASEMENT AND ROOF LEVELS OF THE GROUP OF SIX BUILDINGS OF THE OFFICE OF THE COAST AND GEODETIC SURVEY. THESE BUILDINGS ARE JOINED TOGETHER BY FRACTIONAL STAIRWAYS, BRIDGES AND NARROW PASSAGEWAYS.

No. 3.

CONDITION OF HYDROGRAPHY, ATLANTIC COAST.



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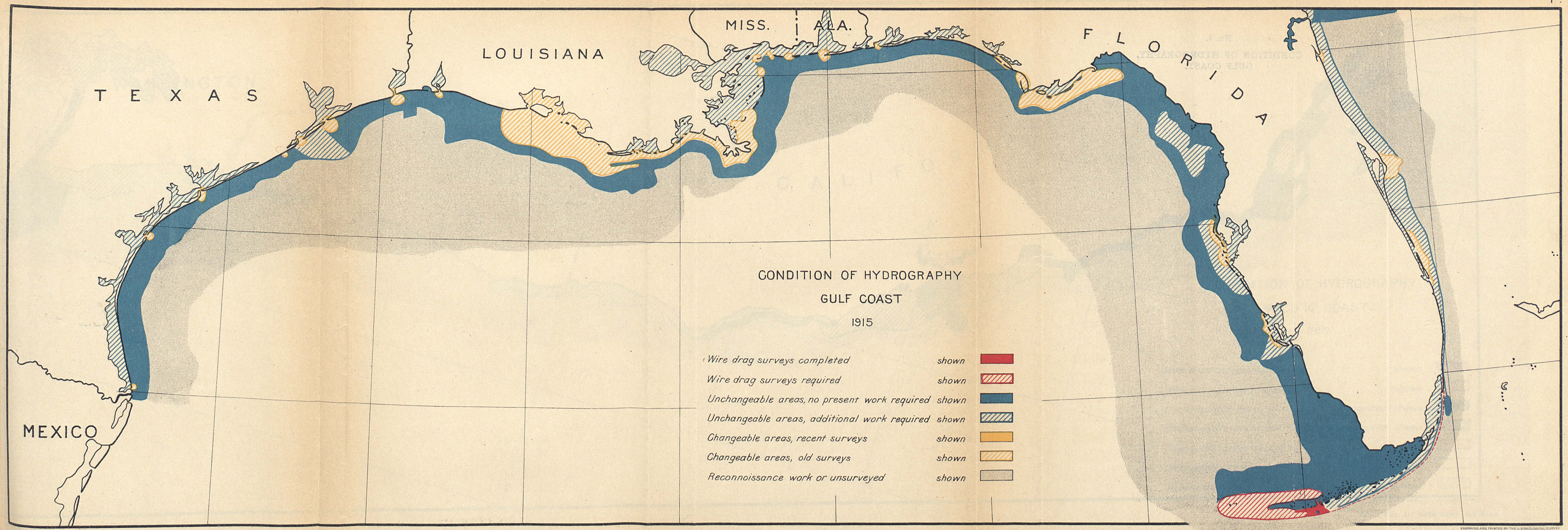
No. 4.

CONDITION OF HYDROGRAPHY, GULF COAST.



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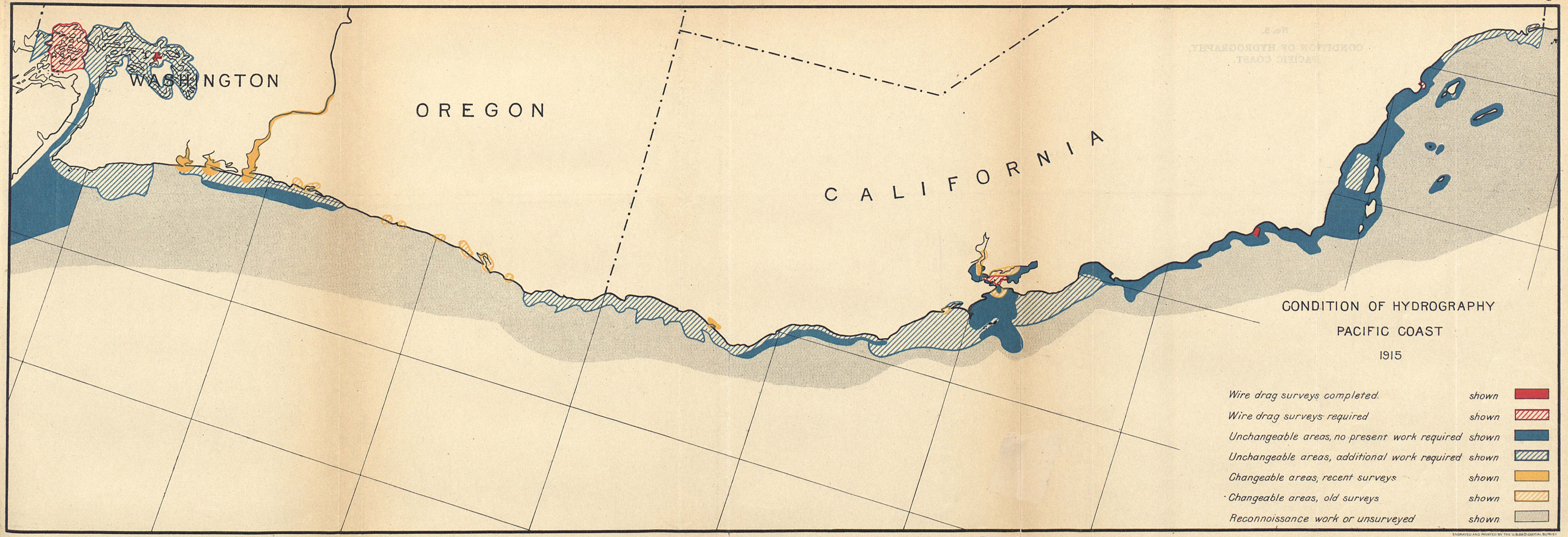
No. 5.

CONDITION OF HYDROGRAPHY, PACIFIC COAST.



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No. 6.

CONDITION OF HYDROGRAPHY, ALASKA.

160° 170° 180° 170° 160° 150°

ARCTIC OCEAN

SIBERIA

Pt. Barrow

Icy Cape

Pt. Hope

BERING STR

Nome

St. Michael

YUKON RIV

St. Lawrence I.

KUSKOKWIM RIVER

60°

St Matthew I

Nunivak I.

Nushagak

BRISTOL BAY

Pribilof Is

BERING SEA

ALASKA

Shumagi

Unimak I.

Unalaska I

Umnak I.

ALEUTIANS

Attu I

Kiska I

Atka I

Tanaga I

East from Greenwich.

180° 170° 160

140°

130°

120°

60°

50°

160°

150°

140°

West from Greenwich

B R I T I S H C O L U M B I A

A L A S K A

I V E R

L A S K A

P E N I N.

A P E N I N.

G U L F O F A L A S K A

S O U T H E A S T A L A S K A

N P A C I F I C O C E A N

TANANA RIVER

Fairbanks

Dawson

PRINCE WILLIAM SD.

Valdez

Cordova

Anchorage

COOK INLET

KENAI PENIN.

Seward

Controller B.

Mt.St.Elias

C St Elias

Yakutat

Skagway

Juneau

Sitka

Wrangell

Petersburg

Ketchikan

Gross Sound

DIXON ENTRANCE

Iliamna L

Nushagak

Kodiak I.

Shumagin Is

CONDITION OF HYDROGRAPHY
ALASKA
1915

Wire drag surveys completed	shown
Wire drag surveys required	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.

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present work required, solid blue; unchangeable areas, additional work required, hachured blue; changeable areas, recent surveys, solid yellow; changeable areas, old surveys, hachured yellow; reconnoissance work or unsurveyed, tinted gray.

The colored areas cover regions with depths less than 100 fathoms on the Atlantic coast and 1,000 fathoms on the Pacific coast, and represent the extent to which our surveys should be prosecuted as vigorously as the facilities will permit.

TWO NEW VESSELS.

In the report of the Secretary of Commerce for the previous fiscal year the condition of some of the vessels of this service was thoroughly described with the result that Congress appropriated enough money to buy, ready built, a vessel for the work on the Atlantic coast to replace the *Endeavor;* and a contract has now been let for the building of another vessel, to be known as the *Surveyor*, to replace the condemned *McArthur*, for the Pacific coast and Alaskan service. This is a move in the right direction, but is far from meeting the present needs of this Bureau.

On the Pacific coast two vessels should be replaced without delay by new ones suitable for work in exposed localities. The *Gedney* has been condemned. The *Patterson*, now 33 years old, is no longer serviceable for the exposed offshore work. In her weakened condition, exposure to a heavy sea might prove very serious. The vessel was lightly built and underpowered, and the fact that in the future her work, even under favorable conditions, must necessarily be confined to protected waters, emphasizes clearly the necessity for a new vessel for work in western Alaska and on the coast of California, Oregon, and Washington. The *Explorer* also shows structural weakness, and extensive repairs are necessary; her future work should be confined absolutely to the protected waters of southeast Alaska.

In view of the unsafe condition of the *McArthur* and *Gedney* and the fact that neither is seaworthy, they have been ordered sold, as their future existence is a menace to human life and their further use would be without the slightest justification. There is urgent work needed off the coasts of Washington, Oregon, and California; also off central and western Alaska and Hawaii; but until the *Surveyor* is in commission and other similar vessels are built we can not hope to accomplish any of this work, as at the present time there is not a vessel in the Pacific coast service sufficiently seaworthy to be exposed to the risk of this work.

The two new vessels recommended would be used in the unsurveyed and exposed offshore work on the coasts of California, Oregon, and Washington, and off the central and western part of Alaska and Hawaii, where they are urgently needed.

LAUNCHES FOR INSHORE WORK AND WIRE DRAG.

In the past, the more or less established custom of the Survey seems to have been to provide an equipment of surveying vessels of a type suitable for all classes of sounding operations without

definite considerations as to either the character or location of the working grounds. Obviously, an economical and safe surveying vessel properly designed for efficient offshore hydrography should be of an ocean-going type, and consequently of considerable size and expensive to maintain. On the other hand, a vessel properly designed for inshore or inside hydrography might be, and usually should be, for economical reasons, a comparatively small craft. The net result of the previous custom has been that the effort to provide a type of vessel suitable for both classes of operations has had the unfortunate effect of giving the Survey ships which are for the greater part either too large and expensive to maintain for inside or inshore sounding or too small and unsafe for offshore operations.

Our surveying vessels at present in use, while engaged on inshore work, usually anchor in protected waters and the hydrographic surveys are executed by utilizing ship's launches and boats frequently too small for the purpose. On offshore hydrography these same vessels being too small for safe ocean navigation, necessarily are compelled to wait for good weather before going outside to do their work, and for like reasons must seek shelter whenever bad weather threatens.

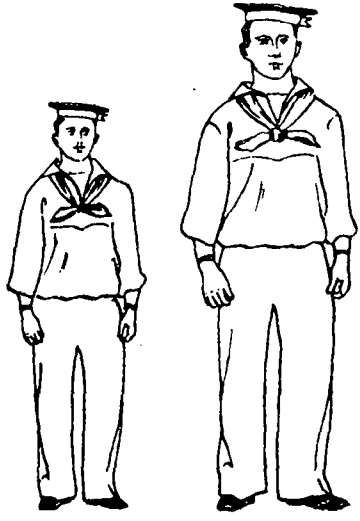
The *Isis* and *Bache* are performing useful and economical service on the Atlantic coast offshore work, in regions conveniently located to safe harbors. Otherwise, the *Pathfinder*, now in the Philippines, and the new ship, the *Surveyor*, now under construction, are the only vessels of the Coast Survey large and staunch enough for offshore work. None of these vessels is small enough for economical work in sheltered waters.

In the case of the wire-drag operations, neither these ships nor their launches are of suitable size for the work to be performed, and the custom has grown up of hiring or chartering at a comparatively great cost all the large launches employed on this important class of surveying work.

In the future it is proposed to remedy this unsatisfactory and inefficient condition of affairs by providing vessels and launches of such types and sizes as will suit them in each case to the special work they are to perform.

The question of the larger ocean-going vessels is covered more fully under a previous heading, which leaves only the "one-party launches" and "wire-drag launches" for immediate consideration in this section of this report.

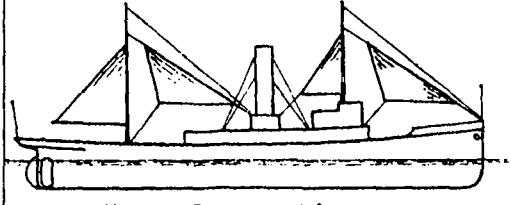
A large proportion of the hydrographic work of the Coast Survey is located close to shore or in inside waters. For reasons already indicated, "one-party launches," each with a complement of officers and crew of about 10 men, are more economical for this class of work than the existing semiocean-going type which frequently can employ only one or two parties on inside operations, although carrying an ocean-going complement of officers and crew large enough for three or four parties. But in spite of this fact the Coast Survey has only two "one-party" vessels of inferior type (now employed in Alaska) when in reality there should be at least six on the Atlantic and Gulf coasts and an equal number on the Pacific coast and in Alaskan waters.



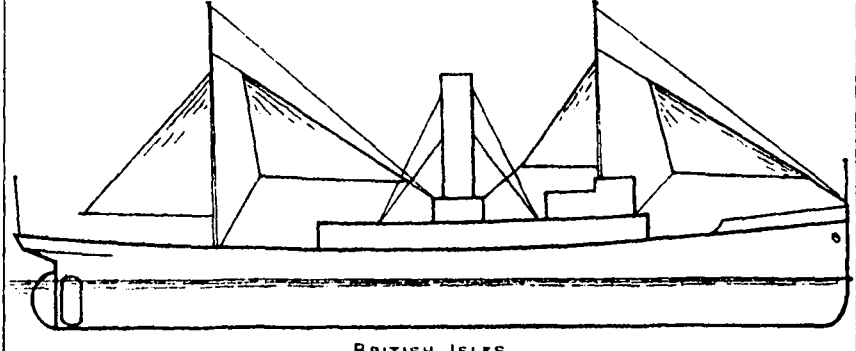
UNITED STATES and ALASKA

BRITISH ISLES

Diagram of Men, Ships and Coast Line of the British Isles, and of the United States and Alaska, showing relative number of surveying officers and men, tonnage of surveying vessels, and the coast line covered by their respective surveying services



UNITED STATES and ALASKA



BRITISH ISLES

Coast line of the United States and Alaska

Coast line of the British Isles

The need for resurveys of changeable areas and the outlets of nearly all bays and inlets from Sandy Hook to the Rio Grande, for the completion of the original surveys in places, and for revision of topography due to changes all along the coast, in order to keep the charts up to date, is imperative and these will be prosecuted with greater vigor as funds are available.

It can be stated here that the ever-increasing demands for new hydrographic surveys due to the increased size, draft, and speed of ships of commerce and of war, together with the constant changes along the sandy shores of the Atlantic coast, are already overtaxing the forces and equipment of the Coast Survey. And now that submersible war vessels, with their requirements of fairly accurate knowledge of depths of 100 feet and more, form an essential part of the national defense, the necessity for new surveys and resurveys is more pressing and vital to the best interests of the country.

As stated previously, the wire-drag surveys, which are of recent origin and which are rapidly developing valuable results, are exclusively carried on by the aid of hired or chartered launches. During the current fiscal year four separate wire-drag parties are in operation, two in Alaska and two on the Atlantic coast. The average cost for these wire-drag parties is estimated at about $20,000 each for the six or eight months' season in which they can best perform their work, or a total of $80,000 for their combined operations.

As a matter of fact, the cost of rental of these launches, which are usually poorly designed and equipped for the work to be performed, would pay for them in three or four years if it were possible to purchase them outright; nor does this take into consideration the time lost on account of their unsuitable design. And this latter saving is no small matter, as the cost of each working day of a wire-drag party actually utilized in surveying operations averages from $200 to $300.

Therefore the money which it is hoped will be appropriated for the purchase of launches for inshore work and wire-drag operations would result not only in considerable saving to the Government but would also add to the efficiency and consequently to the quantity of work done.

WIRE-DRAG WORK.

Due to the increase Congress gave us last year we were able to place in the field four parties instead of two. The results prove the wisdom and the necessity of doing this work on a much larger scale.

The use of the wire drag has revolutionized hydrographic surveying. It was, of course, realized long ago that sounding with the lead line, no matter how closely the soundings were spaced, was not an infallible means of detecting submerged rocks and bowlders, and that ledges and shoals of considerable extent are missed by the lead. This fact was emphasized by many disasters to vessels and by the large number of hidden dangers which became known and were shown on the chart only as the result of such disasters.

Certain portions of our coasts constitute a veritable ocean graveyard in which the submerged rocks are the monuments and bear the names of the ships which were wrecked upon them. But it was not

until the method of dragging was fully developed and systematically applied that it became clearly apparent that a very large number of submerged dangers might exist, even in much-frequented waters, and remain entirely unknown and unsuspected simply because by fortuitous circumstances no vessel of considerable draft ever happened to pass immediately over them. This applies especially to the rock-bound portions of our coasts.

WIRE-DRAG WORK ACCOMPLISHED IN PAST 5 YEARS.

Fiscal year.	Dragged area.	Shoals examined.[a]
ATLANTIC COAST.	*Square miles.*	
1911	256	685
1912	250	252
1913	169	561
1914	202	731
1915	250	875
PACIFIC COAST.		
1915	214	300

[a] Probably one-half of the shoals examined had less depth than charted.

COST OF WIRE-DRAG WORK PER ACTUAL WORKING DAY.

Locality.	Month.	Year.	Cost per day.
Atlantic coast:			
Portland	June to September	1914	$333
Buzzards Bay	October to November	1914	213
Key West	January to March	1915	293
Boston	May to August	1915	187
Buzzards Bay	June to September	1914	200
Cape Cod Bay	May to August	1915	194
Southeast Alaska	May to August	1915	328
	July to October	1914	413
	May to August	1915	268

The differences in cost in the same locality in the above table are due to two principal causes:

1. The initial cost includes the first cost of the outfit, a part of which is available for subsequent work.

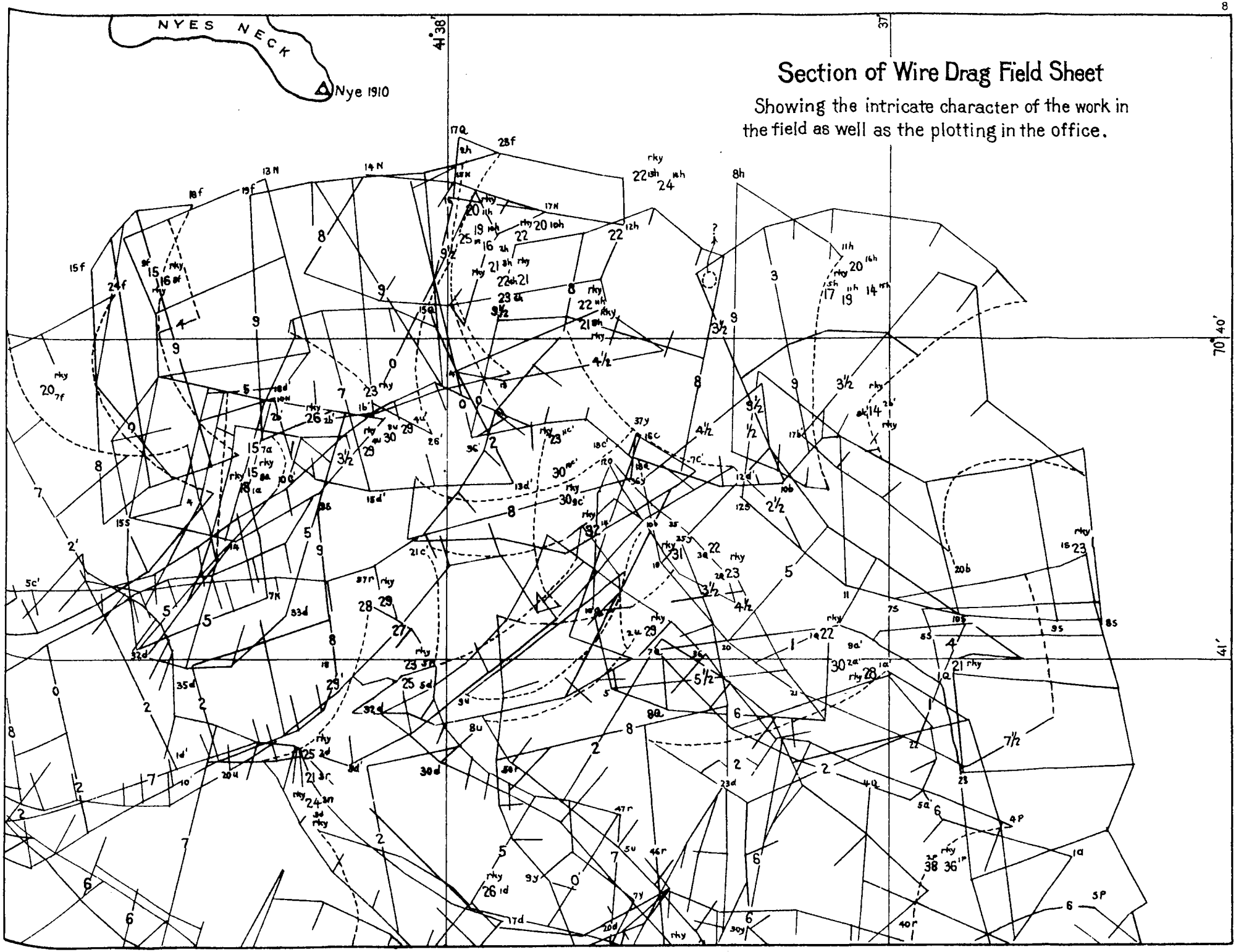
2. Some variation is due to weather conditions which affect the number of days available for work.

INCREASED APPROPRIATION FOR MANNING AND EQUIPPING VESSELS.

The insufficient complement and equipment for our vessels is so evident that at times it seriously disturbs the efficiency of the work. The enlisted men on the Pacific coast (particularly those in the lower grades, such as seamen and firemen) are paid less than in any other service, either governmental or commercial. Union wages for seamen in the coastwise trade, which control the rates paid in the mer-

No. 8.

SECTION OF WIRE-DRAG
FIELD CHART.

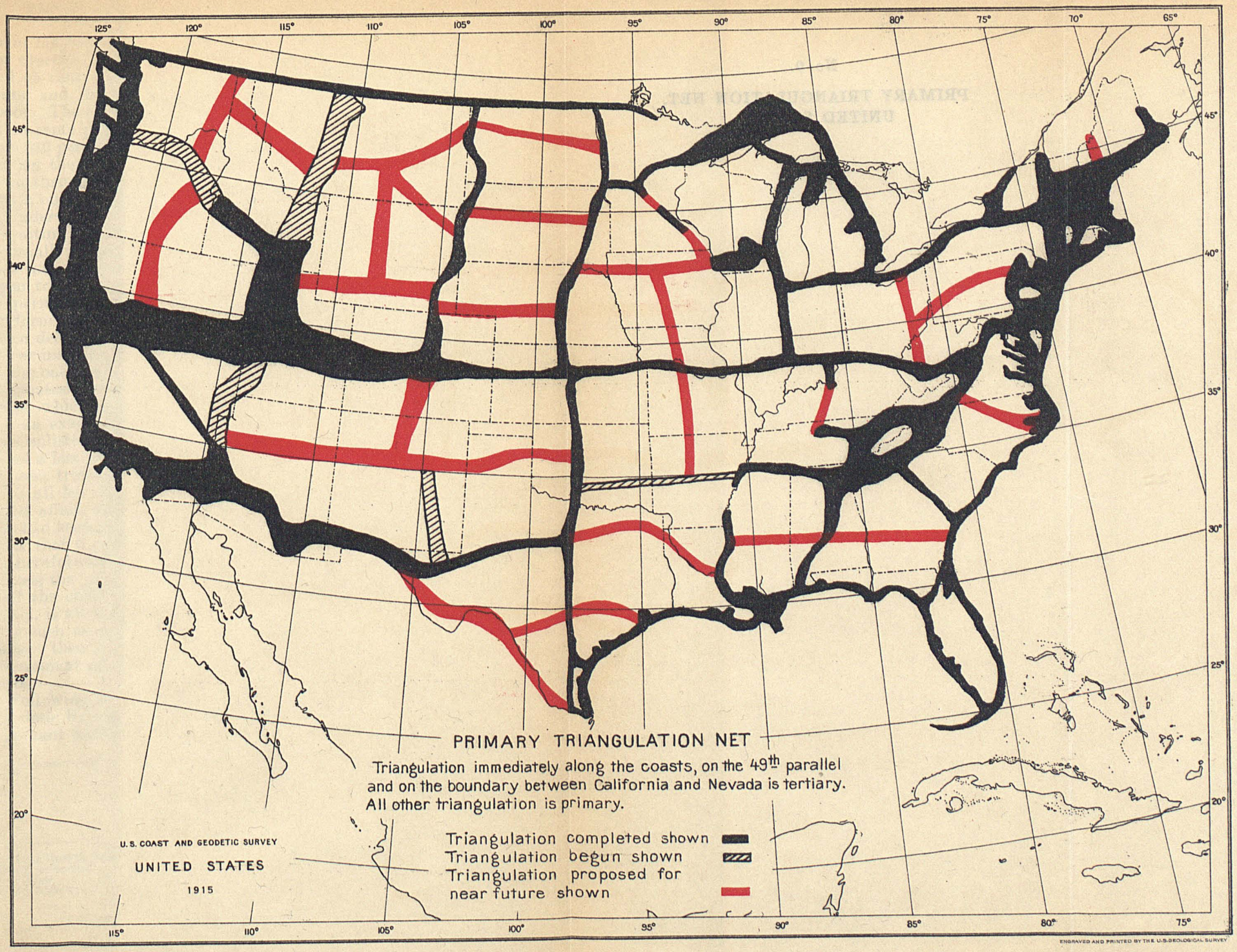


Section of Wire Drag Field Sheet

Showing the intricate character of the work in the field as well as the plotting in the office.

No. 9.

PRIMARY TRIANGULATION NET, UNITED STATES.



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chant marine service, are $55 per month and found, with double pay for overtime. The Lighthouse Service pays seamen $50 per month and 45 cents per day for rations, excepting Alaska where it is 60 cents, and in addition furnishes its seamen with oilskins and sea boots. The Coast Guard pays its seamen $44 per month and rations of 48 cents per day. The Coast and Geodetic Survey pays its seamen $40 per month and 45 cents per day for rations. Besides underpaying the men of this service, they are not assured of continuous work throughout the year, as insufficient funds make it necessary to retain only the number needed to carry on part of the work.

Under the present arrangements it is extremely difficult when recruiting in the spring to get even moderately good crews, and it is usually impossible to build up a permanent organization of reliable men experienced in the specialized work which they are called upon to perform, and sufficiently devoted to the service, by reason of permanent association with it, to willingly and without protest perform extremely arduous work, which the exigencies of the service often demand.

For instance, the crews on the Pacific coast are recruited at Seattle at the one time of the year when men of the type we are seeking are in greatest demand by the lumber interests, the canneries, and fishing fleets, which are then getting ready for their summer work. It is not an exaggeration to make the statement that 70 per cent of the men enlisted in this service, especially on the Pacific coast, come to us as a last resort. We are constantly losing time through the lack of men trained in the work of the service. The surveying vessel with all her appurtenances, is an exceedingly complex and complicated affair, and requires a correspondingly large amount of judgment to keep her in condition. Much of this work is of such a character that it can not be undertaken during the working season, and is therefore another reason why trained men should be kept on these vessels the year around.

If the chief of the party, who is the commanding officer of the vessel, is allowed to build up a permanent organization composed of men such as are absolutely needed for the highest standard of efficiency, then in due time he can be relied upon to greatly increase the amount of work turned out by his vessel and to reduce the unit costs.

Following is a table showing the pay of seamen in the Coast and Geodetic Survey, the Lighthouse Service, the Coast Guard, and the merchant marine on both the East and West coasts:

Service.	East coast.		West coast.	
	Pay per month.	Rations per day.	Pay per month.	Rations per day.
Coast and Geodetic Survey	$30.00	$0.45	$40.00	$0.45
Lighthouse Service	35.00	.45	50.00	[a] .45
Coast Guard	30.00	.45–.51	44.40	[b] .48 up.
Merchant marine	35.00	.50	55.00	.45 to .53

[a] Alaska, pay $55, rations 60 cents.

[b] Rations at Juneau 59 cents.

COMPARISON OF PRESENT MONTHLY RATES OF PAY OF ENLISTED MEN IN COAST AND GEODETIC SURVEY WITH THAT OF THE PAY OF SIMILAR RATINGS IN THE COAST GUARD, BUREAU OF LIGHTHOUSES, AND MERCHANT MARINE.

Rating.	Atlantic Coast.				Pacific Coast.		
	Coast Survey.	Light-house Service.	Coast Guard.	Merchant marine.	Coast Survey.	Light-house Service.	Coast Guard.
Assistant to engineer, second class	$55.00	.....	$75.00-110.00	$75.00-80.00	$75.00	.....	$75.00-110.00
Assistant to engineer, third class	40.00	$50.00	44.40	75.00-80.00	60.00	.....	.....
Boatswain	65.00	.....	75.00-110.00	.....	75.00	.....	75.00-110.00
Boatswain mate, chief	50.00	.....	75.00-110.00	.....	65.00	.....	75.00-110.00
Boatswain mate, first class	40.00	.....	75.00-110.00	.....	55.00	.....	75.00-110.00
Boatswain mate, second class	35.00	.....	75.00-110.00	.....	50.00	.....	75.00-110.00
Coxswain for power launch	35.00	.....	38.40	.....	45.00	.....	46.80
Quartermaster, first class	40.00	45.00	44.40	.....	50.00	$55.00	54.00
Quartermaster, second class	35.00	45.00	40.80	.....	45.00	55.00	50.40
Quartermaster, third class	35.00	45.00	.....	.....	45.00	55.00	.....
Seamen	30.00	45.00	36.00	35.00-40.00	40.00	55.00	44.40
Seamen, ordinary	25.00	.....	28.80	.....	35.00	.....	38.40
Writer, first class	40.00	.....	.....	.....	50.00	.....	.....
Writer, second class	35.00	.....	.....	.....	45.00	.....	.....
Wireless operator, first class	40.00	.....	68.00	.....	65.00	.....	68.00
Wireless operator, second class	40.00	.....	40.00	.....	45.00	.....	50.00
Mess attendant, first class	20.00	30.00	21.60	.....	35.00	.....	.....
Mess attendant, second class	16.00	.....	18.00	.....	30.00	.....	21.60

As with the seamen, it will be noted that the other enlisted men are not paid as much as in other departments of the Government service and in the merchant marine. It would seem only proper that their pay be increased to meet other standards. To do this, however, will require a material increase in the appropriation "For all necessary employees to man and equip the vessels."

GEODESY—MORE FUNDS NEEDED FOR EXTENDING PRIMARY TRIANGULATION AND PRECISE LEVELS IN THE UNITED STATES AND ALASKA.

The question has been asked whether or not the geodetic work of the United States should be done by individual States. This must be answered in the negative, and consideration of the following facts will bear this out:

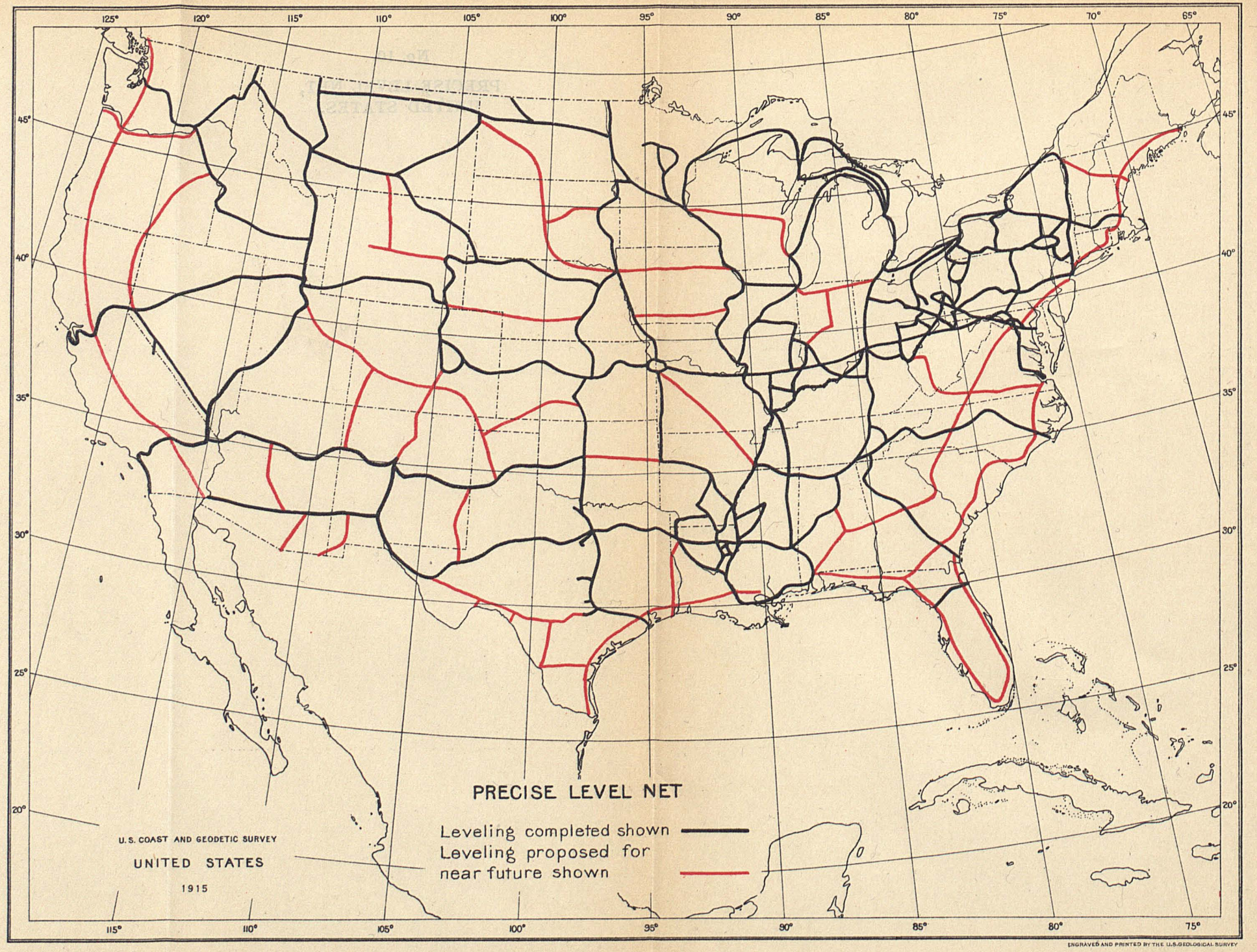
It is necessary to have primary triangulation and precise leveling in each State for the framework of State and county boundary surveys; for national and local topographic, drainage, irrigation, mineral, and other surveys; and for various engineering operations. The necessity for this primary control we must accept as a fact, in view of the experiences of other nations as well as of our own.

The United States is divided into 48 States, some of which are very limited in area. Each of the long arcs of primary triangulation and each of the lines of precise leveling traverses several States, and it is reasonably certain that it would be difficult to obtain the cooperation of all of the States involved in any one arc or line.

Take, for instance, the transcontinental arc of primary triangulation which passes through 14 States; the Texas-California arc which crosses 4; and the ninety-eighth meridian arc which goes through 6. A similar condition obtains with regard to the long-level lines. But,

No. 10.

PRECISE LEVEL NET, UNITED STATES.


125°
120°
115°
110°
105°
100°
95°
90°
85°
80°
75°
70°
65°
45°
40°
35°
30°
25°
20°
PRECISE LEVEL NET
Leveling completed shown
Leveling proposed for
near future shown
U. S. COAST AND GEODETIC SURVEY
UNITED STATES
1915
ENGRAVED AND PRINTED BY THE U.S.GEOLOGICAL SURVEY

suppose each State were willing to do that part of the primary triangulation and precise leveling within its own area, how then could there be a comprehensive scheme for the whole country? It would be absolutely necessary to have a national geodetic association, with each State represented in it, and with a central bureau to direct its operations. If each State worked independently, there would be little or no agreement with the work in adjoining States, and the gaps and overlaps at the boundaries would be a constant source of trouble to surveyors and map makers. Another annoying feature would be the lack of uniformity in the results of the work, as each State would be free to adopt its own standards of accuracy, if there were no supervising bureau. It would require many decades to complete the work, even if executed by the cooperation of all the States, each covering its own territory, and then a central organization would be necessary to adjust the work of the States, and obtain from it a comprehensive whole.

As a concrete example, let us consider the experience of Australia. For a number of years each State of that country conducted its own geodetic surveys independently of the others, with the final result that, at a conference of the surveyors general, held in 1912 at Melbourne, a resolution was adopted recommending that the principal geodetic control be carried on by the Commonwealth Government.

The striking provisions of this resolution are the following:

1. That a geodetic survey of Australia should be undertaken.

2. That, in order to give effect to the foregoing resolution, this conference respectfully recommends that such survey be undertaken by the Commonwealth Government, and submits in support thereof the following reasons:

* * * * * * *

(*c*) That the system which has hitherto prevailed by which the individual States carried out this work with instruments of varying character has resulted in divergent standards of accuracy, rendering the work, to a great extent, unsatisfactory, and, though much of it is of high grade, portions of it are impossible of reconciliation and coordination with a continental scheme.

(*d*) That the desirableness of this work being undertaken by the Commonwealth Government is evidenced by the fact that the Geodetic Survey of the United States is carried out under the direct control of the Federal Government, and that the South African Geodetic Survey is also under one central control.

During the discussion preceding the adoption of the resolutions Mr. Spowers, surveyor general of Queensland, said:

At the present time there is no trigonometrical vote in Queensland, and only a very small area is covered by the major triangulation which was carried out about 1890. In addition to other reasons we are greatly in need of this survey to assist us in the correct compilation of our maps; much time is now lost and expense incurred in endeavouring to make accurate maps from information that is faulty or altogether wanting. We are in the unenviable position of being about the only civilized nation that has not an accurate trigonometrical survey. The work is rightly one for the Commonwealth Government to undertake.

Mr. Poate, surveyor general of New South Wales, remarked:

The geodetic survey of Australia should be undertaken by one body, and that body should undoubtedly be the Federal Government, in order that one standard of accuracy should be applied to the whole of the work, and that it should be similar in character to the great geodetic surveys of the world. It should be conducted on similar lines to those adopted in the United States Coast Survey, and, taking the coast line first, should be gradually extended inland.

The only logical conclusion seems to be that our National Government should complete the general program which is being followed by the United States Coast and Geodetic Survey. This plan is, briefly, that the primary triangulation scheme and the precise-level net should be so extended that there will be no place in the United States distant more than about 100 miles from a primary triangulation station and from a precise-level bench mark.

Whether the National or State Government should execute the control work in the intermediate areas is another problem. Many of these areas will lie wholly within single States and, as far as State and local surveys and engineering works are concerned, the States could properly supplement the fundamental schemes. However, it is probable that this can not be done by the States.

To carry on geodetic work requires a corps of highly trained specialists and an expensive instrumental equipment, besides trained experts to compute and adjust the results. The State engineering departments are not at present able to do this class of work. For some time after the main schemes of primary triangulation and precise leveling are completed, the National Government must furnish additional control for the national surveys and engineering. Other control for purely State, county, and city use should probably be done by the National Government, with the local political unit paying all or part of the cost.

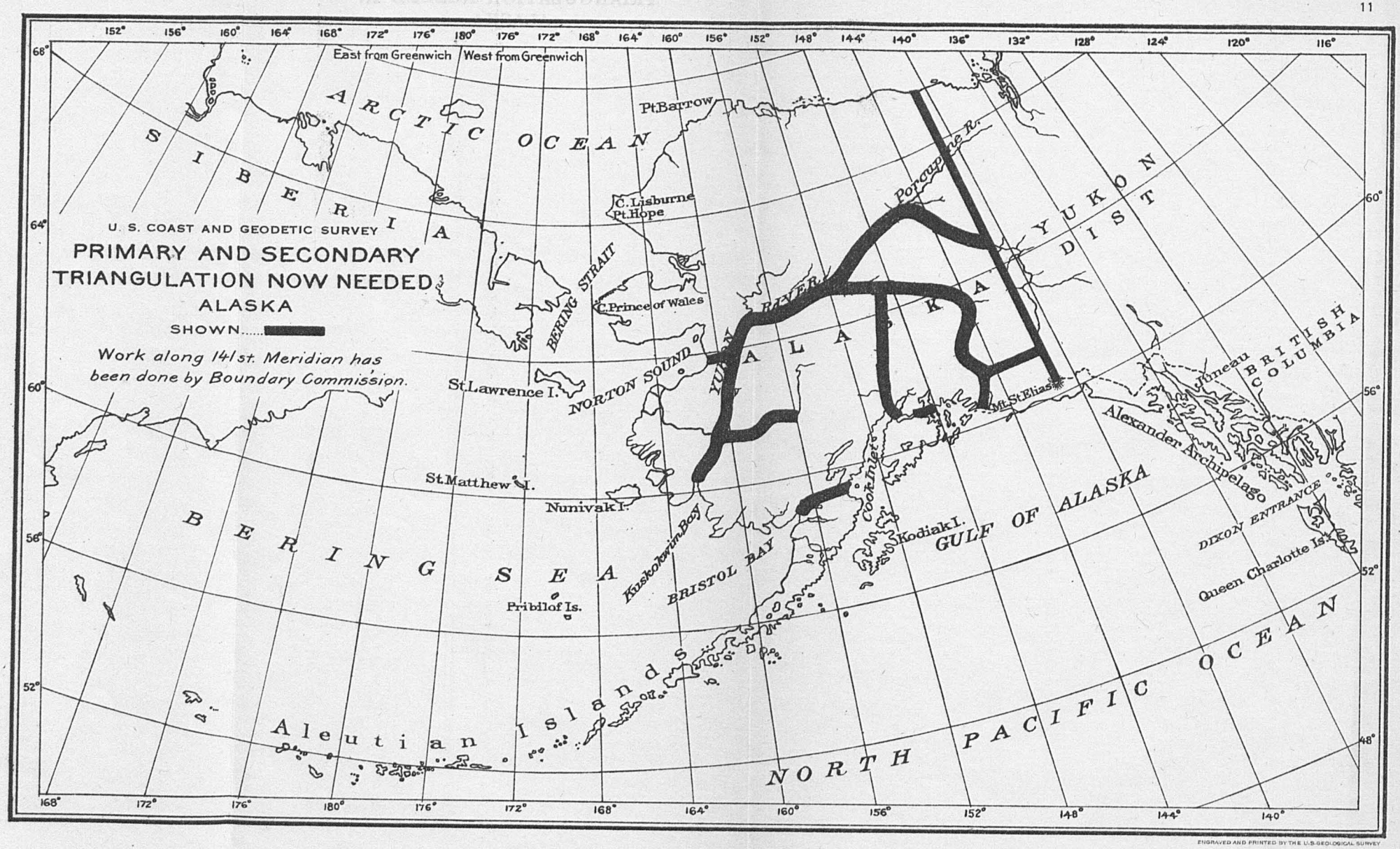
Even greater New York was forced to have an officer of the Coast and Geodetic Survey to direct the primary triangulation of its area. The Survey was willing to cooperate in this work, because the results would be of great value in the revision of charts in the vicinity of New York City. The city of Cincinnati requested the Coast and Geodetic Survey to detail one of its officers to direct the primary triangulation and precise leveling of that city, but as it was not practicable for this Survey to permit one of its officers to do this, the city of Cincinnati employed a former officer of the Coast and Geodetic Survey to take charge of the work. Several years ago the city of Memphis requested the Survey to extend a primary triangulation over its area, and during the past winter Richmond, Va., requested the Survey to cooperate with it in making primary triangulation and precise leveling over its area. In the case of Cincinnati, Memphis, and Richmond the problem was not similar to that of New York, as the results would not be of value to the Coast and Geodetic Survey in its charting work. However, in the case of Memphis an arc of primary triangulation was carried to that place from which the city may be triangulated. This arc is in the general scheme which the Survey proposes to extend over the whole country eventually.

Atlanta, Ga., and Lufkin, a town in Texas, have recently requested that precise leveling bench marks be established by the Coast and Geodetic Survey for the basis of city surveys and maps. This the Survey can not do now for lack of funds.

The National Government is spending several millions of dollars annually for surveys and maps of various kinds. The efficiency of this work will be materially aided by having the fundamental control extended rapidly. Accurate surveys and maps are national assets and aid materially in the industrial development of the Nation. Primary triangulation and precise leveling are not of immediate value only, for their monuments and bench marks may be used repeatedly

No. 11.

TRIANGULATION NEEDED IN ALASKA.



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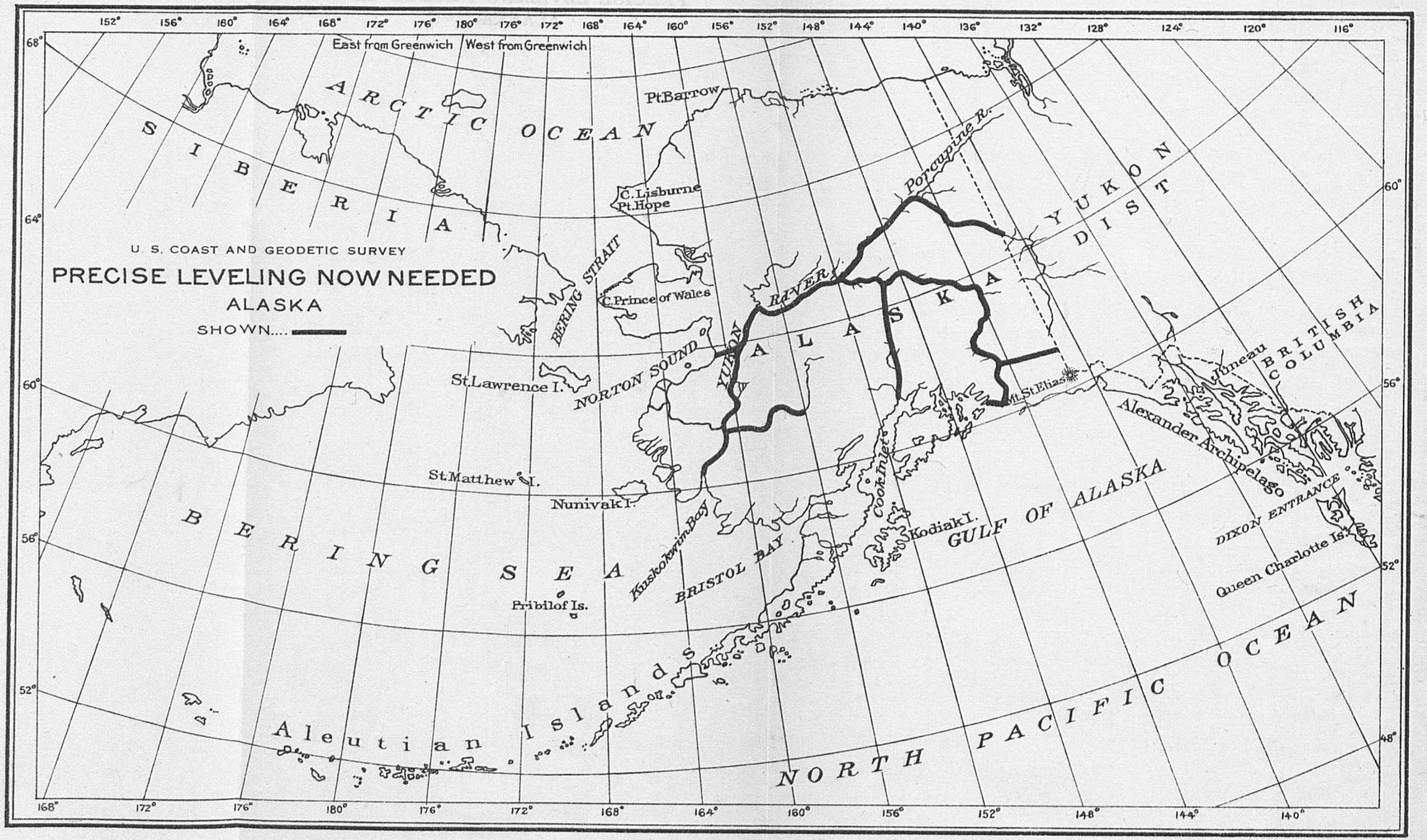
House Doc. 31; 64th Cong., 1st Sess.

No. 12.

PRECISE LEVELING NEEDED IN ALASKA.



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for an indefinite time, and in any given area, will probably never have to be duplicated. The National Government can well afford to adopt a plan of carrying the fundamental geodetic control to a rapid completion, as only about $1,250,000 is needed to finish the geodetic work here contemplated. If this work could be done at all by the several States, the field and office work and the overhead charges would no doubt cost several times this amount and the great delays would make the Nation the loser by much more than the cost of the work if it were done by the Federal Government.

Illustrations Nos. 9 and 10, which are inserted between pages 11 and 12, show the primary triangulation and precise leveling nets which are being extended by the Survey. The first one, which is the triangulation net, shows the completed work in solid black, the work which has been begun in shading, and the work which should be done in the near future in red.

The other illustration, No. 10, shows the precise level net, with the work completed in heavy black lines, and the proposed work in red.

The work shown on these illustrations should be carried to a rapid completion while the primary control in the intermediate areas should be extended as the work is specifically called for.

Considering this important phase of the work of this Bureau, the necessity of having precise levels and primary triangulation extended along the principal rivers in Alaska is most important. This Territory is rapidly developing and it is certain that if primary triangulation and precise leveling can be carried into the interior ahead of the detailed surveys, much money will be saved in consequence.

In addition to the triangulation and leveling in the interior of Alaska there is needed a triangulation across the Alaska Peninsula connecting Cook Inlet and Bristol Bay. There are several datums now in Alaska and it is desirable to have the detached schemes of triangulation connected and all the work placed on one datum.

In this connection it is recommended that a primary triangulation be carried from Dixon Entrance northward to White Pass at the head of Lynn Canal, Alaska, and also that the triangulation of Puget Sound and other waters between Point Roberts and Tacoma be strengthened. These two pieces of work are portions of an arc of primary triangulation which will connect Alaska with the United States. The Canadian Government is now undertaking a primary triangulation to extend from Dixon Entrance southward to Point Roberts. If the United States will extend the triangulation to White Pass, as mentioned above, it is expected that the Canadian Geodetic Survey will then carry the triangulation from that point down the Yukon River to a connection with the one hundred and forty-first meridian triangulation in the vicinity of Eagle City. The desirability of having all of the triangulation of North America on the North American datum is apparent to all who have to use the results of triangulation in surveys and maps.

For the purpose of carrying on the triangulation and leveling in the interior of Alaska, there should be appropriated, specifically for this object, at least $20,000 per annum until the work is completed.

The item of the appropriation bill, "Party expenses, Pacific coast," should be sufficiently large to permit of $10,000 being used on the triangulation along the coast between Dixon Entrance and White

Pass, and between Tacoma and Point Roberts; also for the connection between Cook Inlet and Bristol Bay.

There is also needed triangulation revision along the Atlantic coast of the United States and a slight amount on the Gulf coast. This is needed for two reasons. In the first place, the triangulation there is very old and many of the points have been destroyed by the erosion of the shores and by the work of man. Such points as have been destroyed should, in most cases, be reestablished. In the second place, until recent years, the mark of a triangulation station was not of such a character as to insure permanency. When a concrete mark is used without some tablet or lettering designating the purpose, it is very apt to be destroyed by thoughtless persons who imagine that it is a mark for buried treasure. Many of our important stations have been lost for this reason. At present, practically all of the stations of the Survey are being marked by an inscribed metal disk set into the concrete or solid rock which allays any curiosity the visitor may have in regard to the purpose of the mark. Wherever old stations can be found along the coasts they should be re-marked in a substantial manner and one of the tablets should be set in the concrete or rock. About $7,500, as a minimum, should be available each year for a rather indefinite time for the revision of triangulation on the Atlantic and Gulf coasts. This fund should be provided for in the item of the appropriation bill entitled "Party expenses, Atlantic coast."

The following statements show the amount of precise leveling and primary triangulation needed in the interior of Alaska:

TRIANGULATION NEEDED IN ALASKA.

	Miles.
Norton Sound to Eagle, via Yukon River	750
Yukon River to Kuskokwim Bay	350
Upper part of Kuskokwim River	250
Across Alaskan Peninsula, Cook Inlet to Bristol Bay	120
Susitna River, Cook Inlet to Fairbanks	300
Cordova to Tanana, along Copper and Tanana Rivers	700
From Copper River to one hundred and forty-first meridian	100
Total	2,570

PRECISE LEVELING NEEDED IN ALASKA.

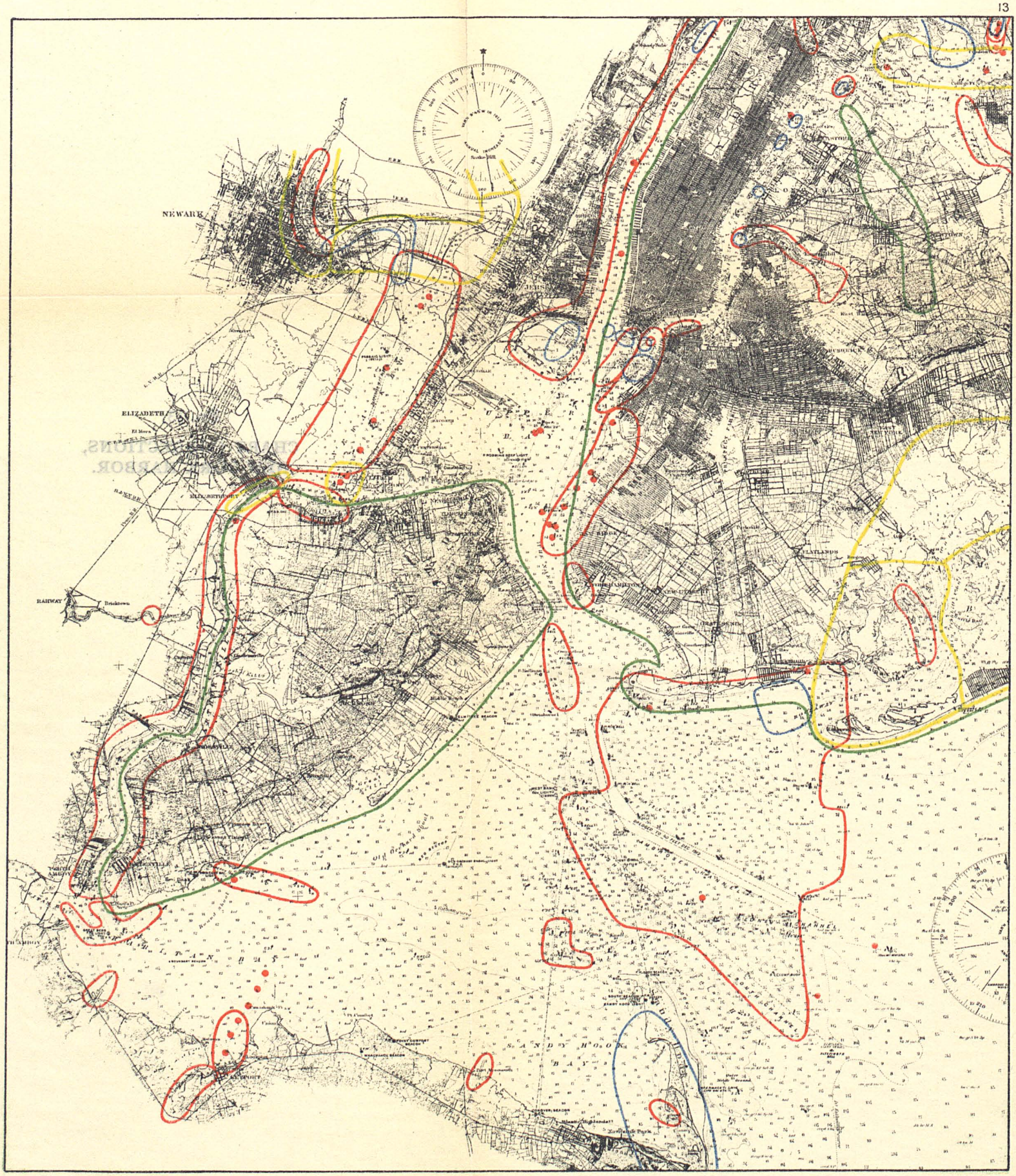
Norton Sound to Eagle, via Yukon River	800
Yukon River to Kuskokwim Bay	400
Upper part of Kuskokwim River	300
Susitna River, Cook Inlet to Fairbanks	325
Cordova to Tanana, along the Copper and Tanana Rivers	750
Copper River to one hundred and forty-first meridian	110
Total	2,685

URGENT NEED OF INCREASE IN OFFICE FORCE.

The mass of material directly affecting our charts has so increased in recent years, with further increases in prospect, that it has not been possible with the present force to handle it so as to place it before the navigator in the shape of new charts or new editions of existing charts with the expedition that its importance demands. The importance of this information will be recognized when it is

No. 13.

CHART CORRECTIONS, NEW YORK HARBOR.



Corrections which have accumulated in
a year to keep this chart up to date.

11 Original field sheets
65 Blueprints, U.S. Engineers
125 City Maps
52 Light and Buoy corrections

understood that in addition to our own numerous detailed surveys, all the vast river and harbor improvements in tidal waters, all the lights, beacons, and buoys on our coasts, and every report of change in navigable waters has to be handled and shown on the chart.

Corrections to charts were made as follows: From blue-print surveys furnished by Corps of Engineers, United States Army, fiscal year 1910, 193; fiscal year 1915, 524. Changes in aids received from Bureau of Lighthouses, fiscal year 1910, 1,900; fiscal year 1915, 2,500.

With reference to our own surveys, the additional work in the office necessary to complete them is indicated by the fact that during the fiscal year 1915 over two and one-half times the work was spent on their completion as compared with that consumed in 1910.

In addition to taking care of new information, the scheme of making new charts on 1–80,000 scale on the Atlantic and Gulf coasts, and the 1–200,000 scale on the Pacific coast should be prosecuted as rapidly as possible; also the charts of southeast Alaska need reconstructing, as they are based on unadjusted data and their defects are becoming more and more apparent with the establishment of new aids to navigation and new examinations made with the wire drag.

The fact that in 1911 there were made a total of 207,568 impressions, and in 1915 a total of 304,799, in connection with the printing of the charts, or a net increase of nearly 50 per cent, furnishes another argument for a substantial increase in our office force. During the past year and in previous years many of the men in the office connected with the various divisions worked overtime.

The inadequate force in the drawing section and printing office of the chart division, and the computing division, and the insufficient number of clerks and messengers are seriously retarding the progress of the work and making it difficult at times to get out necessary work with any degree of promptness. In fact, it has become almost an accustomed condition to have work accumulate owing to the lack of assistance in getting it out.

The recommendation for a further increase in the drawing section is owing to the fact that the present staff is insufficient to handle the chart material received from all sources. The number of employees should be increased adequately to meet the demands, so that charts containing the latest information may be issued at the earliest possible moment.

There is urgent need of the addition of several computers for the computing, tidal, and terrestrial magnetism divisions. The necessity for this increase in the computing force is to enable those divisions to expedite the reduction and publication of the results of the Survey's operations, and make them available for the use of the public as soon as possible. The present force can do little more than keep up with the current needs of the Survey itself, and can do little toward putting new results in final form for publication.

The computation and adjustment of precise levels and the gravity and astronomic observations are practically up to date, but there are at present in the archives data for about 16,000 triangulation stations ready to be computed, the results of which should be published for the public use. These stations are located along the coasts and in the interior of the United States, Alaska, Porto Rico, and Hawaii. They have controlled the original coast surveys and can be used for

general public surveys for an indefinitely long time if data concerning them are published and thus made available. These stations were established at an average cost of about $65 each, and it would certainly be good business to make the computations and publish the results at a cost of only about $9 per station. The same thing is true of the tidal and current observations, many hundreds of volumes of which are available and awaiting increased force for their discussion and utilization. It is also apparent that placing the results in print is an insurance against loss by fire. At present such a loss would be complete and incalculable.

The clerical service in the Bureau is conspicuously inadequate. For example, the Superintendent has no clerk or stenographer. In a number of the divisions it is found that work has so accumulated, owing to the fact that there is not sufficient assistance in the way of stenographers, that it seriously disturbs the efficiency. For a number of months it has been necessary for the Superintendent to appeal to the Department for help in order to partially catch up with the work. There is no fact which shows more conclusively the need of more office assistance than the inability to keep up with the general routine, even with much overtime work now performed.

There is urgent need of additional force in the printing section. At the present time most of the men who carry on this work are not paid standard salaries in accordance with those paid for similar work in some other departments of the Government and in commercial houses. With the great increase in the output of charts, the force in the printing section has not increased proportionately, and one of the main reasons for back orders is the fact that facilities are not adequate for turning out the work.

ANNUAL SCALES OF PAY.

	Coast Survey.	Hydrographic Office.	Engraving and printing.	Norris-Peters.	Geological Survey.
Plate printer	$1,200.00	$1,200.00	[a] $5.44 and $5.76		
Assistant plate printer	1,000.00 900.00	1,000.00 900.00 800.00			
Plate printers' helper		700.00 600.00			
Lithographer	1,800.00	1,800.00			$1,200.00–$1,680.00
Assistant lithographer	1,000.00	1,000.00			
Lithographic pressman	1,200.00	1,400.00		[b] $22.00–$28.00	
Lithographic artist	1,700.00 1,200.00 900.00			[c] .60	2,100.00
Transferrer		1,400.00		[b] 20.00–30.00	1,800.00

[a] Per day. [b] Per week. [c] Per hour.

The messenger service is inadequate, largely owing to the fact that the buildings are unsuited to the Bureau's functions. The necessity of a messenger having to take so many steps in order to perform an errand would not exist in a modern office building. Nevertheless, such is the condition, and until it is remedied several additional messengers are necessary.

BETTER FACILITIES FOR PRINTING CHARTS.

By far the larger part of the results of our surveys reaches the navigator and engineer in the form of charts. Every effort should be made to have this final product of an excellence commensurate with the large amount of time and money spent in collecting and arranging the material the chart shows in a condensed form. The final stage in producing the chart is its printing, and the best press adapted to the work should be employed in order to maintain this branch of the work at the highest standard, and a sufficient number should be provided to render it possible to meet urgent demands promptly.

Each copy of a chart is run through the press from two to five times, the average being three times. First, for the black plate; second, the buoy plate, by which the buoys are colored; third, the tint plate, by which the land areas are distinctly defined from the water areas; and on certain charts blue and yellow tints are also used.

It is most important for the distinctness of the chart that the colors on the different plates should register or fit exactly in their assigned places. How close this register must be will be understood when it is stated that the outline of the symbol which represents a buoy is only one-twentieth of an inch in width. Within this outline the red color must fit.

Faulty register is produced by the expansion or contraction of the chart paper during the intervals between the printings of the three plates.

To obviate this lack of register and to assure the same conditions for the three runs, the second and third runs should follow the first as closely as possible, all three being completed in one day. With a single press this rapid sequence in printing is impracticable, due to the amount of unproductive work it involves. This consists in the necessary cleaning up of the press after the run of the black plate to prepare it for the red buoy color, and a second clean-up after the run of the buoy plate to prepare the press for the tint color. Each of these clean-ups consumes at least an hour's time of additional unproductive work from this source alone.

It therefore becomes necessary to run a number of different charts through the press for one color before it is changed for another color.

Our press is the flat-bed type, which is being rapidly replaced by the rotary offset press in all large commercial lithographic establishments. The Hydrographic Office, United States Navy, has two of the latest type one-color offset presses which have proved highly satisfactory.

A two-color offset press has now been perfected which can be run with the same force as a single-color press. By means of this type of press the two most important impressions, the black base and the buoy color, could be done at one printing.

The offset press presents three distinct advantages for our chart work. First, sharper prints; second, the rapid drying character of the ink used permits the printing of the various colors in rapid succession; third, a reduction in the cost of paper, by omitting the high-surface finish of the paper required by the present press.

It is therefore recommended that Congress be asked for one of these modern two-color offset presses.

HEATING AND LIGHTING THE BUILDINGS.

The question of lighting and heating the buildings occupied by this Bureau is of more serious importance than ever before. At the present time they are heated by two antiquated low-pressure boilers, which must either be replaced by two new boilers, at an estimated cost of $2,000, or they must be again ineffectually repaired, at an estimated expense of $1,000. In addition to this, there is expended for coal $1,400 per annum in order to heat the Richards Building, and the Treasury Department expends about $1,000 per annum for coal to heat the Butler Building, two-thirds of which is occupied by this Bureau. In addition to the cost for fuel, the care of the boilers entails a considerable burden during six months of the year. The facilities for handling the coal are most inconvenient, the coal being dumped from the trucks into bins under the parking at the front of the building and then taken in wheelbarrows, in small quantities, to the boilers, which are located almost at the rear of the buildings. This coal must be wheeled in the open, over a tortuous route, where the handler is exposed to the inclemencies of the weather throughout the winter. The coal can not be stored in the immediate vicinity of the boilers because there is not adequate storage room.

At present a branch line from the heating main of the central power and heating plant, from which heat is supplied to the buildings under the supervision of the Superintendent of the Capitol Grounds, runs directly through the buildings occupied by this Bureau.

It is a well-recognized elementary principle among those who have examined the question that economy is effected in heating buildings from a large central plant, rather than from many small plants in various buildings.

It is therefore recommended that authority be requested from Congress to tap this heating main that runs through the Survey's buildings, for the purpose of supplying them with heat, which will allow the fuel-wasting and uneconomical boilers now in use to be discarded and the room they occupy to be utilized for other purposes.

If this permission is given, the annual saving to the Government would be $2,460, in addition to the time and labor required for the care and supervision of the present boilers. This involves the work of three laborers from approximately the first of September to the last of April, the clerical help employed in their supervision, the purchase of coal, disposal of ashes, etc. In addition to this, there would be saved considerable annoyance from smoke and ashes, and by no means of least importance, the danger from fire would be lessened.

Regarding the lighting of these buildings and the furnishing of electric current needed, when the present incumbent assumed the Superintendency of this Bureau he learned that a portion of the electric current was being furnished from the Capitol Building, a practice which was started at the time of the Spanish War, and before the power plant was erected. In addition to approving the continuance of this practice, it is recommended that Congress authorize us to run a wire across the street to connect with a current of

sufficient voltage to supply the necessary power at a cost very much lower than that charged by the Potomac Power Co.

In view of the foregoing, and the fact that this Bureau is located adjacent to this excellent Government service, which can supply the electric current and heat needed by the Survey at a trifling cost, scarcely appreciable, and in view of the fact that there is consumed $2,400 worth of coal per annum in heating the two buildings, to say nothing of the cost of current, and for other reasons already mentioned, it would seem a wise and economical move if the foregoing request could be carried into effect.

TRANSFER OF NAUTICAL EXPERTS TO STATUTORY POSITIONS.

It is recommended that the coast pilot section be reorganized to the extent of transferring its members from their present designations of nautical experts to those of assistants, of equal grade. This will necessitate an increase in the number of assistants, and a corresponding decrease in the appropriations for offshore soundings, the item from which the salaries are now paid. The change will add to the efficiency of the Survey by rendering the high ability of the nautical experts available for all branches of the work, instead of to the strictly coast-pilot work, which is now the case. These officers are the equals of assistants in the survey in education, efficiency, and results accomplished, and should be placed on an equality with them in the items of assignments and advancement.

Additional reasons advanced for the necessity of this change are homogeneity in the field force of the Survey and the assurance of an ample force to draw from at all times to do coast-pilot work. Further, it gives an opportunity to the younger members of the field force, assigned to the coast-pilot work, to know better the needs of the navigator and the requirements of hydrography as well as other branches of our work.

It will eliminate these lump-sum salaries, which are not in harmony with the present policy of Congress.

INTERCHANGEABLE FEATURE OF APPROPRIATIONS.

It is recommended that authority be given in the appropriation bill for the transfer of at least 10 per cent from one specific item appropriated for field expenses to any other item appropriated under that general head. The advantages of such a provision will be readily seen from the following:

First. It is necessary to submit estimates for the appropriations so long in advance that it is impossible to foresee just what work may become imperative during the year, in addition to the systematic plan of work contemplated. Just now it has become necessary to suspend the regular work on Long Island Sound to take up a piece of work on the Maryland coast, which might have been done by an independent party if the necessary expenses could have been met by a transfer from other appropriations. The necessity for special, unanticipated surveys frequently comes up, and must be met at a loss to the Survey by suspending work in progress.

Second. Any piece of work is liable to cost more than anticipated and will need to be left incomplete unless there is a way to meet the increased expense; this condition occurs near the end of the fiscal year, after all available funds have been allotted. It would generally be possible to meet such emergencies if a transfer from one or more other items of the appropriation was authorized.

Third. The appropriation can not be used to the best advantage because there is always an uncertainty in the exact cost, and consequently a margin of safety must always be maintained in each item of the appropriation. The expenditures are made by widely scattered parties, often in remote regions such as Alaska and the Philippine Islands, and maintaining a margin of safety frequently means a considerable balance.

SUPPORT OF THE INTERNATIONAL GEODETIC ASSOCIATION.

The question of our remaining a member of the permanent commission of the International Geodetic Association is a serious one. Not that there is any question whether we should be represented, but we have entered into what is in effect a treaty with foreign countries with reference to our membership in this association. Congress for the last two years has failed to appropriate funds for the continuation of this country in the International Geodetic Association, but that does not relieve us from responsibilities. This failure to meet our obligations does not sever our connection with that association.

It is believed that the officers of the association do not feel or take the position, because of our not paying our contribution in 1914 and 1915, due to the negative action of Congress, that this is the settled policy of the nation; and this assumption on the part of its officers is shown by the fact that although the United States did not contribute its portion to the expenses of the association for the year 1914, nevertheless the permanent secretary of the association invited the American representative to vote on the question of whether or not the association should continue the convention for another 10-year period, and whether or not there should be any alteration in this convention which will expire December 31, 1916.

In other words, this country's representative was considered to be a member of the permanent commission of this association, in good standing, though the contribution was still unpaid.

The following letter from the Secretary of State was the authority on which Dr. Tittmann based his reply to the permanent secretary:

[Copy.]

DEPARTMENT OF STATE,
Washington, December 22, 1914.

Hon. WM. C. REDFIELD,
Secretary of Commerce.

MY DEAR MR. SECRETARY: I find that I have not answered your inquiry of November 24. The appropriation asked for as our share of the permanent advisory committee of the International Geodetic Association is so small that I heartily agree with you in the opinion that we should continue our membership and that our representatives should be advised to so vote. I shall be glad to join with you in recommending action to Congress.

Very truly yours,

W. J. BRYAN.

Dr. Tittmann's reply to the permanent secretary of the International Geodetic Association is as follows:

[Copy.]

WASHINGTON, D. C., *December 28, 1914.*

MY DEAR SIR: Referring to previous correspondence on this subject, I now feel at liberty to state that I am in favor of continuing the International Geodetic Convention without alteration for another period of 10 years.

Wishing you a very happy New Year, I am,

Very truly yours,

O. H. TITTMANN,
Superintendent.

Mr. H. G. VAN DE SANDE BAKHUYZEN,
Perpetual Secretary, International Geodetic Association,
Leyden, Holland.

It is shown by the foregoing correspondence and the following letter that the United States has entered into an agreement with other nations, and that we have obligated ourselves to pay the amount due for the last two years, for which no money has been appropriated by Congress.

The following letter shows that the United States agreed to continue in the International Geodetic Association for a period of 10 years after December 31, 1906:

[Copy.]

EMBASSY OF THE UNITED STATES OF AMERICA,
Berlin, November 9, 1905.

M. No. 8004.

The undersigned, ambassador of the United States of America at Berlin, has the honor to inform Monsieur van de Sande Bakhuyzen, permanent secretary of the International Geodetic Association, that the Government of the United States approves of the proposition to continue for a period of 10 years after the 31st of December, 1906, without modification, the agreement under which the International Geodetic Association is operating and which will expire at that date.

The undersigned ambassador avails himself of this opportunity to express to Monsieur van de Sande Bakhuyzen the assurance of his distinguished consideration.

CHARLEMAGNE TOWER.

MONSIEUR VAN DE SANDE BAKHUYZEN,
Permanent Secretary of the International Geodetic Association,
Observatory of Leyden, Holland.

The agreement referred to in the letter of Mr. Tower will expire at the end of the calendar year 1916.

In view of the above it is believed that the United States is still a member of the International Geodetic Association, and this country should not only be represented by a member of the permanent commission, but sufficient funds should be made available by Congress to meet the contributions covering the past two years as well as for the next fiscal year.

ITEMS FOR URGENT DEFICIENCY BILL.

There are two matters which it is believed need consideration in the urgent deficiency bill.

The question of whether the important international latitude observatory at Ukiah, Cal., should be abandoned is a serious one. The board of directors of the Astronomical Society of the Pacific,

feeling that the European war might make it necessary for the International Geodetic Association to abandon its work at the variation of latitude observatories, passed the following resolutions at the meeting on November 30, 1914:

Whereas it has come to the attention of this board that the work of the International Latitude Observatories is threatened by the present war in Europe, and that some of the stations may be closed: Be it

Resolved, That it is the sense of the Astronomical Society of the Pacific that the work of these stations is of the greatest importance, and that every effort should be made to continue the stations in this country even though others are necessarily closed;

Resolved, That the president and secretary of this society be authorized and instructed to present the views of this society to the proper authorities of the United States Government and urge upon them the desirability of making some special provision for the maintenance of the stations in this country.

It is recommended that the estimates for the Coast and Geodetic Survey for the year 1917 contain a provision for the expenditure of such funds as may be necessary, up to $2,500, for the maintenance of the observatory at Ukiah, Cal., if the International Geodetic Association is not able to continue this observatory in operation on account of the lack of funds or for any other reason while the European war is going on. It should be understood that after the war is over the association should resume the observations at the Ukiah observatory.

The need of a clerical assistant to act in the capacity of a clerk and stenographer to the Superintendent is a matter that is recommended for immediate consideration. At the present time the Superintendent is greatly handicapped, owing to the fact that he has to call for assistance from those who are rendering customary services to other officials in the same Bureau, and further, owing to the inadequate clerical force, the Department has been appealed to during the last six months, and has, at various times, supplied a stenographer. It is earnestly recommended that a clerk to the Superintendent be provided in the urgent deficiency bill.

SUBOFFICES.

The Coast and Geodetic Survey has suboffices at Manila, Seattle, New York, San Francisco, Galveston, Boston, and New Orleans. The Galveston office was started in May of this year, through the interest of the Chamber of Commerce there, which placed at the disposal of our inspector office room and a clerk, with the understanding that an effort would be made to secure the necessary funds next year to maintain this office.

The Boston and New Orleans offices are conducted in cooperation with the Bureau of Foreign and Domestic Commerce and are in the charge of officers of that Bureau, who have files of our publications and charts for the information of those interested who may call to consult them. The suboffices at San Francisco, New York, and Galveston have only one officer of the Survey at each.

The Seattle suboffice is useful to the Washington office in securing information and otherwise assisting in carrying on the routine business in connection with the surveys of Oregon, Washington, and Alaska. It becomes more evident each year, with the increase of commercial activities along the coast of Alaska, that this suboffice

can not give adequate attention to such a large territory. Therefore the need of a suboffice at a suitable point in Alaska, such as Juneau, is worthy of consideration.

On the Atlantic coast, in addition to the suboffices now established, a suboffice at Norfolk would be helpful, and its establishment is worth while considering.

These offices are proving very useful to the maritime public and others in their localities by enabling them to obtain information immediately and directly. Owing to the lack of funds, these offices are restricted in their activities almost exclusively to office routine. Funds are needed to provide each of these offices with a clerk in addition to the officer in charge, so that the clerk would keep the office open and enable the officer in charge to inspect the coasts in his district and make reports to the Washington office of any errors in the existing charts, the need for revision surveys, and any information of benefit to the maritime public and of use in keeping our charts revised up to date.

It would be of invaluable assistance to this Bureau in keeping its charts up to date if the coasts could be divided up into inspection districts (like those of the Lighthouse Bureau and Coast Guard) with an officer conveniently located in each whose duty it would be to constantly inspect the coasts in his district and report to the Washington office, with recommendations, any errors, changes, etc., affecting the accuracy of the charts.

PROPOSED PURCHASE OF DUTCH HARBOR, ALEUTIAN ISLANDS, ALASKA, AS A FEDERAL GOVERNMENT BASE.

A serious problem confronts the Government in reference to a supply base in western Alaska for coal, oil, and other ship supplies. At the present time Unalaska is the headquarters of the Coast Guard cutters, and acts as a supply base for Government vessels; but the arrangement is not ideal for several reasons.

First, the harbor is a poor one. The only means of reaching the wharf is through a very narrow and crooked channel, which is dangerous to a vessel of even ordinary size. Second, at this place the Federal Government has paid many thousands of dollars to a private company for coal transported from Australia, Canada, and the United States, besides incurring other annual expenses in payment of various privileges received. As it is necessary for Government vessels to dock at a private wharf and to accept courtesies in connection therewith, it thereby places them more or less under obligation to a private concern. Third, there is a very poor fresh-water supply at Unalaska and the buildings are inadequate.

In view of the fact that commerce has greatly increased in this section of Alaska, it is quite necessary and natural to look for a permanent supply base. Upon investigation it would seem that Dutch Harbor, the abandoned village and home of the North American Commercial Co., is the logical place for the Federal Government to own. The only wireless station in this section is located close to this deserted village, making it easy of communication; the harbor is excellent, there being ample room for sufficient wharves, and there is a liberal fresh-water supply. The buildings of this company are in more than a fair state of preservation, and besides the good buildings,

there are coal yards with trackage for hauling coal, scales, derrick, and practical storage bins, already built. As has been stated, the entire village is deserted and can be acquired as a whole. Considering all this it is suggested that it would be highly advisable for the Government to negotiate at an early date for the purchase of this settlement.

The Department of Commerce would be greatly helped by having such a permanent Government station in this isolated section of Alaska as many of its bureaus would be benefited. This Bureau is carrying on important work in that region at the present time, and the natural anticipations are that it will do much more each year. It is necessary for the vessels to have a place where they may readily and cheaply secure their coal and other fuel, which has not been the case heretofore; and in addition to this the new vessels of the Coast and Geodetic Survey, which will do much work in this territory, will be oil burners and could be supplied with fuel from Government tanks, and not from those of a privately owned company.

The Bureau of Fisheries, with its great interests, is custodian of the Pribolof Islands; and the fact that its vessels will ply back and forth from these islands to eastern Alaska, as well as to Seattle, will make this point a valuable one from which to replenish her fuel and other supplies.

The Lighthouse Bureau will also be greatly benefited because of its tenders being in that region at intervals while carrying on their specific work.

Another consideration (and one of the most important features) is that the Coast Guard, which has made its headquarters at Unalaska in the past and which has for some time earnestly recommended the purchase of this property, will feel the benefits to a great extent. Thus, it is not only to the Commerce Department that benefit would accrue.

The Government would immediately feel the beneficial results of this purchase. There are thousands of tons of fuel used by all the Government vessels in that section, which, at present, are purchased from private concerns at large figures; while if the Government owned its own supply base, this same fuel could be furnished from Government bins and tanks, brought there from Government-owned mines and oil wells on Government vessels and colliers. In this way the cost of the purchase of this property would soon be realized in the saving on these supplies. It is earnestly hoped that the coming Congress will act favorably on this recommendation.

RETIREMENT.

The question of retirement for civil service employees has been very justly receiving consideration from all branches of the United States Government. It seems appropriate to invite attention to the subject at this time.

In this Bureau a number of men resign each year and the gravity of these resignations and their effect on the work of the Bureau can not be overestimated. Young men come into the service, remain a few years, and then, just when they have reached a high standard of

efficiency and have gained familiarity with the details of the highly technical work, they, or many of them, for some reason resign.

The result of these resignations is that some of its best men are leaving the service, whose places must be filled by young and inexperienced officers whose lack of training prevents them from fulfilling the best interests of the service. The condition narrows down to the twofold question, What is wrong with the service under existing conditions, and what can we suggest to remedy the wrong?

The wrong seems to be this: The service offers a future so unattractive that few men, when they learn what is in store for them, have the courage to continue in it. The dangers and hardships endured, the sacrifices made, are out of all proportion to the rewards received. The men must devote the best years of their life to the service in all parts of the United States, Alaska, and the Philippines; must go to sea in small craft and at the risk of storms and of unknown dangers in waters which their own efforts are charting for the first time; must give up the home life which every man sooner or later desires; and must endure hardships and discomforts inseparable from the work of the service.

They received during the period of their greatest efficiency a moderate salary, hardly sufficient to meet present needs. Promotion is slow owing to the the comparatively large numbers in the lower grades. This is a consideration which is costing the Survey many of its best young men. They come into the service knowing little or nothing about its conditions, remain a few years, then resign and enter upon other work in which there is, perhaps, a future, a greater reward, and a more desirable mode of life.

The remedy for these conditions seems to be a higher official standing as derived from commissions similar to those of the Public Health Service, a retirement similar to that given to officers of the Coast Guard or at least a waiting-orders status, which would insure one of a small competency in old age when unfit for field duty. It is believed that the men of this service are entitled to such consideration.

In efficiency the men in this Bureau are second to none in the Federal Government; the work is cited as the standard of accuracy among other scientific institutions in this country and abroad.

In view of the hardships endured and the dangers encountered, proper retirement is justified fully as much to these officers as to those to whom it has already been given. Yet, at present, any officer injured in line of duty receives one month of sick leave and is then dismissed.

If a comparison be permitted between services dissimilar in character, it would appear that the value of the work done by these officers in promoting commerce and safe navigation is not inferior to that rendered by the Army or Navy in upholding our national interests; by the Public Health Service in safeguarding health; or by the Coast Guard in saving life and property.

Part II.—FIELD AND OFFICE WORK.

GENERAL STATEMENT OF PROGRESS.

OFFICE OF INSPECTOR OF HYDROGRAPHY AND TOPOGRAPHY.

The inspector has supervision over the work of parties on the surveying vessels and other hydrographic and topographic work, including coast-pilot work in the field and office, and is charged with various duties relating to the repair and equipment of the vessels of the Survey.

VESSELS AND PARTIES, ATLANTIC COAST.

The steamer *Bache* was employed during the greater part of the year on offshore hydrography on a part of the coast of South Carolina, Georgia, and Florida. A number of tall signals were erected on shore for use in this work, and special hydrographic signals, constructed on buoys supplied and placed by the Lighthouse Service, were used in locating lines from which the shore signals could not be seen. Extensive repairs were made to the *Bache* during December, January, and February.

The steamer *Endeavor* was continued on the hydrographic resurvey of a part of Delaware Bay entrance until October 2. Shortly afterwards she was inspected by the local steamboat inspectors and a board of survey examined the vessel on November 9; as a result of their reports she was condemned and ordered to be sold. On May 12 the *Endeavor* was sold to the highest bidder for $1,015.

The steamer *Hydrographer* was employed on hydrographic surveys in Long Island Sound between Execution Rocks and Norwalk Islands, including Oyster Bay. Many uncharted shoal spots and rocky patches dangerous to navigation were discovered. A search was made for reported shoals in Pollock Rip Slue. No shoals were discovered, but some of the aids to navigation were found to be out of position. Afterwards the *Hydrographer* was engaged on a general resurvey of Albemarle Sound, N. C., and a hydrographic resurvey in the vicinity of Sandy Hook, N. J.

The steamer *Isis*, then at Tompkinsville, N. Y., was chartered for the use of the Survey on May 2, in order that she might be prepared for surveying work as soon as practicable after July 1, when the appropriation for her purchase by the Government became available. On May 17 the *Isis* was in the reviewing line at the naval parade and on the 19th she sailed for Washington, D. C., arriving on the morning of the 21st. From that date to June 30 the steamer made several trips down the river and bay, and the remainder of the time she was at the Washington Navy Yard, where plans were made for necessary alterations to fit her for surveying work.

The schooner *Matchless* completed revision work in places on the east shore of Chesapeake Bay, and after undergoing repairs at Baltimore began a general revision of the surveys of Albemarle and Croatan Sounds, N. C. The work in the western end of Albemarle Sound was completed early in May and that in Croatan Sound was begun.

Two wire-drag parties were employed on the Atlantic coast; one in the aproaches to Portland Harbor, Me.; in Buzzards Bay, Mass., in the southern approach to the Cape Cod Canal; in Narragansett Bay, R. I.; in the vicinity of Key West, Fla.; and in the approaches to Boston Harbor, Mass.

The other wire-drag party was employed in Buzzards Bay, Mass., and in Massachusetts and Cape Cod Bays southward from Minots Ledge.

A large number of uncharted rocks and shoals have been found by the wire-drag parties in the regions examined.

Some improvements have been made in the apparatus and methods used in drag work. A publication has been prepared descriptive of the wire-drag work on the Atlantic coast, and a new form has been devised by which the unit cost of drag work in various localities can be accurately determined.

Chart revision work was completed in the Passaic and Hackensack Rivers, N. J., and a resurvey of Arthur Kill was begun.

A revision survey was made of Great South Bay, Long Island, including triangulation, topography, and hydrography. A topographic and hydrographic survey of Jamaica Bay was completed. Signals for hydrographic work were erected between Sea Girt and Little Egg Inlet, N. J. The water front of Philadelphia was revised.

In August, September, and October, 1914, a revision was made at Salem, Mass., of the topographic details on chart 244. Triangulation points were recovered and re-marked and the positions of prominent objects useful as aids to navigation were determined.

The series of current and tidal observations in the Potomac River, undertaken at the request of the Public Health Service with a view to determining the amount of pollution by sewage, etc., was completed in the latter part of the fiscal year.

At the request of the Commissioner of Fisheries of the State of Virginia, a survey was made to determine the position of the low-water mark on the west side of Parramore Island, Va.

Suboffices of the Survey were established at Boston and New Orleans, through the cooperation of the Bureau of Foreign and Domestic Commerce.

For the convenience of the public, a stock of charts and other publications of the Survey are kept for sale at the suboffices and on certain vessels of the Survey, Bureau of Lighthouses, and Bureau of Fisheries.

Field revision for new editions of the Atlantic Coast Pilot volumes was made of Chesapeake Bay, of the inland waters on the coast of New Jersey, of Delaware Bay and River, the Gulf of Mexico from Key West to the Rio Grande, from Point Judith to New York and up the Hudson River, the inside-route along the south shore of Long Island, and of the approaches to the Cape Cod Canal.

VESSELS AND PARTIES, PACIFIC COAST.

The steamer *Explorer* completed the survey of Knik Arm, Cook Inlet, Alaska, and its approaches. Special hydrographic work was done off the mouth of Woodrow Creek, at the request of the Alaskan Engineering Commission. After completing the survey of Knik Arm, an examination was made of a reported shoal area in Seldovia Bay. The *Explorer* then took up supplemental hydrography in the open area of Prince William Sound north of Montague Island and between Hinchinbrook and Smith Islands, between Perry and Lone Islands, and on the bar between Culross and Esther Islands. At Juneau the automatic tide gauge was overhauled and an examination was made of the edge of the shoal flat off the mouth of Sheep Creek. In March and April wire-drag work was done in Richs Passage, Wash. Work was begun at the entrance of Cook Inlet, Alaska, on June 9.

The steamer *Gedney* was engaged in combined operations in the waters west of Prince of Wales Island. During the season which began in April of the previous fiscal year surveys were made in Klawak Inlet, Tonowek Bay, Trocadero Bay, Meares Passage, and Sukkwan Strait. An improvised wire drag was made use of in several localities. The surveys of the main ship channels on the west side of Prince of Wales Island and of a safe inside channel from Tonowek Bay to Sea Otter Sound were completed, but further examination with the wire drag is needed.

The steamer *McArthur* was engaged at the beginning of the fiscal year in Nichols Passage and Felice Strait, carrying on combined operations which had been commenced in the previous April, and including triangulation, shore-line topography, and hydrography of the islands and passages. The hydrography was carried through Nichols Passage and into the northern part of Felice Strait. A wire drag was used to supplement the soundings in certain localities. A search was made of a shoal reported in Portland Canal, but no evidence of it was found. In March and April the *McArthur* was employed on revision work in Richs Passage, Wash.

After repairs had been completed at Seattle, work was resumed June 1, 1915, in southeast Alaska, in Felice Strait and its approach from Clarence Strait.

The steamer *Patterson* was engaged at the beginning of the fiscal year in general surveys in the Shumagin Islands and on the adjacent mainland of Alaska Peninsula. The triangulation was extended from the Shumagin Islands to the mainland and eastward to Kuiukta Bay, and was expanded in the Shumagin Group to furnish control for the hydrography and topography. The topography was extended in the Shumagins to include Nagai, Unga, Andronica, and Korovin Islands and the Haystacks. A topographic reconnoissance was carried along the main shore in connection with the triangulation. Two harbors were surveyed with the plane table. The hydrography covers nearly the same region as the topography. Two harbors on Nagai Island, the west coast of Popof and Unga Islands, and the approaches to West Nagai and Gorman Straits were surveyed. Sounding lines were run between the Shumagin Islands and Unimak Pass and in the locality of the reported Lenard Rock. A bank off Cape Sarichef was developed and lines of soundings were run be-

tween Unimak Pass and Goodnews Bay. A hydrographic and topographic reconnoissance was made in connection with the triangulation from the Shumagins to Kuiukta Bay.

In September and October the *Patterson* made a voyage of 1,700 miles to the assistance of the Coast Guard steamer *Tahoma* wrecked on an uncharted reef in the western Aleutian Islands. Twenty-nine of the crew were picked up and brought back to Unalaska, the remainder of the ship's complement having been rescued by another vessel. The courage of the commanding officer in venturing with the *Patterson*, an old and none too seaworthy vessel, to the rescue of the *Tahoma's* crew is worthy of the highest commendation. Only a few months later he lost his life when the steamer *Lusitania* was destroyed. Work in the field was closed October 23.

The *Patterson* was repaired at Seattle and resumed work in the Shumagin Islands on June 21. On the way a sunken rock with 15½ feet of water in Whale Passage, Alaska, was found and located. Work was in progress at the close of the year.

The work of the steamer *Taku* was the topography and hydrography of Passage Canal and Landlocked Bay, and the triangulation of Landlocked and Fidalgo Bays. The hydrography covers the area between the survey of 1912 off Esther and Culross Islands, across the lower part of Port Wells into Passage Canal, and up the canal to a junction with the 1910 work. Field operations were closed September 28. During the winter revision work in the vicinity of Seattle, Wash., was done by the chief of this party.

Work in Prince William Sound was resumed in June in Ports Gravina and Fidalgo, after a new boiler had been installed and repairs made to the *Taku*.

The work assigned to the steamer *Yukon* was to develop a channel from Kuskokwim Bay through the extensive flats to the main river.

The result of the season's work was the discovery and charting of a good channel across the flats into the Kuskokwim River. Sailing directions for entering and full predictions of the time and height of high and low waters for 1915 for the river were prepared. This survey opens up an extensive region in Alaska which previously was almost inaccessible. The survey of the Kuskokwim was resumed in the latter part of June, 1915.

Wire-drag work in Tongass Narrows, Alaska, was begun in July, 1914. For this work a revision of the triangulation was necessary. A small scheme of triangulation was carried from Mary Island to Mountain Point and Pennock Island. The topography located new wharves at Ketchikan and corrected the shore line in Revillagigedo Channel.

The drag work, to an effective depth of 45 feet, included all of Tongass Narrows from Guard Island to Mountain Point, Nichols Passage in the vicinity of Walden Rocks, Port Chester and entrance, and Revillagigedo Channel from Twin Islands to Alava Point, including the passage north of Bold Island and the entrance to Thorne Arm. Field operations were closed October 10.

Wire-drag work was resumed May 12, 1915, in Revillagigedo Channel and was in progress at the close of the fiscal year. The wire-drag work done in May and June, 1915, covers the area in the main channel between Twin Islands and Cape Fox and the entrance to Boca de Quadra. A 10,000-foot drag was successfully used in the open waters.

In 1914, 21 dangers were reported, 11 of which are of the first importance. In May and June, 1915, several dangerous rocks were discovered and reported.

A second wire-drag party for work in Alaska was organized in April, 1915, and began work on May 19 in Sumner Strait in the latitude of Bluff Island, from which point by June 30 drag work with an effective depth of 50 feet had been carried northward nearly to Point Baker. Drag work was done along the eastern side of the strait out to longitude 133° 43′ and including Calder Rocks, and an area on the west side southeast from Point Amelius. Triangulation and topography were done to locate signals for the drag work and to check the position of Barrier Islands.

The resurvey of Yaquina Bay, Oreg., including triangulation, topography, and hydrography, which was in progress at the beginning of the fiscal year, was completed November 7.

Current observations were begun during the year at San Francisco Light Vessel, Blunts Reef Light Vessel, Columbia River Light Vessel, Umatilla Reef Light Vessel, and Swiftsure Bank Light Vessel.

INSPECTION DUTY.

An officer has continued on duty as inspector for the coasts of California and in charge of the suboffice at the San Francisco customhouse.

Another officer has continued on duty as inspector for the coasts of Washington, Oregon, and Alaska and in charge of the suboffice of the Survey in the Burke Building at Seattle, Wash. He has also been charged with the supervision of the repairs to the vessels of the Survey at Seattle, and with various details of field work.

Three officers of the Survey have been assigned at different times to duty as Assistant Inspector of Hydrography and Topography. Among the duties performed by these officers are the preparation of estimates for future work, the inspection of vessels requiring repairs, and the purchase and preparation of plans for the construction of new vessels.

HAWAIIAN ISLANDS.

In the Hawaiian Islands the revision of the triangulation and topography of the island of Hawaii was resumed in August near Punaluu Harbor and carried northeastward along the coast line to Cape Kunukaki and thence northwestward to Hilo Bay, thus completing the survey of the island on December 31. Numerous points were determined for use in hydrography.

Revision work on the island of Molokai was begun in March and continued until May 31, when work was suspended owing to the exhaustion of the appropriation. The topography was carried from Cape Hawala around the south and west sides of the island nearly to Kalaeokailio.

PHILIPPINE ISLANDS.

The work of the Survey in the Philippine Islands is executed under the direction of the director of surveys, an officer of the Coast and Geodetic Survey, who, acting under authority from the Super-

intendent, makes plans for the work, issues detailed instructions to the field parties, and also has charge of the suboffice at Manila. The expenses of the work are met partly from the appropriation for the Coast and Geodetic Survey and partly from funds provided by the Philippine Government, which also furnishes four vessels for surveying purposes. One steamer, the *Pathfinder*, is furnished by the Coast and Geodetic Survey.

The five vessels of the Survey have been kept in the field as continuously as possible, the principal cause for delay being the necessity for rather extensive repairs.

In the matter of general expenses the increased cost of coal is adding very materially to the expense of the work. This is especially true in the case of the steamers *Marinduque* and *Romblon*, for the reason that the region in which they are employed, the coast of the Calamian Group and of Palawan Island lies apart from the more frequented routes of travel and commerce, in consequence of which the price of coal at ports in that region is much higher than in the principal commercial ports of the archipelago. The same extra expense applies in a great measure to the steamer *Fathomer*, as that vessel has frequent occasion to coal at Port Uson, in the Calamian Group, and consumes much more coal than the *Marinduque* or the *Romblon*.

The steamer *Pathfinder* was engaged in work as follows: A survey was made on the south coast of Mindanao from Parang across the delta of the Mindanao River and southward to Port Lebak. A junction was completed on the east coast of Mindanao, near Hinatuan, between the surveys previously executed on that coast. A special examination was made of certain parts of the Sulu Sea, including Moyune Shoal and vicinity. A survey was made of a reported shoal on the east coast of Negros. A revision was made of the surveys of the coast south of Manila Bay entrance. A special survey was made of Palmas Island. A hydrographic examination was made in vicinity of San Bernardino Island.

The steamer *Fathomer* was employed chiefly in the development of the region around the Cuyo and the Calamian Groups of islands. A special examination was made of a part of Iloilo Strait in which a sunken rock had been reported, and a large-scale topographic survey of the city of Iloilo was made at the request of the secretary of commerce and police in connection with projected harbor and municipal improvements.

The principal work of this vessel has been the hydrography of the important passages between Mindoro, the Semirara Islands, Panay, and the Quinaluban and Cuyo Groups. This work was nearly completed.

The steamer *Marinduque* was chiefly engaged in surveys on the eastern coast of Palawan in the vicinity of Dumaran Island. The main triangulation scheme of Palawan was extended to the vicinity of latitude 10° north. Some shoal spots in Coron Bay, Calamian Group, were developed. The hydrography of unfinished areas east of Coron Island and in the eastern approach to Coron Passage was completed and surveys northward of Dinaran Island were begun.

The steamer *Romblon* was engaged in detailed topographic and hydrographic surveys of the numerous islands and their surround-

ing waters lying between the northeastern coast of Palawan and the Calamian Group. The filling of gaps in the work of the *Marinduque* west and southwest of Dumuran Island and of a large gap including Taytay Bay and the region eastward of that bay between work previously done by the *Marinduque* and *Romblon*, respectively, was assigned to this vessel. The survey of Taytay Bay was well advanced by the close of the fiscal year.

The steamer *Research* was engaged in general surveys of Ticao and Masbate Passes, including a base line near Bulan; triangulation, topography, and hydrography of southern Luzon, and Ticao and Masbate Islands; surveys of the region around Ticao Island, Sorsogon Province, including subordinate triangulation between Burias Island and Luzon; topography at the entrance to Sorsogon Bay and westward nearly to Donsol; along the western shore of Ticao Island; and along the northeastern shore of Masbate Island from Black Rock Pass to Masbate Harbor; and hydrography in the passages between Luzon, Ticao, Burias, and Masbate, including large-scale surveys of Masbate and San Miguel Harbors. At the end of the fiscal year work was in progress between Masbate Harbor and Port Barrera.

NEW VESSELS FOR THE SURVEY.

As a result of representations made to Congress at its last session by the President and by the Secretary of Commerce as to the urgent needs of the Survey, an appropriation of $289,000 was made, available July 1, 1915, for two new vessels to replace others worn out in the service and not worth further repairs.

After extensive inquiry and an inspection of many vessels offered for sale, a contract was made by the department on April 26 for the purchase of the steamer *Isis* for a sum slightly less than $60,000. The vessel was chartered by the Survey until the appropriation should become available on July 1. The *Isis* was built in 1902 at a cost of about $225,000 and could not be duplicated for that price at the present time. She is in almost perfect condition in every respect, having been very carefully used, and she is given a very high rating by the American Bureau of Shipping and by the Steamboat-Inspection Service.

The *Isis* is a twin-screw vessel of steel construction, has a double bottom, and was built in 1902. Her length is 180.4 feet, beam 24.8 feet, draft 11.6 feet, depth 13.5 feet, gross tonnage 377, and net tonnage 256. She has twin triple-expansion engines of 2,000 horsepower and double boilers. Her cruising speed on natural draft is 12 knots. Under forced draft she makes from 15 to 17 knots. Her coal consumption at 12 knots is only 9 to 10 tons in 24 hours. In surveying service it is estimated that she will average about 6 tons per day.

The price paid for the vessel included the cost of inspection and classification, cleaning and painting bottom, and other work necessary for putting her in commission.

Immediately after the signing of the contract preparations were begun for manning and equipping the vessel. She was given a position of honor in the review of the North Atlantic Fleet held in New York Harbor May 17. The *Mayflower*, carrying the President, was first in line, next came the *Dolphin* with the Secretary of the Navy

and guests, and then the *Isis* with the Secretary of Commerce and other officials.

The *Isis* will be employed on offshore hydrographic work along the Atlantic coast. She replaces the old steamer *Endeavor* which was built during the Civil War.

Plans were prepared for a new vessel, authorized in the appropriation act approved March 3, 1915, to be specially fitted and equipped for the exposed offshore work on the coasts of California, Oregon, Washington, western Alaska, and the Aleutian Islands.

SURVEYS REQUESTED.

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

Massachusetts: Survey of Salem Harbor, requested by Salem Chamber of Commerce.

Connecticut: Survey of shoal between Gull Rocks Light and Coasters Harbor Island, requested by Navy Department.

New York: Observations of action of tides and currents on sewage flowing from Paerdegat Basin, requested by the law department of the city of New York.

Virginia: Location of low-water mark on Parramore Island, Va., requested by Bureau of Fisheries. Survey of locality on southern drill ground where U. S. S. *Nebraska* touched, requested by Navy Department.

North Carolina: Determination of positions of aids to navigation in sounds and interior waters, requested by Bureau of Lighthouses.

South Carolina: Examination of locality of wreck of schooner *Frederick W. Day*, requested by Bureau of Lighthouses.

Florida: Continuation of wire-drag work in vicinity of Key West, Fla., requested by Navy Department. Triangulation of St. Vincent Sound, requested by Bureau of Fisheries.

Alabama and Georgia: Precise leveling along the Chattahoochee River, requested by officer in charge, United States Engineer Office, Montgomery, Ala.

Texas: Survey of channel leading seaward from near Sabine Bank Lighthouse, requested by master of steamship *Herman Frasch;* precise level line through Lufkin, requested by city engineer of that place.

Louisiana, Texas, and Canal Zone: Surveys on Gulf coast, coasts of Central America, and approaches to Panama Canal, requested by New Orleans Board of Trade.

Nevada: Line of precise levels from Las Vegas to line between Reno and Hazen, requested by Director of United States Geological Survey.

Ohio: Establishment of meridian line and magnetic station at Portsmouth, Ohio, requested by Board of Trade of Portsmouth.

Alaska: Extension of surveys and wire-drag examinations along the coast in general, requested by Senators and Representatives from the Pacific coast, the Pacific-Alaska Navigation Co., the Alaska Pacific Co., the Alaska Steamship Co., the Governor of Alaska, the Alaska Coast Co., the Humboldt Steamship Co., the Northland Steamship Co., the Pacific Coast Steamship Co., the Seattle Commercial Club, the San Francisco Chamber of Commerce, the masters and

pilots of steamships *Spokane*, *City of Seattle*, *Northwestern*, *Dolphin*, and *Edith;* survey northward from Dixon Entrance and westward from Icy Straits, requested by master of steamship *Senator;* location and marking of mouth of Kenai River, Cook Inlet, requested by United States Bureau of Fisheries; surveys in Knik Arm, Cook Inlet, requested by Alaskan Engineering Commission, also by commanding officer of U. S. S. *Maryland;* wire-drag survey of Sumner Strait, requested by Pacific Coast Steamship Co.; survey of Felice Strait, vicinity of Duke Island, requested by L. D. Ryus; survey of west coast of Prince of Wales Island, requested by master of steamship *Jefferson* and master of steamship *Santa Ana;* survey of Wrangell Narrows, requested by master of steamship *Admiral Evans;* surveys in southeastern and southwestern portions of coast, requested by pilot of steamship *Seward;* survey of Tongass Narrows and west coast of Prince of Wales Island, requested by master and pilot of steamship *Dolphin;* survey of Tongass Narrows, Snow Pass, and Sumner Strait near Point Baker, requested by master of steamship *Seward;* surveys in Aleutian Islands, requested by Coast Guard Service.

Philippine Islands: Survey of Sulu Sea, requested by Philippine Government, communicated by director of coast surveys at Manila.

DANGERS TO NAVIGATION.

Dangers to navigation discovered, investigated, or reported by vessels or parties of the Coast and Geodetic Survey during the year were as follows:

Maine: Shoals and ridges in Portland Harbor and its approaches, discovered and developed with wire drag.

Connecticut: Rock in Pine Island Channel, New London Harbor, Conn., reported.

Rhode Island: Shoals near Newport Harbor, examined.

Massachusetts: Shoal in Pollock Rip Slue struck by steamship *Dimock*, of the Eastern Steamship Corporation, examined; pinnacle rock with 17½ feet of water and numerous shoals and bowlders in Buzzards Bay discovered and located with wire drag.

New York: Eighteen uncharted rocky shoals dangerous to navigation and other rocks and shoals with less depth than charted in Long Island Sound, discovered and located; rock in Hudson River near Peekskill, examined; shoal in East River, on which the steamer *Powhatan* grounded, reported.

Virginia: Reported 27-foot shoal spot in Chesapeake Bay, examined.

Florida: About 100 shoals and coral heads in approaches to Key West, discovered with wire drag and located.

Washington: Rock between Kiket Point and Skagit Island, Wash., reported.

Alaska: Rocks in Passage Canal and pinnacle rock in East Twin Bay, Perry Island, discovered and located; edge of shoal flat off Ship Creek, examined; area of reported shoaling at Seldovia, examined; submerged rock in South Inian Pass, and shoals in channel off Fire Island on which steamer *Alameda* grounded, examined; shoals in western approach to Sukkwan Strait, examined; shoal near

Craig, Alaska, examined and located; shoals in Kuskokwim River and approaches, located; reef near Attu Island, on which Coast Guard steamer *Tahoma* was wrecked, located; banks, shoals, and pinnacle rocks in the vicinity of Shumagin Islands, examined and located; locality of reported Lenard Rock, reexamined; rock with 14 feet of water near Warburton Island and other rocks in Nichols Passage, Alaska, discovered and located; shoal off Point Davidson, examined and located; rock in entrance to Port Chester and bank off Point McCartney, examined and located; three rocks awash south of Moira Rock and midway between Moira Rock and small island south of same, reported; area of reported danger off River Point, Portland Canal, Alaska, examined; 21 important dangers to navigation and other shoal spots and areas discovered with wire drag in Tongass Narrows, Nichols Passage, Revillagigedo Channel, and Port Chester; bank off Cape Clear, Montague Island, Alaska, reported.

Philippine Islands: Mayune Shoal in Sulu Sea, where British steamship *Bengloe* stranded, examined; 16-foot shoal off east coast of Negros, examined; uncharted shoals northeastward of Palawan Island, discovered and developed; depth over wreck of steamship *Pharsalia*, in entrance to Iloilo Strait, determined; 8-fathom bank in north part of Ticao Pass, discovered and located; locality of reported shoal in approaches to harbor of Iloilo, examined; reef off south side of Jolo Island, reported; rock in Maqueda Channel on which steamer *El Cano* was wrecked, reported; shoal on east edge of Framjee Bank, eastward of Busuanga Island, reported; shoal in 16 feet of water on east coast of Panay on which steamship *Rubi* struck, examined.

ASSISTANCE RENDERED IN SAVING LIFE OR PROPERTY.

In October the Coast and Geodetic Survey steamer *Patterson*, in response to an urgent call by wireless, made a voyage of 1,600 miles to the assistance of the officers and crew of the Coast Guard steamer *Tahoma* wrecked on a reef in the western Aleutian Islands. Three boats' crews of the *Tahoma* were picked up on Attu Island and taken to Unalaska by the *Patterson*, the remainder having been rescued by other vessels. In recognition of the service rendered, the members of the party on the *Patterson* were presented with handsome testimonials by the officers and crew of the *Tahoma*.

The unfortunate loss of this vessel is one of many disasters which emphasize the urgent need of means for the more rapid prosecution of detailed surveys in this dangerous region.

On July 25 assistance was rendered by the steamer *Endeavor*, J. B. Boutelle, commanding, to the lighthouse steamer *Iris*, with the Secretary of Commerce and other officials on board, which had gone aground during a sudden storm at Lewes, Del.

On February 28 the officers and crew of the Survey schooner *Matchless* rendered efficient help in putting out a fire in Edenton, N. C.

At midnight on Saturday June 12 the steamer *Gedney*, F. H. Hardy, commanding, rendered assistance to the fishing schooner *Poloris* by hauling her off Klawak Reef, north end of Fish Egg Island, Alaska, on which she had run aground.

On the night of July 22 the *Explorer* rendered assistance to the steamer *Bertha*, which was anchored at Ship Creek for use as a floating wharf. In a fresh wind and heavy current the *Bertha* began to drag, and was being carried in toward the beach. Members of the crew of the *Explorer* aided the crew of the *Bertha* in getting up their anchor, which, because of lack of steam, they were obliged to heave up by hand.

On May 25, 1915, in approaching San Bernardino Straits the four-masted schooner *Alpene*, of San Francisco, was sighted by the steamer *Pathfinder* off the north end of Capul Island flying a distress signal. The master of the *Alpene* asked the *Pathfinder* to stand by, as he had lost an anchor and was afraid of being beached by the strong currents. Noting that the vessel was in a helpless condition and fast drifting to the south side of the straits the *Pathfinder* towed the *Alpene* to a safe position at sea.

COAST-PILOT WORK.

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

The office work includes the preparation of Coast Pilot, Part IV; the Inside Route Pilot of New Jersey; Coast Pilot Notes for Kuskokwim Bay and River, Alaska; supplements for six coast pilots; and correction sheets for insertion in coast pilots. The preparation of coast-pilot directions for the coast of Alaska from Yakutat Bay westward is nearly completed.

Much valuable work has been done by the coast-pilot section in the examination of original sheets and furnishing data as to the condition of the surveys.

A plan for obtaining, with the cooperation of the Bureau of Lighthouses, slack-water observations in the main channels at the easterly end of Long Island Sound and Cape Cod Canal, to furnish data for current tables to be included in the tide tables, was carried into effect. A general plan was prepared for current observations to be undertaken during the fiscal year 1916.

Special information was compiled from field reports and records of surveys for the use of the Alaskan Engineering Commission.

After obtaining the opinions from mariners and others interested in the charts of the Survey, the use of the foot instead of the fathom as the unit of soundings on charts of 1–80,000 and larger scales of the Atlantic and Gulf coasts of the United States was recommended and adopted.

Certain changes in the form and matter contained in the tide tables published by the Survey were recommended and adopted.

A study has been made of the question of steamship lanes for coastwise vessels.

A number of officers of the Survey with experience on the coast of Alaska were assigned to the coast-pilot section for short periods during the winter and aided in the preparation of notes and sailing directions for that coast.

An Inside Route Pilot of the Gulf Coast of the United States from Key West to New Orleans was compiled by an officer of the Survey detailed for that purpose and has been published.

TIDES.

Tidal observations were made in connection with all hydrographic surveys in the United States and its outlying territory, and at regular stations at Portland, Me.; Fort Hamilton, N. Y.; Atlantic City, N. J.; Philadelphia, Pa.; Baltimore, Md.; Key West, Fernandina, St. Augustine, and Cedar Keys, Fla.; Galveston, Tex.; San Diego and San Francisco, Cal.; Seattle, Wash.; and Juneau, Alaska. Tidal indicators, exhibiting automatically the stage and height of the tide, were maintained at Fort Hamilton and New York City, N. Y., and Reedy Island, Delaware River.

With the cooperation of the Bureau of Lighthouses, observations of currents were made at a number of light vessels on the Atlantic and Pacific coasts. Similar observations were made when practicable by the hydrographic parties of the Survey.

OFFICE OF INSPECTOR OF GEODETIC WORK.

The duties of inspector are performed at the Coast and Geodetic Survey office and in the field. They consist mainly in planning field work, preparing the necessary instructions for field parties in geodetic work, and correspondence relating to details of field operations; examination of records, computations, and reports; scientific investigations based on the results of the field observations, and computations in the computing division; and preparation for publications of the results of geodetic field and office work.

The inspector and members of the computing division assisted the International Boundary Commissioner by inspecting the records and computations of triangulation and the reports of field parties and aided in certain other details connected with the boundary work.

The most notable events in the geodetic work during the past fiscal year were:

1. The determination of latitude at a large number of stations between central Texas and the Pacific coast and along the California-Nevada boundary. The rapidity with which this work was done was due in a large measure to the use of an autotruck for transportation.
2. The introduction of the autotruck as a means of transportation for parties engaged in reconnoissance and triangulation, which is expected to increase the amount of work accomplished and to decrease its cost.
3. The great rapidity obtained in precise leveling on the line between Butte, Mont., and Pasco, Wash.
4. The completion of the triangulation along the Pacific coast of the Olympic Peninsula, joining the triangulation of Grays Harbor with that of the Strait of Juan de Fuca.

The geodetic work done during the year is as follows:

TRIANGULATION.

The triangulation between Memphis, Tenn., and Huntsville, Ala., begun during the previous fiscal year, was completed. The length of this arc was 190 miles, and 31 stations were occupied in the main scheme in 104 days. Thirty-eight geographic positions were determined and four primary azimuths were observed.

The erection of signals and marking of stations on the Memphis-Huntsville arc was done by a separate party. Signals were erected at 15 stations. The average height of the tripod on which the instrument rested was 56 feet, and the superstructure on the scaffold on which the observer and the light keeper work was on the average 83 feet in height.

After this work was done a reconnoissance was made for a connection between a detached piece of primary triangulation in the vicinity of Louisville, Ky., and a line of the transcontinental arc in the vicinity of North Vernon, Ind. Signals were then erected and stations marked for this work. In all there were one single and seven double structures and three low stands to support the instrument. The observation of angles in this triangulation were made by a separate party between October 22 and November 19, 1914.

Reconnoissance and preparation of stations for primary triangulation to the northward of Great Salt Lake, Utah, were begun in the latter part of May, 1915, and at the close of the fiscal year the work was in progress. The observation of angles on this triangulation was begun in the latter part of June and was also in progress at the close of the fiscal year. Automobile trucks were used for the transportation both of the reconnoissance and the observing parties. The work to the northward and westward of Utah is being done in response to a request received several years ago from the United States Geological Survey, and will extend into a large area where there is at present no geodetic control based on the North American datum.

The observation of angles on the arc of secondary triangulation which extends from the Strait of Juan de Fuca to Grays Harbor was completed during the year. The reconnoissance for this work and the erection of the signals had been completed during the previous summer. The length of this arc is only 110 miles and there were only 16 stations in the main scheme, but it is probable that no piece of work done on land in the Survey has required greater judgment and skill, as well as ability to face hardships, than this. In much of the area traversed there were no trails and the heavy growth of timber and brush made progress almost as difficult as it is in a tropical jungle. Owing to the character of the country, it was impracticable to clear lines through the timber between stations. It was therefore necessary to elevate the instrument and the heliotropes and lamps above the timber. The lumber used for this purpose was cut in the forest in the vicinity of the stations, and in many cases trees were pulled together to make such supports. A number of the instrument stands were more than 100 feet high. One of them, that at station La Push, was 187 feet above the ground. In one case a tree used to support the lamp and heliotrope was sawed off at a height of 213 feet above the ground. The tower in this case was a single tree, cleared of limbs. It is easily seen that the occupation of these stations at night required steady nerves and great daring.

During the summer of 1914 a triangulation was extended across the Kenai Peninsula, Alaska, between Passage Canal, a branch of Prince William Sound, and Turnagain Arm, a tributary of Cook Inlet. This work was not an extensive one, but there were many difficulties to be overcome, as all of the travel of the party was on

foot and much of it was over glaciers. Progress was greatly retarded by almost continuous rains.

During the winter and early spring of 1915, 12 high signals were erected on the coast of Georgia and Florida for the use of the steamer *Bache* while engaged in carrying on offshore soundings. These signals were of a special type and served the needs admirably. During the progress of the signal building, beach measurements and tertiary triangulation necessary to determine the geographic positions of the signals were completed. Invar base tapes were used in the beach measurements.

In the latter part of November and December a triangulation was made of St. Vincent Sound, Fla., at the request of the Bureau of Fisheries. The scheme of triangulation was 17 miles in length and 13 stations were occupied. The new work was based upon 4 old stations which had been previously established by the Survey.

During the spring of 1915 a study was made of the commercial lamps which might be used as signal lamps in triangulation. A careful study of the problem and the testing of one apparatus led to the conclusion that no portable lamp could be found that would be more suitable than the one now in use in the Survey. It is very desirable to secure a portable lamp which will have a candlepower much higher than the lamp now in use. Further study is being made of this problem and it is possible that an electric or other kind of lamp may be designed which will meet the needs of the Survey. With a powerful light the time of occupying a station would be materially reduced. A slight haze will make the present lamps invisible or too faint for observing over the longer lines of the triangulation.

PRECISE LEVELING.

Between July 1 and November 3, precise leveling was done on a line extending from Butte, Mont., to Pasco, Wash., by way of Spokane, and also on a short line from Sand Point, Idaho, to the Canadian boundary. This work had been begun in the spring of the preceding fiscal year. The amount of work done on these lines during the present fiscal year was 399 miles. During both July and October previous monthly records for precise leveling were surpassed. During July, 1914, 120 miles were run, while in October of the same year the progress made was 149 miles. The maximum result for one day was 20.5 miles of single line, run in 7 hours of actual leveling.

In the spring of 1915 a line of precise levels was run from Seattle to Blaine, Wash. This work was done in order to connect at the latter place with the precise leveling bench marks of the Canadian Geodetic Survey. At the end of the fiscal year work had been begun on a line to extend from Huntley, Mont., to some point on the Great Northern Railway in the vicinity of Mondak, Mont. At the latter place a connection will be made with precise leveling bench marks established along the Great Northern Railway in 1914.

At Louisville, Ky., 12 miles of leveling were run to connect triangulation station Lutz with a precise leveling bench mark on the Ohio River, and about 1½ miles of leveling were run to connect triangulation station Louisville North Base with a precise leveling bench mark.

Between July 1 and October 21, 1914, a line of precise levels was run between Minot, N. Dak., and Devon, Mont. The work on this line was begun in the spring of 1913. At Devon a connection was made with the precise leveling bench marks established at that place during the previous season.

In the spring of 1915 precise leveling was done along a line which will extend from Carson City to Las Vegas, Nev. This work was undertaken at the request of the United States Geological Survey for the purpose of furnishing accurate elevations within the area traversed. A number of connections will be made with detached pieces of leveling already done by the Geological Survey. This work was in progress at the end of the fiscal year.

Between October 28 and November 25, 1914, precise leveling was done on a line between Perth Amboy and Sandy Hook, N. J. The line is 29.4 miles in length and it was run for the purpose of testing the stability of a bench mark at Sandy Hook. The work was done in response to a request from the Corps of Engineers United States Army. It was found that the bench mark which had been used as a reference point for the tide gauges for a number of years apparently had sunk 5.3 centimeters (0.17 foot).

The total amount of precise leveling done during the fiscal year was 980 miles.

ASTRONOMIC WORK.

Between July 1 and October 16, 1914, observations were made for the determination of the astronomic latitudes of a number of points along the Texas-California arc of primary triangulation and the oblique boundary between Nevada and California. This work had been begun on May 14, 1914. During the total season 37 stations were occupied, at the rate of 7.4 stations per month. This is a very remarkable rate of progress, considering the difficult character of the country over which the party operated. It was necessary, in most cases, for the members of the party to handpack the instruments and observing tents and other equipment from the autotruck, which was used as a means of transportation, to the stations on the mountain tops. The weather conditions were variable, the temperature ranging from below freezing on the summits of the mountains to as much as 110° in the shade in the valleys. An unusual rate of progress was made during the first 12 days of October, when seven stations were occupied and completed along the Nevada-California boundary. The automobile truck used by this party is the one which had been used the previous season for a party operating between central Colorado and Canada, approximately along the one hundred and fourth meridian. The two seasons' work with the truck proved beyond a doubt that for certain classes of astronomic work it is much more efficient than teams.

Between July 1 and October 28, 1914, a determination was made of the difference of longitude between each two of the three stations, Far Rockaway, Long Island, Naval Observatory, Washington, D. C., and Cambridge, Mass. This work was done as a part of a plan to determine the difference in longitude by cable between Far Rockaway, N. Y., and Borkum, Germany. The Royal Prussian Geodetic In-

stitute agreed to make the necessary observations at each end of the cable if the Coast and Geodetic Survey would make the observations necessary to connect Far Rockaway with at least two stations of the existing longitude net of the United States. The work of the Coast and Geodetic Survey was completed, but the European war prevented the finishing of the cable work by the observers of the Prussian Geodetic Institute. The longitude work of the Coast and Geodetic Survey observers was done under special instructions which called for the exchange of observers for each difference of longitude, and new transits and chonographs were used for the first time in this Survey. They had been purchased from a firm in Germany for this especial work. They proved very satisfactory and will be used in most of the future determinations of longitude by the Survey.

Upon the completion of the work mentioned above, five differences of longitude were determined between old longitude stations and triangulation stations of the Memphis-Huntsville arc and of the Louisville connection. This work was done between November 1 and January 14.

During the progress of the longitude work, astronomic latitude was observed at five stations.

Azimuths were observed at five triangulation stations of the Memphis-Huntsville arc and the triangulation connecting Louisville with the transcontinental triangulation.

GRAVITY.

During the fiscal year the determination of the intensity of gravity was made at 52 stations in the eastern part of the United States. Western Union Telegraph Co. noon signals were used to rate the chronometers used in this work. This method was substituted for the method by which the time observations were made upon the stars by the gravity observer. Previous to this fiscal year the gravity party consisted of two observers, a station required nine days on an average, and the cost (not including the observers' salaries) was $176. Now only one observer is needed, a station is completed in eight days, and the cost (exclusive of the salary of the observer) is about $57, less than one-third of the former cost. The former high accuracy secured in the results has been maintained since the beginning of the use of the noon signals.

The gravity work has been extended during the year as rapidly as practicable on account of the great value that the results will have for geologists, geophysicists, and others interested in world physics.

OFFICE OF INSPECTOR OF MAGNETIC WORK.

The duties of this office are the planning of magnetic work to be done in the United States and outlying territory under the jurisdiction of the United States; the inspection of magnetic field work on land and at sea and at the magnetic observatories; to recommend the construction or purchase of new magnetic instruments, or alteration of old ones when required, or the designing of new ones; to recom-

mend changes in the design of magnetic instruments, or methods of observing to secure improved results or to save time; to supervise the planning and construction of magnetic observatory buildings, etc.

The magnetic work accomplished during the year may be summarized as follows:

The magnetic observatories at Cheltenham, Md.; Vieques, P. R.; Tucson, Ariz.; Honolulu, Hawaii; and Sitka, Alaska, were in operation throughout the year. The magnetographs gave continuous records except for occasional brief intervals of a day or less. At Tucson the record of the horizontal intensity variometer was lost for a few days on account of the slipping and final breaking of the quartz fiber suspension. The year as a whole was comparatively free from large magnetic disturbances, but the one on June 17 was the largest recorded since 1909. A seismograph was kept in continuous operation at each observatory, the number of earthquakes recorded being less than in previous years. Meteorological observations were made daily. At Tucson the results were communicated by telephone and telegraph to the Weather Bureau office at Phoenix, Ariz. At Honolulu the results were furnished, as heretofore, to the Honolulu office of the Weather Bureau and to the Ewa Plantation Co.

All of the magnetic instruments used in the field work during the year were standardized at Cheltenham. A new magnetometer of the India Survey type, made for the Survey by Cooke & Sons, of York, England, which was compared at the Kew Observatory before shipment to the United States, was standardized at Cheltenham and its constants determined, thus furnishing a comparison between the Kew and Cheltenham standards. An observer of the department of terrestrial magnetism of the Carnegie Institution of Washington took one of their combined magnetometers and earth inductors to Cheltenham and secured a careful comparison by means of simultaneous observations. Instruments were standardized also for the Navy Department and the Lake Survey.

In May the *Carnegie*, of the above Department, called at Honolulu, and an accurate comparison was made of the magnetic instruments in her outfit with those at the Honolulu observatory.

It became necessary during the year to consider the erection of a suitable building for office and residence purposes at Sitka, and complete plans and specifications for such a building were prepared under the direction of the observer.

MAGNETIC WORK ON LAND.

The magnetic elements, declination, dip, and horizontal intensity, were determined at 416 stations, 71 of which were auxiliary stations observed on account of local magnetic disturbance and 12 were new primary stations to replace old ones which had become unsuitable. The observations were distributed in 31 States.

Eighty-one repeat stations were occupied during the year for the purpose of obtaining data for the determination of the secular change in the magnetic elements, especially the declination. These also are included in the total number of stations given above.

The following tabulation shows the distribution of the stations occupied:

SUMMARY OF STATIONS.

State.	New stations.	Auxiliary stations.	Repeat stations.	New stations to replace old ones.	Total.
Alabama	13	9	7	.....	29
Arkansas	8	.....	2	.....	10
Florida	7	.....	4	1	12
Georgia	26	4	6	.....	36
Idaho	2	.....	.....	.....	2
Illinois	4	.....	2	.....	6
Indiana	2	.....	1	.....	3
Iowa	14	20	3	.....	37
Kentucky	3	.....	1	.....	4
Louisiana	4	.....	1	.....	5
Maine	1	.....	2	.....	3
Minnesota	23	20	4	.....	47
Mississippi	26	.....	7	1	34
Montana	6	.....	.....	.....	6
Nebraska	.....	.....	1	.....	1
New Hampshire	5	.....	.....	.....	5
New Jersey	11	.....	.....	.....	11
North Carolina	.....	4	2	.....	6
North Dakota	1	2	2	.....	5
Oklahoma	5	.....	2	.....	7
Oregon	.....	.....	1	1	2
Pennsylvania	11	.....	4	.....	15
South Carolina	1	.....	1	.....	2
South Dakota	13	2	3	.....	18
Tennessee	.....	.....	3	2	5
Texas	32	.....	9	4	45
Vermont	5	.....	2	.....	7
Virginia	7	8	4	.....	19
Washington	8	2	3	1	14
West Virginia	6	.....	1	1	8
Wisconsin	8	.....	3	1	12
Total	252	71	81	12	416

There were also 18 stations in Alaska at which declination observations were made by parties engaged in other branches of the field work.

The magnetic work carried on at sea by vessels of the Survey was as heretofore incidental to the regular work and was small in amount, as the ships' routes have covered little new territory.

The plan of magnetic work heretofore adopted has been continued during the year, and the preliminary survey is still in progress. At the close of the fiscal year there were still 331 counties where magnetic stations have not yet been established, and this number will be somewhat increased by the subdivision, especially in the West, of large counties into two or more smaller ones.

The investigation of local disturbance areas is being carried on in connection with the regular magnetic survey. Sixty meridian lines were established during the year. These were all established at the request of local authorities.

APPROPRIATIONS AND DISBURSEMENTS.

The appropriation made by Congress in the sundry civil act for the fiscal year ended June 30, 1915, was $1,039,720, divided as follows:

Field expenses	$320,400
Repairs and maintenance of vessels	40,000
Officers and men, vessels	252,200
Pay of field officers	160,200
Pay of office force	204,420
Office expenses	50,000
Rebuilding lithographic and aluminum printing room	7,500
One-story building	5,000
Total	1,039,720

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

For the fiscal year ending June 30, 1916, the items of appropriation are as follows:

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

PUBLICATIONS.

The following publications were received from the printer during the fiscal year 1915:

Results of magnetic observations made by Coast and Geodetic Survey, (calendar year) 1913 (with observations made in Philippine Islands, calendar year 1912); by R. L. Faris. 52 p., il. 4to. (Special publication 20.) Paper, 10 cents.

Results of magnetic observations made by Coast and Geodetic Survey, (calendar year) 1914; by Daniel L. Hazard. 69 p. 4to. (Special publication 25; serial 3.)

Results of observations made at Coast and Geodetic Survey magnetic observatory near Tucson, Ariz., 1911-12; by Daniel L. Hazard. 104 p., 8 pl., 4to. Paper, 15 cents.

Catalogue of charts, sailing directions, and tide tables of Philippine Islands, 1914. il. 4to. (From Catalogue of charts, coast pilots, and tide tables, 1914, p. 3, 12, 148-191.)

Catalogue of charts, coast pilots, and tide tables, 1914. 230 p., il. 4to.

Description of long-wire drag; by N. H. Heck. Revised edition. 31 p., il., 7 pl. 4to. (Special publication 21.) Paper, 20 cents.

United States coast pilot, Pacific coast: California, Oregon, and Washington (supplement to 2d edition). Oct. 20, 1914. 10 l. 4to.

United States coast pilot: pt. 1, Alaska (supplement to 5th edition). Apr. 16, 1915. 29 l. 8vo. (Serial 8.)

Precise leveling from Brigham, Utah, to San Francisco, Cal.; by William Bowie. 67 p., il. 4to. (Special publication 22.) Paper, 15 cents.

Statement of expenditures in Coast and Geodetic Survey, fiscal year 1914. Dec. 21, 1914. 16 p. 8vo. (H. Doc. 1424, 63d Cong., 3d sess.)

Primary triangulation on one hundred and fourth meridian and on thirty-ninth parallel in Colorado, Utah, and Nevada; by William Bowie. 163 p., 10 pl., 5 maps, 6 p. of maps. 4to. (Special publication 19.) Paper, 25 cents.

Annual report of Superintendent of Coast and Geodetic Survey, fiscal year 1914. 132 p., il., 16 maps. 8vo. (H. Doc. 1391, 63d Cong., 3d sess.) Cloth, 40 cents.

United States Coast and Geodetic Survey, description of its work, methods, and organization. 1915. 56 p., 17 pl., 3 maps. 8vo. (Special publication 23.) (Printed for distribution at Panama-Pacific International Exposition, San Francisco, Cal.) Paper, 10 cents.

United States coast pilot: pts. 1-2, St. Croix River to Cape Ann (supplement to 3d edition). May 5, 1915. 11 l. 8vo. (Serial 10.)

United States coast pilot, Atlantic coast: pt. 3, Cape Ann to Point Judith (supplement to 3d edition). Jan. 20, 1915. 12 l. 8vo.

United States coast pilot, Atlantic coast: pt. 4, Point Judith to New York. 6th edition; by Herbert C. Graves, assisted by J. T. Watkins. 1915. 259 p., 3 maps. 8vo. Cloth, 50 cents.

United States coast pilot, Atlantic coast: pt. 5, New York to Chesapeake Bay entrance (supplement to 4th edition). Feb. 4, 1915. 14 l. 8vo.

Inside route pilot, Key West to New Orleans, 1914. 96 p., 6 maps in pocket. 8vo. Price, 20 cents.

Triangulation in Alabama and Mississippi; by Walter F. Reynolds. 71 p., 1 pl., 12 p. of diag. (Special publication 24.) 4to. Price, 20 cents.

Coast pilot notes for Kuskokwim Bay and River, Alaska. Mar. 15, 1915. 12 p. 8vo.

Inside route pilot, coast of New Jersey, 1915. 32 p., 3 maps. 8vo. (Serial 4.) Price, 20 cents.

General tide tables for the year 1916 (with list of references). 550 p., il. large 8vo. Price, 50 cents.

Atlantic coast tide tables for eastern North America for the year 1916. (Serial 1.) 184 p., il. large 8vo. (From General tide tables.) Price, 10 cents.

Pacific coast tide tables for western North America, eastern Asia, and many island groups, for the year 1916. (Serial 2.) 178 p. large 8vo. (From General tide tables.) Price, 10 cents.

Tide table for 1915: Kuskokwim Bay and River, Alaska. (Serial 5.) 3 p. large 8vo.

A plane table manual; by D. B. Wainwright. il., 7 litho., 9 pl., 20 p. of pl. (Reprint with corrections, Jan., 1915.) 4to. Price, 50 cents.

The expenditure for printing and binding for the Coast and Geodetic Survey during the fiscal year was $26,345.70.

SPECIAL DUTY.

INTERNATIONAL GEODETIC ASSOCIATION.

The Superintendent continued to supervise the operations of the observatories maintained by the International Geodetic Association at Gaithersburg, Md., and Ukiah, Cal. Observations at Gaithersburg were closed in December, 1914. A report on the results of the observations made with the photographic zenith tube was prepared for publication by Dr. F. E. Ross, the observer in charge. The observations at Ukiah are being continued. No appropriation was made by Congress for the payment of the quota of the United States as an adhering member of the International Geodetic Association for which the United States stands pledged by a joint resolution of Congress. It is hoped that the appropriation of the necessary amount to meet this deficiency will be made. The item for travel of delegates to the meeting of the association was however inserted in the sundry civil act. On account of the European war it is probable that no meeting of the association will be held in 1916.

INTERNATIONAL BOUNDARIES.

UNITED STATES AND CANADA BOUNDARY.

The party engaged in inspecting, determining the positions of monuments, and numbering the monuments on the boundary from the Continental Divide to the Lake of the Woods completed the triangulation over an area of 225 square miles, extending along the boundary for 38.4 miles; determined the positions of 18 monuments, and inspected and numbered 653 monuments, covering 765 miles of boundary line.

The party engaged in the survey and monumenting of the boundary on Rainy Lake and River measured 17 base lines and completed the triangulation for 37 miles along the boundary, occupied two stations for observations of azimuth, completed 234 square miles of topography (including water areas), surveyed 929 miles of shore line, and located and mapped 767 islands. Two hundred and forty-three reference monuments were set for a distance of 116.5 miles along the boundary. All work on Rainy Lake was completed.

On the section of the boundary between the mouth of Pigeon River and Lake of the Woods 97 square miles of triangulation were completed, 182 geographic positions determined, 58 square miles of topography were completed, and 188 miles of shore line of rivers and lakes surveyed. The triangulation covers Basswood Lake and River and the greater part of Crooked Lake. The topography of Crooked Lake was completed.

The party at work in the northeastern boundary in the valley of Halls Stream completed 14 square miles of triangulation and 20.41 square miles of topography, including 30.5 miles of shore line of creeks and 35.3 miles of roads, and determined 114 geographic positions, besides other incidental work.

The work in this region includes the resurvey and marking of the boundary from the eastern extremity of the section from the Connecticut River to the St. Lawrence River and extending northward along Halls Stream to its junction with the section following the crest of the highlands that separate the drainage of the St. Lawrence River from that of the St. John River.

BOARD ON LIFE-SAVING APPLIANCES.

The former Superintendent continued to act as chairman of the board appointed to examine and report upon life-saving appliances until the date of his resignation in April, 1915.

MISSISSIPPI RIVER COMMISSION.

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

AMERICAN ASSOCIATION OF MASTERS, MATES, AND PILOTS.

On March 16 an officer of the Survey addressed this association at its convention in Washington, D. C., on the nautical work of the Coast and Geodetic Survey.

The association adopted resolutions asking for the extension offshore of the hydrographic work on the Atlantic coast to the 100-fathom curve, and for close resurveys and examinations with the wire drag in Long Island Sound and elsewhere.

EXHIBIT AT NATIONAL MOTOR-BOAT SHOW, NEW YORK.

An exhibit was made of the charts and publications of the Survey at the National Motor-Boat Show held in Madison Square Garden, New York City, from January 30 to February 6. An officer of the Survey was in charge.

EXHIBIT AT PANAMA-PACIFIC INTERNATIONAL EXPOSITION, SAN FRANCISCO.

The preparation and care of this exhibit, which consisted of instruments, models, charts, coast pilots, tide tables, and other publications of the Survey, were assigned to an officer of the Survey.

COOPERATION WITH ALASKAN ENGINEERING COMMISSION.

At the request of the Alaskan Engineering Commission, a number of the officers of the Survey furnished to the commission reports relating to certain harbors under consideration for use as railway terminals in Alaska. At the request of the commission the Survey collated all reports received by the commission on this subject. This was in addition to various surveys and examinations made in furtherance of the objects which the commission had in view.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The inspector of geodetic work attended the meeting of the American Association for the Advancement of Science held in Philadelphia December 28 to January 2 and delivered a paper on the subject, "Recent Progress in Precise Leveling."

SURVEY OF GROUNDS OF BUREAU OF STANDARDS.

A topographic survey of the grounds of the Bureau of Standards, supplementing previous surveys, was made at the request of the Director of that bureau.

DETAILS OF FIELD OPERATIONS.

ATLANTIC COAST.

MAINE, MASSACHUSETTS, AND RHODE ISLAND.

[N. H. HECK.]

SUMMARY OF RESULTS.—Triangulation: 1 signal pole erected, 1 station in supplemental scheme occupied for horizontal measures. Hydrography: 76 square miles of area dragged, 222.7 miles run while dragging, 11,053 angles measured, 343 soundings made on uncharted shoals, 2 tide stations established, 5 hydrographic sheets finished.

Wire-drag work in progress on July 1 in Casco Bay and approaches to Portland, Me., was continued until September 28. A total area of 76 square miles was dragged, and 343 soundings were taken on uncharted shoals. The number of soundings indicates the nature of the region, which is characterized by narrow rocky ridges running generally from northeast to southwest but without pronounced pinnacles. The area was laid out in sections to facilitate the removal of lobster pots which was necessary before work with the drag could be done. Considering the length of the drag used, the interference with the work from this cause was exceptionally slight.

The area of the Cod Ledges was included in the work instead of the area between the 18 and 25 fathom curves. The former area was badly in need of a drag survey, as vessels of considerable draft, especially large schooners, had been accustomed to cross the ledges at

various points where the charts indicated ample depth. The usual double purpose of a wire-drag survey, to locate the uncharted shoals and to prove the remaining area free from shoals, was accomplished.

The most notable dangers found were a 29-foot rock in Portland, a 30-foot rock in the channel off Portland Head, extensive shoal areas near Willard Rock, Pine Tree Ledge, and Broad Cove Rock; very shoal extensions of Alden Rock; a shoal with general depths of 29 to 31 feet between Bulwark Shoal and West Cod Ledge Rock, and a long ridge south of West Cod Ledge.

The dragging of this extensive area was a difficult operation, somewhat interfered with by the necessity of keeping out of the danger zones of the heavy-gun target practice of the coast defense forts at Portland during about 20 days in the most favorable part of the season.

The weather was unusually favorable for open sea work. The winds were moderate and the amount of fog below the average.

Improvements.—The automatic winder to guide the wire on the reel so that it would be uniformly wound proved a marked success and made it possible to set out the drag from the guiding launch while proceeding at considerable speed. In this way as much as 4,000 feet of drag was set out in 12 minutes, but such speed can only be used under favorable conditions.

The signaling system operated by compressed air proved a marked success, and made it possible to operate a drag of 4,000 feet or longer from the guiding launch without an additional observer on the end launch. This requires a lengthening of the tow-line base, which in turn is desirable, as it insures the drag keeping more closely to its proper depth. By properly using the various tenders in changing the drag depth, a longer drag can be used in certain areas than was formerly regarded practicable.

On September 30 the party left Portland, Me., for New Bedford, Mass., via the Cape Cod Canal, arriving at the latter place the following day.

The dragging of Buzzards Bay was begun October 5. The work included the dragging of all areas not finished during the previous season, from a line joining the South Dumping Grounds and West Island to the limits of the work done by the party of Mr. J. H. Hawley, and included some unfinished work in New Bedford Harbor and Quicks Hole. This work was continued until November 7. Owing to unfavorable weather the proposed work in Buzzards Bay was not entirely completed.

The principal shoals located in Buzzards Bay were a 16-foot shoal in Quicks Hole, a 15-foot shoal near White Rock, and a number of shoals in the area northwest of Woods Hole. A special effort was made to complete all unfinished areas in the middle of the bay, but some portions were necessarily left for another season.

After closing work in Buzzards Bay an examination with the drag was made at Newport, R. I., of an area of broken ground between Rose and Goat Islands, three-fourths of a mile in extent. The weather during this work was most unfavorable.

The area in the vicinity of a charted 17-foot shoal was examined with unusual care and soundings were made for more than an hour by three tenders over the entire doubtful area. No important changes were found.

MASSACHUSETTS.

[N. H. HECK.]

SUMMARY OF RESULTS.—Triangulation: 84 square miles of area covered, 4 stations in main scheme occupied for horizontal measures, 1 station in supplemental scheme occupied for horizontal measures, 18 geographic positions determined. Hydrography: 57 square miles of area dragged, 128 miles run while dragging, 4,783 angles measured, 151 soundings made on uncharted shoals, 1 hydrographic sheet, scale 1:25,000, partly finished.

After completing necessary preliminary arrangements, work was begun May 10, 1915, on a wire-drag survey of the approaches to the harbor of Boston, Mass. The headquarters of the party was at Hull. Three hired launches were used in this work.

The weather conditions during May and June were favorable, and satisfactory progress was made. The area dragged was of two classes, clear open water and very rocky shoal area. About 42 square miles of the former were finished in May and about 15 square miles of the latter in June. Practically no shoals were found in the former, while 89 shoal spots were found in the latter.

The shoal areas distinctly indicated the need of a drag survey. The bottom is of a different character from that previously dragged elsewhere, though it somewhat resembles that at Portland, Me. The shoals, however, do not extend in well-defined ridges as at Portland. The bottom is rocky but nearly flat over large areas, with sharp rocky points projecting 3 to 8 feet in places. In one section of nearly 8 square miles the lead was dropped at intervals, and only one sounding was obtained with soft bottom and this in a small pocket. All the rest were on rocky bottom.

Tidal information for the reduction of soundings was obtained from an automatic tide gauge maintained at Nut Island by the Metropolitan Water and Sewerage Board, the records of which were kindly placed at the disposal of the surveying party.

A few triangulation stations were occupied for the determination of prominent objects for use as signals.

Improvements in apparatus.—The principal improvement was the adoption of stranded wire cable (Siemens-Martin) for use as the bottom wire of the drag. This had been used by other organizations and had been under consideration by the wire-drag parties for some time. Certain disadvantages in the use of this cable have now been overcome. The advantages are longer life, less resistance, and less weight for the same strength, permitting the use of smaller floats.

New large buoys have been designed and are being constructed. These will have less resistance with greater carrying capacity.

Experiments were made with floats of balsa wood treated by a special process. These floats were found too weak structurally to withstand the heavy wear.

The use of wireless telegraph for communication between the launches is being investigated.

The spacing of area dragged to different depths in plotting has been greatly improved by the adoption of an instrument known as the "wire-drag buoy spacer," constructed at the office of the Survey.

A form of monthly journal for wire drag work has been adopted which makes it possible to estimate the unit cost of the work.

[J. H. Hawley.]

SUMMARY OF RESULTS.—Leveling: 3 permanent bench marks established. Hydrography: 56 square miles of area dragged, 190.7 miles run while dragging, 1,564 angles measured, 75 soundings made on uncharted shoals, 1 tide station established, 1 hydrographic sheet finished.

Wire-drag work in Buzzards Bay, Mass., begun in May, was in progress at the beginning of the fiscal year, Westport Point being used as headquarters for the party.

On account of lobstering in the region, it was necessary in the early part of the season to mark out the areas to be dragged and this was continued until the early part of September, after which time the fishing operations were not extensive enough to interfere with the work.

A tide staff was established at the mouth of Westport River and connected with permanent bench marks. This staff was used during the entire season. Tidal observations were begun June 30 and discontinued September 29. Enough natural objects were located by triangulation to control the work when used in connection with objects previously determined.

Drag operations were continued throughout the season. The usual methods of wire-drag work were followed, the position of the end launch being determined from the guiding launch. The guiding launch was a double ender, and the drag was set out and taken up over the bow. For setting out, the launch was anchored from the stern. A new type of engine was used to furnish power to the reel.

During the season a breakwater at Salters Point, Mass., was located. Work was closed on September 29.

SUMMARY OF RESULTS.—Triangulation: 10 square miles of area covered, 2 stations in supplemental scheme occupied for horizontal measures, 1 geographic position determined. Hydrography: 50.5 square miles of area dragged, 121.9 miles run while dragging, 753 angles measured, 1 hydrographic sheet partly finished, scale 1:25,000.

In April, 1915, preparations were made for wire-drag work on the coast of Massachusetts southward from the vicinity of Scituate, Mass. On April 27 the positions of the beacons marking the entrance to the Cape Cod Canal were determined.

The party was organized at Hull, Mass. The guiding launch and tender arrived on May 7. On May 11 the party removed to Scituate. The end launch arrived on May 12 and the first field work was done on May 13.

From May 13 to June 30 wire-drag work was in progress. A 4,000-foot drag was used in shoal water and one 5,000 to 6,000 feet long in deeper water.

Numerous shoals were found in the area examined. All of these were single large bowlders or piles of smaller rocks on a bottom of sand and pebbles. The approximate northern limit for bottom of this character appears to be a line extending east from Minots Ledge Lighthouse. It seems probable that this formation extends into Cape Cod Bay.

With one exception, less depth than charted was found on every shoal indication, and large patches of bowlders were found in unexpected places. Six separate piles of bowlders were found in an area

supposed to be free from obstructions, with depths over them of 25½ to 41 feet. The charted depths in the vicinity were 48 to 66 feet.

In addition to the usual trouble with lobster traps, the work was interfered with by a large number of mackerel nets. These nets float on the surface and are anchored at the bottom, while the lobster traps rest on the bottom.

The usual practice was observed of marking out sections in shoal water for the operation of the drag and giving advance notice to fishermen of the dates when work would be done.

A larger launch than usual was used as an end launch with satisfactory results.

A few objects were located by triangulation for the control of the work.

A wireless practice set was established on the guiding launch by means of which weather reports, etc., were received daily from Boston. It is proposed to test this means of communication when a 24,000-foot drag is used later in the season.

[ISAAC WINSTON.]

SUMMARY OF RESULTS.—Triangulation: 22 square miles of area covered, 8 signal poles erected, 14 old triangulation stations recovered, 11 intersection points recovered, 3 new triangulation stations established, 14 stations occupied for horizontal measures, 23 geographic positions determined.

Between August 4 and October 22 a revision was made of the triangulation and topography in the vicinity of Salem, Mass.

Preparations for field work were made and several triangulation stations and tidal bench marks were recovered by August 13, when the work was temporarily suspended. Field operations were resumed on September 22 and continued until the work was completed on October 22.

The following old triangulation stations were recovered: Bakers Island Light, Bald Hill, Bolles, Coddon, Coney Island, Derby Wharf Light, F[1] U. S. E., Folly Hill, Fort Pickering Light, Great Haste, Great Misery, Hospital Point Light, Lee U. S. E., Leggs Hill, Marblehead, and North Gooseberry Rock.

The following objects, of which the positions were previously determined, were recovered: Abbott Hall (Marblehead), Abbott Rock, Stone Beacon, tall spire with turrets 1900 (Beverly), Bowditch Ledge Beacon, Great Aqua Vitæ, Halfway Rock, Hardy's Rock, Little Haste, Marblehead Black Top Church, Marblehead Rock Beacon, Marblehead standpipe.

The positions of 21 aids to navigation and prominent objects useful as landmarks were determined. A number of tidal bench marks were recovered.

Various town plans and maps were obtained and corrected where necessary to show present conditions, and these have been filed with a chart on which the positions of new wharves and the location of railway lines within the limits of chart 244 are shown. The water fronts of the towns were examined and changes were noted.

Information was obtained from the United States Engineer's office at Boston, the State Board of Harbor Commissioners at Boston, and the city engineers at Beverly, Manchester, and Salem.

MASSACHUSETTS AND NEW YORK.

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

SUMMARY OF RESULTS.—Triangulation: 35 square miles of area covered, 15 signal poles erected, 20 stations in main scheme occupied for horizontal measures, 60 geographic positions determined. Leveling: 3 miles of levels run, 5 permanent bench marks established. Hydrography: 107 square miles of area covered, 842.8 miles run while sounding, 9,310 angles measured, 39,232 soundings made, 4 tide stations established, 7 hydrographic sheets finished, scales 1:10,000 and 1:20,000.

During the six months ending December 31, 1914, the party on the steamer *Hydrographer* was engaged in a hydrographic resurvey of Long Island Sound between Execution Rocks and Norwalk Islands, including Oyster Bay, also a resurvey of a part of Pollock Rip Slue. Work was closed for the season on December 3 and the ship proceeded to Baltimore for repairs.

The hydrography in Long Island Sound consisted in running intermediate lines of soundings between lines in the old work, developing all doubtful areas, locating all aids to navigation not before located, and showing all improvements along the shore that could be determined from the sounding launch. The inshore areas along the north shore and in the vicinity of Oyster Bay were developed with the launch, and the area of the Sound proper was covered by the ship.

Signals were determined by sextant cuts observed at the different triangulation stations, and consisted of water tanks, flag poles, cupolas, chimneys, etc. Owing to the presence of so many natural objects no signals had to be built. The weather during July was unfavorable for rapid progress.

In the launch work there were discovered 18 rocky shoals, all of which were menaces to navigation and not hitherto known. In addition there were discovered and located numerous rocky patches with from 20 to 30 feet of water on them. All of the dangers located were immediately reported and were published in the Notices to Mariners.

The finding of so many shoals with the lead alone in areas already surveyed and used so extensively by shipping shows the prime necessity of dragging such areas.

Bench marks were established at Stamford, Conn., and at Oyster Bay, N. Y. At Stamford permission was obtained to put a bronze marker, in addition to others, in the Stamford Yacht Club building, which was in course of erection. At Oyster Bay two bronze markers were placed, one in the town hall and one in a bank building.

At Saugatuck the United States Army Engineers' bench marks were connected with the bench marks of the Survey by a line of levels, thus ascertaining the relation of the plane of reference used by the Engineers to that of the Coast and Geodetic Survey.

In Oyster Bay and Cold Spring Harbor the hydrography was executed, and in addition a tertiary scheme of triangulation was observed which will serve as a basis of a new topographic survey. All prominent objects were cut in and described.

In the vicinity of Throgs Neck a search was made for some reported shoal soundings, but they were not found.

In the middle of November work in Long Island Sound was suspended and the ship proceeded to Monomoy Point, Mass., to search for reported shoals in Pollock Rip Slue. It was found that nun buoy

No. 2 had shifted so far south-southwest as to leave unmarked a 16-foot spot in the fairway, and it was concluded that this was the shoal that had been struck. Hydrography was executed to cover the doubtful area. Upon the completion of this survey the ship returned to Oyster Bay and finished the work in that vicinity.

Assistance was rendered a motor boat with broken tail shaft belonging to J. S. Blackton, vice president of the Vitagraph Co. She was towed by the *Hydrographer* to Oyster Bay, where further help could be obtained.

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

[E. F. DICKINS.]

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

The duties of the inspector are to obtain information in regard to reported dangers for the correction of charts, Coast Pilots, and Notices to Mariners; to furnish information in regard to charts, Coast Pilots, tide tables, and other publications of the Survey; to supervise the construction and shipment of material needed for the repair or outfit of vessels and boats of the Survey; and to receive and forward instruments or material for the field parties and vessels.

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

In the latter part of June, 1915, arrangements were made for keeping for sale a stock of charts and publications of the Survey at the suboffice.

CONNECTICUT AND NEW YORK.

[J. T. WATKINS.]

In August a field revision was made and information collected from the offices of the United States Army Engineers and other sources for the correction of Coast Pilot, Part IV, Point Judith to New York. Visits were made for this purpose to New Haven, New London, and Albany.

On the return trip from Albany examinations of reported dangers were made and the positions of aids to navigation determined at the north end of Esopus Island, and a 9-foot rock was located in the channel of the Hudson River just above Iona Island. This work was completed August 31.

NEW YORK.

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

SUMMARY OF RESULTS.—Leveling: 3 miles of levels run. Hydrography: 13 square miles of area covered, 137.4 miles run while sounding, 1,616 angles measured, 5,320 soundings made, 2 tide stations established, 1 hydrographic sheet partly finished, scale 1:20,000.

On June 15, 1915, the party on the steamer *Hydrographer* began a hydrographic resurvey of the channels at the entrance to New York Harbor.

Tidal data for this survey were obtained from an automatic tide gauge maintained by the Corps of Engineers, United States Army, and from a tide staff established on the iron steamboat pier at Coney Island. This staff was connected by leveling with the Engineer's staff and bench mark on the old iron steamboat pier.

Sounding was begun June 17 in the vicinity of West Bank Lighthouse and continued whenever weather permitted through the remainder of the month.

The area surveyed up to the close of the fiscal year lies southward of Ambrose Channel, between the limits of the United States Army Engineer survey and Sandy Hook, and as far north as West Bank Lighthouse. The western limit includes the old main channel. Sounding lines were run 100 meters apart and soundings were taken frequently at a speed of 3½ to 4 knots. Strong variable currents in the vicinity of Sandy Hook made difficult the proper spacing of lines at this slow speed. Soundings were taken only in moderate weather and comparatively smooth water.

The positions of West Bank Lighthouse and North Beacon, Sandy Hook, were determined.

[H. C. DENSON.]

SUMMARY OF RESULTS.—Triangulation: Area in square miles, 85; signal poles erected, 12; observing tripod and scaffold built (height 15 feet), 1; stations occupied for horizontal measures, 13; geographic positions determined, 69. Topography: Area surveyed in square miles, 50; topographic sheets finished, 4, scales 1:10,000 and 1:20,000. Hydrography: Area sounded in square miles, 15; number of miles run while sounding, 242; number of positions determined, 1,347; number of soundings, 8,613; number of tidal stations occupied, 5.

The work of chart revision along the shores of Great South Bay and Fire Island Inlet, Long Island, was in progress July 1 and continued until October 31.

The triangulation was started from the line Nicoll-Island, previously determined, and extended eastward through five figures to Smiths Point, a distance of 16 miles. The geographic positions of all prominent objects, such as factory chimneys, windmills, standpipes, etc., of a permanent nature, were carefully determined, so that in the future topographic and hydrographic revision in this locality sufficient points should be available to readily carry on the work without additional triangulation. Many of these objects may be used in the work of offshore hydrography.

The topography of this section was found to have greatly changed since the last survey. Numerous improvements have been made along most of the shores of Great South Bay, additional beach resorts and summer colonies have been established, canals dug, and bulkheads erected, and the old settlements and villages have expanded considerably.

No marked change has occurred in the general shore line, except around the inlets. Point Democrat, westward of Fire Island Lighthouse, has extended about one-fourth mile farther westward than shown on the present chart; Oak Island Beach has receded approxi-

mately 300 feet; Gilgo Inlet has entirely closed; and changes have occurred at Jones Inlet.

The only changes in the hydrography of Great South Bay from that shown on the existing chart are in the vicinity of the inlets and where dredging has been done in the creeks and canals. A careful survey was made of Fire Island Inlet and the bar. The results of this survey show a channel with a depth of 9 feet over the bar at mean low water.

The channel has changed its course from that shown on existing charts and now runs along Oak Island Beach. It is buoyed and has been in use for two years. The bar and channel leading into Fire Island Inlet are subject to rapid changes, and are almost invariably affected by severe southerly gales. Lines of soundings were run from the mainland to the beach resorts, but no changes were noted from the information as now published.

Numerous piers of a temporary character are built in the bay from the beach resorts and remain during the summer months, but are taken up for the winter on account of ice. A depth of 4 feet at low water will be found at the end of these piers. All creeks and canals affording sufficient depths for motor boats were carefully sounded, but the depths at the mouths of these are constantly changing. A hydrographic reconnoissance of the entire bay was made, with the result that the depths found conformed to those that appear on the existing chart.

[P. C. WHITNEY, Commanding Steamer *Isis*.]

The steamer *Isis* was put in commission in the latter part of May, 1915, having been chartered by the Survey until the appropriation for her purchase should become available.

The vessel took part in the naval review at New York on May 17 and 18. On May 19 the *Isis* sailed from New York for Washington, arriving on the morning of May 21. From May 21 to June 6 the vessel was used for inspection trips down the Potomac River and in Chesapeake Bay.

On June 7 the ship was inspected by the local steamboat inspectors. During the remainder of the month the vessel was at the Washington Navy Yard outfitting, and the officers were engaged in drawing up plans and specifications for certain proposed changes to be made to the vessel after July 1.

[E. B. LATHAM.]

SUMMARY OF RESULTS.—Topography: 36 square miles of area surveyed, 107 miles of general shore line surveyed, 12.5 miles of roads surveyed, 3 topographic sheets finished, scale 1:10,000. Hydrography: 20 square miles of area covered, 961.4 miles run while sounding, 7,576 angles measured, 41,190 soundings made, 3 tide stations established, 4 current stations occupied, 3 hydrographic sheets finished, scale 1:10,000.

The topographic and hydrographic survey of Jamaica Bay, N. Y., begun in May, 1914, was in progress at the beginning of the fiscal year. The plane-table work was completed on September 4.

The shore line was transferred to projections furnished by the office from old topographic sheets, and from a blue print of a drawing compiled by the department of docks and ferries of the city of

New York from surveys by the Coast and Geodetic Survey and other sources. These sheets were then taken into the field, and where the shore line had changed and along the main channels and shore the shore line was rerun to a junction with the transferred shore line. All changes were noted and joined in correct position with the old work. Numerous stacks, chimneys, spires, and other objects were determined as a control for the hydrography and topography and to afford objects from which the position of aids to navigation may be determined.

The hydrographic work was begun on September 10 and continued until December 12. From December 12 to December 22 additional topographic work was done of connecting the street plans with the objects determined with the plane table. Exceptionally good weather conditions prevailed in September and October and a part of November. In October soundings were made on 21 days, 412 miles of sounding line were run, and 17,512 soundings were made.

Positions of aids to navigation for channels into Sheepshead Bay and Jamaica Bay were furnished for use on the charts.

NEW JERSEY.

[R. P. STROUGH.]

SUMMARY OF RESULTS.—Leveling: 29.4 miles of levels run, 10 permanent bench marks established.

In October and November a line of precise levels was run between Perth Amboy and Sandy Hook, N. J., connecting bench mark "R" at Keyport, the State Geological Survey bench mark at Perth Amboy, and bench mark "C" on Sandy Hook. This work was done in accordance with the general instructions for precise leveling, the line being run in both directions and all sections checked within the required limit. The line was carried along the railroad track, using the rail for the rod supports. Transportation for the party was by an electric car line.

Besides the 3 bench marks recovered from the old work, 10 new permanent bench marks were established in the 29 miles of line. Connection was also made at Sandy Hook with two of the United States Army bench marks, one known as the ordnance bench mark, which is in front of the proving ground office, and the other known as the Engineers' bench mark, at the northeast corner of the Engineers' building. The latter was also connected directly with the tide staff at Sandy Hook.

NEW JERSEY, DELAWARE, MARYLAND, AND VIRGINIA.

[L. A. POTTER.]

Field revision of Coast Pilot, Section C, including the coast from Sandy Hook, N. J., to Cape Henry, Va., which had been temporarily suspended June 23, was resumed on July 9. Between this date and August 27 an examination was made of the navigable tributaries of Chesapeake Bay from Norfolk to the head of the bay on the western shore, and from Miles River to the head on the eastern shore. The

tributaries were visited by regular steamer lines wherever possible, otherwise by hired launches operated by pilots familiar with the locality.

On September 7 an examination was begun of the interior channels and inlets on the coast of New Jersey from Cape May to Sandy Hook. This work was done in hired launches, operated by local pilots, and was completed on September 18. An examination of Delaware Bay and River was then begun. Much of the information concerning the smaller tributaries of Delaware Bay was obtained by interviews with boat owners and captains, the tributaries being visited by means of regular steamers where necessary. This section of the work was completed on October 2.

NEW JERSEY.

[STEHMAN FORNEY.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme, 12 miles; 26 square miles of area covered, 92 lines of intervisibility determined, 66 points selected for scheme. Triangulation (tertiary): 20 square miles of area covered, 90 signal poles erected, 63 stations in main scheme occupied for horizontal measures, 93 stations in supplemental schemes occupied for horizontal measures, 145 geographic positions determined. Topography: 19 square miles of area surveyed, 97 miles of shore line of rivers and creeks surveyed, 50 miles of roads and railroads surveyed, 5 topographic sheets finished, scale 1:5,000. Hydrography: 4½ square miles of area covered, 13 miles run while sounding, 158 angles measured, 918 soundings made, 1 tide station established, 2 hydrographic sheets finished, scale 1:5,000.

From July 1 to September 14 work was continued on the topographic survey of the Passaic River. This work was executed on a scale of 1:5,000, and includes much detail in the vicinity of the city of Passaic, such as wharves, docks, bridges, and trolley and steam railroads. Surveys by city and county engineers were utilized for lines of streets, etc.

On September 15 work was begun on the survey of the Hackensack River, and was completed by April 30. It was found necessary to erect observing tripods for the triangulation, in many places from 9 to 14 feet in height, to see over the high meadow grass. A portable observing scaffold 9 feet in height designed and built by the party was successfully used.

The tertiary triangulation of the river was extended to Anderson Street Bridge in Hackensack and was completed January 4. It was connected with a base line measured on the Anderson Street Bridge by the United States Army Engineers, the computed length of the base as determined by the Coast and Geodetic Survey triangulation agreeing satisfactorily with the measured length. In the early part of the fiscal year the triangulation had been connected with a base line measured by the United States Army Engineers at Little Ferry Bridge.

The topographic survey was also extended to Anderson Street Bridge, and was completed April 22. This work covers three plane-table sheets, scale 1:5,000, and includes the Hackensack River from triangulation station Public to Anderson Street Bridge. The detailed topography was carried into the interior one-half mile from the shores of the river.

The shores of the river from its mouth to the town of Hackensack are bordered by low meadow land, interspersed with small, crooked creeks, except at Snake Hill, which is an isolated hill of trap rock rising abruptly out of the lowland to an elevation of 208 feet above mean high water. Little Snake Hill to the eastward is also an isolated hill rising abruptly out of the meadow and has an elevation of 80 feet above mean high water. New Canal cut into Berrys Creek, on the west shore of the Hackensack, was excavated by the Erie Railway Co. This canal shortens the distance between the river and Rutherford, N. J., and is the only route with 12 feet draft at mean low water to Rutherford. The canal is navigable for light-draft motor boats to Carlstadt, N. J.

Local maps furnished by the municipal engineers were used where practicable for details of streets, buildings, and in some places for contours in the towns and villages.

A rapid reconnoissance was made of the river above Anderson Street Bridge. For about 2 miles above the bridge both shores are low and marshy; from there upward the banks become steeper and the river is contracted until at New Milford it is but 25 meters wide.

The hydrography of the Hackensack from Sawmill Creek to triangulation station Brick was surveyed between March 23 and April 16. This portion of the river had not been sounded or dredged by the United States Engineers, as the depth is 12 feet or more. There are strong tidal currents in the river. Numerous creeks emptying into Hackensack River are navigable for small boats.

The Army Engineers are maintaining a dredged channel 150 feet wide and 12 feet deep at mean low water from the mouth of the river to the Court Street Bridge at Hackensack.

Tides were observed at Patterson Plank Road Bridge during the progress of the hydrographic work.

On May 1 the party proceeded to Perth Amboy, N. J., and began a resurvey of Arthur Kill. Observation of horizontal angles was begun May 25. A scheme of triangulation was developed, based on stations of existing triangulation by the Federal and State authorities, and connected with the triangulation of the Coast and Geodetic Survey.

Observations for the triangulation of Arthur Kill were completed June 21.

[E. B. LATHAM.]

The determination of points and erection of signals for use in offshore hydrography on the coast of New Jersey was begun June 19. On June 29 the work was completed between Barnegat Inlet and Belmar.

All prominent objects along shore or visible therefrom were determined in position, and poles 16 feet in height with flags on them were placed and determined about 1 mile apart. Two or three smaller poles were placed between the higher flagpoles. The most northern and southern houses in each town, also all isolated houses or those of characteristic outline, were determined and described.

Only where the topographic features could be obtained without delaying the determination of objects for use in the hydrography was any attempt made to fill in the topography. The main road, a well paved State highway, and the new bridge across Barnegat Bay

were determined. A portion of the shore line in the vicinity of Barnegat Inlet was rerun, as the position of the inlet has materially changed from previous determinations.

Signals were erected by June 30 south from Beach Haven to Barnegat Inlet, and signal material and transportation were arranged for to continue the work during the next fiscal year.

Azimuth and distance were carried by plane-table and stadia readings for a distance of 23 miles and all prominent objects were located.

[J. B. BOUTELLE, Commanding Steamer *Endeavor*.]

SUMMARY OF RESULTS.—Triangulation: 224 square miles of area covered, 10 signal poles erected, 8 stations occupied for horizontal measures, 10 geographic positions determined. Hydrography: 79 square miles of area covered, 1,325 miles run while sounding, 8,230 angles measured, 43,000 soundings, 3 tide stations established, 2 hydrographic sheets finished.

Between June 11, 1914, and October 2, 1914, the party on the steamer *Endeavor* was engaged in hydrographic surveys at the entrance to Delaware Bay.

A signal, Fly, was established on the eastern shore of Delaware Bay, about 3 miles north of Cape May, and from this and the various lighthouses, which were old stations, a number of objects in Cape May and the new lighthouses at Brandywine Shoal and Deadman Shoal were determined. At Cape May a number of objects previously determined approximately were reobserved and determined, and also the large pavilion at Cold Spring Harbor.

The hydrography was extended from the shore line at Cape May, from a point about opposite the large Cape May Hotel, southward to beyond the 6-fathom curve on the edge of the main ship channel and northward up Delaware Bay to Deadman Shoal and vicinity. Enough of the south and west sides of Crow Shoal were included to join the new 3-fathom curve with the old. That part of Crow Shoal north and east of the 1914 work was crossed at numerous places while under way with the ship running on course and time sounding, but no indications of changes were found in this area. Very extensive changes were found in the shoals and channels south and west of Cape May. The old shoals have changed in position and extent and new channels have been formed. These changes were all followed out and developed. Deadman Shoal was found to have cut away somewhat at the northwest end and extended slightly on the east side. More extensive changes were found on the shoals southwest of Deadman Shoal and these were followed out and developed. The work was closed October 2.

PENNSYLVANIA.

[E. B. LATHAM.]

In April a revision was made of the surveys of the water fronts of the city of Philadelphia with a view to obtaining information for the correction of charts of the Delaware and Schuylkill Rivers.

The triangulation of the Delaware River in front of Philadelphia by the United States Engineers was in progress, and arrangements were made to have the results of this work furnished to the Coast

and Geodetic Survey office when completed. Results of the trangulation of the Schuylkill River were obtained from the authorities of the city of Philadelphia.

Information necessary for the correction of the charts, changes in the location of wharves, piers, etc., were indicated on photographic prints furnished for the purpose. Notes were also collected for use in the preparation of Coast Pilot volumes.

VIRGINIA AND NORTH CAROLINA.

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

SUMMARY OF RESULTS.—Triangulation: 98.5 square miles of area covered, 66 small signal poles erected (for hydrography), 32 large signals erected (average height about 37 feet), 8 stations in main scheme occupied for horizontal measures, 5 stations in supplemental schemes occupied for horizontal measures, 49 geographic positions determined. Leveling: 3.2 miles of levels run, 17 permanent bench marks established. Topography: 19 square miles of area surveyed, 133.2 miles of general coast line surveyed, 51.8 miles of shore line of creeks surveyed, 44.3 miles of roads surveyed, 3 topographic sheets finished, scales 1: 20,000 and 1: 40,000. Hydrography: 267.5 square miles of area covered, 2,036.1 miles run while soundings, 9,601 angles measured, 79,271 soundings made, 6 tide stations established, 4 hydrographic sheets finished, scale 1: 20,000.

The resurvey of the east shore of Chesapeake Bay and its tributaries in the vicinity of Cape Charles, Va., by the party on the schooner *Matchless* was in progress at the beginning of the fiscal year.

The hydrography of the creeks and the close development of all shoal areas, bars, and channels from the shore to a depth of 6 or 7 fathoms were continued until November 30, when the vessel sailed for Baltimore.

The hydrography covered all of the creeks and the bay for a distance of 2 to 5 miles from shore. Special development was made of creek bars and channels.

A special examination was made for a shoal spot with 17 feet of water reported in latitude 37° 37′ 12″ and longitude 76° 01′, but no depth less than 26 feet was found. The mean low-water plane for this work was determined by simultaneous tidal observations at Cedar View Wharf, Nandua Creek, and Onancock, on Onancock Creek.

The shore line of Nassawaddox Creek was surveyed, and 48 miles of telemeter line were run to locate hydrographic signals on this creek and on the main shore of the bay.

The triangulation for control of the hydrographic and topographic work was completed, and the triangulation stations were permanently marked.

A hydrographic survey was made of Nassawaddox, Occahannock, Craddock, Nandua, Butchers, Pungoteague, and Onancock Creeks, and the hydrography remaining to be done in the area from Nassawaddox to Pungoteague Creek and from Pungoteague to near Chesconessex Creek was completed by November 30.

From January 1 to February 28 the schooner *Matchless* was undergoing repairs at Baltimore, outfitting, and en route to the working ground in Albemarle Sound, N. C.

During the period from March 1 to May 13 the party was engaged on the triangulation, topography, and hydrography of the west end of Albemarle Sound from Bluff Point to Edenhouse Point, including an area about 14 miles long by 11 miles wide.

Triangulation stations, Cypress and Pan, of 1909, were recovered and occupied, and two new stations, Skinner and Capehart, were established and occupied. Observations were made on a sufficient number of points to serve for the control of the hydrographic and topographic work.

The topography of the shores was done on a scale of 1:40,000. Large areas were added to the topography south of Salmon Creek and about Scotch Hall. The topography of Pembroke Creek was well developed to Bolton Bridge, 2 miles above the United States fish hatchery. Large areas were added to the topography around Edenton and in its approaches.

All of the area mentioned was covered by sounding lines about 700 meters apart north and south and 900 meters east and west.

The channels leading to Edenton, the mouth of Roanoke River, and all bars were developed by lines of soundings from 100 to 300 meters apart as required. Particular attention was paid to the 6-foot and 12-foot contours.

The hydrography of Pembroke Creek was carried 4 miles above the United States fish hatchery, or 5 miles from Edenton. Tidal information for the reduction was obtained from an automatic tide gauge maintained by the United States Engineers at the Pembroke fish hatchery and from gauges at Edenton and Laurel Point Lighthouse. Simultaneous readings were made at Edenton and Laurel Point Lighthouse and between the Edenton gauge and the Pembroke gauge. The tide gauges were connected by leveling with permanent bench marks.

The work in the western end of Albemarle Sound was completed on May 14 and the *Matchless* took up the survey of Croatan Sound, including topography and hydrography. Sufficient old triangulation stations were recovered to control the topography and hydrography, and such additional signals as needed were cut in from known points.

The topography of all of the shore of Croatan Sound was excuted on a scale of 1:40,000, all prominent objects on or near the shore line being located. Sounding lines were run north and south one-fourth mile apart, and channels and bars were developed by lines from 100 to 200 meters apart with cross lines about 400 meters apart.

Tides were recorded on a gauge established at Burnside Wharf, on the west side of Roanoke Island.

NORTH CAROLINA.

[P. C. WHITNEY, Commanding Steamer *Hydrographer*.]

SUMMARY OF RESULTS.—Triangulation: 40 square miles of area covered, 12 signal poles erected, 10 observing tripods and scaffolds built, heights 20 to 55 feet, 14 stations in main scheme occupied for horizontal measures, 20 stations occupied for vertical measures. Magnetic work: 1 sea station occupied for magnetic declination. Topography: 15 square miles of area surveyed, 45 miles of general coast line surveyed, 5 miles of rivers surveyed, 2 topographic sheets partly finished, scale 1:40,000. Hydrography: 300 square miles of area cov-

ered, 857 miles run while sounding, 2,900 angles measured, 24,817 soundings made. 2 tide stations established, 1 hydrographic sheet finished and 1 partly finished, scales 1:20,000 and 1:30,000.

At the beginning of January the *Hydrographer* was undergoing repairs at Baltimore, Md., and the officers of the vessel were engaged in the completion of the records of the previous season's work.

On January 16 the ship left Baltimore to take up a resurvey of Albemarle Sound, N. C., going by way of the Chesapeake and Albemarle Canal.

Headquarters were established at Hertford, about 11 miles up the Perquimans River, where coal and provisions could be obtained. There being no regular means of water supply, a pipe line was run from a private water tank to a near-by wharf. Coal for the vessel was delivered at the same wharf.

The work was done in cooperation with the party on the schooner *Matchless*, the *Hydrographer* doing as much as possible of the work in the more exposed localities and the sheltered portions being left for the *Matchless*.

The triangulation was extended from the line Batts 2–Laurel Point Lighthouse of the work of 1909 to the mouth of Perquimans River and well up toward Hertford. Considerable difficulty was experienced in joining the river triangulation with the long lines in the sound, and to accomplish this it was found necessary to erect a signal in 20 feet of water in the sound.

All shore stations established were securely marked with standard station marks set in concrete and reference marks were placed at each station.

The topography on the north shore of the sound covered the shore from Bluff Point to Harvey Point, except Yeopin River; 5 miles eastward from Canaan Cove, Perquimans River; and eastward from the mouth of Little River to Wade Point, including the greater part of Flatty Creek. On the south side of the sound the topography included the shore line from 2 miles east of the Scuppernong River to Long Shoal Point, Alligator River. The shore line was difficult to survey, consisting largely of wooded marsh. On the north shore it was necessary to run plane-table traverse lines connecting the triangulation points to control the topography. At places dead stumps extend out to quite a distance from the shore line, making navigation for small boats dangerous. There are few objects of importance to the navigator along these shores and no settlements except a few fish houses and wharves.

The hydrography, which was the principal work done, covers nearly all the water areas of the main body of the sound from Bluff Point to Powells Point. The inshore and sheltered portion of the work was left to be done by the party on the schooner *Matchless*. The distances being great, it was necessary to erect tall hydrographic signals. One of these, at station Wade, was observed on at a distance of 12 nautical miles. This signal was constructed in one working day, which includes the work of cutting trees, etc. The highest part is 55 feet above the water and the lowest part of the visible section is 36 feet.

Tide gauges were established and tidal planes determined at Laurel Point Lighthouse and Wade Point Lighthouse.

Field work in Albemarle Sound was discontinued April 20 and the vessel proceeded to Baltimore.

[E. H. PAGENHART.]

SUMMARY OF RESULTS.—Triangulation (tertiary): 130 square miles of area covered, 24 signal poles erected, 10 stations in main scheme occupied for horizontal measures, 17 stations in supplementary schemes occupied for horizontal measures, 46 geographic positions determined.

Work was begun May 14 on the determination of geographic positions of aids to navigation in Core and Bogue Sounds, N. C. This work was undertaken at the request of the Bureau of Lighthouses.

A launch and a house boat were chartered at Beaufort for the use of the party, and actual field work began on May 18. Twenty-five old triangulation stations were recovered and occupied and two new ones established and occupied by June 10, when the field work was completed. When this work was undertaken all of the lights necessary for the navigation of Core and Bogue Sounds were in place, the structures were of substantial concrete construction, and no changes in the lighting were contemplated, so that with the lights determined in position and plotted on the charts and the triangulation stations permanently marked and described, any future changes deemed necessary in the aids to navigation may readily be made by the officers of the Lighthouse Service.

At most of the stations the work consisted in observing a round of horizontal directions (direct and reverse) on the stations, lights, and natural objects. Where no suitable natural objects for aids to navigation were visible, marks were placed in trees close to the station and located by tape or intersection. These marks were usually made of eight wooden strips, 2 by 4 inches and 4 feet long, painted white and spiked to large and prominent trees. They will serve as points for hydrography, topography, and triangulation. A special effort was made to locate all church spires, club houses, and other prominent objects. At each station occupied all objects visible which are suitable for the purposes sought were observed upon. Many reference points were occupied and a round of observations taken on all prominent objects, including the station. Many of the lights were occupied with a sextant to furnish directions to objects which could not well be determined from the shore stations alone.

SOUTH CAROLINA.

[ISAAC WINSTON.]

On July 1 the construction of seven large hydrographic signals on the coast of South Carolina for the use of the party on the steamer *Bache* was in progress. A hired motor boat was used for the transportation of the party. Lumber for the signals in most instances had to be towed a long distance to the nearest point on the beach to the locality where it was to be used and then carried by hand to the desired location.

Tripods 35 feet in height, strongly braced and anchored in the sand, were erected. A 4 by 4 inch pole was extended above the tripod, to which the upper portion of the target was fastened, and galvanized wire guys were attached as an additional safeguard.

Targets 10 by 12 feet in size were placed on the signals, with the bottom of the target 40 to 50 feet above sea level. It was afterwards found necessary to board up the signals on the ocean side to make them show more distinctly against the background of the woods.

Observations on known positions were made from the signals wherever visible, and from Cape Romain and Georgetown Lighthouses on such signals as could be seen from them. This work was completed July 13.

SOUTH CAROLINA, GEORGIA, AND FLORIDA.

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

SUMMARY OF RESULTS.—Triangulation: 65 square miles of area covered, 10 stations occupied for horizontal measures, 5 geographic positions determined. Magnetic work: 1 shore station occupied, 3 sea stations occupied. Hydrography: 10,572 square miles of area covered, 54 stations occupied by ship for location of signals, 988 angles measured (sextant cuts to locate signals), 19 shore objects located by ship angles, 73 offshore buoys and objects located by ship angles, 6,470 angles measured (to determine position while sounding), 8,267 miles run while sounding, 105,017 soundings made, 468 current stations occupied, 1,778 current observations taken, 4 tide stations established.

The hydrographic surveys by the party on the steamer *Bache* on the coast of South Carolina between Bull Bay and Georgetown Jetties were in progress at the beginning of the fiscal year. The command of the vessel was transferred to the present commanding officer July 6. By that date tide stations had been established at Georgetown and Cape Romain, S. C., two triangulation stations had been occupied to locate shore signals and buoys, and arrangements had been made to borrow buoys for the survey from the Lighthouse Service. High shore signals had been built along the coast from Charleston to Georgetown by another party. The work after July 6 was to locate these signals by triangulation and sextant angles, to place the buoys to be used in the survey, and to sound over the area between Charleston and the Georgetown Jetties, extending from the 3-fathom curve out to the 100-fathom curve. This work was completed by October 23, and the *Bache* proceeded to Norfolk for repairs.

The shore signals erected prior to July 6 at various points along the coast were named as follows: Dewees, Price, Bull, Raccoon, Santee, South, and North. Station Bull was the site of an old lighthouse which had been previously located by triangulation, and cuts had been taken on stations Santee and South from Romain and Georgetown Lighthouses. As it was the intention to locate the remainder of these stations subsequently by triangulation, it was deemed sufficient for immediate use to locate them by sextant cuts from the ship at anchor offshore, although additional triangulation cuts were obtained on a few of them.

Inasmuch as the coast in this vicinity is very flat, without hills or even high sand dunes, it was impossible to get locations for the hydrography from shore signals more than about 9 miles from shore, and as the 10-fathom curve runs parallel to the coast and about 15 miles offshore it was impossible to get locations from shore objects for several miles inside the 10-fathom curve. Since it was deemed of prime importance to make a careful development out to and be-

yond the 10-fathom curve, and it was not considered sufficiently accurate to attempt to develop this outer area by dead reckoning, it was decided to use buoys dropped in a line parallel to the shore at frequent intervals as far offshore as they could be accurately located. Six first-class bell and whistle buoys were loaned by the lighthouse inspector at Charleston for this purpose; and in order to make them visible for as great a distance as possible, wooden superstructures carrying a flagpole and a flag were designed for them. The buoys were placed by a lighthouse tender as nearly as possible in the desired location and about 4 miles apart, and they were then located by sextant cuts from the *Bache* anchored at the greatest distance from shore at which it was possible to see shore objects. Sextant angles to locate the ship and to cut in the buoys were taken very carefully with the ship at anchor, and good locations of the buoys were thus obtained. As the work covered a greater stretch of the coast than could be covered by the six buoys at one time they were shifted by the lighthouse tender from time to time as required.

The inshore hydrography covers the area between Charleston and Georgetown Jetties, and extends from a depth of between 2 and 3 fathoms inshore to a line of signal buoys placed about 14 miles offshore. All of this work was located by positions either on shore objects or on the signal buoys. The hand lead was used in depths less than 14 fathoms, and the trolley sounding apparatus in greater depths. Lines were spaced slightly less than 1 mile apart and run normal to the coast; but a close development was given to an area of about 30 square miles in the vicinity of Charleston Jetty, and a slightly larger area off Georgetown Jetties. Special care was given to developing areas where shoal or uneven depths were found, and about 36 such spots were closely developed. The total area covered by these developments was approximately 76 square miles. Soundings in all the inshore work were taken from 50 to 150 meters apart, depending upon the depth of water.

At the request of the lighthouse inspector at Charleston, S. C., the position of the wreck of the schooner *Frederick W. Day* off Charleston Light Vessel and the least water over it were determined and published in the Notice to Mariners.

The offshore hydrography covers an area bounded on the inshore side by a line of buoys about 14 miles offshore, and extends seaward to outside the 100-fathom curve. The lines were run in a northwest and southeast direction, and in all an area of about 1,800 square miles was covered. All of this work was done by dead reckoning, and lines were spaced 4 miles apart. All patent logs used in the work were carefully standardized, and the ship was swung three times for compass deviation. On the dead-reckoning lines the ship was anchored every two hours for current observations, and the resultant of the two observations made at start and finish of the two-hour run was used to correct the course steered. At the 100-fathom curve current observations were taken from an anchored buoy by means of a current pole and line from a small boat. Astronomic observations on the sun and stars were taken when possible on these lines. Up to 15 fathoms the soundings were taken with the hand lead. At greater depths a trolley sounding apparatus was used with a special device for reeling in the line by steam.

In addition to the current observations before mentioned, currents were observed every half hour day and night whenever the ship was at anchor on the working ground and the sea was not too rough. An anemometer was installed on the ship and the velocity of the wind taken at the same time with the current observations.

An automatic tide gauge was maintained during the work at the Georgetown Jetty, and continuous staff readings were made day and night at Cape Romain, near the lighthouse, to facilitate the reduction of soundings.

On January 1, 1915, the *Bache* was at Norfolk, Va., undergoing extensive repairs. These being completed, the vessel sailed for the working ground on February 19 to make hydrographic surveys off the coasts of Georgia and Florida. For this work a separate party had been engaged in building tall signals along the coast and determining their positions. The work of the *Bache* after February 19 consisted in adapting, placing, and determining the position of survey buoys; magnetic observations in Chesapeake Bay and on the working grounds; and sounding over the area between St. Simons Lighthouse, near Brunswick, Ga., and a point about 5 miles south of the jetties at the entrance to St. Johns River, Fla., and extending from the 3-fathom curve out to the 100-fathom curve. This work was completed by June 20, when the vessel sailed from Fernandina, Fla., for Baltimore, Md., for overhauling and repairs.

In February, 1915, six shore signals had been erected by Mr. J. S. Bilby on the coasts of Georgia and Florida for the use of this party, five of them being new stations and one an old triangulation station. A number of other points, such as lighthouses, water tanks, and windmills which had previously been determined in position, were used by the vessel in the location of soundings. These signals proved more satisfactory than any previously used in similar work, being tall enough to show over the tops of any trees either near the coast or farther inland, so that they were plainly visible in the morning when the sun was shining on their front surfaces and in the afternoon when the sun was back of them.

At the request of the lighthouse inspector at Charleston, S. C., the new St. Andrews Sound Lighthouse and two channel beacons in St. Andrews Sound were located by triangulation, two stations being occupied for that purpose.

In the work off the coasts of Georgia and Florida the same system of offshore signals was used as in the previous work off the coast of South Carolina. Six first-class bell and whistle buoys were loaned by the inspector of lighthouses at Charleston, and superstructures were installed on them to make them visible to as great a distance as possible. The superstructures were of the same design as those used in the previous work; but extra heavy 1-inch pipe was substituted for the three-fourth-inch pipe used in their construction, and plain black flags were used instead of the international code flags previously used, and this change increased the visibility of the signals considerably. Experiments were made to determine the proper distance apart these buoys should be spaced, and it was found that 4 miles was the most economical spacing consistent with the accurate location of sounding lines.

The buoys were dropped by a lighthouse tender as close as possible to the desired location. They were then located by sextant cuts from

the steamer anchored at frequent intervals at the greatest distance offshore from which shore objects could be seen. Sextant cuts to locate the ship and cut in buoys were taken very carefully with the ship at anchor, and angles all around the horizon were taken to close the circle as in triangulation as far as possible; very good locations of the buoys were thus obtained. The buoys were shifted from time to time by the lighthouse tender as required.

The inshore hydrography extends from St. Simons Lighthouse to 5 miles south of the jetties at the entrance to the St. Johns River, Fla., and from the 3-fathom curve inshore to about 2 miles outside a line of survey buoys placed about 13 miles offshore; a few lines and some development work were done outside of this in clear weather when the buoys showed plainly. All of this work was located by sextant positions either on shore objects or on the signal buoys. All soundings were taken from the ship with the hand lead. Lines were spaced usually slightly less than 1 mile apart and run normal to the shore line. Off the entrances to Fernandina, Brunswick, and the St. Johns River, over an area in each case of about 40 square miles, lines were spaced not over one-half mile apart. Special care was taken to develop areas where shoals or uneven depths were found, and about 30 such areas were closely investigated. Soundings were taken from 50 to 150 meters apart.

At the request of the lighthouse inspector at Charleston, a small amount of launch work was done between the jetties at Fernandina, Fla. On the way south the shoalest water on the wreck of the schooner *Frederick W. Day*, off Charleston Light Vessel, was determined.

The offshore hydrography covers an area bounded on the inshore side by a line of buoys about 13 miles offshore and extending offshore to outside the 100-fathom curve. The lines were run in an east and west direction, the most northerly line beginning about 8 miles north of buoy A, due eastward of St. Simons Lighthouse, Ga. The most southerly line began at buoy M, due east of the Continental Hotel and 5 miles south of the jetties at the entrance to St. Johns River, Fla. All of this work was done by dead reckoning, lines being spaced 1 mile apart to just outside the 10-fathom curve, 2 miles apart out to the end of the inshore hydrographic sheet, and 4 miles apart out to the 100-fathom curve, except that from the northern end of the work to Brunswick Light Vessel lines were spaced not more than 1 mile apart out to the end of the inshore hydrographic sheet on account of the very uneven character of the bottom. Each line started from a fixed position near the inshore end of the line of survey buoys and extended out to the 100-fathom curve and back to connect with a location from the buoys again. Great care was exercised in the dead-reckoning work to make it as accurate as possible. Patent logs used were carefully standardized. The ship was swung four times for compass deviation. Current observations were taken from the ship at anchor at frequent intervals and the results used to correct the courses steered. Astronomical observations were taken on the sun and stars when practicable. Sea-water temperatures were taken at frequent intervals on all dead-reckoning lines. Mean velocities of the wind were obtained for each two-hour section of the line to determine leeway for different wind velocities. Soundings were taken with the hand lead up to 15 fathoms and with a trolley apparatus,

with a special device for reeling in the line by steam, at greater depths. Soundings were taken at intervals of from one to five minutes, the vessel running at a speed of 4 to 4½ knots until a depth was reached where a vertical sounding could not be obtained. This usually occurred at 30 to 40 fathoms. It was then found expedient to run full speed for three minutes and stop the engine for two minutes, the sounding being then taken. The soundings on the line were spaced from 150 meters apart in shoal water to 2 miles apart in deep water.

Current observations were taken every half hour, day and night, when the ship was at anchor, and anemometer readings were taken at the same time to determine wind velocities. On a few of the lines the 100-fathom curve came in the Gulf Stream and a current velocity of nearly 3 knots was encountered.

Tidal records were obtained from automatic tide gauges at Fernandina and St. Augustine, Fla., and from a tide staff on St. Simons Island.

FLORIDA.

[H. C. DENSON.]

SUMMARY OF RESULTS.—Triangulation: Area in square miles, 37; signal poles erected, 25; observing tripods and scaffolds built, 1, height 20 feet; stations occupied for horizontal measures, 14; geographic positions determined, 31.

At the request of the United States Bureau of Fisheries a scheme of triangulation was extended from Apalachicola Bay through St. Vincent Sound, Fla., in order to furnish points for a survey of the oyster beds existing in the latter body of water.

This triangulation was started from the line St. Vincent Point 2–St. George Lighthouse and extended through seven figures to the head of St. Vincent Sound, a distance of 20 miles, where a connection was made with the station Ragged Point, determined in 1860.

Between the main scheme triangulation stations and on points affording the most desirable conditions concrete blocks 8 by 8 inches by 3½ feet were placed in the ground, leaving about 6 inches above the surface; these were appropriately marked and their positions carefully determined. These intersection stations, together with the main scheme stations, afford a sufficient number of points for the hydrographic survey of the entire sound.

In the selection of sites and marking of stations care was taken to guarantee their permanency. The main scheme stations were marked by a subsurface mark buried in concrete 3 feet below the surface. The surface marks consist of a regulation standard disk station mark inserted in a concrete block 8 by 8 inches by 3 feet placed in the ground, leaving about 4 inches above the surface.

The reference marks used were concrete piers about 10 inches square and of varying lengths, placed sufficiently well in the ground to insure their stability; standard reference disks were inserted in these piers. At the station sites where tall marsh grass exists the piers were built of such heights that they top the grass about 1 foot.

The field work was begun November 18 and completed December 23. It was much retarded by fogs and gales and on account of the necessity of waiting for favorable stages of the tide in order to visit some localities where stations necessarily had to be placed.

On December 24 data sufficient for immediate needs were prepared and transmitted to the Bureau of Fisheries steamer *Fish Hawk*, which had arrived in Apalachicola Bay.

In accordance with the Superintendent's instructions dated December 14, 1914, the automatic tide gauge at Cedar Keys, Fla., was overhauled and put in order.

FLORIDA, ALABAMA, MISSISSIPPI, LOUISIANA, AND TEXAS.

[A. J. Ela.]

In the winter of 1915 the more important harbors and ports on the Gulf Coast were visited, and the inland water routes from Galveston to Corpus Christi and parts of the inland waterway system of Louisiana west of the Mississippi were inspected, using the regular passenger steamers or chartered launches operated by local pilots, in order to collect information for a revision of United States Coast Pilot, Part VIII, Gulf Coast of the United States.

The offices of the United States Enginer Corps, the officials of the Lighthouse Service, local pilots and pilots' associations, and others interested in navigation and shipping were interviewed.

In connection with this work information was obtained for plotting on charts various landmarks and other aids to navigation existing along the portions of the coast visited.

Apparatus for current observations was installed on two light vessels, at Southwest Pass and Heald Bank, and later an inspection was made of the apparatus and the method of making these observations. Facilities for this work were afforded by the lighthouse inspector of the eighth district.

Changes and repairs to the tide station at Galveston were made, a new bench mark was established, and levels were run between the tide gauge and the old and new bench marks.

Various Government officials were consulted as to the unit of soundings desirable on charts of the 1:80,000 scale.

GEORGIA AND FLORIDA.

[J. S. Bilby.]

Summary of results.—Triangulation: 54 signal poles erected for traverse and triangulation, 12 hydrographic signals erected, average height 75 feet, 52 stations in main scheme occupied for horizontal measures.

In January instructions were issued for the erection of hydrographic signals on the coast of Georgia and Florida for the use of the party on the Coast and Geodetic Survey steamer *Bache* engaged in offshore hydrographic surveys between St. Simons Island, Ga., and Matanzas Inlet, Fla.

After selecting sites for the signals on Jekyl and Cumberland Islands and making arrangements for the transportation of material, field work was begun on Jekyl Island on January 13. The first signal was built on Jekyl Island and its position was determined. The work was then continued southward, signals were built, and their positions determined as far as Matanzas Inlet, Fla.

In all, 12 hydrographic signals were built ranging in height from 68 to 86 feet, the average height being 75 feet above the station mark. The position of each signal was determined by triangulation or traverse, and a permanent mark was placed at each signal. During the progress of the work the building of signals and location of points were carried along together. Photographs and descriptions of the signals were transmitted to the office at Washington.

All necessary signals were built and their positions determined by March 27 and work was closed on March 30.

These signals are an innovation and decided advancement in this class of hydrographic work, enabling accurate development to be carried much farther seaward than otherwise possible in a region without natural elevations. The design and construction of the signals were by the builder, and the method of having an inexpensive shore party to erect them greatly facilitated the prosecution of the work by the *Bache*.

FLORIDA.

[N. H. HECK.]

SUMMARY OF RESULTS.—Leveling: 3.5 miles of levels run. Hydrography: 10.8 square miles of area dragged, 47 miles run while dragging, 2,813 angles measured, 238 soundings made, 1 tide station established, 1 hydrographic sheet finished, scale 1:20,000.

Wire-drag work was begun at Key West, Fla., on January 6. The work to be done included an examination of the west channel from the limits of previous work south of Man Key for a distance of 10 miles to a point south of the eastern side of Marquesas Keys, with a width of 1 mile; also such small areas unfinished in the work of the previous season as could be dragged without interfering with the work first named.

It was desired to drag the most doubtful remaining part of the channel from Key West to Dry Tortugas. This channel is used regularly by a naval tug and by the lighthouse tenders, but is very little used by commercial vessels. This is partly due to the well-established belief that no undragged area is safe. As soon as sufficient width had been dragged to make the channel safe for navigation the work was to be closed.

There were several practically new features in this work. The original survey was not sufficiently close for control of the wire-drag work, and a day had to be spent in sounding over undeveloped spaces. The area to be examined lies from 10 to 20 miles from Key West. There is a good boat harbor with an entrance depth of 7 feet within 3 and 7 miles, respectively, of the ends of the working ground at Boca Grande Key. In order to use this it was necessary to put down a heavy mooring, as the use of anchors would cause delay each day. The launches were barely large enough to carry the party and provide very inadequate living accommodations. Boca Grande is without fresh water or other facilities for camping.

The plan was adopted of having all work of assembling and repairing the drag done at Key West, as well as the office work. The drag party was required to have on hand a two days' supply of provisions and the necessary equipment for catching fish. Whenever at the

close of a day the weather prospects appeared favorable, the party remained at Boca Grande and was ready for an early start next morning. The weather conditions were usually unfavorable and high winds prevailed during much of the time.

No triangulation, topography, or signal building was necessary, although several signals had to be repaired. The signals built by the party on the steamer *Bache* were found to be in good condition.

An area of 10.8 square miles was dragged and 100 shoals were found. Instead of the indicated safe depth of 28 feet, a maximum safe depth of 22 feet when using great care is available. About 5 square miles of the area is entirely obstructed. Vessels using care to keep in the dragged area and drawing not more than 18 feet are safe.

Owing to the nature of the locality and the existence of so many obstructions the cost of the work was greater than in similar work elsewhere.

No changes were made in the drag during the season. A new signal system was installed and a new apparatus which had been designed and built during the preceding season was put in operation. A new tripping device received at the beginning of the season was used with satisfactory results. The hired launches proved satisfactory.

An inspection was made of the automatic tide gauges at Key West, St. Augustine, and Fernandina.

Pacific Coast.

WASHINGTON.

[G. T. Rude.]

On January 21 apparatus for current observations was installed on lightship *No. 88*, off the mouth of the Columbia River. This apparatus was inspected on March 6. On March 7 current apparatus was installed on Umatilla Reef Light Vessel at Portland, Oreg.

In March triangulation work was begun to connect the Lake Washington triangulation of 1914 with that by the Coast and Geodetic Survey and that by the Army Engineers along Lake Union and Salmon Bay. Many of the stations in this work were on the tops of buildings and were marked by drill holes in the walls or in some other permanent manner. This work was completed on April 23. All stations on the ground were marked with regulation disk triangulation station marks and the usual reference marks were placed. The work was started from stations Brush, Golf, and Cross of the 1914 work and carried across Portage Bay to Union Bay, connecting with station Army, a United States Army Engineers monument on the Washington Boulevard near Union Bay. This scheme connects with the triangulation of 1913 by E. E. Smith, of the Coast and Geodetic Survey, and also with other stations of the Army Engineers. The work was extended from Lake Union through Ross Valley and down Salmon Bay to the Sound, following the whole course of the Lake Washington Canal, then in course of construction. A reconnoissance was made with a view to extending the work down the valley.

In March an inspection was made of the apparatus for current observations installed on the Columbia River Light Vessel. Transportation was furnished by the lighthouse tender *Manzanita*. The observations were being made in accordance with directions given when the apparatus was installed in January.

Current apparatus was afterwards installed on the Umatilla Light Vessel and the officers in charge were instructed as to the method of making the observations. These observations are being made with the cooperation of the Bureau of Lighthouses.

[C. G. QUILLIAN, Commanding Steamer *McArthur*.]

SUMMARY OF RESULTS.—Triangulation: 24.6 square miles of area covered, 25 stations occupied for horizontal measures, 42 geographic positions determined, 4 old stations recovered, 15 new stations occupied and marked.

A revision of the triangulation and topography of Rich's Passage and Port Orchard, Wash., was made in March and April, 1915.

Some of the stations of the old triangulation were recovered to serve as a base for the revision work, and a sufficient number of new stations were established for the control of the shore line. All old stations recovered were connected with the main scheme of the new work and re-marked.

The triangulation was extended from the base Orchard-Restoration to the vicinity of station Harper through two quadrilaterals. This carried it through Rich's Passage and up Port Orchard to Battle Point.

The shore line was rerun and all improvements such as buildings, wharves, and other features which are of value on a chart were added to the topographic sheets. No contours were run.

The shore line was surveyed from the settlement of Manchester to Waterman on the south shore of Rich's Passage, and from Restoration Point to Battle Point on Bainbridge Island, and from Enetia settlement to Brownsville on the west shore of Point Orchard. The work was included on two topographic sheets on a scale of 1:10,000.

[R. S. PATTON, Commanding Steamer *Explorer*.]

WIRE-DRAG WORK.—Nine square miles of area covered, 51.6 miles run while dragging, 3,013 angles measured, 2 wire-drag sheets finished, scale 1:10,000.

On March 3, 1915, the *Explorer* took up wire-drag work in Rich's Passage, Wash., continuing on this work until April 22, when it was suspended on account of the necessity of repairing and outfitting for the summer's work in Alaska.

[H. C. DENSON, Commanding Steamer *Patterson*.]

April 1 the *Patterson* was undergoing general repairs at the Puget Sound Navy Yard and remained there until April 29, on which date all work was completed. The vessel then proceeded to Eliott Bay and coaled.

From May 1 to May 15 the vessel was at quarantine station and Port Townsend, where a thorough fumigation and cleansing of the ship was completed. While this work was in progress a survey of the approaches to the canal between Port Townsend Bay and Oak Bay was made, and the vessel then returned to Seattle to outfit for the Alaskan season. On May 30 the *Patterson* left Seattle for the

Shumagin Islands via Port Townsend, where a stop of three days was made to do some additional work in Port Townsend Bay.

[F. H. HARDY, Commanding Steamer *Gedney*.]

SUMMARY OF RESULTS.—Triangulation: 14.5 square miles of area covered, 19 signal poles erected, 19 stations in main scheme occupied for horizontal measures, 19 geographic positions determined. Topography: 2.8 square miles of area surveyed, 15.1 miles of general coast line surveyed, 10.9 miles of shore line of ponds surveyed, 2 topographic sheets finished, scales 1:10,000 and 1:5,000. Hydrography: 10 square miles of area surveyed, 6.3 miles run while sounding, 338 angles measured, 906 soundings made, 1 hydrographic sheet partly finished, scale 1:10,000.

On March 1, 1915, the *Gedney* left Seattle and began revision work in Liberty (Dogfish) Bay on Puget Sound. The triangulation was extended from the line joining the stations Jackman-Rock of 1880 to the head of the bay. A topographic survey was made of the shore line and soundings were made around the docks.

On March 16 the vessel was taken to the navy yard. While there the triangulation of Port Orchard from the limits of the work by the steamer *McArthur* to the head of the bay was completed.

OREGON.

[J. W. MAUPIN.]

SUMMARY OF RESULTS.—Base lines: 1 secondary 600 meters in length. Triangulation: 10 square miles of area covered, 92 signal poles erected, 60 stations in main scheme occupied for horizontal measures, 1 station in supplemental scheme occupied for horizontal measures, 118 geographic positions determined. Topography: 13 square miles of area surveyed, 7 miles of general coast line surveyed, 26 miles of shore line of rivers surveyed, 2 topographic sheets finished, scale 1:10,000. Hydrography: 20 square miles of area covered, 297.3 miles run while sounding, 3,167 angles measured, 10,854 soundings made, 2 tide stations established, 1 current station occupied, 2 hydrographic sheets finished, scale 1:10,000.

The resurvey of Yaquina Bay, begun in June, was in progress at the beginning of the fiscal year, by which time a triangulation scheme had been laid out and the stations permanently marked.

In July a base line was laid out and measured and the signal building and the observation of angles begun. It was found necessary to carry a continuous scheme of triangulation along the shores of the river from the entrance of Yaquina Bay to the town of Toledo, and owing to the narrowness of the river short lines were used, in some cases less than 200 meters in length. Several stations had to be established on the mud flats and this necessitated the construction of eight platforms as stands for the observer. The lines of sight being so short very accurate methods were used in erecting the signals and great care taken in making the observations. A launch was hired for the outside hydrography on the bar and reefs, and advantage was taken of every day on which work could be done on the bar but these were very few. At the same time the topographic work was being carried on. Much of the old shore line had to be rerun, and the work back from the shore on one of the old topographic sheets had to be done over, owing to changes that had occurred since the former survey.

The inside hydrography was continued in conjunction with the other work. In order to establish the existence of a 10-foot channel

claimed as far as Toledo very close work had to be done. In places lines were run only 25 meters apart. Soundings were reduced to the nearest foot.

One day was spent in observing currents during an ebb tide, at the entrance to the bay near the jetties. The season's work was closed on November 7.

WASHINGTON AND OREGON.

[J. F. PRATT.]

An officer stationed at Seattle was engaged in inspection duty on the coasts of Washington and Oregon with headquarters at the suboffice of the Survey at Seattle of which he was also in charge. He has also been charged with the supervision of the repairs to vessels of the Survey at Seattle and with various details of field work.

The work of the inspector includes the collection of data relating to the charts of Washington, Oregon, and Alaska, and furnishing information promptly to the public concerning the work and publications of the Survey, and special notices to mariners relating to newly discovered dangers in Alaska.

In the latter part of the year arrangements were made for supplying the suboffice with charts and publications of the Survey for sale, as a convenience to the public.

CALIFORNIA.

[FREMONT MORSE.]

Between March 6 and 10 a determination was made of the position of the Marconi wireless station at Bolinas Point, Cal.

A station was selected on the roof of the power house from which the lights on Southeast Farallon Island, Point Reyes, Bonita Point, Mile Rock, and Point Montara were visible. Direct and reverse readings were taken on the objects and these were found from the computations to be sufficient for the purpose.

[F. WESTDAHL.]

An officer of the Survey has continued on duty as inspector for the coast of California and in charge of the suboffice of the Survey at San Francisco.

The work of the inspector includes the collection of data relating to the charts of the Pacific coast and furnishing information to the public concerning the work and publications of the Survey. Attention is also given to forwarding instruments and supplies sent from or to the office at Washington, the transportation of officers traveling to or from Pacific coast points and the Philippine Islands, directing the work of the tide observer at Sausalito, carrying on the necessary official correspondence, and various other duties.

In the latter part of the fiscal year arrangements were made for supplying the suboffice with a stock of charts, coast pilots, and tide tables for sale.

INTERIOR STATES.

TENNESSEE, ALABAMA, AND INDIANA.

[J. S. BILBY.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme, 40 statute miles; 600 square miles of area covered, 11 points selected for scheme. Signal building: 26 observing tripods and scaffolds built, average height 72 feet.

At the beginning of the fiscal year work was in progress on the arc of primary triangulation between Memphis, Tenn., and Huntsville, Ala., the erection of signals and marking of stations having been extended from Memphis eastward to the line joining stations Ellis and Jones in the vicinity of Booneville and Corinth, Miss. By September 10 the signal building and station marking were completed to Huntsville, Ala.

During the period from July 1 to September 10 signals were built at 15 primary stations, all of which were marked with station and reference marks. Tripods and scaffolds were built at all stations. The average height of the tripod head was 56 feet above the station mark. In addition to this a 20 to 56 foot superstructure was built on each of the signals, making the average height of the light stand 83 feet above the station mark.

The precise-level bench mark in the city of Huntsville having been destroyed, it was necessary to revise the scheme in that locality to provide for a connection with the bench mark at Madison, Ala. A connection was also provided for a Laplace station at Madison.

On September 11 the party and outfit were moved to Huntsville, Ala., and thence by rail to Charleston, Ind. On September 16 a reconnoissance was taken up to connect the triangulation north of Louisville with the transcontinental arc. The work of building signals and marking stations was begun on September 19 and completed by November 15, after which the chief of party returned to stations Tripp, Stout, and Miller to clear obstructed lines. By November 18 all lines were cleared.

The work was begun at the triangulation stations Lutz, Sixmile, and O & M, in the vicinity of Charleston, Ind. These three stations were established by Prof. Campbell in 1884, 1885, and 1886, and are stations of the State survey to the northward of Louisville, Ky. From these three stations the work was extended northward. The stations on the western side of the scheme are on high timbered knobs, while on the eastern side the land is flat, partly cultivated and partly covered with timber about 95 feet high. Miller and Stout, with Tripp as the third point, are the connecting stations on the transcontinental arc. In all there are 11 primary stations in the scheme. Stands for the instrument were built at only three of the stations. The timber on lines near these three stations was cut and the lines cleared. At seven of the stations tripod and scaffold signals were built, the average height of the tripod head being 63 feet above the station mark. In addition to this a superstructure varying in height from 20 to 38 feet was built on each of the seven signals, making the average height of the light stand 88 feet above the station mark. At station Tripp a light stand was built, the top

of which is 95 feet above the station mark. To avoid extra high building it was necessary to cut a few high trees on several of the lines.

TENNESSEE AND ALABAMA.

[E. H. PAGENHART.]

SUMMARY OF RESULTS.—Base lines: 1 secondary, 1.2 kilometers in length. Triangulation: 2,900 square miles of area covered, length of scheme 190 miles, 31 stations in main scheme occupied for horizontal measures, 2 stations in supplemental schemes occupied for horizontal measures, 33 stations occupied for vertical measures, 38 geographic positions determined, 38 elevations determined trigonometrically. Leveling: One-half mile of levels run. Azimuth: Observations made at four stations.

The observation of angles in the primary triangulation between Memphis, Tenn., and Huntsville, Ala., begun in the latter part of the fiscal year, was in progress on July 1. The observing party used horses and wagons belonging to the Survey for transportation between stations while the light keepers traveled by rail or by hired conveyances. At all but two of the main-scheme stations it was necessary to elevate the instrument from 30 to 75 feet and the light-stand 20 feet higher.

The base figure and the work extending 15 miles westward to connect with the stations of the United States Engineers and the Mississippi River Commission had been completed before July 1, and the work after that date was the extension of the triangulation from the base figure eastward to Huntsville, Ala., to connect with previous work of the Coast and Geodetic Survey. Spirit-level connection was made between the Coast and Geodetic Survey bench mark near the depot at Madison, Ala., and the Laplace station Madison. On October 16 the party left Memphis for Charleston, Ind., to take up the work of connecting the triangulation in the vicinity of Louisville, Ky., with the thirty-ninth parallel arc.

INDIANA.

[E. H. PAGENHART.]

SUMMARY OF RESULTS.—Triangulation: 480 square miles of area covered. length of scheme 40 miles, 10 stations in main scheme occupied for horizontal measures, 10 stations occupied for vertical measures, 12 geographic positions determined, 11 elevations determined trigonometrically. Azimuth: Observations made at one station.

Connection between existing primary triangulation to the northward of Louisville, Ky., and the transcontinental arc along the thirty-ninth parallel was undertaken by the same party immediately after the completion of the work between Memphis, Tenn., and Huntsville, Ala. The work required the occupation of 10 primary stations and 1 intersection station, and the determination of 1 astronomic azimuth.

Actual observing was begun on October 22. All horizontal observations at first were made at night, but after four stations had been occupied observations were interrupted after 8 p. m. by haze and smoke from brush fires. Afterwards part of the observations were made in the afternoon and but little delay was experienced from failure of lights. The line from station Miller to Tripp passes over

the highest hill in the vicinity. The trees were cleared from this hill and the instrument was raised to the elevation of the light stand while observing on Tripp. The work was completed on November 19.

UTAH AND IDAHO.

[J. S. BILBY.]

SUMMARY OF RESULTS.—Reconnoissance: 5,400 square miles of area covered, length of scheme 135 miles, 20 lines of intervisibility determined, 7 points selected for scheme. Signal building: 18 observing stands built.

In April instructions were given covering the preparation for occupation and marking of stations between Pilot Peak and Ogden Peak, Utah, northward to and including Middlebutte and Caribou, the reconnoissance for which was made in 1913. This work was to be followed by a reconnoissance for primary triangulation from stations Cache and Bigbutte westward to a connection with stations of the California-Washington arc at some point between Portland, Oreg., and Tacoma, Wash.

The party arrived at Salt Lake City on May 15, and preparations for field work were begun. On May 23 the party left Salt Lake City to take up the work of preparing stations, returning to Salt Lake City June 5.

On June 9 an automobile truck ordered for the transportation of the party and equipment was received and put in commission, and on June 10 the party again left Salt Lake City to resume work in the field.

By June 17 the stations up to and including Cache-Bigbutte had been made ready for occupation, and on June 18 the reconnoissance and preparation of stations to the westward were begun. By June 30 seven new stations had been selected and marked and an instrument stand erected at each. Provision was made for connection with three triangulation stations of the United States Geological Survey and with one precise level bench mark. At the close of the fiscal year work was in progress in the vicinity of Boise, Idaho.

The automobile truck proved to be an efficient method of transportation as it decreased considerably the unit cost of the work from what it would have been with horses and wagons for moving the party with its outfit and supplies.

IDAHO.

[C. V. HODGSON.]

Work was begun about the middle of June, 1915, on the primary triangulation from stations in the transcontinental triangulation in Utah northward to the vicinity of Pocatello, Idaho, and thence westward along the Oregon Short Line Railroad.

The observing party went first to Oxford, Idaho, reaching the station on June 26. The party was occupying this station from that date until June 30, the end of the fiscal year.

The party used as the means of transportation two motor trucks, each with a carrying capacity of about 1 ton. The Survey had used motor trucks before on latitude work and they proved to be very suc-

cessful. The present season was the first time they were used by a primary triangulation party, and although they were used only a few days before the close of the fiscal year, yet they gave promise of being equally valuable for triangulation.

WASHINGTON.

[H. A. SERAN.]

SUMMARY OF RESULTS.—Triangulation: 2,768 square miles of area covered; heights of observing towers, 125 to 187 feet, 10 stations in main scheme occupied for horizontal measures, 10 stations occupied for vertical measures, 35 geographic positions determined, 26 elevations determined trigonometrically.

Work on the secondary triangulation along the coast of Washington between Grays Harbor and the Strait of Juan de Fuca, which had been begun in 1913, was taken up again in July, 1914.

The necessary scaffolds and light-stands had been erected in 1913 so that the only work to be done was the observation of angles. The triangulation was to be of secondary accuracy and a 7-inch instrument was used in the work. All transportation was by pack animals, as the country is practically without roads. The observing party reached Ellis, the first station to be occupied, on July 12. Between July 12 and November 4 stations Ellis, La Push, James Island, Hoh, Destruction Island Lighthouse, Queets, Tajolah, Baldy, and Langley were occupied. The original plan called for the occupation of another station, Pioneer, but weather conditions were so unfavorable in the latter part of the season that it was deemed advisable to close work on November 1 without occupying that station. Enough observations were made during the season to get a position check on station Langley and an azimuth check on the line Langley to Pioneer. In order to expedite the work a second observing party was used during the latter part of the season.

The scaffolds and instrument stands for this work were necessarily so very high that it was out of the question to build separate instrument stands and observing platforms. In every case except at Langley the instrument stand and observing platform were built together. In occupying these stations extreme care in observing was necessary, and observations were often prevented by the swaying of the platform caused by wind.

The highest scaffold occupied with the instrument was the station at La Push, 187 feet above the ground. There were two light stands higher than this, Moclips 213 feet, and Copalis 190 feet above ground. These two stations were concluded points in the main scheme.

The scaffolds built were of several types, varying from those in the top of a single large tree without braces or guys, to those built in the top of one large tree with two or more trees of about the same height pulled against it for support after they had been sawed and notched at the bottom. There was also the usual tripod for the instrument with an observing platform built on a separate structure free from the instrument stand. From experience it was found that where the instrument stand and observing platform must be built together the best type is one tree braced by two or more trees of about the same height drawn against it.

The method used in climbing these trees was to drive in 14-inch spikes similar to those used on telegraph poles, one above the other about 18 inches apart. In driving these spikes, a man standing on one spike hooks his safety belt over the next one above and drives the third at about the height of his head.

MONTANA, IDAHO, AND WASHINGTON.

[JOHN H. PETERS.]

SUMMARY OF RESULTS.—Leveling: 398.6 miles of precise levels run, 142 permanent bench marks established.

At the beginning of the fiscal year work was in progress on the line of precise levels between Butte, Mont., and Pasco, Wash., which had been extended westward of Missoula, Mont., to Plains, Mont. After July 1 this line was continued to a point about 25 miles west of Sand Point, Idaho. Work on the line from Butte to Pasco was then suspended for a period of over a month, during which time the line was extended from Sand Point to Port Hill. Work on this line was completed September 15, and work on the line Butte to Pasco was resumed on September 16 from Rathdrum, Idaho.

The line Butte to Pasco follows throughout its entire length the line of the Northern Pacific Railway. It is necessary to give a list of towns along the line of levels in order that the particular line of railroad followed may be identified, as there are several places where two lines of railway run between the same points by different routes. The line of leveling passes through Silver Bow, Deer Lodge, Drummond, Missoula, De Smet, Frenchtown, St. Regis, Paradise, Plains, Thompson Falls, Kildee, Childs, Trout Creek, Noxon, Clark Fork, Kootenai, Sand Point, Athol, Ramsey, Rathdrum, Spokane, Marshall, Cheney, Ritzville, Cunningham, Connell and Pasco.

The line from Butte to Pasco connects with standard bench marks of the Coast and Geodetic Survey precise-level net at Silver Bow, Mont., and Pasco, Wash. At frequent intervals throughout its entire length, the line touches upon bench marks of the United States Geological Survey and the profiles of the railway engineers.

Motor velocipede cars were used on the Butte-Pasco line during 2½ months and hand velocipedes during the remaining period.

The rate of progress for the whole season on the line Butte-Pasco averaged 97.42 miles per month. In July 120 miles and in October 148.8 miles of progress were made, and on one day, October 12, 20.54 miles of single line were run in seven hours of actual observing.

MONTANA AND NORTH DAKOTA.

[GEO. D. COWIE.]

SUMMARY OF RESULTS.—Leveling: 344 miles of precise levels run, 240 permanent bench marks established.

Work on the line of precise levels between Berthold, N. Dak., and Devon, Mont., begun in May, 1914, was in progress at the beginning of the fiscal year. The work was completed to Devon, Mont., on October 21.

The total period occupied, including portions of both fiscal years, was about 5½ months, and the length of line was 509 miles, so that the average monthly progress was about 92.5 miles and the rerunning about 9.4 per cent. The maximum rate per day was about 15 miles. The best speed sustained throughout a single day was about 2½ miles per hour.

The average distance between bench marks was about 1½ miles. The bench marks used were of the usual types. Connections were also made at various points with bench marks established by the United States Geological Survey and by the Missouri River Commission. Throughout the line a special effort was made to set standard bronze disks in permanent buildings where they could be easily seen.

A two-horse motor speeder and one light hand velocipede car were used for transporting the party.

KENTUCKY AND INDIANA.

[JOHN H. PETERS.]

SUMMARY OF RESULTS.—Leveling: 13.5 miles of levels run, 3 permanent bench marks established.

In March a line of precise levels 13.5 miles in length was run for the purpose of determining the elevations of triangulation stations Lutz near Charleston, Ind., and Louisville North Base, near Louisville, Ky. The line of levels was begun at bench mark No. 86 of the precise level net. This bench mark is situated at the corner of Main and Eleventh Streets in the city of Louisville, and its elevation in the 1912 adjustment of the precise level net is 138.481 meters. The elevation of this bench mark was checked on bench mark No. 94, established by the War Department on the sea wall at the head of Portland Canal in the city of Louisville.

The elevation of Louisville North Base was determined by a line extending from bench mark No. 28 of the Louisville Sewer Commission. This bench mark was established by an engineer detailed from the United States Geological Survey to the engineering department of the city of Louisville.

WASHINGTON AND MONTANA.

[JOHN H. PETERS.]

SUMMARY OF RESULTS.—Leveling: 126.1 miles of precise levels run, 35 bench marks established.

On May 1 a party was organized to extend a line of levels from Blaine, Wash., to Seattle, Wash. Field work on this line began May 10, 1915, and was completed June 8, 1915.

This line, which follows the Great Northern Railway through the cities of Bellingham and Everett, Wash., connects precise level bench marks of the Canadian Geodetic Survey at Blaine with precise level bench marks of the Coast and Geodetic Survey at Seattle.

A party was afterwards organized to extend a line of precise levels from Huntley, Mont., to Snowden, Mont. The work on this line was under way at the end of the fiscal year.

An innovation was made on this line by having two motor velocipede cars in the party for transporting its members to and from the work and for use during the actual leveling.

NEVADA.

[GEO. D. COWIE.]

SUMMARY OF RESULTS.—Leveling: 121 miles of precise levels run, 64 permanent bench marks established.

Precise leveling on the line from Reno to Las Vegas, Nev., was begun May 20 and continued until the end of the fiscal year.

The line was carried from Reno via Carson City to Mound House over the tracks of the Virginia & Truckee Railway, and from there via Churchill to Gillis, Nev., over the Southern Pacific Railroad. The weather was generally fair and warm. A considerable amount of rerunning was necessary on the heavy grades. The railroad officials manifested a great interest in the work and assisted the party whenever there was an opportunity.

At Wabuska and Schurz connections were made with bench marks of the United States Geological Survey. Motor and hand velocipede railway cars were used in this work.

The total progress made was 121 miles in 1⅓ months, or at the rate of about 90 miles per month, and the total number of permanent bench marks established was 64. The bench mark used was a wrought-iron pipe spread at the bottom to give a good bearing and carrying a standard bronze cap on the top. Standard bronze disks were set in buildings of masonry construction, but these were few.

CALIFORNIA, NEVADA, COLORADO, NEW MEXICO, AND TEXAS.

[C. V. HODGSON.]

SUMMARY OF RESULTS.—Latitude: 25 latitude stations occupied.

Between July 1 and October 23 work was continued on the determination of latitudes at stations on or near the Texas-California arc of primary triangulation and on the California-Nevada boundary.

Of the 37 stations occupied during the entire season, beginning April 23, 6 were in western Texas, 5 in New Mexico, 14 in Arizona and 9 on the California-Nevada boundary.

By including stations of the U. S. Geological Survey and the California-Nevada boundary survey in the scheme a much better distribution of stations was secured than could have been obtained otherwise. Wherever stations were available, observations for latitude were made at points from 35 to 40 miles apart, but in many places the distances necessarily exceeded that amount.

Although during July the weather was unfavorable for observations, from August 1 to the close of the season only three nights were lost on account of unfavorable weather. The rate of progress, therefore, depended only upon transportation and the roads.

During August eight stations were occupied and 726 miles traveled. This completed all stations in Arizona but one and included one station in southern California. The remaining three stations in

California, Cuyamaca, San Jacinto, and Butte, were taken up in the order named. At San Jacinto it was necessary to transport the instrumental outfit on pack horses 18 miles from Idyllwild to the summit of San Jacinto Mountain, 10,830 feet above sea level. The next station, Butte, 35 miles north of Imperial Junction, could only be reached over a trail on which the sand was so heavy that the motor truck could not be used, and a four-horse team had to be substituted.

Butte marked the completion of the observations along the Texas-California arc of triangulation. There remained the stations on the oblique boundary between California and Nevada, and it was thought best to begin at the Lake Tahoe end and work southeastwardly. This not only gave better weather for the work in the mountains at the north end but also gave the advantage of transportation from higher to lower altitudes.

The run of 630 miles from Los Angeles to Carson City was made in six days, September 18 to 24, and observations were finished at two of the boundary stations before the end of the month.

During September 5 stations were occupied and 1,270 miles traveled, and during the first 16 days of October the 8 remaining stations were completed. Work was closed for the season on October 23.

Observations for latitude were made in an observing tent with zenith telescope No. 4, mounted on a portable observing stand of aluminum. From 15 to 18 pairs of stars were observed at a station, the Horrebow-Talcott method being employed.

Owing to the necessity of packing the instrumental outfit on the backs of the men to the summits of most of the mountains, the weight to be carried was reduced to the lowest possible limit. The observing tripod of aluminum alloy, weighing only 48 pounds, was especially constructed for this work and was used with great success. As it was, the average weight of the packs was 75 pounds per man.

The 1½-ton autotruck used in the previous season was overhauled and some changes made in its equipment and gearing at the beginning of the season. The road conditions in eastern Arizona and southern California were generally good, but in the remaining sections they were so bad as to test the capacity of this means of transportation very severely. The truck was run more than 5,000 miles during the season and only about two hours were lost in all on account of engine trouble.

The use of a lighter truck is recommended on account of its superior advantages in running through heavy sand and mud and in passing over weak bridges. The saving effected by the use of the truck as compared with horses and wagons is estimated at about 35 per cent in money and 50 per cent in time.

MASSACHUSETTS, NEW YORK, TENNESSEE, ARKANSAS, MISSISSIPPI, AND ALABAMA.

[FREMONT MORSE AND O. B. FRENCH.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 3 miles, 3 square miles of area covered, 4 points selected for scheme. Triangulation: 3 square miles of area covered, 5 signal poles erected, 4 stations in main scheme occupied

for horizontal measures, 4 geographic positions determined. Astronomic work: 4 latitude stations occupied, average of 15 pairs of stars observed at each station, 8 telegraphic longitude stations occupied, signals exchanged on 45 nights.

In the latter part of June, 1914, instructions were issued for the determination by two cooperating observers of the difference of longitude between Washington, D. C., Far Rockaway, N. Y., and Cambridge, Mass., and preparations for starting work were begun, but no field work was done until July.

This work was planned to afford a connection between the Coast and Geodetic Survey longitude net and the end of a cable at Far Rockaway, for the purpose of comparing a proposed trans-Atlantic cable determination of the difference of longitude between Borkum, Germany, and Far Rockaway, with previous trans-Atlantic longitude determinations as well as with such determinations as might be made in the future. Hence, a high degree of accuracy was required, and it was decided to exchange observers on each line and to secure four or five nights' observations each way. The method followed by the observers of the Prussian Geodetic Institute was adopted as nearly as was practicable. Three time sets were observed each night with an exchange of arbitrary signals between each two, thus giving two almost independent determinations of longitude each night.

Each time set consisted of 5 to 7 time stars and an azimuth star. The time stars were all nearly in the zenith so that no azimuth factor was greater than 0.3 and the algebraic sum of the factors for all the time stars of a set less than 0.3. A preliminary catalogue of 6,188 stars by Lewis Boss was used for the selection of stars and also for the star places. The stars for a time set were taken as rapidly as consistent with deliberate observations. As each star was observed both direct and reversed to eliminate the effects of collimation and pivot inequality, it had to be taken a minute or more away from the meridian on each side, thus causing the selection of stars with intervals of little less than 4 minutes. The time required for a time set was therefore about 35 minutes.

The instruments used for this work were quite different from any previously used in the Coast and Geodetic Survey, and several days were required to get them properly fitted up and put in condition and to enable the observers to become familiar with the method of using them.

An observatory was erected at Far Rockaway to be used jointly by the observers of the Coast and Geodetic Survey and by the German observers.

At the United States Naval Observatory permission was given to use the observatory erected the year before for occupation by the French observers who were making the determination of the difference of longitude between Washington and Paris by wireless telegraphy.

As the Coast and Geodetic Survey observers used the same pier as the French observers, which was only 7 meters distant from the one occupied by the observers of the Naval Observatory on the same work, the Coast and Geodetic Survey results should be directly comparable with their work without the introduction of station deflections at this end.

The instruments were mounted at the Naval Observatory early in July, but owing to continuously unfavorable weather, both at Washington and Far Rockaway no exchange of signals was obtained until August 1. On August 15 the fifth night of complete exchanges was obtained and the observations on the line from Far Rockaway to Cambridge were taken up. Exchanges between Far Rockaway and Cambridge were completed September 24.

At each of the three stations the use of clocks was obtained for the chronograph record, thus eliminating the uncertainties due to the use of chronometers. At the Naval Observatory the standard Riefler sidereal clock was used. At Cambridge the exclusive use of the standard sidereal clock of Harvard University was obtained, and at Far Rockaway, except during the first part of the first line, direct connection was had with a Dencker sidereal clock set up by the German observer in a room in the cable house.

During the first exchange of observers, latitude observations were made at Far Rockaway with the new transit. Observations were also made to determine the value of the micrometer screw and of the latitude levels of this instrument. During the same period a trigonometric connection was made between the astronomic station and the triangulation of Greater New York. One of the triangulation stations in Far Rockaway was recovered from which four other points could be seen. By establishing two new stations a point was located on top of the cable building and this point was connected with the astronomic station by a small triangle. These stations were placed on the tops of high buildings.

During the second exchange of observers a trigonometric connection was made between the transit pier and the large dome at the Harvard Observatory, which is the point of reference for longitudes. A tracing was also made of a map showing the relative positions of the various buildings on the grounds of the observatory and showing elevations with contours.

The observations on the Cambridge-Washington line were begun October 1 and completed October 11. The observers then exchanged places and were ready for work on October 15. However, rain prevented observations until October 21, when three consecutive clear nights were obtained with satisfactory results, and work was then closed.

After the completion of the longitude work on the Washington-Far Rockaway-Cambridge circuit, differences of longitude were determined as follows: Little Rock, Ark., to Germantown, Tenn.; Germantown, Tenn., to Strickland, Miss.; Strickland, Miss., to Madison, Ala.; Madison, Ala., to Nashville, Tenn. The first and last of these are stations in the primary longitude net of the Coast and Geodetic Survey. In addition the difference of longitude was determined between Nashville and O & M, a triangulation station near Charleston, Ind. This work was completed by January 13.

On this southern work no stars were used except those given in the American Ephemeris. The method recently followed by the Survey and described in Special Publication No. 14 was followed on this work with only a slight modification. Chronometers were used, and as the temperature was about freezing their rates were large, one of them being about 10 seconds per day. Breaks for arbi-

trary signals were made in unison with the swings of a pendulum as when working with clocks instead of chronometers.

At all new stations on the southern work the pier for the support of the transit was constructed of wooden timbers set in the ground to a depth of from 2½ to 3 feet. By the use of such a pier a considerable saving in time and expense was effected, and the stability of the instrument was found to be quite as good as on any masonry pier and better than on a new concrete pier.

The free use of the wires of the Western Union Telegraph Co. was granted on this work as previously, the Survey paying only for the extra connections and services of the operators on nights when observations were made. The accuracy in the results obtained with the new instruments is greater than with any instruments previously used in the Survey.

VIRGINIA, NORTH CAROLINA, SOUTH CAROLINA, AND TENNESSEE.

[JOHN D. POWELL.]

SUMMARY OF RESULTS.—*Gravity determinations*: 11 pendulum stations occupied. Leveling: 16 miles of levels run. Latitude: 4 latitude stations occupied.

During January, 1915, a complete restandardization of the pendulums used in gravity work was made at the base station in the basement of the Coast and Geodetic Survey Building at Washington, D. C.

The new values of pendulums B_5 and B_6 were found to agree remarkably well with their former values, whereas that of B_4 had changed considerably. The irregularities of this pendulum had been previously noted. When, with the beginning of field work, its period was found to have changed again, this pendulum was returned to the office and the other two were used at the stations occupied, an extra swing being made at each station with one or the other of these pendulums.

From experience during the previous season it appeared that the greatest error in the determination of gravity was due to inability to secure absolutely accurate temperature values. Investigations were made of thermographs which could be adapted to the pendulum cases, but no definite result was reached.

For temporary improvement of the existing conditions, temperature jackets were devised consisting of heavy walls of three-ply felt, lined with canvas, and covered with leather. They were made to fit snugly against the case and to cover it completely, being provided with plugs for covering holes and openings which had to be exposed at certain times for making the necessary observations and readings and in operating the pendulums. By the use of these jackets more stable temperature conditions inside the case were obtained.

Field work was begun on February 6, 1915, and concluded on May 22, 1915. During this time 11 stations were occupied, the average time at each station being 8 days. One of these stations was occupied twice, a slight change of location having been found necessary after the first occupation.

The stations occupied were Richmond, Emporia, and Bristol, Va.; Greenville, Wilmington, Charlotte, Winston-Salem, and Asheville, N. C.; Cheraw, S. C.; and Cleveland and Knoxville, Tenn.

No change was made in the method of observing or computing. The noon signals sent out from the Naval Observatory at Washington over the Western Union telegraph lines were used as heretofore with satisfactory results.

Experiments were made at Emporia, Va., to determine the relative values of wooden and concrete floors for pendulum supports The results indicated that it is not advisable to use wooden floors as supports in gravity work unless they rest on heavy beams.

Between May 22 and June 5 the elevations of Hughes and Cloudland, Tenn., gravity stations were determined by spirit leveling.

GEORGIA, FLORIDA, ALABAMA, ARKANSAS, KENTUCKY, VIRGINIA, AND TENNESSEE.

[C. L. GARNER.]

SUMMARY OF RESULTS.—Gravity observations: 20 pendulum stations occupied.

The pendulums used in gravity work during the previous season were restandardized at Washington, D. C., in January, 1915, and a leather and wool-padded temperature jacket was constructed for better temperature control in the pendulum receiver.

Field work was resumed February 12, the first station occupied being Homestead, Fla. From this time the work was carried on continuously to the end of the fiscal year when 20 stations had been occupied at the rate of about 1 station per week. But slight delay was encountered in the progress of the work and this was due to the difficulty in finding suitable places for the gravity stations. At Wilmer, Ala., it was necessary to erect a special building for the purpose.

The stations occupied, in order of occupation, were: Homestead, Titusville, Sebring, Leesburg, and Cedar Keys, Fla.; Albany and Macon, Ga.; Opelika, Birmingham, Huntsville, and Greenville, Ala.; Pensacola, Fla.; Wilmer, Ala.; Arkansas City, Ark.; Memphis, Tenn.; Mammoth Springs, Ark.; Hopkinsville, Danville, and Prestonburg, Ky.; and Clifton Forge, Va.

ILLINOIS, INDIANA, OHIO, MISSOURI, ARKANSAS, MISSISSIPPI, AND LOUISIANA.

[JOHN D. POWELL.]

SUMMARY OF RESULTS.—Gravity determinations: 12 pendulum stations occupied. Latitude: Observations made at 4 stations.

To carry out a series of gravity observations at stations in the Middle Western States, the work of standardizing the B set of pendulums was undertaken at the base station at the Coast and Geodetic Survey office at Washington in July, 1914.

Besides obtaining standard values of the periods of the pendulums at Washington for use in computing relative gravity at the field stations, this standardization was designed to test the possibility of using on the field the noon time signals sent out by the Naval Observatory over the telegraph lines for rating the chronometers, instead of making local astronomic observations which had hitherto been employed in gravity determinations. With this end in view separate sets of observations were made with each of the methods.

The results obtained indicated a very close agreement and justified the use of the telegraphic time signals at all stations.

The field season extended from August 18 to November 27, 1914. There were 86 working days and in that time 12 stations were occupied, namely, Parkersburg, W. Va.; Columbus, Ohio; Indianapolis, Ind.; Springfield, Ill.; Lebanon, Mo.; Joplin, Mo.; Fort Smith, Ark.; Little Rock, Ark.; Hot Springs, Ark.; Texarkana, Ark.; Alexandria, La.; and Laurel, Miss. The average time for occupation of a station was $8\frac{1}{3}$ days.

Besides the regular gravity work it was necessary to make astronomic observations for latitude at four stations, Indianapolis, Lebanon, Alexandria, and Laurel. At each station the elevation of the pendulum above sea level was also determined.

The mean value of the probable error of observed gravity at any station was between 0.001 and 0.0015 dyne.

Changes were noted in the period of one of the pendulums, making it necessary to eliminate the results with this pendulum from the final computations of the values of gravity.

The new method of using Western Union time has considerably reduced the cost of the work. Whereas, formerly, two officers were engaged on gravity determinations now only one is required. There is also considerable saving in transportation, in the elimination of observatories, and in time formerly lost on account of bad weather.

MAINE, NEW HAMPSHIRE, MASSACHUSETTS, NEW YORK, NEW JERSEY, AND PENNSYLVANIA.

[C. L. GARNER.]

SUMMARY OF RESULTS.—Gravity determinations: 11 pendulum stations occupied.

Between August 30 and December 2 gravity observations were made at Rockland, Me.; Chatham, Mass.; Lancaster, N. H.; Bridgehampton, Whitehall, Albany, Little Falls, Watertown and Southport, N. Y.; Atlantic City, N. J.; and Erie, Pa.

Before actual field observations were begun, the A set of pendulums was standardized at the office in Washington, with C. H. Swick assisting in the work. The standardization was made with time signals sent from the Naval Observatory over the wires of the Western Union Telegraph Co., and also with local time observations on the stars. The probable errors of the results showed the time by telegraph to be in every way satisfactory for the gravity work.

An electric light was substituted for the oil lamp in the flash apparatus. This light was placed inside, thus making the whole flash apparatus more compact and simple. During this season the thermometers and manometers were carried by hand in small cases constructed for that purpose.

The average time for the completion of one station was 8.6 days, including Sundays. The total cost for the 11 stations occupied was $566.80, or an average cost of $51.54 per station, not including observer's salary or instrumental equipment. A comparison with previous results shows a reduction of more than two-thirds in the cost of determining relative intensity of gravity with the present methods.

MARYLAND.

[GEORGE HARTNELL.]

The regular work of the Cheltenham magnetic observatory was continued during the year. This includes the operation of two magnetographs and a seismograph, absolute observations for declination, dip, and horizontal intensity, sun observations for time, the scaling of hourly ordinates from the magnetograms and the computation of the absolute observations, and of the base-line values for both magnetographs. Beginning with January 1, 1915, the practice was adopted of integrating the curves on the magnetograms instead of reading the ordinates at the exact hour of local mean time.

Instruments used in the field work were standardized as usual. A new magnetometer of the India Survey type, made for the Survey by Cooke & Sons, of York, England, which had been compared at the Kew Observatory before shipment to the United States was standardized at Cheltenham in February and March, thus furnishing a comparison between the Kew and Cheltenham standards. In June a magnetometer and earth inductor belonging to the Carnegie Institution of Washington were compared with the standard observatory instruments. The largest magnetic storm recorded since 1909 occurred June 16 to 18, 1915.

ALABAMA, FLORIDA, GEORGIA, ILLINOIS, INDIANA, KENTUCKY, MISSISSIPPI, AND TENNESSEE.

[F. L. ADAMS.]

STATIONS OCCUPIED.—*Alabama:* Athens, Bay Minette, Butler, Carrollton, Chatom, Clinton, Clayton, Florence, Hillsboro, Linden, Livingston, Luverne, Marion, Mobile, Opelika, Rockford, Selma, Town Creek, Tuscaloosa, Wedowee. *Florida:* Panama City. *Georgia:* Fort Gaines and La Grange. *Illinois:* Golconda and Salem. *Indiana:* Mount Vernon, Princeton, and Vincennes. *Kentucky:* Calvert City, Herndon, Princeton, and Smithland. *Mississippi:* Ashland, Carthage, Columbia, De Kalb, Jackson, Marks, Mendenhall, Meridian, Monticello, Pascagoula, Poplarville, Prentiss, Quitman, Senatobia, and Tylertown. *Tennessee:* Nashville and Pulaski.

Between February 9 and June 30 observations of the three magnetic elements were made at the stations named.

At Pulaski, Tenn., repeat observations were made at a point in the vicinity of the old station and a new station was established in another position. Auxiliary observations were made at Clayton, Mobile, Hillsboro, and Athens, Ala.

Old stations were reoccupied at Athens, Florence, and Selma, Ala.; La Grange, Ga.; Vincennes, Ind.; Princeton, Ky.; Jackson, Meridian, and Pascagoula, Miss.; and Nashville and Pulaski, Tenn.

Much interest was manifested in the magnetic work by local surveyors in the towns visited.

NEW JERSEY AND PENNSYLVANIA.

[J. R. BENTON.]

STATIONS OCCUPIED.—*New Jersey:* Bloomfield, Chester,* Franklin Furnace, Frenchtown,* Hackettstown,* Millington,* Mount Arlington, Plainfield, South Orange, Summit, and Westfield.* *Pennsylvania:* Blossburg, Coatesville, Easton,*

Elizabethville,* Hamburg,* Harrisburg,* Laporte,* Manheim, Pottstown,* Quarryville,* Slatington, Watsontown, Williamsport,* and Womelsdorf.

Magnetic observations were made at the stations named above between July 1 and September 12, 1914. The stations marked with an asterisk (*) were old stations which were to be reoccupied. Some of the old stations could not be recovered and it was necessary to establish new stations. All new stations were permanently marked in the usual manner, except those which were selected merely for present occupation.

At all of the places where observations were made the declination differed by less than 1° from what was expected from the last isogonic chart.

LOUISIANA, MAINE, MISSISSIPPI, NEW HAMPSHIRE, TEXAS, AND VERMONT.

[FRANK NEUMANN.]

STATIONS OCCUPIED.—*Louisiana:* De Ridder, Oberlin, Port Allen, and Ville Platte. *Maine:* Bangor,* Canton, and Portland.* *Mississippi:* Edwards, Mayersville, and Raymond.† *New Hampshire:* Canaan,† Franklin,† Laconia,† Warren,† and Whitefield. *Texas:* Abilene,† Baird, Barstow,† Eastland,† Monahans, Odessa,* and Stanton.† *Vermont:* Bethel, Barnett, Burlington,* Island Pond,† Roxbury, St. Johnsbury,* and Waterbury.

Between July 1 and November 21, the three magnetic elements were observed at the stations named above.

The five stations in the list marked with an asterisk (*) were repeat stations. Meridian lines were established at the 10 stations marked with a dagger (†).

VIRGINIA, WEST VIRGINIA, NORTH CAROLINA, SOUTH CAROLINA, GEORGIA, AND FLORIDA.

[FRANK NEUMANN.]

STATIONS OCCUPIED.—*Virginia:* Bedford, Buchanan, Covington,* Danville, Gladys, Gretna, Lynchburg, Mount Airy, Nathalie, Roanoke, and Rustburg. *West Virginia:* Blakeley, Blue Creek, Charleston, Meadow Creek, Montgomery, Rainelle, and Union. *North Carolina:* Concord and Graham. *South Carolina:* Ridgeland * and Spartanburg. *Georgia:* Alma,* Alpharetta,* Bainbridge, Blackshear, Cairo,* Camilla,* Claxton,* Clayton, Cumming, Decatur, Ellaville,* Eastman,* Fargo, Folkston,* Hartwell,* Homer,* Homerville,* Jefferson, Lawrenceville, Lincolnton, Lyons, McDonough, Metter,* Milledgeville, Moultrie, Newton, Ocilla, Statenville, Waycross, and Winder. *Florida:* Bronson, Crawfordville,* Detroit, Fort Pierce,* Jupiter, Key West, Long Key, Miami, Palm Beach,* and Tampa.

Meridian lines were established at the stations marked by an asterisk (*).

Between February 7 and June 30 the three magnetic elements were determined at the stations named. Of the stations occupied, 9 were repeat stations, 6 were new stations established near the old repeat stations, and 2 of these old stations were occupied. Two repeat stations were not marked. Four auxiliary stations were established at each of the following places: Milledgeville, Concord, Rustburg, and Bedford.

ARKANSAS, LOUISIANA, MISSISSIPPI, OKLAHOMA, TENNESSEE, AND TEXAS.

[WALLACE M. HILL.]

STATIONS OCCUPIED.—*Arkansas:* Berryville, De Witt,* Eureka Springs, Jonesboro,† Lake City, Melbourne,* Mountain View, Pocahontas, Powhatan, and Van Buren.† *Louisiana:* Shreveport.† *Mississippi:* Aberdeen, Booneville,* Brookhaven,†* Carrollton,* Cleveland,* Friar Point, Fulton, Greenville,† Okolona, Port Gibson, Vaiden, Walthall, and West Point.† *Oklahoma:* Apache, Lindsay, McAlester,† Minco, Pauls Valley,† Stegler,* and Walter.* *Tennessee:* Memphis.† *Texas:* Alice,* Anahuac, Austin,† Batesville,* Boerne,* Brownsville, Edinburg,* Encinal, Falfurrias, Fort Davis, Galveston,† Goliad, Hebronville, Hempstead, Johnson City, Jourdanton, Kingsville,* Laredo,*† Lufkin,* Marlin, McKinney,† Midland,* Oakville,* Port Lavaca,† Post,* Raymondsville, Rio Grande, Rockport, Sanderson, Sarita, Sierra Blanca,† Tilden, and Van Horn.

Between July 1 and November 25 and between February 9 and June 30 observations of the three magnetic elements were made at each of the above stations. Meridian lines were established at the places marked by asterisks (*). Old stations were reoccupied at the places marked by daggers (†). Observations were also made at new stations at Brookhaven, Galveston, Laredo, Memphis, and Port Lavaca.

IDAHO, ILLINOIS, MONTANA, NORTH DAKOTA, OREGON, SOUTH DAKOTA, WASHINGTON, AND WISCONSIN.

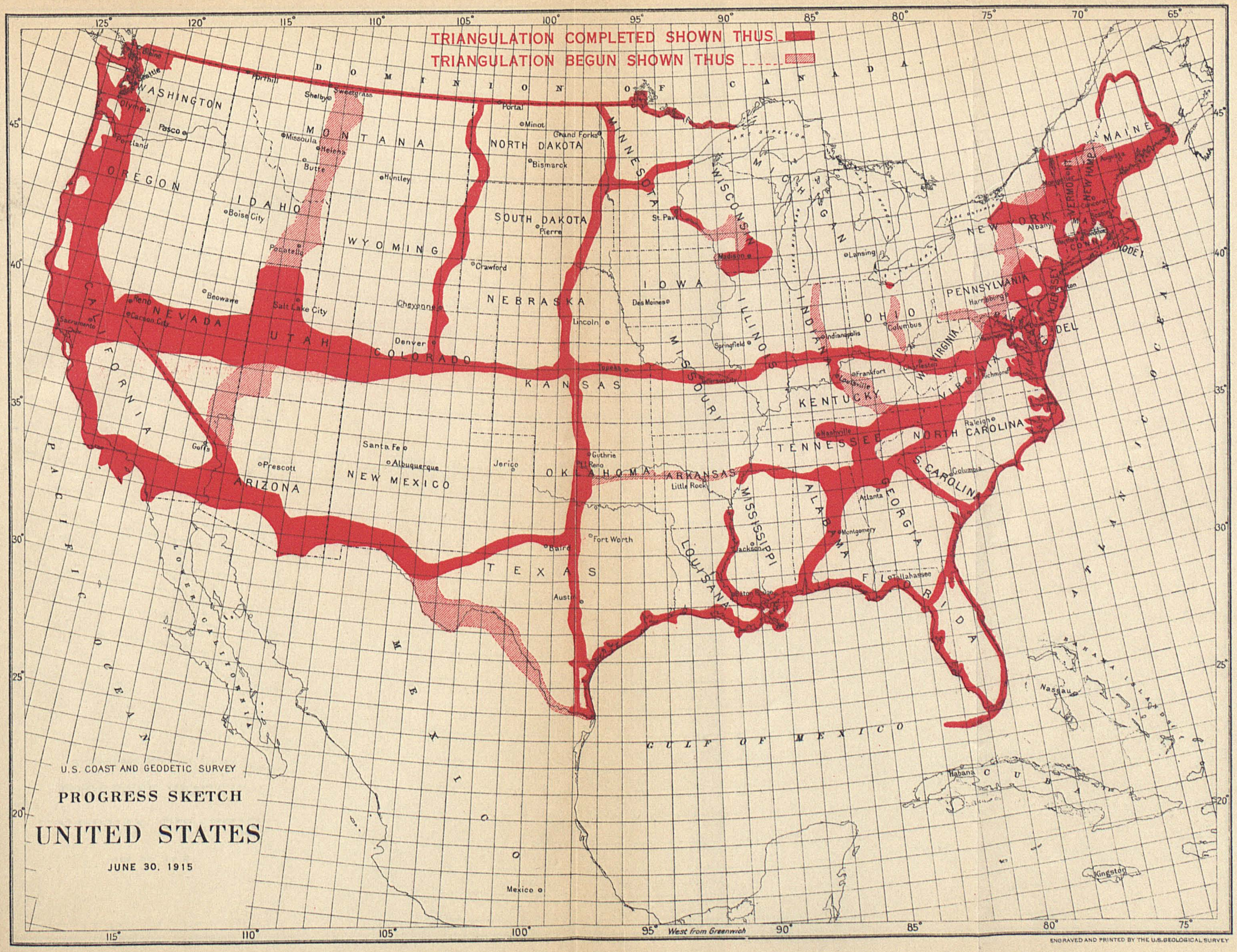
[F. L. ADAMS.]

STATIONS OCCUPIED.—*Idaho:* Rathdrum and Sand Point. *Illinois:* Bloomington, Caledonia, Harvard, and Joliet. *Montana:* Hamilton, Phillipsburg, Roundup, Terry, and White Sulphur Springs. *North Dakota:* Hettinger. *Oregon:* Pendleton. *South Dakota:* McIntosh. *Washington:* Chehalis, Dayton, Goldendale, Kalama, Lacrosse, Montesano, Ritzville, Seattle, South Bend, Spokane, and Walla Walla. *Wisconsin:* Appleton, Burlington, Colby, Durand, Genoa Junction, Lacrosse, Lake Geneva, Marshfield, Milwaukee, and Stanley.

During the period from July 1 to October 9 the magnetic elements were observed at the 35 stations named above, of which 9 had been previously occupied, namely, Seattle, Walla Walla, and Spokane, Wash.; Pendleton, Oreg.; La Crosse, Appleton, and Milwaukee, Wis.; and Joliet and Bloomington, Ill. Seven of the stations named were not permanently marked, namely, La Cross, Wash.; Terry, Mont.; Colby, Burlington, and Lake Geneva, Wis.; Harvard and Caledonia, Ill.

At Seattle, Wash., and Lacrosse, Wis., the old stations were occupied, and at each place a new station was established in a different location. At Pendleton, Oreg., it was found that the old station had been destroyed. Meridian posts were established at Montesano, Wash., and McIntosh, S. Dak.

At Kalama, Wash., Hettinger, N. Dak., and McIntosh, S. Dak., the result obtained indicated local disturbance and auxiliary stations were occupied. Large local variations were reported by engineers and surveyors in many localities in Washington and Montana where volcanic rocks abound.



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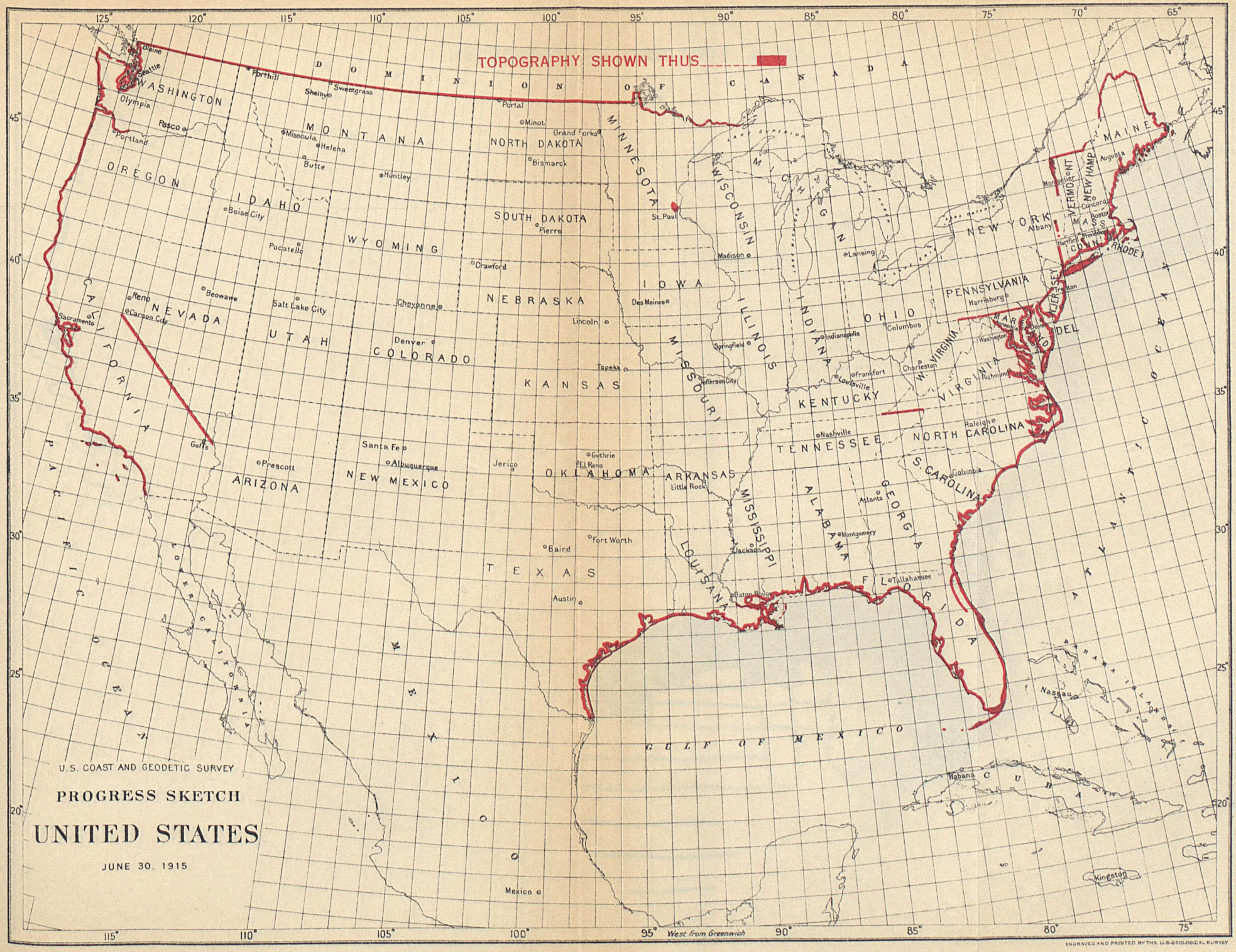

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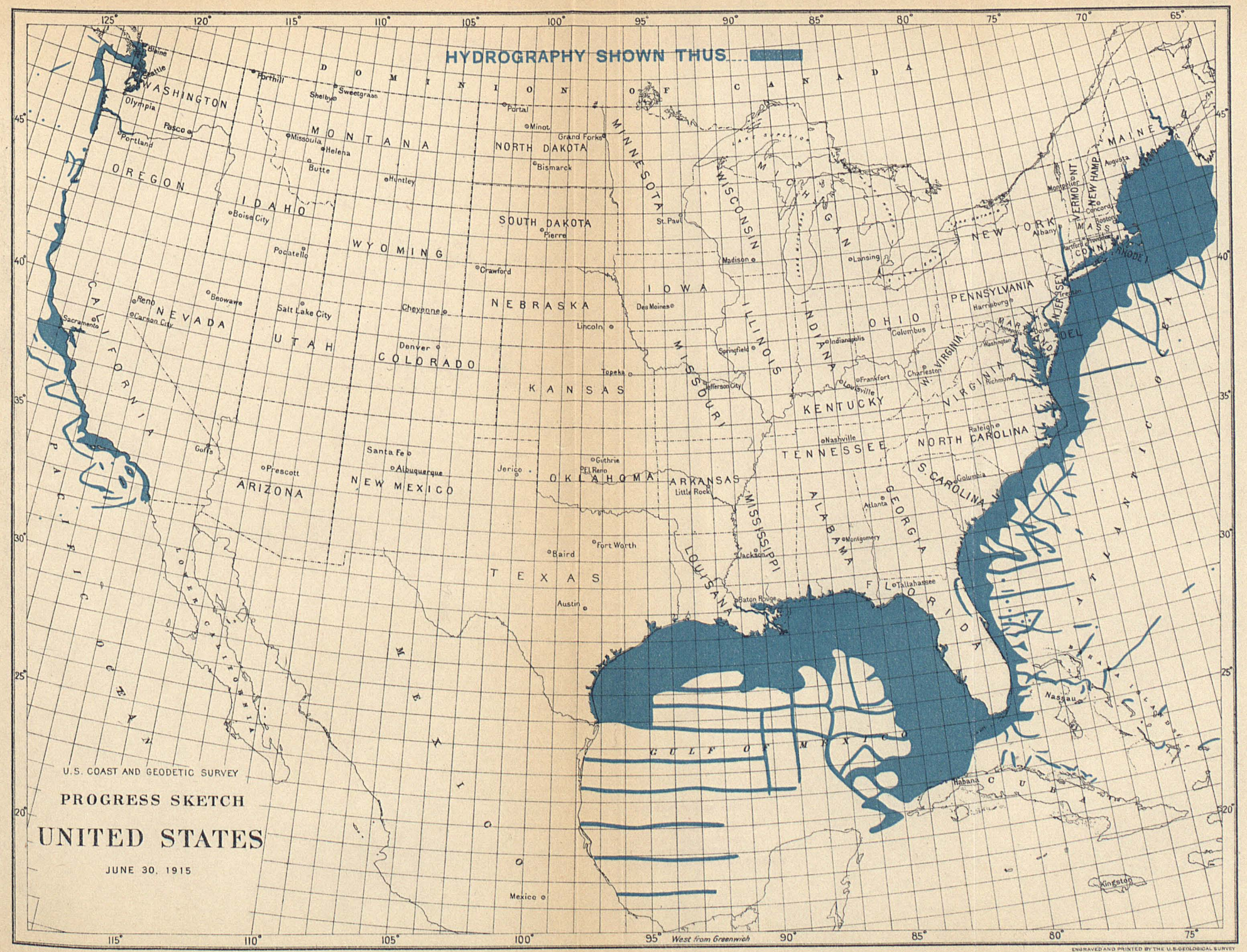

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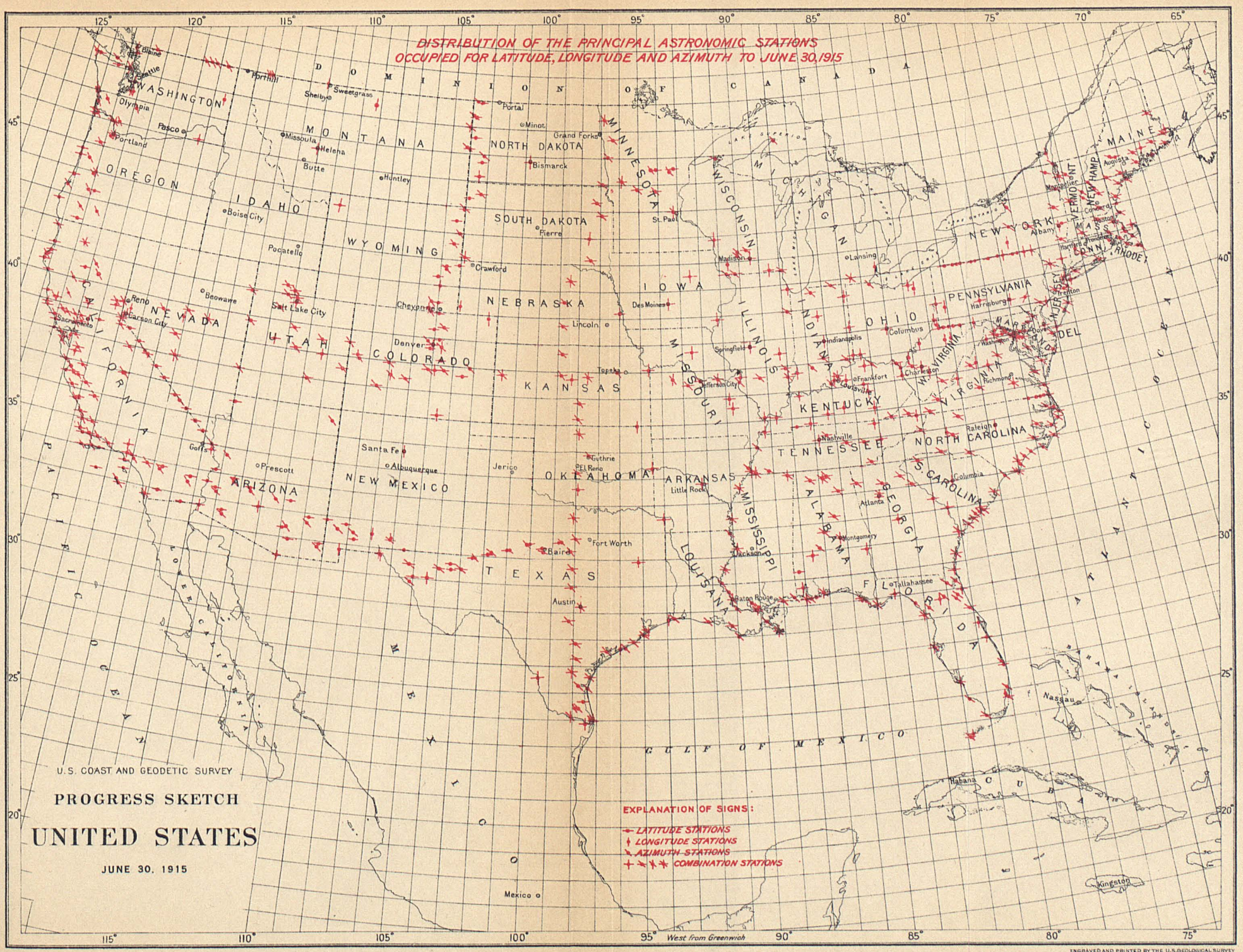

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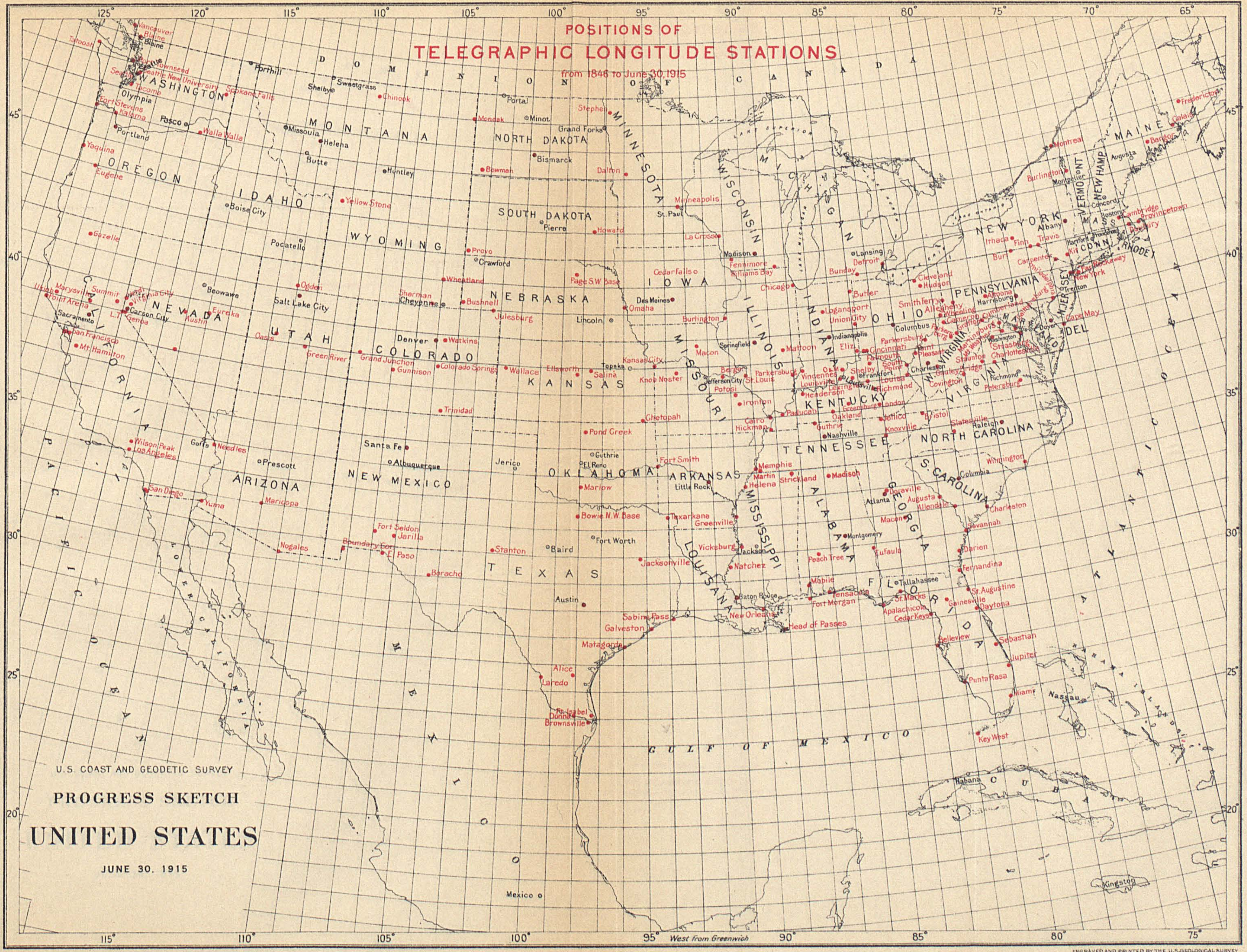
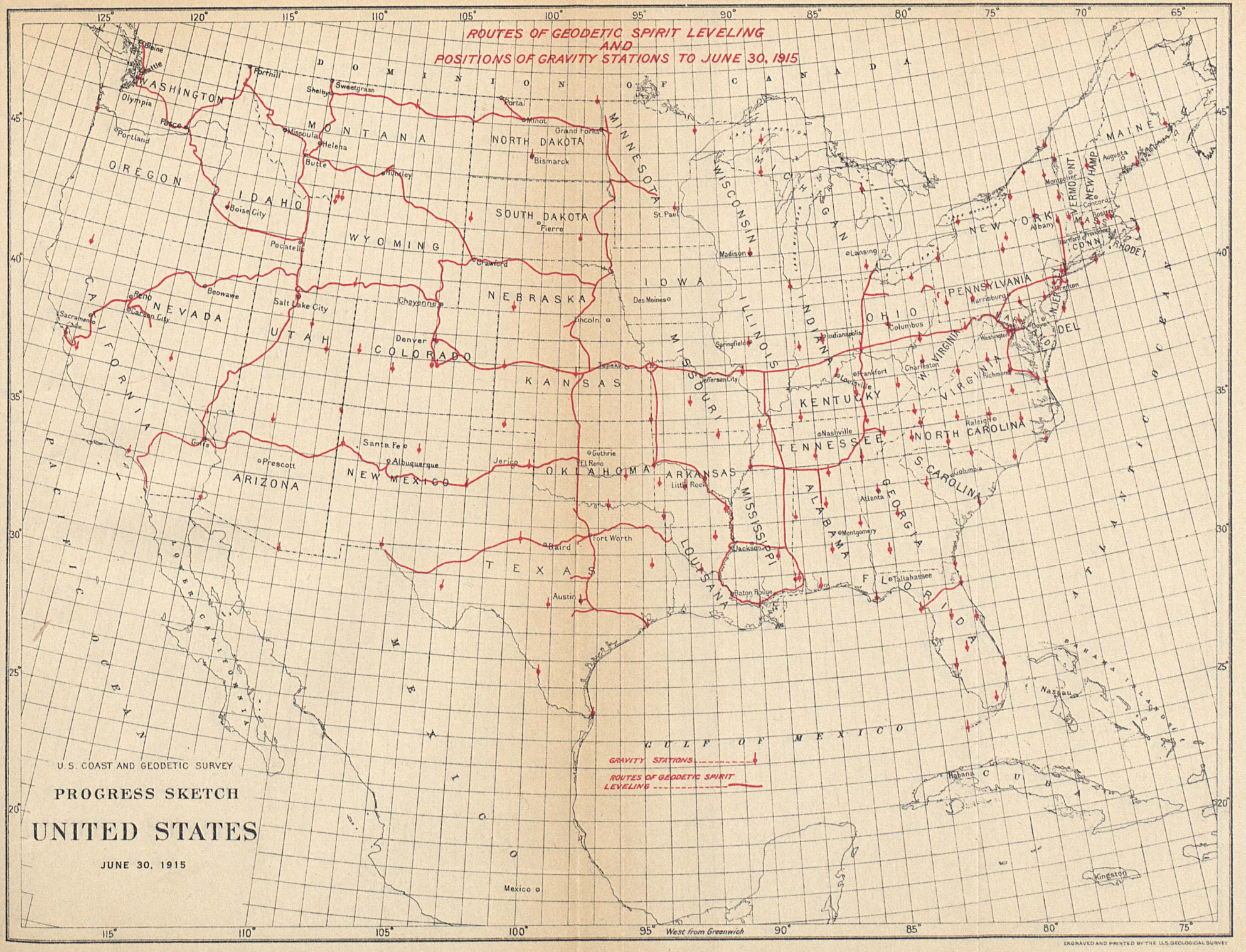
House Doc. 31; 64th Cong., 1st Sess.


POSITIONS OF
TELEGRAPHIC LONGITUDE STATIONS
from 1846 to June 30, 1915
U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
UNITED STATES
JUNE 30, 1915
West from Greenwich
DOMINION OF CANADA
GULF OF MEXICO
MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
ENGRAVED AND PRINTED BY THE U.S.GEOLOGICAL SURVEY


ROUTES OF GEODETIC SPIRIT LEVELING
AND
POSITIONS OF GRAVITY STATIONS TO JUNE 30, 1915
U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
UNITED STATES
JUNE 30, 1915
GRAVITY STATIONS
ROUTES OF GEODETIC SPIRIT LEVELING
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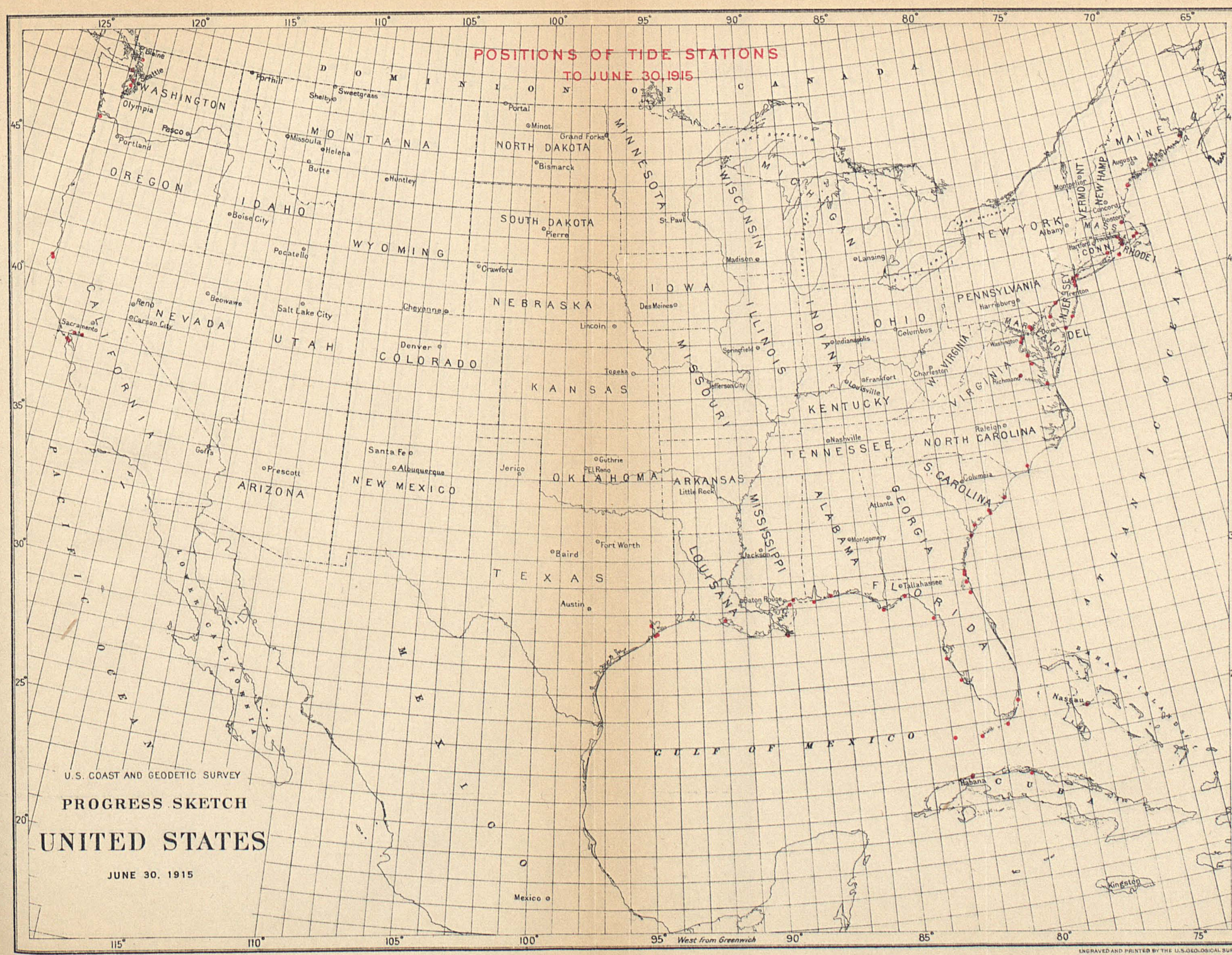

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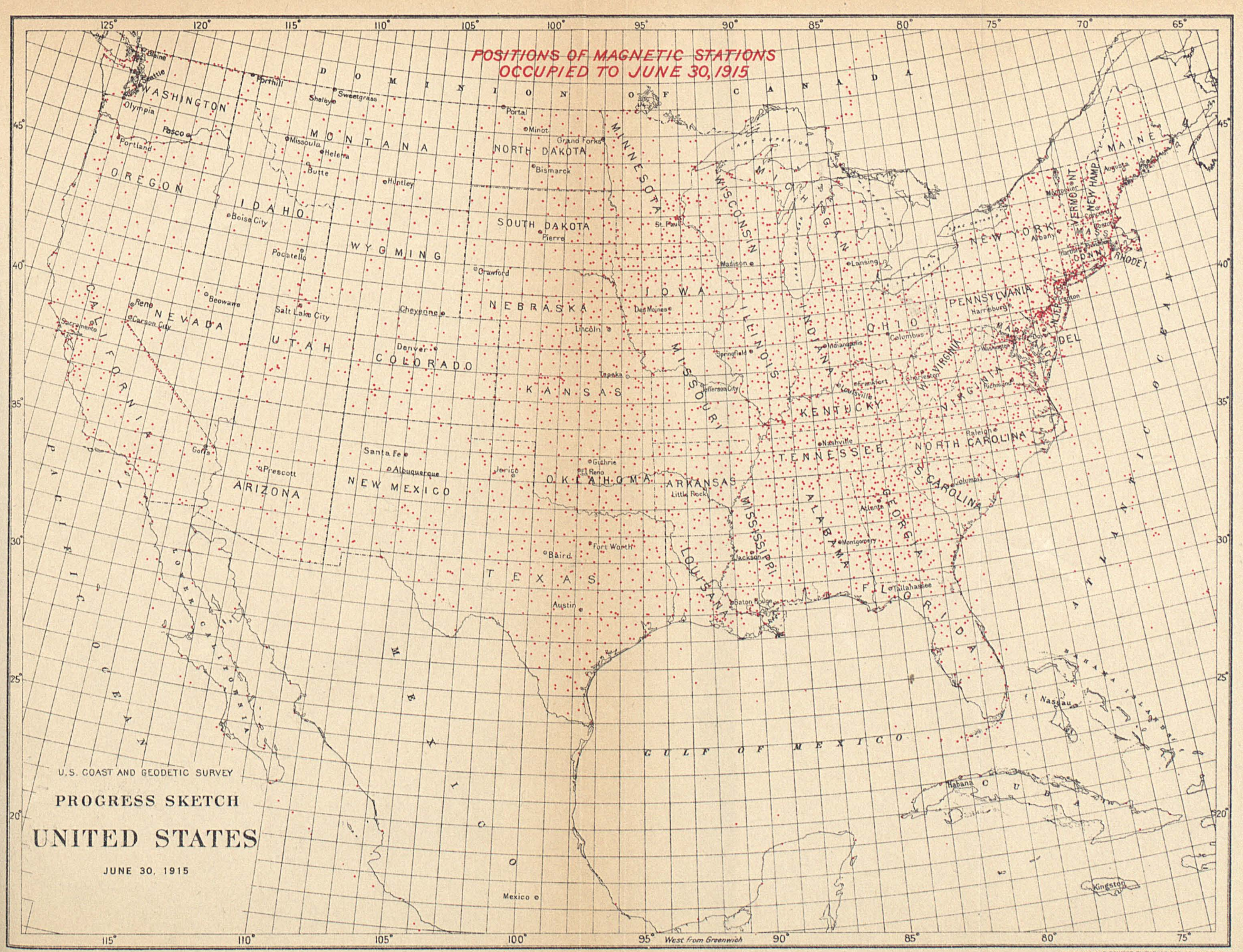

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IOWA, MINNESOTA, AND NEBRASKA.

[H. E. McCOMB.]

STATIONS OCCUPIED.—*Iowa:* Sioux City. *Minnesota:* Baudette, Bemidji, International Falls, Warroad ,and Willmar. *Nebraska:* Lincoln.

The stations in the list given above were occupied for magnetic declination during the month of June, 1915. A station was also occupied at Buffalo Point, Manitoba, and at monuments 899 and 877 on the international boundary.

Old stations were reoccupied at Lincoln, Nebr., Sioux City, Iowa, Willmar, Minn., and Bemidji, Minn. The stations at International Falls, Baudette, and Warroad were marked with cement posts. Buffalo Point and monument 899 were not marked.

ARIZONA.

[A. F. BEAL, FRANK NEUMANN, FRANKLIN P. ULRICH.]

The work of the Tucson magnetic observatory was continued throughout the year. The magnetograph and seismograph were kept in continuous operation except for a few short breaks in the record of the horizontal intensity variometer. Absolute observations of declination, dip, and horizontal intensity were made twice a week, the hourly ordinates were scaled from the magnetograms, and the base-line values were computed. Meteorological observations were made daily and the results reported to the local office of the Weather Bureau.

The magnetic storm beginning June 16 was the largest recorded since the establishment of the observatory in 1909. The number of earthquakes recorded during the year was 39.

PORTO RICO.

[HAROLD W. PEASE.]

At the magnetic observatory at Vieques, P. R., the magnetograph and seismograph were kept in operation with slight interruptions throughout the year.

Absolute observations were made twice each week, a double set of horizontal intensity, a set of dip observations, and two sets of declinations comprising the day's work. Scale-value observations were made at least once each month. Time observations were made about once in 10 days.

Few earthquakes were recorded during the year and these were of small intensity.

ALASKA.

[L. O. COLBERT.]

SUMMARY OF RESULTS.—Triangulation: 20 signal poles erected, 5 old triangulation stations recovered. Leveling: 1 mile of levels run, 6 permanent bench marks established. Topography: 7½ miles of general coast line surveyed, 1 topographic sheet partly finished, scale 1:20,000. Hydrography: 34 square miles

of area covered, 104.4 miles run while dragging, 3,504 angles measured, 52 soundings made, 2 tide stations established, 8 current stations occupied, 2 hydrographic sheets partly finished, scales 1:20,000 and 1:40,000.

Wire-drag work in Sumner Strait, Alaska, was begun May 19, 1915. The plan adopted was to begin in the latitude of Bluff Island and work northward, including the investigation of a spot on the west side of the strait off Point Amelius where a depth of 8 fathoms was shown on the chart. A dangerous pinnacle rock was located in the fairway between Calder Rocks and Barrier Rocks which is used by all vessels stopping at ports on the west coast of Prince of Wales Island and by the regular passenger boats when calling at Shakan cannery. There is but 15 feet over this rock at extreme low tides. In the vicinity of the 8-fathom sounding, on the west-central side of the strait, a pinnacle with 25 feet at extreme low waters was found, rising sharply from depths of 27 and 30 fathoms. In the entrance to Shakan Bay nine uncharted shoals were discovered, with least depths ranging from 24 to 54 feet.

The area completed to June 30 is as follows: First, an area covering 7 square miles, three miles southeast of Point Amelius, vicinity of the 8-fathom sounding on chart 8200, on the west side of Sumner Strait. Second, an area covering 7 square miles extending off the east side of the strait to longitude 133° 43′ and including a strip off the west side of Calder Rocks. The southern limit of this area is at latitude 56° 07′, about one-half mile north of Bluff Island, and the northern limit is at latitude 56° 21′ just south of Point Baker. All of this area was dragged to an effective depth of 50 feet, except that inside the entrance to Shakan Bay, which was dragged to a depth of 40 feet.

As control for the drag work five old triangulation stations established in 1886 were recovered and used. Twenty-six new signals were built and located. A topographic sheet was made in order to locate certain signals and to determine the true position of Barrier Islands. The charted position of these islands had been reported to be in error.

An automatic tide gauge was established in Port Protection on May 28 and kept in continuous operation. A tide staff was set in the entrance to Shakan Bay and connected with the automatic gauge by comparative readings. On June 28, during the spring tidal flow, the direction and velocity of the currents in this part of Sumner Strait were observed.

Photographic views were obtained of the wreck of the steamer *Delhi* in Sumner Strait. This steamer went ashore on the south end of Strait Island in January, 1915. The cause of the wreck is commonly attributed to the strong and swirling currents in Sumner Strait which put the vessel off her course, and to the thick weather which shut out the land.

[JOHN A. DANIELS.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 67 statute miles, area 203 square miles, 36 points selected for scheme. Triangulation: 192 square miles of area covered, 54 signal poles erected, 35 stations in main scheme occupied for horizontal measures, 76 geographic positions determined. Leveling: 7 permanent bench marks established. Topography: 32½ miles of

general coast line run, 1 topographic sheet partly finished, scale 1:20,000. Hydrography: 165 square miles of area dragged, 349 miles run while dragging, 2,910 angles measured, 227 soundings made, 3 tide stations established, 5 hydrographic sheets finished, scales 1:10,000, 1:20,000, and 1:40,000.

The party organized in June for wire-drag work in southeastern Alaska arrived at Ketchikan early in July with the chartered launches *Chehalis*, *Arnold*, and *Viking*. The preparation and assembling of the wire-drag apparatus was completed and work with the drag was begun by July 18. The necessary signals had previously been erected in Tongass Narrows northward of Ketchikan where the first work was done.

A tide gauge was established at the cannery dock in Ward Cove and tides were observed there whenever work was being done northwestward of Ketchikan.

On August 22 instructions were received to continue work to the southward and eastward for the remainder of the season. Accordingly, a tide gauge was established at Hassler Harbor on Annette Island. The old tidal bench marks at that place were also recovered. Hassler Harbor proved to have excellent holding ground and safe shelter from southeasterly gales.

In Revillagigedo Channel between Spire Island and Mary Island the shore line shown on the charts was found to be considerably in error, especially off the entrance to Thorne Arm. A projection was made and the shore line was partly rerun.

Between October 6 and 9 a wire-drag examination was made of Metlakatla Harbor and its approaches. Work was closed for the season on October 10.

The triangulation in Tongass Narrows consisted only in the recovery and reoccupation of stations for the location of signals. All stations recovered were re-marked where found in bad condition. The magnetic station on Pennock Island was located and the new wireless towers recently erected northwest of Ketchikan were determined. Signals for use in Nichols Passage had been built and located by the party on the steamer *McArthur*.

In Revillagigedo Channel a small scheme of tertiary triangulation was carried from Mary Island to Mountain Point and Pennock Island, starting from a line of the 1914 triangulation in Felice Strait the main scheme was carried to Pennock Island and connected with the work brought through Nichols Passage, making a complete scheme of triangulation around Annette Island. It was also connected with the work of 1910 in Tongass Narrows.

The object of the hydrographic work done was to verify a clear depth of 45 feet below mean low water in all areas where that depth was charted and to verify all soundings of less depth within the area examined in the probable path of navigation.

In Tongass Narrows from Guard Island to Mountain Point, including the south channel, the examination was very thorough, much care being taken to locate any points protruding from the shore to a less depth than charted. Throughout this area the drag boats ran to within a few feet of the kelp line on each side of the channel.

In Nichols Passage the unusually strong tides in the neighborhood of Walden Rocks made the survey difficult. As in Tongass Narrows the work was carried close to the shore, and care was taken to locate

rocks near the beach. The area dragged extends to a line about 2½ nautical miles south of Walden Rocks.

In Revillagigedo Channel the shore line was not approached so closely as in the narrower channels, the object being more to insure the safety of the main fairways rather than to locate rocks near the beach line. In this region the area was covered more rapidly than in Tongass Narrows. It was demonstrated here that very rapid progress can be made in wide channels, generally clear, but with occasional pinnacle rocks. In this channel the work was extended to a line from Twin Islands to Alava Point, including the passage north of Bold Island and Thorne Arm for a distance of about 2½ nautical miles.

The survey in Port Chester was to verify shoal soundings near the entrance to the harbor discovered by the party on the steamer *McArthur* in the progress of a regular hydrographic survey. A thorough examination of the harbor and entrance was made, the examined area extending from abreast Cedar Point to within half a mile of Driest Point and east of Warbuton Island and Kelp Rocks buoy. The entire survey was made in four working days.

The experience gained in this season shows that kelp is not a serious obstacle to wire-drag work, but the drag can not be towed over kelp against the tidal current.

In Tongass Narrows two new wharves in Ward Cove and three uncharted wharves at Ketchikan were located. In Revillagigedo Channel the shore line was carefully sketched in and one day's work with the plane table was done near the entrance to Thorne Arm.

Two tide stations were established, one at Ward Cove and the other at Hassler Harbor, and observations were made on staff gauges. Automatic gauges were maintained during the season at Ketchikan and Metlakatla. At the latter place 10-minute observations were taken upon the staff during the hours when work was being done.

During the season 21 dangers were discovered of importance to navigators in Tongass Narrows, Nichols Passage, Revillagigedo Channel, and Port Chester. Of these the most important were a 7-foot pinnacle rock off Vallenar Point, in Tongass Narrows; a 19-foot pinnacle rock near the north shore; a 3-foot pinnacle rock near East Clump Light; a 26-foot pinnacle rock near the New England Fish Co.'s dock. In Revillagigedo Channel a 13-foot pinnacle rock near Spire Island Light; a 5-foot rocky patch in same locality; a 26-foot rocky patch in the entrance to Hassler Harbor; a 15-foot pinnacle rock in the same locality; a 17-foot pinnacle rock near the entrance to Thorne Arm; and a sounding of 26 feet off Hog Rocks. In Port Chester a 10½-foot sounding on shoal near Kelp Rocks Buoy discovered by steamer *McArthur*.

Wire-drag work was resumed May 12, 1915, in Revillagigedo Channel southeast of Ketchikan from the limits of the 1914 work to the British Columbia boundary line. A tide gauge was established at Hassler Harbor and later on one at Kah Shakes Cove in the entrance to Boca de Quadra.

From May 11 to the end of the fiscal year dragging was in progress whenever the weather permitted. On June 21 reconnoissance and signal building were begun in Clarence Strait.

The triangulation done consisted in subsidiary work only, the main scheme stations being all recovered. The positions of lights on Lord Rocks, Mary Island, and Tree Point were determined and other points were located for control of the hydrography. Reconnoissance and signal building in Clarence Strait were carried from Guard Island to Point Lemesurier.

The topography covers the entrance to Boca de Quadra and the shore line in Revillagigedo Channel from this entrance to Foggy Bay. A reconnoissance of this locality showed almost no detail, and that a large inlet leading 3 or 4 miles back from Foggy Bay, and known as Very Bay was not included on the charts.

The hydrography consisted in sweeping with a wire drag all areas in the main ship channel between Twin Islands and Cape Fox and the entrance to Boca de Quadra. The exposed nature of this channel made work possible only in the best weather. A 10,000-foot drag proved satisfactory for the open work. Several rocks and rocky reefs were discovered, investigated or determined in position before the close of the fiscal year, but in general the area examined was found to be free from dangers.

[F. H. HARDY, Commanding Steamer *Gedney*.]

SUMMARY OF RESULTS.—Triangulation: 86.8 miles of area covered, 50 signal poles erected, 33 stations in main scheme occupied for horizontal measures, 6 stations occupied for vertical measures, 50 geographic positions determined. Leveling: ½ mile of levels run; 18 permanent bench marks established. Magnetic work: 2 land stations occupied for observations of magnetic declination. Topography: 165.2 square miles of area surveyed, 277.1 miles of general coast line surveyed, 2 miles of shore line of creeks surveyed, 5 topographic sheets finished and 2 partly finished, scales 1:10,000 and 1:20,000. Hydrography: 82.2 square miles of area covered, 1,192.7 miles run while sounding, 10,988 angles measured, 14,894 soundings made, 5 tide stations established, 6 hydrographic sheets finished and 2 partly finished; scales 1:10,000 and 1:20,000.

Progress made in the surveys of the main ship channels on the west coast of Prince of Wales Island, Alaska, prior to July 1, 1914, is mentioned in the last annual report.

At the beginning of the fiscal year the general survey of Trocadero Bay and Klawak Inlet was in progress.

The triangulation of Trocadero Bay was completed prior to the beginning of the fiscal year. The topography of the whole of Trocadero Bay was completed August 8. The hydrography of the bay was done with the *Cosmos* and launch *No. 117*, and was completed August 22. The main channels to the Copper Mine were dragged and a careful development was made of suspicious soundings. The average number of soundings per square mile was 98, and 8.5 square miles were gone over with a wire drag. The soundings were reduced from readings on the tide gauge at Craig.

A small hydrographic sheet was made southward of Craig and joining the work done in Trocadero Bay, and a close survey made of this locality where it is rumored that a wharf will be built.

The triangulation of Meares Passage was done by a detached party on the *Cosmos* and was completed August 21. The work extends from the triangulation by E. F. Dickins in 1907 in Ulloa Channel to Divers Island. The topography of this section is shown on one sheet on scale of 1:20,000. The work extends from Juel Point on

the southeast to the limits of the sheet on the northwest. This work was done chiefly by a detached party on the *Cosmos* between August 14 and September 4. The hydrography of this area was done by the *Cosmos* and launch *No. 117*, and is shown on one sheet completed between August 26 and September 7. Outside of the limits of this work are numerous places where breakers occur in heavy weather and which could not be examined in the time available.

The topography of Sukkwan Strait was done on one sheet, scale 1:10,000, between September 11 and 15, and joins the topography in Hetta Inlet with that in Sukkwan Narrows. The hydrography done with launch *No. 117* between September 12 and September 17 also joins previous work in Hetta Inlet with that in Sukkwan Narrows. The sounding lines were spaced about 200 meters apart, being closer at the western end.

The hydrography of the western approach to Sukkwan Strait was done between September 13 and September 18 by the *Cosmos* and launch *No. 117*. This sheet connects the work in Sukkwan Strait with that in Tlevak Strait. The work was not carried south of Corlies Islands nor eastward into the north pass of Sukkwan Strait. Sounding lines were spaced about 200 meters apart. Several shoals were found and thoroughly developed.

The topography of Revillagigedo Channel from Cone Point to Safety Cove was done while the *Gedney* was undergoing repairs at Ketchikan as the result of damage done by the steam whaler *Star III*.

A wire drag was fitted up on board the *Gedney* to supplement the work done by the sounding parties. Launches *No. 117* and *No. 27* were used to tow the drag.

The work assigned to the *Gedney* of surveying the main ship channels on the west coast of Prince of Wales Island, the development and marking of a good inside channel from Tonowek Bay to Sea Otter Sound, and the survey of Meares Pass, an approach from the sea, was completed during the season which closed September 30.

The commanding officer of the *Gedney* recommends that this region be thoroughly examined with the wire drag. The following is quoted from his report:

> From my one year's experience in this vicinity I doubt if there is any body of water which requires to be gone over with a wire drag more than these narrow channels. To get good contours of the bottom with the hand lead alone is more difficult and unsatisfactory than the development of the sky line of New York or any large city would be if made by dropping a lead from an air vessel, which might possibly land on a church steeple, but most likely would give no indication of its existence. It was my endeavor to keep the quality of the work done this year up to the high standard of the work previously done in this vicinity but even with a very close system of lines and development of all indications, there undoubtedly exist some dangers which have not been located, and their presence can only be located by the use of the wire drag.

The *Gedney* left Seattle April 29 to resume work in Alaska, arriving at Ketchikan May 3 and at Metlakatla May 4. At the latter place repairs were made to the launch *Cosmos* and boats.

Field work was begun May 15 on the topography of Ulloa Channel which was completed from the limits of the work of the *Gedney* in 1913 to a junction with the work of the same vessel in 1914. This completes the topography along the main ship channels on the west coast of Prince of Wales Island.

The triangulation was extended from the line Baptiste-Floris of 1907 to Cape Bartolome and Cape Felix. The reconnoissance in Bucareli Bay to locate signals for the determination of Capes Lookout and Augustine, Forrester Island, and Wolf Rock was completed. Many intersection stations were computed for the control of the topography.

Besides the work previously mentioned, the topography of the eastern shore of Bucareli Bay from that of the previous season to Cape Felix (with the exception of Port Dolores), a small piece of shore around Cape Cocos (Ignace Island), and the whole western shore of Bucareli Bay from Copones Bay south to Cape Bartolome (with the exception of Port San Antonio) has been completed. There remained at the end of June only about 2¼ miles of shore line to join this work with that of the previous season in Meares Passage.

The hydrography of Bucareli Bay was completed from about 1 mile south of the work by the *Gedney* during the previous season to a line nearly due west of the southern entrance of Port Santa Cruz and San Antonio. The inshore hydrography approximately out to the 100-fathom curve was developed by lines spaced 150 meters apart, with soundings not exceeding 150 meters apart and in most cases much less. Between the 100-fathom curves on each side of the bay the maximum distance between lines and soundings was 300 meters, with closer development where shoals were found. Below Point Arboleda the lines and soundings were spaced not more than 250 meters apart with closer development over shoals. The entrance and bay of Port Asumcion was developed with lines and soundings not more than 100 meters apart, and closer where there were shoal indications.

[C. G. QUILLIAN, Commanding Steamer *McArthur*.]

SUMMARY OF RESULTS.—Triangulation: 211 square miles of area covered, 34 signal poles erected, 18 stations occupied for horizontal measures, 64 geographic positions determined, 13 old triangulation stations (main scheme) recovered, 16 intersection stations recovered. Magnetic work: 2 land stations occupied for magnetic declination, 1 sea station at which ship was completely swung. Topography: 104.7 square miles of area surveyed, 177 miles of general coast line surveyed, 3 miles of shore line of creeks surveyed, 13 miles of shore line of ponds surveyed, 3 topographic sheets finished, 3 topographic sheets begun, scales 1:10,000 and 1:20,000. Hydrography: 190.2 square miles of area covered, 1,163.8 miles run while sounding, 8,990 angles measured, 15,355 soundings made, 4 tide stations established, 7 current stations occupied, 4 hydrographic sheets finished and 3 hydrographic sheets begun, scales 1:10,000, 1:20,000, and 1:40,000.

The survey of Nichols Passage and Felice Strait, southeastern Alaska, by the party on the steamer *McArthur* was in progress at the beginning of the fiscal year.

After June 30 the triangulation was extended into Felice Strait, but weather conditions so delayed work that the observations were not completed until August 15.

The triangulation in Felice Strait began on the line Ken to Lazaro (1912), and extended through five quadrilaterals to the line Ham to S. Twin (1895).

Signals at Ken and Lazaro were standing and tide marks at Ham and S. Twin were recovered. Station Ken is at an elevation of 1,200 feet, Lazaro 1,700 feet, Round 2,600 feet, and the other stations are near tidewater. The line Ken to Round is 25.8 miles in length, and

Ken to Lazaro is 25.2 miles in length. In this scheme 13 triangulation stations were occupied. This scheme covered 197.7 square miles.

The topographic work of the season covers the east shore of Gravina Island from Gravina Point to Dall Head, the west and south shores of Annette Island from Walden Point to Indian Rock, Hotspur Island, and the greater part of Percy Islands. The work done after June 30 is included on three topographic sheets on a scale of 1:20,000.

Before July 1 sounding had been completed in Port Chester and the greater part of Blank Inlet, and the sounding extended into Nichols Passage from Walden Rocks to Bostwick Inlet.

Hydrographic work was continued after June 30 throughout Nichols Passage, around Port Davidson, and along the northern side of Felice Strait to Indian Rock. Soundings were spaced over the entire area with an average of 93 soundings to the square mile. Depths varied from 265 fathoms to shoal soundings inshore. The launch *Delta* with a Cosmos hand-sounding machine was used in depths up to 100 fathoms.

In Felice Strait particular attention was given to the channel between Annette Island on the northern side and Ajax Reef, Wallace Reef and Snipe Island on the southern side, and finally the channel was swept with a wire drag to assure a depth of 22 feet at low water.

Ship hydrography covered the approach to Nichols Passage and Felice Strait. Soundings are deep and widely scattered.

Automatic tide gauges were maintained during the season at Ketchikan and Metlakatla and staff readings were taken at Hotspur Island.

Magnetic observations with compass declinometer were made at five triangulation stations. Current observations were made in Port Chester, off the north end of Hotspur Island and off the southeast end of Annette Island. The current station at Hotspur Island was a little inshore of the strongest current. The ebb current on the spring tides runs from 3 to 4 knots off Harris Island and 3 to 5 knots between Snipe Island and Annette Point.

Wire-drag work was done in the ship channel in Felice Strait and off Point Davidson. In Felice Strait the drag set to an effective depth of 22 feet was taken through the ship channel south of Annette Island and beyond Indian Rock.

Off Point Davidson a shoal with 45 feet was found where previous soundings showed 13 fathoms.

In November an investigation was made of a reported danger off River Point, Portland Canal, Alaska. In the fall of 1913 the master of the cannery tender *Hidden Inlet* reported that some years before while fishing off River Point, Portland Canal, about mid-channel, a fish line grounded at about 4 fathoms and that he considered the place to be very near the 112-fathom sounding shown on the chart between River Point and White Point.

Signals were erected and determined in position, a tide staff erected and connected by leveling with a permanent bench mark erected for the purpose, and tides were observed hourly during the day from November 2 to November 6.

In order to establish with certainty the existence or nonexistence of the reported danger the channel was dragged with a long wire. A

section of 1,800 feet of drag, with two large end buoys and 165-pound weights, and 4 small buoys with 20-pound weights together with the necessary uprights, towing bridles, etc., was obtained for the purpose. This drag was set at the maximum depth, nearly 63 feet, and was towed through the channel for a distance of 1 mile on either side of the position of the reported danger without encountering any obstacle. The greatest range of tide was 18 feet and the drag proved that there was no danger at a depth of 40 feet below the lowest water. The drag passed to within 218 yards of River Point, and on the Canadian side the drag was towed to within 100 yards of the beach between Raw Point and White Cliff.

On one line soundings were taken with Cosmos machine with a Basnett tube attached while the vessel was going ahead slowly towing the drag. In no case was there less than 100 fathoms.

The *McArthur* sailed from Seattle to resume work on the coast of Alaska on May 15, arriving at Metlakatla May 21. The next day the launch *Delta* was put in the water and towed to Ketchikan. The *Delta* was overhauled and repaired and a new boiler put in. An automatic tide gauge was erected in the meanwhile on the lighthouse dock at Ketchikan. On July 1 the party proceeded to Ryus Bay and began signal building and general surveying work.

On June 8 two steam sounding engines, ordered for the Cosmos sounding machines, were received and their installation was at once begun.

The regular type of Cosmos machine was provided with a rope-drive pulley secured to the same shaft as the wire drum. A friction brake was secured to the framework and to brake against the inner rim of the wire drum. The frame of the Cosmos machine was bolted to an iron plate bedded against a 2-inch board. A three-cylinder, self-contained, Ingersoll-Rand steam engine, with a rope-drive pulley on shaft, was bolted to the same bed. A heavy idling wheel on a swing arm gives the tension to the rope drive. On the ship the machine is mounted abreast the bridge on the port side, and the sounding wire leads from the drum through the sheave on the weighted end of a long arm. The tension of the lead on the arm holds the same out of vertical, and the arm swinging to a vertical position when the lead strikes bottom takes up the slack line until the brake is applied. The wire leads from the arm mentioned over a Ballauf registering sheave mounted on the ship's bridge, and thence over a fair-lead at the end of a pipe davit to the water.

The method of applying the power on the launch *Delta* was similar to that on the ship.

The use of steam power on the sounding machine resulted in a considerable saving in time and labor.

By June 30 the hydrography had been practically completed in Sealed Passage and up to Ryus Bay in Felice Strait. The greater part of the offshore work intended to be done was completed. Submarine sentry lines were run in going to and returning from work.

Soundings made in the reported position of Hassler Reef failed to indicate the existence of such a danger in that locality.

The survey of the shore line of the Percy Islands and of Duke Island from Ryus Bay to about 3 miles south of Point White was completed. The greater part of the Percy Islands already surveyed

was retraversed in locating signals for the hydrographic party. A topographic survey of Ryus Bay was made on a scale of 1:10,000 and the topography extended from Ryus Bay to Dog Bay.

Only such triangulation stations were occupied as was necessary for the location of signals for the hydrography and topography. Tide observations with automatic gauge were made at Ketchikan and staff gauge readings were made at Ryus Bay. Compass declinometer observations were made at Seattle and Ketchikan. The ship was swung at Seattle and at other points on the way north.

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

SUMMARY OF RESULTS.—Triangulation: 129 square miles of area covered, 15 signal poles erected, 26 stations occupied for horizontal measures, 40 geographic positions determined. Magnetic work: 7 land stations occupied for magnetic declination. Topography: 41 square miles of area surveyed, 54 miles of general coast line surveyed, 10 miles of creeks and sloughs surveyed, 6 topographic sheets finished, scales 1:10,000 and 1:20,000. Hydrography: 44 square miles of area covered, 376 miles run while sounding, 2,698 angles measured, 5,690 soundings made, 1 tide station established, 5 hydrographic sheets finished, scales 1:10,000 and 1:20,000.

At the beginning of the fiscal year the party on the steamer *Taku* was engaged in general surveys in the region of Passage Canal, Alaska. Upon the completion of that work on August 7 the general survey of Landlocked Bay was taken up and continued until the close of the season on September 23.

The triangulation of Passage Canal had been completed in the previous June, and tide observations with an automatic gauge were being recorded at a station in Passage Bay. A base line had been measured across the flats at the head of Passage Canal and connected with the triangulation.

After July 1 magnetic declination was observed at 6 triangulation stations in Passage Canal and Landlocked Bay, and at the magnetic station in Seward Park, Bailey Peninsula, Lake Washington, Wash.

The topography of Passage Canal was done on three sheets on a scale of 1:10,000, and joins topography executed by the party on the *Taku* in 1913. A fourth sheet covers the north end of Culross Island, connecting with the work of 1912 and also the point of the mainland west of Culross Passage.

The contour interval on these sheets is 10 feet to the 40-foot contour, and 100 feet above this elevation. In general, the timber line in the canal is at an elevtion of about 600 feet. The shore line in the canal in general is rocky and steep, with few outlying dangers.

The hydrographic work is covered by three sheets. Sheet "A" covers the area between the survey of 1913 off Esther and Culross Islands, across the lower end of Port Wells, into the entrance of Passage Canal to Point Decision. Sheet "B" covers Passage Canal from Point Decision to connect with the hydrography executed in 1913 at Billings Delta. Sheet "C" covers the upper end of the Canal, and supplements the work of 1913 along the south shore, at the head, and over the shoal between stations Ped and Saw.

Passage Canal, together with its approach, Perry Island Passage and the south end of Port Wells, is a beautiful stretch of water, ranging in depth from 100 to 200 fathoms and in width from 1 to 2 miles.

The shores bordering these waters are steep with practically no outlying rocks, reefs, or hidden dangers of any kind. The land rises directly from the water to an elevation of 2,000 to 3,000 feet. These characteristics together with its lack of any strong surface currents, due to its great depth and broad expanse, render it an ideal channel for purposes of navigation.

An automatic tide gauge was installed on W. A. Dicky's wharf near the head of Landlocked Bay and a continuous record obtained from August 11 to September 25.

The triangulation was carried to the head of Landlocked Bay from the line Pine-Fido. It was not practicable to use an old station on Copper Mountain Point. The only station found was on the Boulder Bay side of the point. While the triangulation was being carried into Landlocked Bay a scheme was taken up Port Fidalgo to Irish Cove. Two triangulation stations at the entrance to Landlocked Bay were occupied for observations of magnetic declination.

The topography of Landlocked Bay, on a scale of 1:20,000, covers the shore line from Copper Mountain Point into Landlocked Bay and around the point at the entrance to Port Fidalgo. The contour interval is 100 feet. The shore included in the limits of the sheet is variable, in places steep-to and in others gradually receding, with off-lying rocks and islands.

The hydrographic work was done on a scale of 1:20,000 and covers the area included between a line from Bidarka or Copper Mountain Point to the west point at the entrance to Port Fidalgo and all the shores bordering on Landlocked Bay.

The main bay from Copper Mountain Point to the head of the narrow arm is clear except for a shoal in mid-channel at the entrance to the Narrows on which the Lighthouse Service maintains a buoy. This shoal was closely developed and a least depth of 2½ fathoms found.

The head of the bay back of the small islands is very shoāl, generally bare at extreme low water. This area was sounded over.

The shores from the Narrows to the point at the entrance to Port Fidalgo is very foul, with off-lying rocks, reefs, and small islands. This area was sounded over, but no drag work was done.

This bay varies in depth from 50 fathoms in the outer bay to 10 fathoms off Dicky's dock, gradually shoaling from the greater to the less depth. Good anchorage in 15 fathoms, mud bottom, is found in the broader part of the bay about halfway between the Narrows and the head.

The party for the steamer *T'aku* left Seattle on April 24 on the steamer *Alameda* to resume field operations in Alaska, arriving at Cordova, April 29. Work was at once begun of preparing the *T'aku* for service, on repairs and installation of the boiler and engines, and painting the vessel, which occupied the time until June 3. On May 28 while the vessel was beached at Orca for painting and cleaning bottom, a local survey was made at Orca, locating the new dock at that place, and a few sounding lines were run in that vicinity. On June 4 work was begun in Comfort Cove, Port Gravina, where a camp was established for the topographic party, and an automatic tide gauge was installed and put in operation. Signal building for the survey of Port Gravina was begun June 5 and completed June 25.

Plane-table work was begun June 17 and hydrography on June 16 and were in progress at the close of the fiscal year. The triangulation in this locality had been executed in 1913.

[R. S. PATTON, Commanding Steamer *Explorer*.]

SUMMARY OF RESULTS.—Base lines: 1 secondary, 1,852.9 meters in length. Triangulation: 74.1 square miles of area covered, 20 signal poles erected, 12 stations occupied for horizontal measures, 14 geographic positions determined. Leveling: 3 miles of levels run, 12 permanent bench marks established. Magnetic work: Ship completely swung at 1 station at sea. Topography: 35 square miles of area surveyed, 68¼ miles of general coast line surveyed, 10 miles of shore line of creeks surveyed, 1 topographic sheet finished, scale 1:40,000. Hydrography: 1,184 square miles of area covered, 1,925 miles run while sounding, 5,097 angles measured, 21,981 soundings made, 6 tide stations established, 5 topographic sheets finished, scales 1:5,000, 1:40,000 and 1:80,000.

At the beginning of the fiscal year the steamer *Explorer* was engaged in the survey of Knik Arm, Cook Inlet, Alaska, having previously completed the survey of Excursion Inlet and Icy Passage, the hydrography of Glacier Bay, the location of wharves and cannery buildings at Hoonah and Idaho Inlet, and determined the position of a submerged rock in South Inian Pass.

On arrival at Knik Arm it was found that the Alaskan Engineering Commission had just landed at Ship Creek, where they were to make their headquarters for the summer. The parties cooperated in making simultaneous tide observations at Cairn Point and Knik to enable the commission to obtain an approximate half-tide level from which to start lines of level into the interior. The party on the *Explorer* also assisted the commission in making a detailed cross section off the mouth of Ship Creek, in order to determine the amount of dredging necessary to construct a basin at that point. In this work the sounding was done by the *Explorer*.

During the early portion of this work the shoals in the channel off Fire Island were located. The masters of vessels calling at Ship Creek were at once notified of the positions of these shoals, thus enabling them to pass through in safety. Two of these vessels had previously grounded in this vicinity.

On the night of July 22 the *Explorer* rendered assistance to the steamer *Bertha* which was anchored at Ship Creek for use as a floating wharf. In a fresh wind and heavy current the *Bertha* began to drag and was being carried in toward the beach. Members of the crew of the *Explorer* aided the crew of the *Bertha* in getting up their anchor which because of lack of steam they were obliged to heave up by hand.

Some of the shore work in connection with this survey was exceedingly difficult. The head of the Arm was one vast mud flat, so that it was not feasible, because of the loss of time involved, to use boats for transportation in executing the triangulation and topography. The larger part of this work, therefore, had to be done on foot, working from a centrally located camp. The officers and men engaged in this work were compelled to make long marches through mud, marsh, or undergrowth, tormented by myriads of mosquitoes, and worked at any hour of the day or night when the tide served. In topography, particularly, where it was impracticable to drive them away by means of smudges, the mosquitoes proved such a torment

that the use of the plane table was abandoned and the shore line was run in with the sextant. Signals were located by triangulation or plane table along the east side of the Arm all the way up to its head and these signals were subsequently used for sextant positions in running in the marsh at the head of the Arm and on the west side.

The work in Cook Inlet was completed on August 17 and on the same day the ship left for Prince William Sound, stopping en route at Port Graham for coal and at Seldovia to investigate a reported shoaling in the harbor there.

The work in Prince William Sound consisted of the hydrography in the open area north of Montague Island and between Hinchinbrook and Smith Island; an examination of the bar between Culross and Esther Island; and the hydrography between Perry and Lone Islands.

On the principal work in this locality, namely, the hydrography north of Montague Island and between Hinchinbrook and Smith Islands, it was possible to work only with the ship. On the few days when work was possible sounding was continued without interruption from daylight, or shortly after, until dark. The work was discontinued on September 28. On the return voyage the vessel stopped at Juneau where the automatic tide gauge installed on the dock of the Pacific Coast Steamship Co. was thoroughly overhauled and a new gauge installed. A hydrographic examination was also made of the edge of the shoal flat off the mouth of Sheep Creek.

The *Explorer* sailed from Seattle for Alaska May 29, 1915. Arriving at Juneau on June 3 an inspection was made of the automatic tide gauge there. The *Explorer* then proceeded to Seward arriving on June 6. Here a supply of coal was taken on board and the vessel proceeded on her voyage, arriving at Port Chatham about the center of the proposed field of operations on June 8.

At Port Chatham an automatic tide gauge was set up and immediately thereafter the work of reconnoisance, signal building, and hydrography was begun. For the offshore soundings various mountain peaks, determined by triangulation in previous years, were used as signals, and by June 30 the greater portion from Point Gore to the Barren Islands had been completed. These soundings were taken with Basnett tubes, an up and down cast being taken every fifth sounding in order to furnish a check on the accuracy of the tubes.

[J. B. MILLER, Commanding Steamer *Patterson*.]

SUMMARY OF RESULTS.—Triangulation: 1,914 square miles of area covered, 15 stations occupied for horizontal measures, 15 stations reoccupied, 42 signal poles erected, 12 stations occupied for vertical measures, 136 geographic positions determined, 48 elevations determined trigonometrically. Magnetic work: 3 sea stations occupied for magnetic variation, 1 land station occupied for magnetic observations, and 1 station reoccupied. Topography: 108 square miles of area surveyed, 135 miles of general shore line surveyed, 29 miles of rivers, creeks, and ponds surveyed, 5 topographic sheets finished. Hydrography: 795 square miles of area covered, 2,749 miles run while sounding, 16,798 soundings made, 4,439 angles measured, 2 automatic tide stations established, 4 tide staff stations occupied, 13 hydrographic sheets finished. Physical hydrography: 7 current stations occupied in 5 localities, 152 readings of current pole taken, 834 surface temperatures observed.

Progress made in general surveys in the Shumagin Islands and along the coast of the Alaska Peninsula by the party on board the steamer *Patterson* to June 30, 1914, is detailed in the last annual report.

Work was continued until the close of the season in October in the same region, the work along the Alaska Peninsula extending as far eastward as Chignik and as far westward as Unimak Pass. The chartered schooner *Hunter* furnished supplies to the camp parties on the Shumagin Islands throughout the season. The *Patterson* also made two voyages into Bering Sea to transport the party of the Coast and Geodetic Survey steamer *Yukon*, and one voyage to Attu Island to the relief of the revenue cutter *Tahoma*. On all of these voyages valuable hydrographic information was secured.

The survey of the Shumagin Islands was continued by the schooner *Hunter* with one officer and six men employed on triangulation and hydrography. One base camp was maintained with two officers and seven men employing a steam launch for hydrography, and two topographic parties were operated with two officers and seven men, using motor dories and fishing dories for transportation. A reconnoissance and triangulation party was placed on the mainland, consisting of one officer and three men using a sailing boat. There remained on board the ship four officers and 24 men, and the time of the vessel was divided about equally between the mainland coast adjoining the Shumagins early in the season, and later in the season, Unimak Pass and its southeastern approaches. The camp was visited once each month.

In the Shumagin Islands the triangulation was not extended much beyond the limits of the hydrography and topography. Three figures were completed to supplement the 1913 scheme, and many concluded points were located from new and old stations.

The topography of the most important part of Nagai Island, comprising the northwestern coast to the northern point, and of Andronica and Korovin Islands, the Haystacks, and the southern and southwestern coasts of Unga Island, was completed. The topography remains slightly in advance of the hydrography and it was not considered advisable to advance it farther. The work consisted entirely of plane-table traverses and the scale of 1:20,000 was used. The entire land area was covered to the limits of the sheets and all elevations were determined.

The hydrography covers nearly the same portion of the coast as the topography. The two most important harbors on Nagai Island were surveyed and the entire northwest coast to a connection with the work around Popof and Unga Islands. Both approaches to West Nagai Strait, Gorman Strait, and Karovin Strait, the most frequented passes in the Shumagins, were covered. The southern coast of Unga Island was included, thus providing for the seaward approaches. The survey was on a scale of 1:20,000. The work of this season is continuous at all points with the previous one. All shore lines were carefully developed, and enlarged plans of four harbors were made, and many banks, shoals, and pinnacles were carefully examined. For general development lines were run at one-eighth mile intervals to 20 fathoms, one-fourth mile to 50 fathoms, one-third mile to 75 fathoms, and one-half mile to 100 fathoms. There were

few depths greater than 100 fathoms and the ruling depth was 30 fathoms. The hand lead was used to 20 fathoms and vertical casts with wire at greater depths. The Basnett pressure tube was used successfully by the *Hunter* for a short time.

There are many islands and passages in the eastern portion of the Shumagin Group which could not be surveyed this season as the hydrography of this locality is slow and laborious. There is much broken ground and suspicious shoals are often met with; but this season's work, together with that of the previous season, covers all the waters commonly used, including an important portion of the track followed by all westward bound vessels which use the inside passage.

The ship met with much worse weather near Unimak Pass than in 1913. All of the volcanoes of the Alaska Peninsula were active and two violent eruptions occurred so that clear weather could scarcely be expected. Whenever it was necessary to go to Unalaska a delay was made eastward of Unimak Pass to await fair weather, and in September 10 days were spent there, at the most promising season of the year. In this manner several valuable lines of soundings were obtained, and the reported bank off Cape Sarichef was found and developed. The ship passed several times over the reported locality of Lenard Rock and secured more soundings there, confirming the results of the previous season. On three occasions it proved possible to carry the sounding line from the Shumagin Islands to Unimak Pass, once by the inside passage and once outside. Two lines of soundings were carried between Unimak Pass and Goodnews Bay. Thus, there are comprised in the season's work continuous lines of soundings from Goodnews Bay by way of Unimak Pass and the Shumagins to a point 90 miles northeastward of the Shumagins, a distance of 600 miles. The Bassnett and the Tanner-Blish pressure tubes were used on these lines, employing the usual precautions to verify the tubes, and the results were satisfactory.

During the early part of the season the scheme of triangulation was carried from the Shumagin Islands to the mainland by the ship's party, and was extended by a party from the ship along the coast of the peninsula to Kuiukta Bay. Here it rests at the entrance to a valley leading to Chignik and the coast beyond. Fifteen new stations were established, forming five figures. This scheme advances the Unalaska datum 90 miles along the coast of the Alaska Peninsula. The observing was done in accordance with the general instructions for tertiary triangulation, and the mean closure of the triangulation was four and one-half seconds. The stations are at elevations of 1,600 to 2,200 feet. Frequent concluded points were determined and marked on the ground, so that it is possible to proceed with the survey of this coast without further triangulation. Mountain peaks were determined as far as the crest of the Alaska Peninsula, which here is 5,000 to 8,000 feet high. Among these peaks is the active volcano of Veniaminof, 8,000 feet high.

A reconnoissance was carried along with the triangulation depending upon theodolite and sextant angles, which shows the shore line and soundings on the usual vessel tracks on the scale of 1:100,000. The result is ample for all ordinary needs of navigation. Two harbors in this region were also surveyed with the plane table, and one

of them was partly developed by soundings. It is called Kupreanof Harbor, and is far the best harbor in all respects which exists in the whole region. A tide station and a magnetic station were established on it. Several important corrections were discovered here which will assist in the navigation of the inside passage.

Two voyages were made to Goodnews Bay and return. This took the ship a distance of 350 miles from Unalaska and 600 miles from the Shumagin Islands. The officers of the Coast and Geodetic Survey schooner *Yukon* were transported to Goodnews Bay at the beginning of the season, and assistance was given in placing the *Yukon* in commission. At the end of the season the officers and crew of the *Yukon* were transported to Unalaska. Two lines of soundings were made between Unimak Pass and Goodnews Bay.

The *Patterson* made a voyage of 800 miles and return in response to urgent distress calls from the revenue cutter *Tahoma* wrecked near Attu Island. This voyage occurred between September 20 and October 3. A portion of the wrecked crew, 29 in number, were rescued, the others having been saved by another vessel. Much rough weather was experienced on this trip. A complete report of the incident was made and is here given.

[Copy.]

A REPORT ON THE VOYAGE OF THE COAST AND GEODETIC SURVEY STEAMER "PATTERSON" FROM UNALASKA TO ATTU ISLAND, ALEUTIAN ISLANDS, TO THE RELIEF OF THE WRECKED REVENUE CUTTER "TAHOMA," SEPTEMBER 22 TO OCTOBER 3, 1914.

I have the honor to report as follows on the rescue of survivors of the United States revenue cutter *Tahoma*, wrecked on a reef near Attu Island, Aleutian Islands, on September 20, 1914. There were 87 persons on board the *Tahoma*, and of this number 58 were found by the steamship *Cordova* and 29 were found by the *Patterson*. One boat had been four days and nights at sea when found, and the others had been three days and nights at sea and three days on the uninhabited islands of Agattu and Semichi. All the boats had traveled 100 to 150 miles in rough weather.

On September 20 the revenue cutter *Tahoma* was on her return from Attu Island, and at 9 p. m. of that day she struck on a reef 31 miles from the nearest land. At 11 p. m. of the same day her distress signals were received by the radio station at the Pribilof Islands, 600 miles distant from the wreck, and from there were received by the *Patterson*, which was 700 miles distant from the wreck. The *Patterson* was on her return from Goodnews Bay with the crew of the Coast and Geodetic Survey steamer *Yukon* on board and had reached shelter from a northwest gale a few hours before. On receiving the distress call the vessel started at once for Unalaska to take coal and discharge her passengers. The gale continued, and she arrived after 16 hours' steaming. She was coaled on the night of the 21st and started for the wreck at 5 a. m. on the morning of the 22d, 30 hours after the distress call was received. No other ships had started at that time.

The following ships also received the distress signal: The revenue cutter *Bear* was near Nome, 960 miles from the wreck, and her captain refused to give assistance on account of lack of coal and because he was then relieving the steamer *Corwin*, aground near Nome. The Japanese steamer *Tacoma* was supposed to be 400 miles from the wreck, but could not be reached by radio. The steamship *Senator* was near Unimak Pass, 1,000 miles from the wreck, and offered assistance, but was delayed by the northwest gale and later declined to go. The steamship *Cordova* was at Nome, 950 miles from the wreck, and offered assistance; she started at once, turned back once, and finally arrived at Kiska Island at the same time as the *Patterson* and proceeded to Agattu Island, near which place she found 4 boats containing 58 persons. The steam whaler *Kodiak* started from Unalaska 18 hours after the *Patterson* and arrived at the wreck at almost the same time.

The *Patterson* is not a seaworthy vessel. She is slow and underpowered and must depend to a great extent on her sails. All the other vessels mentioned above are faster; and although there was no doubt whatever that the situation called for every effort to be made to save the wrecked crew, it was expected that other relief would arrive sooner, and that it would then be possible to turn back. The weather proved unexpectedly favorable, however, with favorable winds, and the *Patterson* arrived at the wreck on September 26 at noon.

The *Tahoma* was found to have been abandoned; she lay partly on one side, with decks awash. The reef extended for about a mile on all sides, and was covered with thick kelp; on the shoalest part near the wreck were breakers, and the least depth is less than 2 fathoms; there are no rocks above water. There was a 16-foot swell at that time. I boarded the wreck, and found everything apparently a total loss; the ship was entirely filled with water to the upper deck. The weather was unusually clear, and Buldir Island could be seen 31 miles away; in ordinary weather no land can be seen.

A good lookout had been kept from the *Patterson* the previous night for Coston lights, and electric lights had been shown from the rigging, and the same was done the following night; during the day a lookout was kept from the foretop, bridge, and deck. The steamship *Cordova* had reported by radio that 4 boats with 58 persons had been found before dark on September 26, near Agattu Island, 80 miles northwest of the wreck; this arrangement had been made, that she should search there and the *Patterson* nearer the wreck; she therefore did not visit the wreck at all. From the wreck the *Patterson* proceeded northwestward searching for boats; but neither she nor the *Cordova* had any success on the 27th. On the night of the 27th the *Cordova* started on her return to Unalaska, as she had insufficient fuel to remain longer. On the 28th the *Patterson* proceeded to the western point of Agattu Island, and found there the remaining 3 boats with 29 persons, thus accounting for all. The survivors were in good condition, but had no provisions, and were reduced to one meal a day; they were living on sea gulls, puffins, mussels, and snails. They had no clothing except what they wore.

The *Patterson* then started at once for Unalaska, and, having favorable winds, reached there October 3, before the other ships. The return passage was made southward of the Aleutian Islands. The voyage out and returning amounted to 1,600 miles. The engines were not forced at any time, as it was not thought safe to attempt this; and it was only on account of favorable weather that the vessel was able to make the trip as she did. Gales and rough seas were experienced on the return, but the wind was generally favorable.

Copies of distress calls from the *Tahoma* are attached. It is not considered necessary to inclose copies of the voluminous radio correspondence with other steamships and with the commandant of the Bering Sea revenue cutter fleet at Unalaska.

Respectfully submitted.

JAMES B. MILLER,
Assistant, Coast and Geodetic Survey, Commanding.

UNALASKA, *October 4, 1914.*

To the SUPERINTENDENT COAST AND GEODETIC SURVEY,
Washington, D. C.

MESSAGES RECEIVED ON THE NIGHT OF SEPTEMBER 20 FROM WRECK OF THE UNITED STATES REVENUE CUTTER "TAHOMA," PICKED UP BY COAST AND GEODETIC SURVEY SHIP "PATTERSON," AT AKUN ISLAND.

Tahoma fast on uncharted reef with Buldir Island bearing northeast by north Mag. 41 miles distant. Agattu bearing west-northwest quarter west, distant 60 miles. Grave danger; pounding heavily; and nearest land Buldir Island, 42 miles off. Send *Senator*. If weather comes bad ship will fill. If forced to abandon ship will attempt to make Agattu.

Send fast ship *Senator* to latitude 51.42 north, longitude 175.44 east. First position sent 15 miles too far to westward.

2.55 a. m.: *Tahoma* breaking up fast and taking water and can't last much longer. Send *Cordova* or any other. Holes are stove in the bottom and the dynamo is nearly out. Send help, quick.

4.20 a. m.: Appears impossible to save ship; water making rapidly as vessel pounds. Will remain by her and await help, but should vessel begin to break up will try to make Agattu.

[H. C. DENSON, Commanding Steamer *Patterson.*]

On June 2, 1915, the steamer *Patterson* sailed from Port Townsend for Alaska, arriving in the Shumagin Islands on the 21st, where work was immediately begun.

En route to the Shumagin Islands a stop of three days was made in Kupreanof Strait, Kodiak Island, in order to locate a rock in Whale Passage reported by the steamer *Santa Ana.* The rock was located in practically the same position as had been reported; a depth of 15½ feet at mean lower low water was found.

The *Patterson* arrived at the working grounds, Shumagin Islands, on the afternoon of June 21. A camp was established at Mist Harbor, east coast of Nagai Island. Four officers and 16 men, equipped with two launches, one motor whaleboat, and with necessary tenders, were left in camps while the vessel engaged in signal building on the outlying islands. The remainder of the month was occupied in signal building and reconnoissance, no other survey work was accomplished, consequently no progress sketch or statistics accompany this report. On June 30 the vessel was at Sand Point, Popof Island.

[R. R. LUKENS, Commanding Steamer *Yukon.*]

SUMMARY OF RESULTS.—Base lines: 1 secondary, 1 mile in length. Triangulation: 90 square miles of area covered, 3 signal poles located by triangulation, 11 observing signals and scaffolds erected, height of scaffolds 30 feet, 16 geographic positions determined. Leveling: 2 miles of levels run (along base line). Azimuth: 1 station occupied for azimuth observations on 1 night. Topography: 10 miles of general coast line surveyed (shore line only), 1 topographic sheet finished, scale 1:20,000. Hydrography: 100 square miles of area sounded, 817.8 miles run while sounding (includes reconnoissance), 1,707 angles measured, 12,945 soundings made, 4 tide stations established, 5 current stations occupied, 2 hydrographic sheets finished, scales 1:100,000 and 1:20,000.

Work by the party on the steamer *Yukon* at the entrance to the Kuskokwim River, Alaska, the primary object of which was the charting of a navigable channel into that river, was begun about the middle of June, 1914, as mentioned in the last annual report, but the details of the work done during June were not available for that report.

On June 16, 1914, the *Yukon* started from Goodnews Bay on a reconnoissance trip to Eek Island. That night she anchored at the northern limit of the 1913 work and early in the morning proceeded up what was supposed to be Warehouse Channel until a position off Warehouse Bluff was reached where the channel seemed to end with shoal water on every side. Finally, however, the *Yukon* drifted through a narrow cut into a fine 4-fathom channel which was followed for several miles. After two or three more similar experiences the vessel reached Apokak Creek where she remained at anchor overnight. The following morning a tide observer was put in camp at Apokak and about noon the *Yukon* started downstream with a strong ebb tide, expecting to go out by either the Eek or the West Channel. Dropping down with the current of the Eek Channel, another channel was observed crossing a mud flat to the westward. Turning back

and entering this channel against a strong current the head of the mud flat was rounded and the West Channel was entered and followed with deep water for several miles. After passing another narrow shoal place and continuing due south for 15 miles farther the channel was again lost and recovered and deep water was followed to a junction with the 1913 work. That night the *Yukon* proceeded to Goodnews Bay. On June 21 the *Yukon* again left Goodnews Bay bound for Apokak, this time assisting the coal schooner *Harold Blekum* which had just arrived off Goodnews Bay. After an uneventful but difficult trip the channels were successfully navigated and both vessels anchored off Apokak where the work of building a small warehouse and storing supplies was begun. By the 29th this work was completed and a large tower signal with observing tripod had been erected at Apokak. On the following day the *Blekum* started for sea but had considerable difficulty in getting out. During this time both the *Yukon* and the *Blekum* were caught in a six days' storm far out in the West Channel. This experience shows that no vessel should try to ride out a strong gale in this vicinity, as the offlying shoals do not afford protection to vessels anchored there.

During July the party was able to work only one and one-half days in developing the channels through the great estuary. This work had to be controlled by distant mountains and only on perfectly clear days was it possible to see signals.

During thick and hazy weather the party was engaged in measuring a base line, extending the triangulation, building large signals, and sounding in the vicinity of Eek Island.

In August there were four days on which the distant mountains were visible, and during this time the Eek Channel was well located and defined, and one days' work was accomplished in locating the West Channel. In doing this work it was always planned to work with a favorable tide. Current observations were made during the night when the vessel was at anchor. The week of August 10 to 17 was spent in making a series of tide observations at Warehouse Creek and Quinhagak. A tide staff was erected at Goodnews Bay and connected by leveling with the old bench marks.

On August 25 a reconnoissance trip was made to Bethel under the guidance of a native pilot. Only two shoal bars were crossed; the first crossover above Eek Island where 17 feet was found and the last crossover before reaching Bethel where 13 feet was found. In the main the channels are deep carrying from 4 to 12 fathoms. At Bethel theodolite observations on Polaris for latitude and sextant observations on the sun for longitude were obtained. Tide observations were also made and bench marks established. On the night of September 3 an azimuth was measured at station Apokak by observations on Polaris.

On September 12 the steamer *Yukon* and launch *Alpha* were laid up at Goodnews Bay and on the 17th the party went on board the steamer *Patterson*, which conveyed them to Seattle by way of Unalaska.

The party again proceeded to the field in June, 1915, and at the close of the fiscal year was nearly ready for work.

[R. P. STROUGH.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 12 miles, 10.5 miles of area covered, 72 lines of intervisibility determined, 24 points selected for scheme. Base lines: 1, secondary, 1,200 meters in length. Triangulation: 10.5 square miles of area covered, 29 signal poles erected, 29 stations in main scheme occupied for horizontal measures, 24 stations occupied for vertical measures, 32 geographic positions determined, 29 elevations determined trigonometrically.

A party was organized at Seattle in June of the previous fiscal year for the triangulation to connect Prince William Sound and Turnagain Arm, a tributary of Cook Inlet, Alaska.

Leaving Seattle June 26, the party arrived at Ellamar, Alaska, on July 4. From Ellamar transportation was furnished by the Coast and Geodetic Survey steamer *Taku* to Portage Bay, arriving July 8.

On the following day one of the triangulation stations established during the previous season was recovered and one new station was selected. A reconnoissance trip was made over Portage Glacier to Bear Valley and return. The glacier at this time was fairly smooth and crossing was not difficult. The snow bridges across the deeper crevasses were generally safe and as the snow along the edge of Tunnel Shoulder had not melted it was easy to reach the solid ice of the glacier.

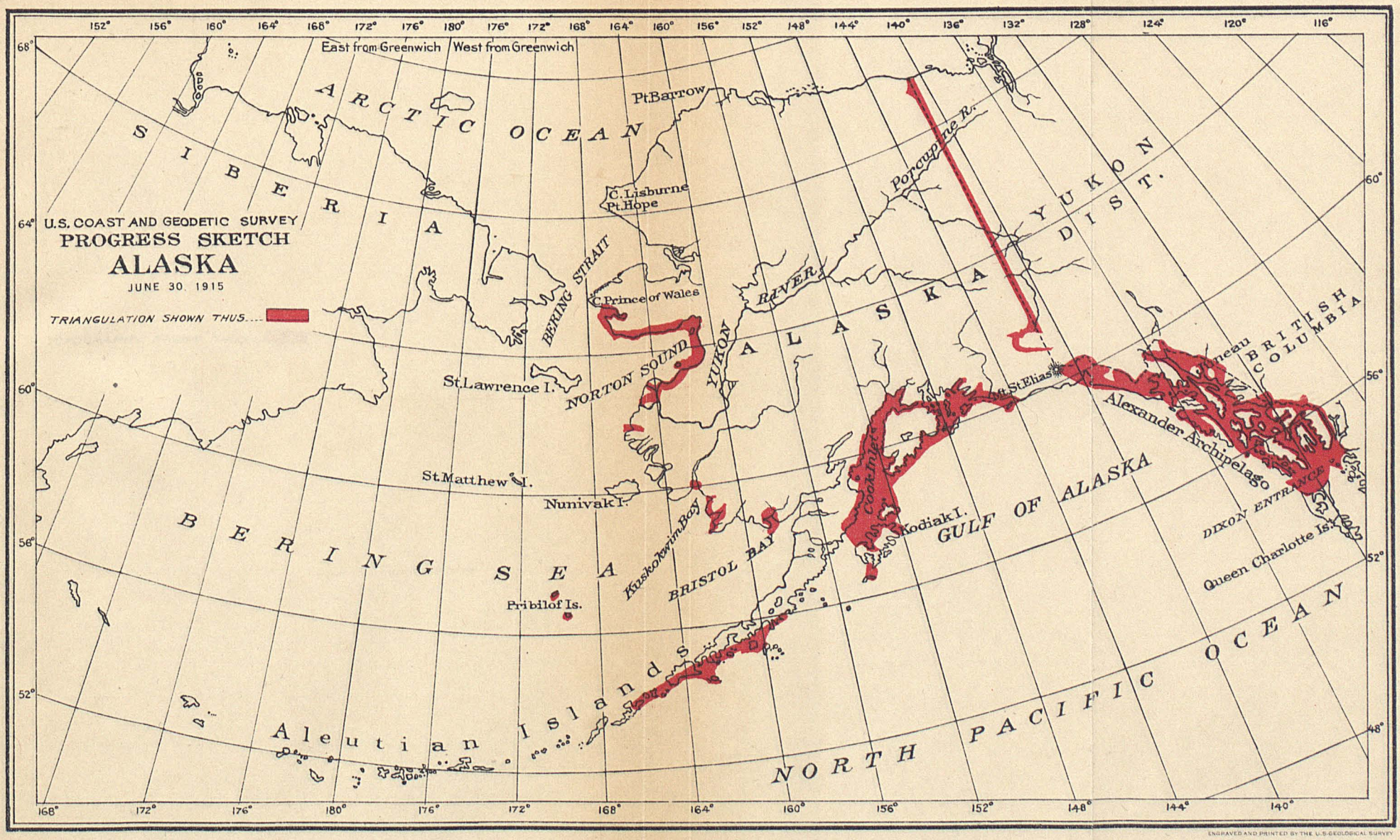
The party remained at the Portage Bay camp until July 21 at which time the reconnoissance for all stations east of Portage Glacier was completed and the stations established. Three of the stations selected during the previous season at the head of Passage Canal were recovered and reoccupied.

A new camp was then located on the foot of rock slide about a quarter of a mile from the east end of Portage Glacier. The hills in this locality are of a very rocky formation, and as there is no growth of any kind above the gravel flats it was necessary to pack the firewood up the 800 feet elevation to the camp. From this base were established the two stations Portage and Turnagain on the west side of the glacier, and all the stations to the east of these two were occupied.

Camp was moved to the west side of the glacier on August 6. For the scheme up to this point only the higher elevations had been used but after carrying the triangulation across the glacier it was found that the work could be carried on more rapidly by using smaller figures and confining the stations to the low ground of the gravel flats of Turnagain Valley. From the glacier to the two stations Rail and Road on the line of the Alaska Northern Railway all the stations are at low elevations and the lines are from one-half to 1½ miles in length.

The gravel flats between Portage Glacier and the head of Turnagain Arm are badly cut up by the glacial streams from the south side of the valley and by Portage River and its numerous branches. The main branch of Portage River is very swift and too deep to ford in most places. Boats were borrowed from the Alaskan Engineering Commission party for crossing the river. Owing to the difficulty of transporting cement all stations from Gravel and Ford to the western end of the work are marked with stakes only.

The base camp was moved on August 27 to the north side of Portage River just east of the Alaskan Northern Railway. A boat



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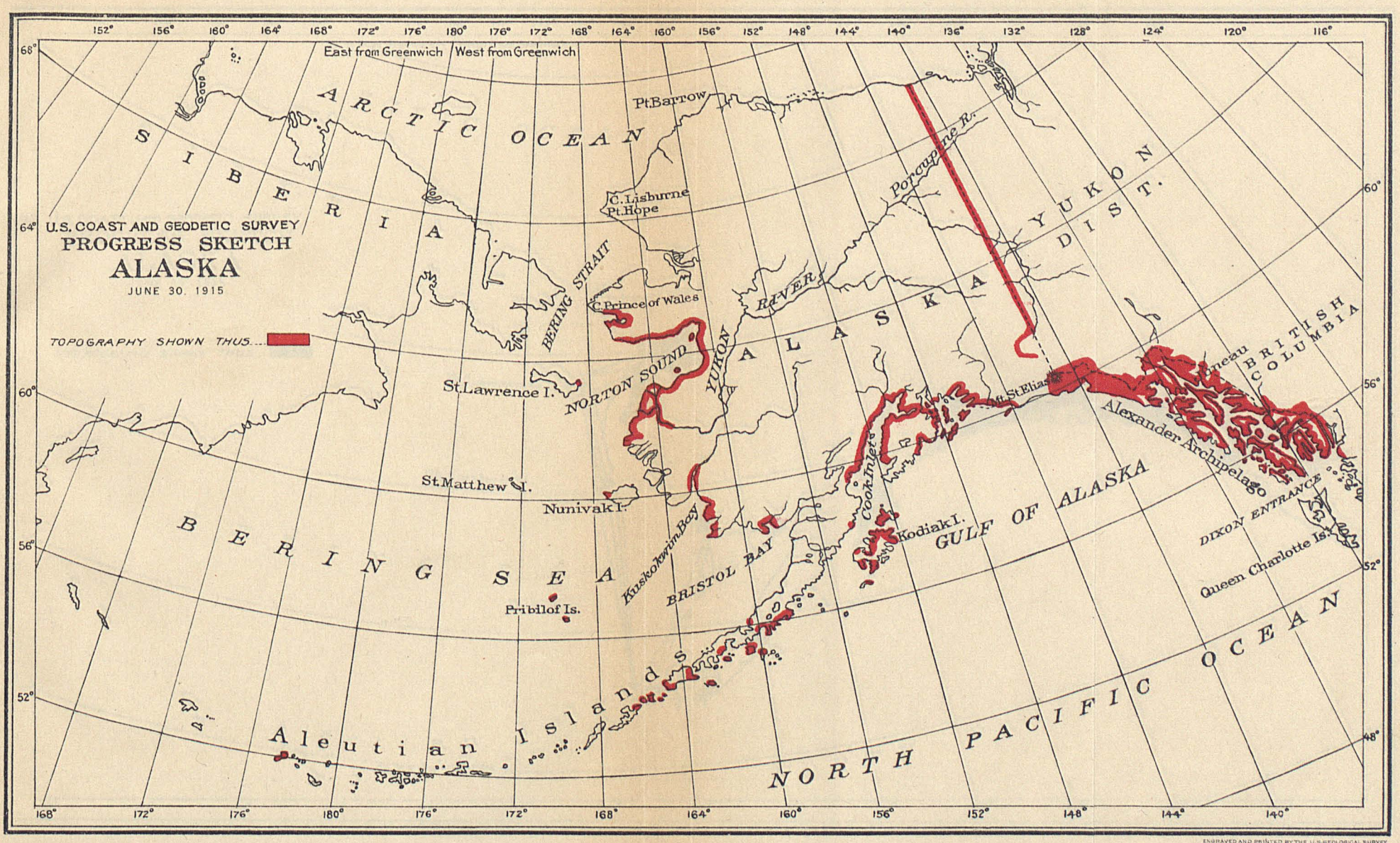

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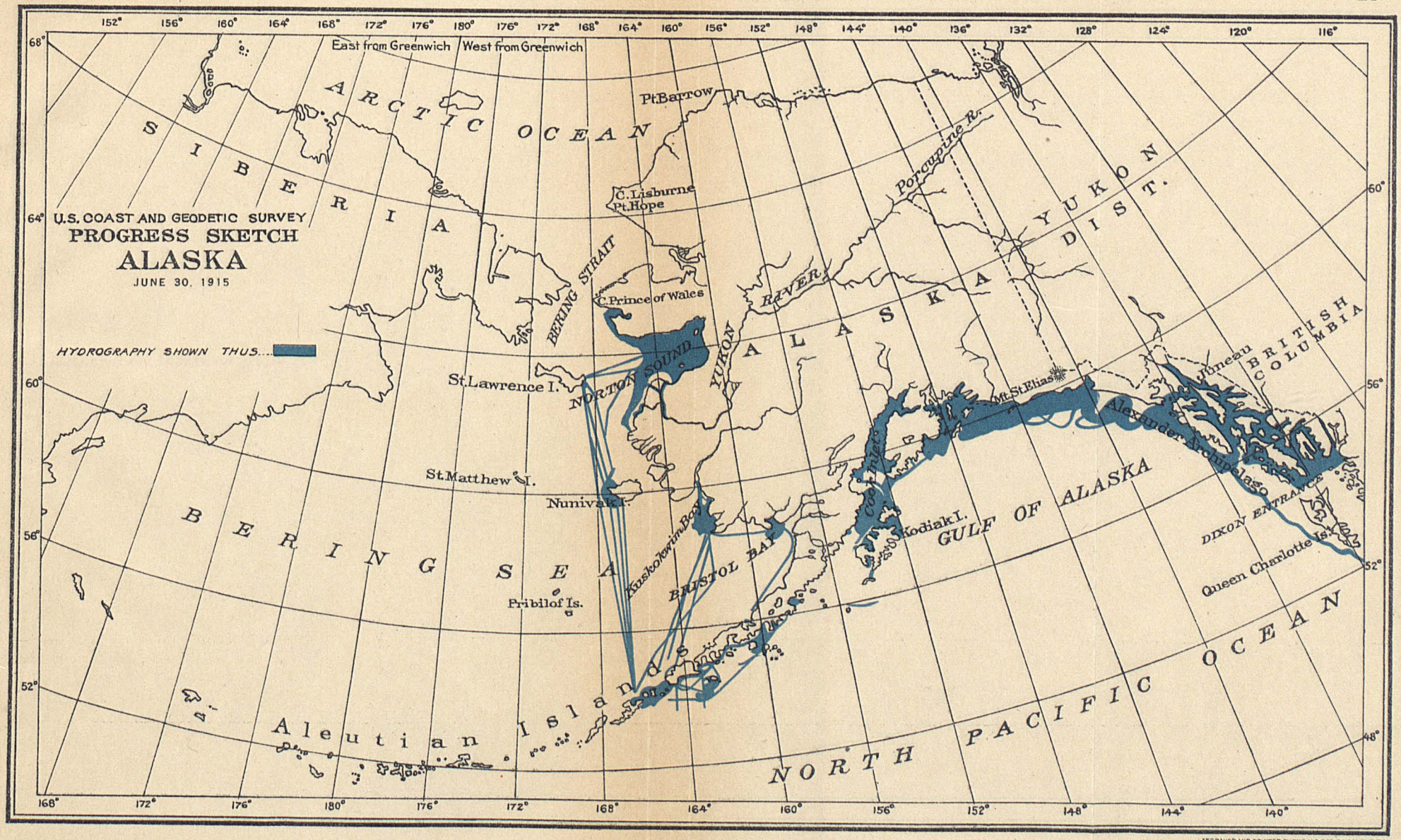

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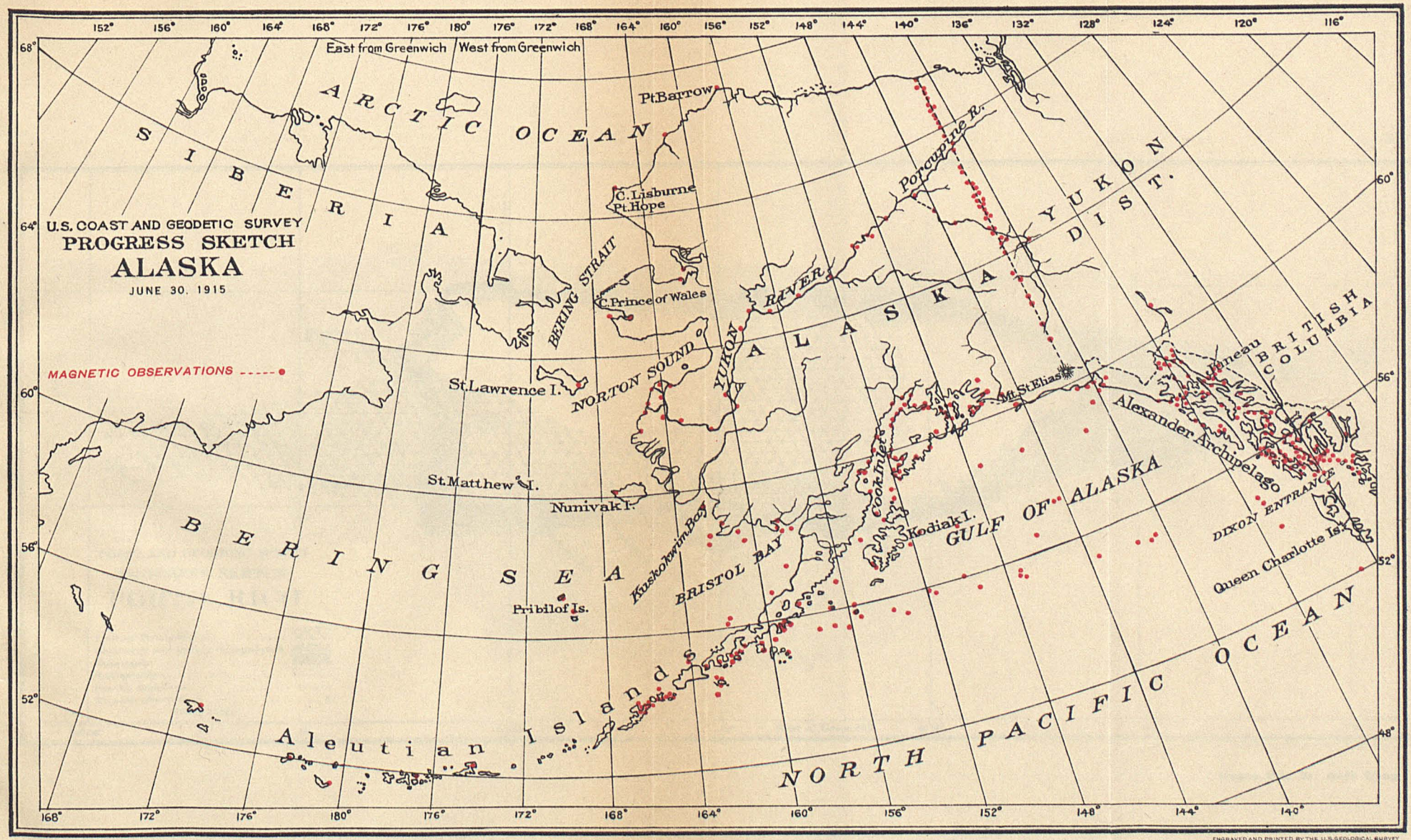

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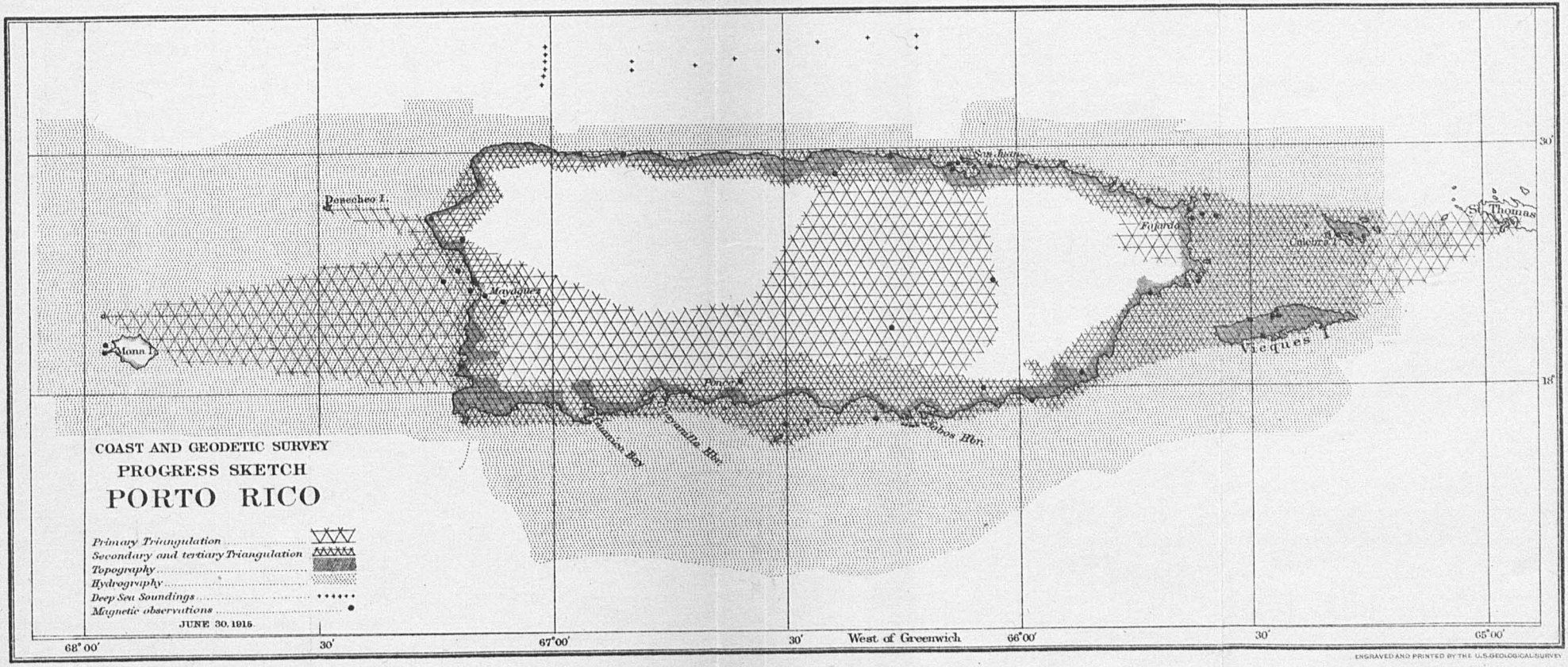

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was constructed by the party for the work on the south side of Turnagain Arm. A 1,200-meter base was measured on the mud flats from station Sand to the eastward, and was connected with the work across the glacier and also with the work of 1912.

On September 11 the final observations were completed and the computations were sufficiently advanced to show that the connection between the two bases was satisfactory. On the afternoon of the 11th the party moved to Kern Creek and on the following day was transported on a launch chartered by the Alaskan Engineering Commission to the headquarters of the commission at Ship Creek. Here they remained for six days, being housed and subsisted by the commission until the arrival of the steamer *Admiral Evans*, which took them to Seattle.

A sketch of the work east of and across Portage Glacier, together with the angles and distances was given to R. J. Weir, of the Alaskan Engineering Commission, for use in locating the tunnel entrances and for other purposes relating to the railway location.

[J. W. GREEN.]

The usual observations were continued without interruption during the year with the photographic recording instruments at the magnetic observatory at Sitka.

Absolute observations, consisting of three sets of declination, two sets of dip and the regular double set of horizontal intensity were obtained on one day of each week. Time observations from noon transits of the sun were obtained when practicable.

The seismograph was kept in constant operation throughout the year and 17 earthquakes were recorded.

HAWAIIAN ISLANDS.

[E. R. HAND.]

SUMMARY OF RESULTS.—Triangulation: 100 square miles of area covered, 12 signal poles erected, 12 stations in main scheme occupied for horizontal measures, 6 stations occupied for vertical measures, 13 geographic positions determined. Topography: 87 square miles of area surveyed, 131 miles of general coast line surveyed, 57 miles of roads surveyed, 9 topographic sheets finished, scales 1:20,000 and 1:10,000.

Work on the survey of the shore line of the island of Hawaii which had been temporarily suspended in June, 1914, was resumed early in August. The party was reorganized at Punaluu supply base, provisions and water were conveyed from Pahala plantation 5 miles down to the sea by pack mules, and the animals then sent back, there being no forage or water for them.

The topography was carried northeastward along the coast toward station Puu Kapukapu for 5 miles, half the distance to that station, and the party then returned to the starting point. This work occupied three days, during which each member of the party was obliged to carry his own blankets, provisions, and water. Returning to Pahala plantation the party again outfitted and started with pack train over an ancient lava trail to station Puu Kapukapu, a distance of 15 miles. From this station the party proceeded, packing on their

backs the necessary provisions, water, and blankets and worked back the remaining 5 miles, afterwards returning to Puu Kapukapu and Pahala plantation and thence by automobile and train across the volcano and around to Pahoa in the Puna district, a distance of about 60 miles.

No difficulty was encountered in the survey of Puna, the east end of Hawaii. Pahoa was a base centrally situated from which all parts of the coast were easily accessible over fair roads and trails and an abundance of fresh water was found everywhere.

As in other parts of the Hawaiian Islands the primary triangulation stations of the old Hawaiian Government were recovered and enough supplemental work was done to adequately control all parts of the shore. All stations were described and marked. Hills and stacks, useful as offshore hydrographic signals, were located, and in order to aid in their identification from offshore most of these, as well as the primary stations, were photographed.

Owing to natural difficulties and the great expense involved, it was not considered advisable to continue the triangulation along the coast toward station Puu Kapukapu beyond the line Laeapuki-Panau, and particularly as the determination of Puu Kapukapu from the above line by plane-table triangulation coincided with its plotted position from the other side, indicating an accuracy more than sufficient for topographic and hydrographic purposes.

The topography was executed on a scale of 1:20,000 and 16 sheets were required to complete the island. An accurate delineation of the shore line was made, including the off-lying rocks and shoal water as indicated by breakers. Heights of cliffs were shown, though there was but little cliff line and the height rarely exceeded 50 feet. Those spots were indicated where landing under favorable conditions is most feasible. There are no protected anchorages for small boats, the nearest approach to one being inside the islet at Keauhou.

In connection with the topography, stone cairns were erected or pinnacle rocks utilized, and painted white, for the use of hydrographic parties, and every few miles exceptionally large ones were marked to aid in offshore work. The latter were whitewashed.

A revision of the chart of Hilo Bay was made to show the new Kuhio Bay wharf and changes in buoys. The breakwater remained practically the same as shown by the survey made in 1912.

The topography of the shore line from Kalapana to Keauhou, a stretch of 30 miles lying between Punaluu and Kalapana below the volcano, was afterwards executed, and the survey of the island of Hawaii was completed on December 31.

Field work on the survey of the island of Molokai was begun on March 16.

The existing triangulation of the island was used for control of the topography, and as nearly all prominent objects useful as aids to navigation or for offshore hydrographic signals were included in the system of triangulation, no additional triangulation work was necessary. The old triangulation stations useful in work along the coast were recovered and re-marked. In one or two instances the redwood posts marking the stations were missing but the stations were recovered by means of reference marks on the rocks.

The monuments used in re-marking the stations were of uniform pattern, consisting of truncated pyramids of concrete about 8 inches

square at the top and 1½ to 2½ feet square at the base and from 3½ to 6½ feet in height, 1 foot projecting above ground when in place. A bronze station mark was placed in the center of each monument. Glass bottles were used as subsurface marks, except where the monuments were set in rock.

The topographic survey of the shore line on a scale of 1:20,000 was extended from the extreme northeast point of the island, Lamaloa Head, southward around Halawa Point, thence westward around Laau Point, and northward to within 2½ miles of Ilio Point, the extreme northwestern corner of Molokai, a general coast line of 56½ miles. This work was included on three topographic sheets.

The chart of Kaunakakai Harbor was also revised. The work on the island of Molokai was suspended on May 31.

[W. W. MERRYMON.]

The regular work of the Honolulu magnetic observatory was continued throughout the year without interruption. The magnetic variometers were kept in continuous operation and are in good condition. The seismograph was also in continuous and successful operation. Absolute observations of the magnetic elements for determining magnetic base line values were made weekly. Meteorological observations were made twice daily, and morning and afternoon sun altitudes taken with the sextant for time corrections were made weekly. The number of earthquakes recorded was 167.

The meteorological observations were sent to the local office of the Weather Bureau and to the observer at Ewa, Hawaii. Earthquake reports were furnished to the Hawaiian Volcano Research Association Observatory at the Volcano House, Hawaii.

In May and June comparisons were made of the magnetic instruments at the observatory with those used on the Carnegie Institution's yacht *Carnegie*.

PHILIPPINE ISLANDS.

[W. C. HODGKINS, Director of Coast Surveys.]

During the year covered by this report no change was made in the general plan of operations or in the previously existing arrangement for the division of expenses between the Federal and the Insular Governments.

The five steamers in the service of the Bureau were kept at work in the field continuously except when repairs became necessary and also near the end of the year when it became necessary to call in two of the vessels in order to avoid the possibility of exceeding the appropriation.

The time so lost from the field work was utilized in repairing the vessels and in bringing up the office work of computation and drawing.

The administrative work in the Manila office was conducted under the immediate supervision of the Director, assisted by the accountant, the chief clerk, and the chiefs of the four divisions of the office force.

The computation and adjustment of the triangulation, the reduction of tidal observations, and the registration and classification of

the records of the triangulation, hydrography, and tides have been continued.

The work of collating the work of the field topographers and hydrographers in order to produce the charts needed for the use of navigators was continued. After the completion of the drawings for such charts, they are very carefully verified and are then traced and the tracings are sent to Washington, where they are reproduced by lithography and issued for sale.

The collection and preparation for publication of all kinds of nautical information and the issue of charts and nautical almanacs was continued.

The collection, compilation, and preparation for publication of all manner of topographic information concerning the interior of the islands were continued in the geographical division. The several maps already published have thus far found ready sale at the established price of ₱1 each.

[O. W. SWAINSON, Commanding Steamer *Research*.]

SUMMARY OF RESULTS.—Reconnoissance: 336 square miles of area covered, length of scheme 18 miles, 9 lines of intervisibility determined, 5 points selected for scheme. Triangulation: 330 square miles of area covered, 23 signal poles erected, 2 observing tripods and scaffolds built 34 feet in height, 5 stations in main scheme and 3 stations in supplemental schemes occupied for horizontal measures, 5 stations occupied for vertical measures, 25 geographic positions determined. Topography: 136 square miles of area surveyed, 176 miles of general coast line surveyed, 25 miles of shore line of rivers and creeks surveyed; 6 topographic sheets finished, scales 1:10,000 and 1:20,000. Hydrography: 456 square miles of area covered, 1,763 miles run while sounding, 5,043 angles measured, 21,167 soundings made, 1 tide station established; 3 hydrographic sheets finished, scales 1:20,000 and 1:40,000.

From January 1 to March 16 the steamer *Research* was undergoing repairs and outfitting at Manila. On the afternoon of March 16 the vessel left Manila for the working ground in the vicinity of Sorsogon Bay and to the northward, stopping at Port San Miguel, Ticao Island, to inspect the automatic tide gauge established there during the previous season.

Upon arrival at the entrance to Sorsogon Bay signals were at once erected and the topography begun. The work here was well controlled by numerous triangulation stations occupied during the previous season. From these stations nearly all of the hydrographic signals were cut in. By May 15 the topography was completed as far north as Dumaquit Point. It was then taken up on the west side of the south end of Ticao Island and continued northward.

Two main-scheme triangulation stations, Dulan and Cabrian, the secondary stations necessary for the topography along the Luzon coast from Donsol to Cabarian Point and from the south end of Burias Island to Claveria, were established. Intersection stations were placed from 2 to 4 miles apart on both Luzon Island and Burias Island. Heliotropes were used on the lines Enganso-Donsol and Sagurun-Donsol. When the triangulation was finished the topography was continued and the hydrographic work begun.

The hydrography of the entrance to Sorsogon Bay and all of Ports Panlatuan and Putiao as far offshore as the 20-fathom curve was done by the launch party. The rest of the hydrography was done with the ship.

An automatic tide gauge was kept in continuous operation throughout the season in Port San Miguel, Ticao Island.

During the progress of the work tide staff readings were taken every 20 minutes at Bagatao Island.

Work at the north end of Ticao Island was continued in June and was completed by the 18th of that month. Operations were then transferred to Masbate Harbor and Mobo Bay. Signals were located by triangulation and the topography and hydrography begun. Tides were observed at Masbate.

[P. M. TRUEBLOOD, Commanding Steamer *Research.*]

SUMMARY OF RESULTS.—Base line: 1, 5,820 meters in length. Reconnoissance: Length of scheme 33 miles, 262 square miles of area covered, 14 lines of intervisibility determined. Triangulation: 228 square miles of area covered, 25 signal poles erected, 1 observing tripod and scaffold built 35 feet in height, 7 stations in main scheme occupied for horizontal measures, 8 stations in supplemental schemes occupied for horizontal measures, 13 stations occupied for vertical measures, 30 geographic positions determined, 5 elevations determined trigonometrically. Topography: 93 square miles of area surveyed, 79 miles of coast line surveyed, 1 mile of rivers and creeks surveyed, 2 topographic sheets finished, scale 1:20,000. Hydrography: 291 square miles of area covered, 1,089 miles run while sounding, 16,221 soundings made, 2 tide stations established, 4 hydrographic sheets finished, scales 1:20,000 and 1:40,000.

This vessel was employed at the beginning of the fiscal year in the survey of the region between Masbate and southern Luzon which includes Ticao Island.

The triangulation was extended to a junction with former work in Burias Island, a base line was measured near Bulan, the shore line of Luzon from Ticlin Strait to Sorsogon Bay and of the eastern side of Ticao Island was surveyed and the hydrography was completed in Black Rock Pass and between Ticao and Luzon.

An examination was made for a shoal off the east coast of Panay on which the steamer *Rubi*, drawing 15 feet of water, was reported to have struck in May 1914. No spot on which a vessel could touch was found in the position reported but depths of 16 and 17 feet with rocky bottom were found on a shoal approximately 1 mile to the eastward.

In Ticao Pass and Black Rock Pass the topography included a small area around the town of Magallanes on the Luzon side, the east coast of Ticao south from a point 1 mile south of Nunun Point, Matabas Island, and the Masbate coast from Tabunan Point around Uson Bay to Gorda Point.

The hydrographic survey of Ticao Pass, completed August 26, 1914, includes the greater part of the area north of a line running east from Biton Bay to longitude 123° 57′, thence N. 33° E. to longitude 124° 00′, and thence east to Ticklin Strait and south of a line from San Miguel Lighthouse to Bagatae Lighthouse.

A base line 5,820 meters in length was measured at Bulan, and seven points in the base net were occupied. Three new stations were required to connect the base line with the main scheme.

A supplemental scheme of triangulation was executed between Masbate and Ticao.

The topography and hydrography of Jamelo Cove were revised.

An automatic tide gauge was established at San Miguel and kept in operation during the season. Staff readings were taken in Ticlin

Strait, Black Rock Pass, Batoan Bay, and on the west side of Matabao Island. The position of a sunken schooner in the anchorage at Araroy was determined.

[PAUL M. TRUEBLOOD, Commanding Steamer *Marinduque*.]

SUMMARY OF RESULTS.—Reconnoissance: 4 points selected for scheme. Triangulation: 132 square miles of area covered, 7 stations occupied for horizontal measures, 22 geographic positions determined, 5 elevations determined trigonometrically, 22 signal poles erected. Topography: 6 square miles of area covered, 13 miles of detail coast line surveyed. Hydrography: 127 square miles of area covered, 1,236 miles run while sounding, 3,180 angles measured, 19,835 soundings made, 3 hydrographic sheets partly finished, scales 1:20,000 and 1:40,000.

On May 15, having completed repairs and outfitting at Manila, the steamer *Marinduque* sailed for the working grounds east of the Calamianes Islands, arriving on the 16th. Work was begun on the following day.

The first work undertaken was the development of the open area which extends some 9 miles to the eastward from Delian Island and includes Magallanes Bank, Alpha Shoal, and two other shoals, one of which appears to have been previously unknown and neither of which had been accurately delimited. Signals had been previously determined by triangulation by another party, so that it was possible to begin soundings at once. All of the open area was developed by the ship, using Tanner-Blish tubes for most of the work. The depths were from 30 to 50 fathoms and the tubes were tested at intervals of an hour or an hour and a half by stopping the ship and getting an up and down machine sounding at the same time that the tubes were lowered to the bottom. No tubes were used which had a correction of more than 2 fathoms.

Magallanes Bank was developed by the ship and whaleboat parties using the hand lead. The least depth found after very careful examination was 4⅝ fathoms, to which there is little or no tidal reduction. This is near the southern end of the bank. The shoal area is a coral ridge about 2 miles long and a quarter of a mile wide, lying northeast and southwest but curved convex to the northwest. It is steep-to at the northeast end and has detached spots with 8 to 12 fathoms at the south end.

Alpha shoal was developed by the whaleboat and launch parties. It is much smaller in extent than Magallanes Bank and is farther offshore than is shown. A least depth of 3⅛ fathoms was found. This is also a coral area.

A launch party with camp on shore recovered old stations and built signals for the inshore hyrography. The launch hydrography was then begun at Calis Point and carried northward as rapidly as possible in order to finish up the area exposed to the southwest monsoon. A uniform system of lines was run over this area and then a special examination was made of all shoal spots discovered and of all suspicious and doubtful area. All shoal spots were thoroughly developed with the hand lead and in depths of 5 fathoms or less special care was taken to watch for coral heads in order to get the shoalest soundings on them. The launch work was in progress at the close of the year.

The ship work was completed on May 28, and a reconnoissance was made of the region between Busuanga and the small islands to the northeast. A scheme was laid out for the location of intersection stations; on the 29th two signals were built and a reconnoissance made at stations Nanga and Lubutglubut. The scheme as planned is strictly tertiary and includes the determination of 22 new points for the control of topographic and hydrographic surveys.

During June the tertiary triangulation between the northeast coast of Busuanga and the offlying islands and the hydrography north along the Coron coast to and including most of the Coron Islands and part of Minangas Bay and two small areas of topography north of Alonon Point and in Minangas Bay, were completed. Magnetic declination was observed at five triangulation stations.

The shoals along the east coast of Coron Island were well developed, as most coasting vessels when southbound run well in toward Delian Island. The 1 and 2 fathom soundings on coral heads are so numerous and so widely distributed as to make this area very dangerous. Southbound vessels should keep at least 1½ miles eastward of a line drawn from Metaya Island to the east tangent of Delian Island. Alpha shoal has a least depth of about 3 fathoms.

The least depth found on a reported shoal spot in Coron anchorage was 3 fathoms.

In the latter part of June topographic work was begun near Alonon Point and in Minangas Bay.

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

SUMMARY OF RESULTS.—Triangulation: 46 square miles of area covered, 7 signals and scaffolds erected, 6 stations in supplemental schemes occupied for horizontal measures, 12 geographic positions determined. Topography: 51 square miles of area surveyed, 112 miles of detail coast line surveyed, 3 miles of rivers and creeks surveyed, 5 topographic sheets finished, scale 1:20,000. Hydrography: 603 square miles of area covered, 4,323 miles run while sounding, 47,506 soundings made, 3 tide stations established, 6 hydrographic sheets finished, scales 1:20,000, 1:80,000, and 1:100,000.

This vessel was employed at the beginning of the fiscal year in the survey of the region extending from the northern end of Palawan to the southern end of Culion and west of the latter island.

This area includes a very great number of islands of various sizes, Linapacan being the largest, and almost all of these have now been surveyed, as also the intervening passages, but the extreme northern end of Palawan is still unfinished.

At the end of November the vessel returned to Manila for repairs, which were in progress at the close of the year.

On July 1 the *Romblon* was at work on the east coast of Linapacan Island among the numerous islands off the northeast coast of Palawan Island.

The topography and hydrography on the east side of Linapacan Island and around the islands between Linapacan and Culion Island were first completed, and then work was taken up on the north and west coasts of Linapacan Island and carried north from Batas Island so as to fill in a gap between Palawan and the islands offshore to the eastward from Palawan, of which Linapacan and Iloc Islands are the largest. A narrow strip along Palawan and a small area north of Iloc Island were left unfinished.

Offshore work was done by the ship east of Linapacan Island and north of Palawan. The numerous reefs and shoals and the rocky character of the bottom required a close development in nearly all of the inshore hydrography. The strong currents encountered interfered with hydrographic work both inshore and offshore. In the offshore work the Tanner-Blish tubes and Cosmos sounding machine were used, the tubes being frequently tested. A special method of drying the tubes was devised. All depths of 20 fathoms or less were sounded with the hand lead. Only a few shoals dangerous to navigation were found.

An automatic tide gauge was operated at Batas Island to the close of the season and staff readings were taken at San Miguel and Dicabaito Channel.

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

SUMMARY OF RESULTS.—Triangulation: 70 square miles of area covered, 7 signal poles erected, 5 stations in supplemental schemes occupied for horizontal measures, 9 geographic positions determined. Topography: 36 square miles of area surveyed, 45 miles of detail coast line surveyed, 1 mile of shore line of rivers surveyed, 2 topographic sheets finished, scale 1:20,000. Hydrography: 480 square miles of area covered, 4,403 miles run while sounding, 16,497 angles measured, 96,641 soundings made, 2 tide stations established, 2 hydrographic sheets finished, scales 1:20,000 and 1:40,000.

After the completion of necessary repairs at Manila the steamer *Romblon* proceeded on February 23 to the east coast of Palawan to resume general surveys in the region in which the steamer *Marinduque* had been working during the past year.

The principal work to be done was the completion of the hydrography in the area along the Palawan coast immediately southwestward of Dumaran Island. This area is full of shoals which require much time for careful development. Dumaran Island offers but little protection against sea and wind making small-boat work difficult during the northeast monsoon.

The topography has been completed south as far as Flechas Point. No further triangulation was done in this area.

After the northeast monsoon subsided the party on the *Romblon* was shifted to Taytay Bay on May 13 to take advantage of the coming good weather in exposed localities. The work in the vicinity of Taytay Bay consists of a gap left between the work of the steamer *Marinduque's* northern limit of 1913 and the southern limit of the *Romblon's* work of 1914.

By the close of the fiscal year the subsidiary triangulation for topographic and hydrographic control had been completed and practically all of the topography in the area mentioned. At the end of June the hydrography was in progress. The existing charts were found to require many corrections. Many of the shoals shown on the chart were probably from reports in which the positions were not accurately determined. The inshore areas require careful development. Most of the soundings were made with the hand lead as few depths were over 20 fathoms.

Two tide stations were established, one at Flechas Point and the other at Taytay. The automatic tide gauge at Araceli was in continuous operation.

During the month of June the topography of the outlying islands in the region of Taytay Bay was completed, making the topographic survey of the east coast of Palawan from northern Palawan to Flechas Point continuous and complete.

The inshore hydrography along the mainland of Palawan in Taytay Bay was nearly completed and the offshore hydrography between latitudes 10° 51′ and 10° 59′ was completed with the exception of the development of some shoals.

[T. J. MAHER, Commanding Steamer *Fathomer*.]

SUMMARY OF RESULTS.—Triangulation: 16 signal poles erected, 15 stations in main scheme occupied for horizontal measures, 15 geographic positions determined. Leveling: 4 miles of levels run, 16 permanent bench marks established. Magnetic work: 2 land stations occupied for observations of magnetic declination. Topography: 23 square miles of area surveyed, 108 miles of general coast line surveyed, 9 miles of shore line of rivers surveyed, 20 miles of roads surveyed, 13 topographic sheets finished, scales 1:5,000 and 1:20,000. Hydrography: 3,125 square miles of area covered, 9,753 miles run while sounding, 25,344 angles measured, 73,241 soundings made, 4 tide stations established, 34 current stations occupied, 4 hydrographic sheets partly finished, scales 1:40,000, 1:60,000, and 1:100,000.

The party on the *Fathomer* was employed throughout the year in the survey of the large area extending from the coast of Panay across the Cuyo Islands to the Calamian Group, with additional work in the vicinity of Iloilo.

In the first named region some subordinate triangulation was done for the determination of points for the local surveys, especially in the Quiniluban Group. The topographic survey of the Cuyo Group north of Cuyo Island has now been completed. The islands centrally located in the northern part of the Sulu Sea, important as landmarks, are accurately charted. The topography is well controlled.

The chief work of the party, however, was that of sounding out these large water areas which, though generally deep, are studded with numerous shoals rising abruptly from deep water and often forming dangers to navigation.

In the vicinity of Iloilo considerable time and labor were expended in an attempt to locate the position of a shoal in the southwestern approach to that port which had been reported earlier in the year by another vessel. An area of 48 square miles was sounded over without finding any trace of a shoal.

A large-scale topographic survey of the city of Iloilo was made for special use in connection with projects for improvements.

The survey around Culion Island was completed.

The water area west of Mindoro and Panay is the route of considerable ocean traffic. Vessels of large tonnage, Spanish mail steamers, and Australian, Japanese, and tramp steamers of various nationalities pass continually. The greater part of the hydrography in this region has now been completed. Panay has been connected with the Cuyos and Mindoro with Busuanga. A triangular area of about 500 square miles joining the areas above described remains to be done. This gap is southwestward from the Semirara Islands and at such a distance from them that they are generally not visible. Peaks in Panay, Mindoro, and the Calamianes, distant from 30 to 60

miles, are used for control in this work and clear weather is necessary. Numerous shoals hitherto unknown have been found. Falmouth Bank and the bank passed over by Coutts have been located. These shoals and others in this area are small in extent and rise from depths of 200 to 400 fathoms.

Some few gaps remain in the hydrography in the Cuyos Islands. The bottom in this region is irregular and many uncharted shoals have been found.

An automatic tide gauge was kept in continuous operation during the year. Staff gauges were read at various times at Iloilo River, Santa Ana Bay, Guimaros Island, and in the Quinaluban Group.

Currents were observed at night when on the working ground and at all times when the vessel was at anchor. Fifty-five stations, covering all portions of the northern part of the Sulu Sea, were occupied.

One set of observations for magnetic declination was made at Paya Island.

In sounding in depths from 65 to 450 fathoms the ship was stopped. Stranded wire was used. At less depths than 65 fathoms soundings were made while the ship was running at a speed of 6 to 7 knots, using Tanner-Blish sounding tubes. The sounding tubes were frequently tested.

By June 30 only about 75 square miles of the area south of the Semirara Group remained to be sounded. The completion of this work will close the only gap in the area extending from Cape Calavite at the northwest end of Mindoro to Nogas Island Light on the south end of Panay Island, a very important and much-used route of ocean-going vessels.

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

SUMMARY OF RESULTS.—Reconnoissance: 375 square miles of area covered. Triangulation: 679 square miles of area covered, 1 observing tripod and scaffold built (height 60 feet), 5 stations in main scheme occupied for horizontal measures, 6 stations in supplemental schemes occupied for horizontal measures, 10 stations occupied for vertical measures, 36 geographic positions determined. Topography: 16 square miles of area surveyed, 27.5 miles of general coast line surveyed, 3 topographic sheets finished, scales 1:10,000 and 1:20,000. Hydrography: 183 square miles of area covered, 2,913 miles run while sounding, 94,940 soundings made, 2 hydrographic sheets finished, scale 1:20,000.

This vessel was employed up to the end of November in general surveys, including triangulation, topography, and hydrography, on the east coast of Palawan, chiefly around Dumaran Island. The main triangulation of Palawan Island was also extended to the southwestward to the vicinity of the parallel of 10° north latitude.

On November 26 the *Marinduque* was caught in a typhoon while at sea southeast of Dumaran Island and had one boat washed from the davits but escaped without any other very serious damage. She returned to Manila for minor repairs and during the remainder of the year was employed in the survey of several shoals in Coron Bay, Calamian Islands.

The survey in vicinity of Dumaran Island included the hydrography of the northern end of Dumaran Channel, inshore hydrography on north and east coast of Dumaran Island joining with offshore work by the ship; the development of a number of shoals off

the south coast of Dumaran Island and unfinished areas west of Langoy Island. The topography included the north coast of Dumaran Island, bold parts of the islands off Araceli Bay, Dumaran, and an area on the mainland of Palawan from Esfuerzo Point to Squall Point. All of the hydrography in this region was done by the ship and whaleboats, the launch not being in condition for service.

Numerous shoals made it necessary to run sounding lines not more than 100 meters apart for inshore work.

In December hydrographic work was begun in Coron Bay, Caliamianes Group. A large number of shoals were developed. Observations with an automatic gauge were continued at Araceli during the season.

[R. B. DERICKSON, Commanding Steamer *Pathfinder*.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 25 miles, 225 miles of area covered, 6 lines of intervisibility determined, 3 points selected for scheme. Triangulation: 406 square miles of area covered, 32 signal poles erected, 16 observing scaffolds and tripods built, heights 25, 60, and 100 feet, 6 stations in main scheme occupied for horizontal measures, 25 stations in supplemental schemes occupied for horizontal measures, 18 stations occupied for vertical measures, 28 geographic positions determined. Leveling: 2.3 miles of levels run, 16 permanent bench marks established. Latitude, longitude, and azimuth work: 9 latitude stations occupied, 10 longitude stations (chronometric) occupied, 1 azimuth station occupied. Topography: 189 square miles of area surveyed, 162 miles of general coast line surveyed, 1 mile of shore line of rivers surveyed, 16 topographic sheets finished, scales 1:10,000 and 1:20,000. Hydrography: 8,220.3 square miles of area covered, 6,313 miles run while sounding, 5,404 angles measured, 25,592 soundings made, 11 tide stations established, 1 current station occupied, 21 hydrographic sheets finished, scales 1:10,000, 1:20,000, 1:40,000, 1:160,000, and 1:400,000.

At the beginning of the fiscal year the steamer *Pathfinder* was engaged at work on the southern coast of Mindanao, where a survey was made of the coast from Parang, across the delta of the Mindanao River, and southward to Port Lebak. This work included the extension of the triangulation across some very heavily wooded country as well as the topography and hydrography along the coast. With the change to the southwest monsoon and the coming of the summer rains the conditions on that coast became unfavorable for progress and the work was closed there at the end of July.

During August and the first half of September the *Pathfinder* worked on the eastern coast of Mindanao and completed the junction, in the neighborhood of Hinatuan, between the surveys previously executed on that coast, proceeding to the southward from Surigao and to the northward from Cape San Augustin.

The ship then returned to Manila for docking and overhauling, but unexpected obstacles developed, and she was therefore outfitted for a special examination of certain parts of the Sulu Sea and in particular of Moyune Shoal and vicinity, the British steamship *Bengloe* having stranded on that shoal on September 13.

The information obtained in this preliminary survey has proved to be very valuable and has already led to the establishment of several much needed lights in a region where there have never been any aids to navigation.

That work occupied the time from the middle of October to the end of November and while the ship was in southern waters a sur-

vey was made of a shoal on the eastern coast of Negros which had been reported by the master of a coasting steamer.

Again returning to Manila the *Pathfinder* was engaged for two days in a revision of the survey of the coast south of Manila Bay entrance and for the balance of the year was undergoing repairs at Olongapo and Manila.

Repairs to the *Pathfinder* having been completed the vessel proceeded on January 24 to Subic Bay and determined the least depth over Moron Rock. This work being completed on January 26, the *Pathfinder* proceeded to the Sulu Sea, running sounding lines from Sombrero Rock to Balabac Strait, via Calusa Island, Tubbataha Cays, and Barcoran Island, and thence to Zamboanga. Search was made for a 28-fathom spot east of Balabac Strait and also for the Temerario Rock south of North Tubbataha.

Astronomic observations were made at North Tubbataha in connection with the plane-table traverse along the south side of the reef. The position of Calusa Island was verified by astronomic observations and a plane-table survey was made of the entire island.

While en route from South Islet to Zamboanga the vessel passed over the reported position of C Antibeg Shoal. A depth of 2,422 fathoms was found at the position of the shoal as shown on the chart.

From February 8 to May 7 the party was engaged in the survey of the southwest coast of Mindanao and in taking deep-sea soundings in the Moro Gulf. Between May 8 and 12 a survey was made of Palmas Island. A number of deep-sea soundings were taken while en route from Sarangani Straits. Between May 13 and 15 a small piece of hydrography at Cape San Augustin was completed. A line of deep-sea soundings was run from Palmas Island to Cape San Augustin. The *Pathfinder* then proceeded to San Bernardino Straits, arriving on the morning of May 25. On that date assistance was rendered the four-masted schooner *Alpine* which was wind bound and in a dangerous position in the straits.

The *Pathfinder* was engaged in the survey of Palmas Island from May 7 to 12. Seven deep-sea soundings, ranging from 990 to 3,400 fathoms, were taken on the way to the island. Strong northeast currents were experienced between Palmas Island and Sarangani Straits.

The natives of Palmas Island, who are Dutch subjects, at first made objection to the landing of the party, but upon explanation friendly relations were established and they permitted the survey to be made.

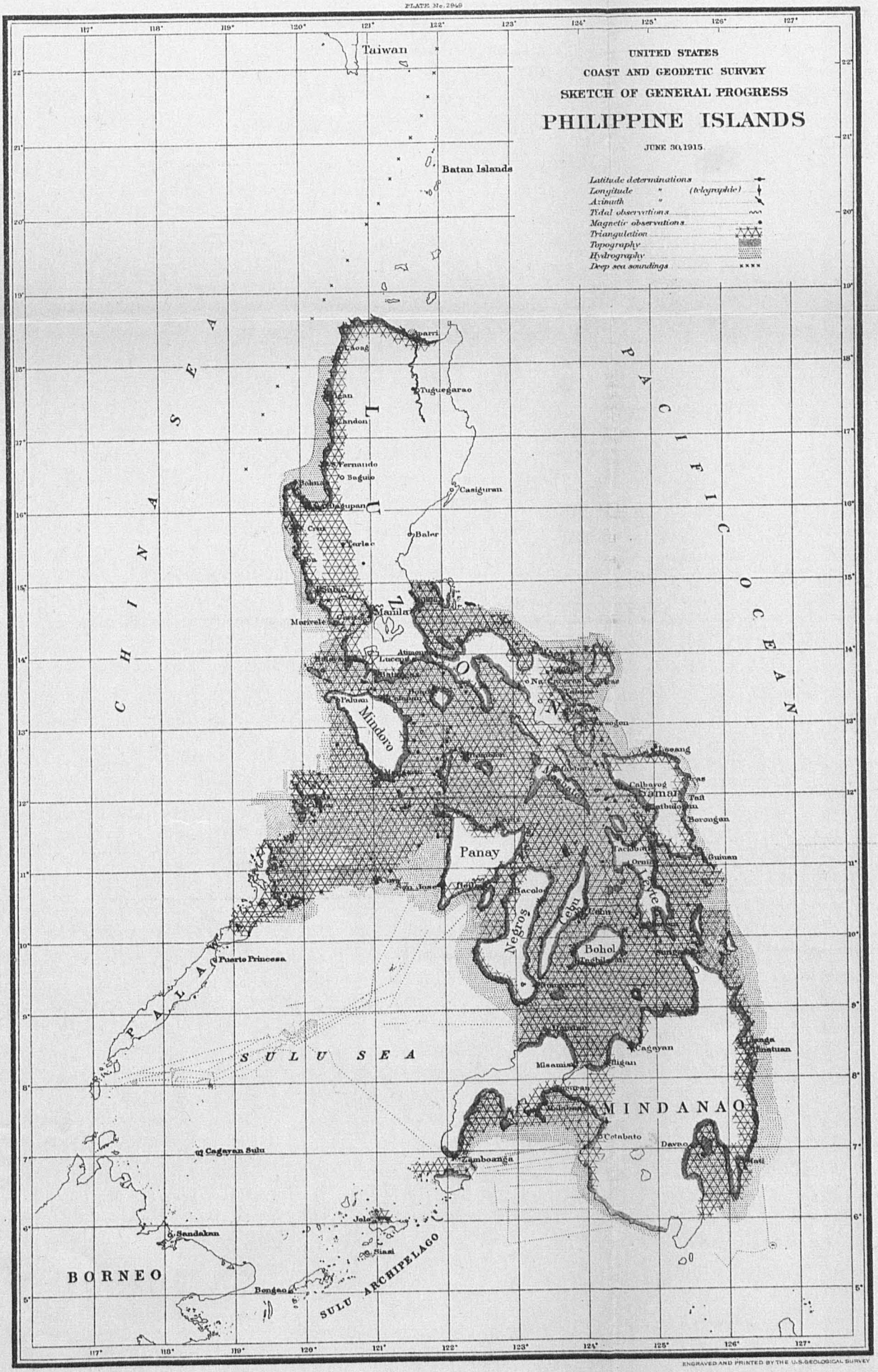
Astronomic observations were made near the south point of the island for latitude and longitude and the station occupied was marked.

A plane-table survey on a scale of 1:10,000 was made of the entire island, a traverse along the coast line locating each topographic and hydrographic signal. A magnetic meridian was drawn through the position of the astronomic station.

From the west side of Palmas Island Balut volcano and Saddle Peak near the south point of Mindanao, also the entire range along the southwest coast of Davao Gulf are distinctly visible in clear weather. The mountains north of Cape San Augustin could not be seen on account of clouds to the westward.

Sounding lines were run from the reef line offshore a distance of one-third to 1 mile to the 100-fathom curve at intervals of 200 meters, the possible anchorages receiving close attention. This system was

PLATE No. 2949



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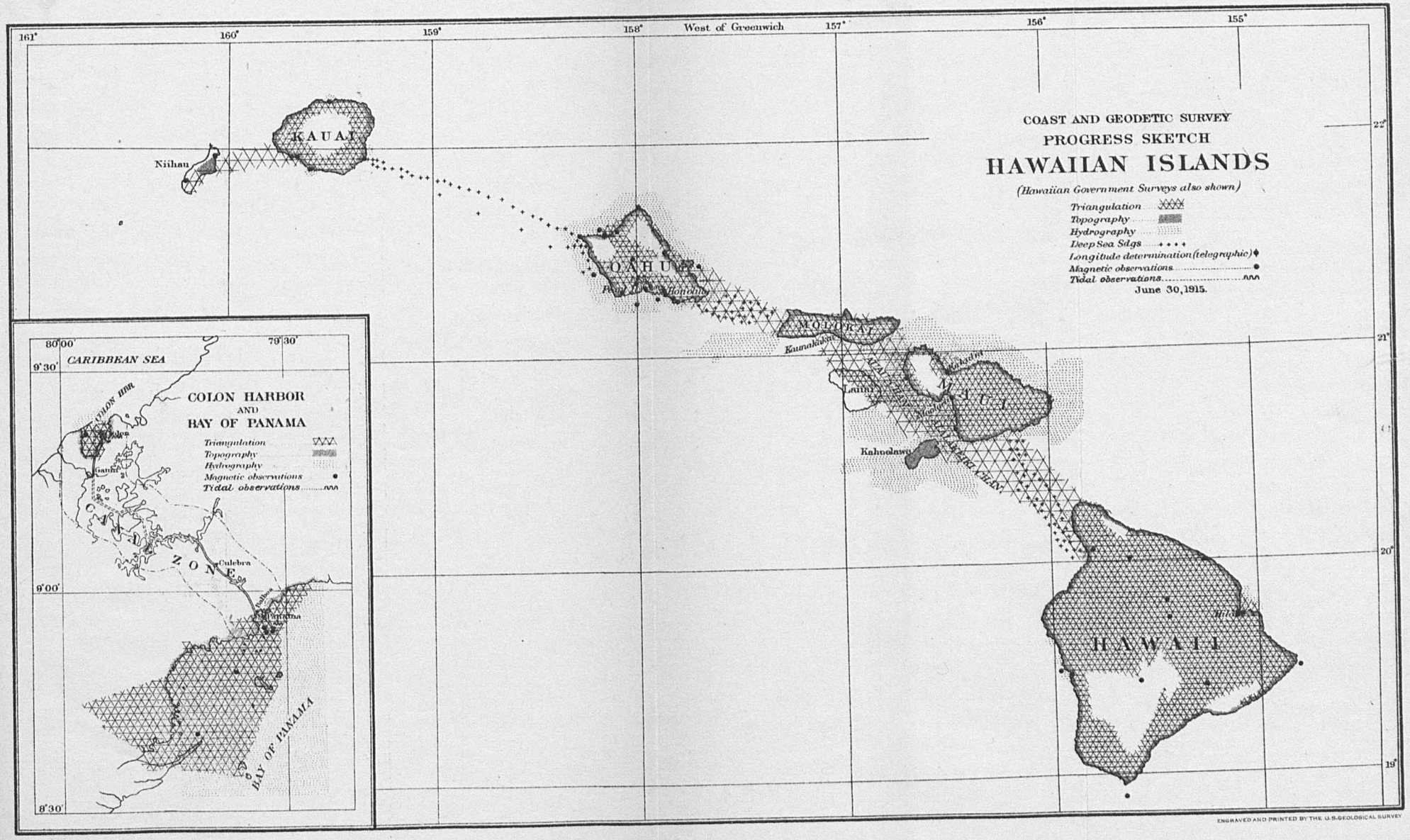

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carried completely around the island with the exception of a small area at the north point of the island which could not be approached on account of violent overfalls and tide rips. The sounding launch was nearly lost in attempting to cross this area.

The survey was concluded with a line of deep-sea soundings ranging from 110 to 500 fathoms around the island. A line of deep-sea soundings was also run between Palmas Island and Cape San Augustin after the survey of the island was completed.

A tide staff was erected on the reef at the southwest point of the island and readings were taken every 20 minutes for 52 consecutive hours. Bench marks were established and connected with the staff.

In June the *Pathfinder* completed a special hydrographic examination of an area of 18 square miles in the vicinity of San Bernardino Island. A survey of the approaches and anchorage off the town of Bobon was completed, a survey of the channel south of Cabauan Island was partly finished, and the survey of the north end of this channel was begun. General hydrographic work in San Bernardino Strait was in progress at the close of the year.

SPECIAL DUTY.

CAPE COD SHIP CANAL.

[O. H. TITTMANN.]

In accordance with instructions from the Department the Superintendent attended the formal opening of the Cape Cod Canal on July 29. This canal connects Buzzards and Cape Cod Bays so as to avoid the dangerous coasting navigation around Cape Cod Peninsula and by the inner Nantucket Shoals. On and after July 30 the canal was open to traffic during the day for vessels and barges drawing not over 15 feet.

The Coast Survey, as early as 1860, made a topographic survey of the route at the request of the Legislature of the State of Massachusetts, and a commission of which Superintendent A. D. Bache was a member made a report and estimated the cost of the project at $10,000,000. As the cost of the present canal is given as under $12,000,000, this old estimate is of interest.

In anticipation of the opening of the canal the survey of Buzzards Bay with the wire drag had already been commenced.

After the opening of the canal an inspection was made by a nautical expert and sailing directions for approaching and passing through the canal were prepared and published as a notice to mariners.

In the spring of 1915 wire-drag examination of the northern approaches to the canal were begun.

EXHIBIT OF COAST AND GEODETIC SURVEY AT NATIONAL MOTOR BOAT SHOW.

[E. B. LATHAM.]

In accordance with the request of the National Association of Engine and Boat Manufacturers, and with the approval of the Department, a collection of charts and publications of the United States Coast and Geodetic Survey was prepared and exhibited at Madison

Square Garden from January 30 to February 6, and an officer of the Survey was placed in charge.

About 50 charts were displayed in the space assigned and in two cabinets provided for the purpose, besides sketches showing progress in the various classes of work.

The coast pilot volumes, inside route pilot, tide tables, table of depths in rivers and harbors, and other publications of interest to yachtsmen and motor-boat men were also shown. Of the annual report of the Secretary, the annual report of the Superintendent, and of Special Publication No. 23, describing the work of the Survey, a large number was distributed.

Much interest was shown in the charts, particularly in those of the vicinity of New York City and the Hudson River, and in the publications descriptive of the inside waterways along the coast and in the interior of the country.

Publications of the Bureau of Lighthouses, Bureau of Navigation, Bureau of Foreign and Domestic Commerce, Bureau of Standards, and Steamboat-Inspection Service, of interest to mariners, were included in the exhibit.

At the close of the exhibition the Secretary of the National Association of Engine and Boat Manufacturers in a letter addressed to the Secretary of Commerce expressed his appreciation of the display made by the Survey.

TOPOGRAPHIC SURVEY OF A PORTION OF THE GROUNDS OF THE NATIONAL BUREAU OF STANDARDS, DISTRICT OF COLUMBIA.

[GEORGE D. COWIE.]

SUMMARY OF RESULTS.—About 1½ acres of area covered, 700 elevations determined.

At the request of the Director of the National Bureau of Standards a topographic survey was made in January of a section of the grounds adjoining the buildings occupied by the Bureau and supplementing surveys previously made.

Beginning at the intersection of the tangent to the east face of the east building with the north boundary line, a rectangle was laid out giving a control for the whole area. A line of levels was run from a bench mark on the north platform of the east building through the area to be covered touching on another bench mark and closing on the starting point. The temporary bench marks controlled the elevations of the entire plot directly. The field work and office work occupied four days.

PHYSICAL HYDROGRAPHY, DISTRICT OF COLUMBIA, MARYLAND, AND VIRGINIA.

[H. P. RITTER.]

The physical hydrographic work in the Potomac River, in cooperation with the United States Public Health Service, was continued throughout the year, and consisted in observations of currents, densities, temperatures, and tides. The instruments and methods used were the same as in the preceding year.

From July 1 to October 23 eleven series of current observations, from half a day to more than 4 days each, were made on 33 days. The number of miles traversed by the floats was 401, number of current path positions determined 1,004. On account of ice and stormy weather no current observations were made in November and December. The places from which current observations were made at various times during the year were Chain Bridge, south end of Georgetown Channel (Black buoy No. 1), Indian Head, Md., Possum Point, Va., Maryland Point Lighthouse, Upper Cedar Point Lighthouse, Popes Creek Wharf, Md., Black buoy No. 13 (Upper Machodoc Creek) to Colonial Beach.

The reduction of the current observations consists in plotting on a Coast and Geodetic Survey chart the actual path taken by the float during each series of observations and compiling for each series a table giving a synopsis of the observations with reference to the direction of the tidal current, time run, and distance traveled, together with wind and weather conditions.

In addition to the current work, observations bearing on the physical condition of the river were taken at various times and places. They consisted of specific-gravity determinations, water and air temperatures, color, turbidity, ice, wind, and weather conditions.

The 45 localities at which observations of this character were taken are distributed along the river from Chain Bridge, the head of tidal influence, to Point Lookout, where the Potomac empties into Chesapeake Bay. These observations were taken at various times between August 9, 1913 and December 31, 1914.

Turbidity observations, which consisted principally in noting the color of the water, were made at 45 localities on 292 days, and 2,119 observations were taken. Temperatures of water and air were taken on 274 days, with 2,577 water and 2,118 air determinations.

The specific-gravity determinations were made with a field hydrometer, the observations being taken at 2 feet below the surface, middepth, and 2 feet from the bottom, and consisted of hydrometer readings, together with temperature of water at each depth, and the temperature of the air, etc., at each station. Specific gravity observations were made on 75 days, and 1,887 observations were made.

Field work was closed June 5, 1915. By June 30, 85 of the 107 series of observations obtained since July 1913 had been plotted and the corresponding tables had been compiled. By the same date all of the physical observations of the condition of the river made had been tabulated up to May 6, 1915. These observations were taken at various times between August 6, 1913, and June 5, 1915.

The automatic tide gauge at Alexandria, Va., was kept running until May 26, 1915, when the observations were discontinued. A continuous record from this gauge was obtained, beginning July 1, 1913.

The stage of the Potomac at Chain Bridge and of the Anacostia at Bennings Road was frequently determined by tide-staff readings until the end of the season.

Additional observations were made to determine the changes in direction of the current with reference to the stage of the tide. These observations were made on 118 days and the number of observations was 2,180.

Cross sections of the Potomac from Chain Bridge to the mouth of the river were determined for each mile of the river. The sections were plotted on charts of the river and the elements of the section, i. e., width, area, and mean depth, were deduced from the data on the charts. One hunderd and nineteen sections in a distance of 118 miles were thus determined.

The tide-water area of the river from Chain Bridge to its mouth, between the high-water shores on each side of the river, was determined. This area, including arms and tributaries, was found to be a trifle over 491 square miles.

Copies of field records and compiled data were furnished to the Public Health Service.

A series of moving pictures illustrating the work of this party was taken for use in the exhibit of the Department of Commerce at the Panama-Pacific International Exposition.

SURVEY OF SHORE LINE OF PARRAMORE ISLAND, VA.

[W. E. PARKER.]

At the request of the commissioner of fisheries of the State of Virginia a survey was made for the purpose of determining as exactly as possible the position of low-water mark in two coves on the west side of the Parramore Island, Va. The localities for which surveys were desired are known locally as Little Beach Cove and Stingray Point Cove, and lie on the western side of the island, the former about midway of the shore and the latter at the southern limit.

The county surveyors for Accomac and Northampton Counties, respectively, were detailed to aid in the work and the State oyster police boat was placed at the disposal of the officer in charge of the survey. The cost of the work, with the exception of the travel and subsistence of this officer, was borne by the State of Virginia. The field work consisted in three operations, namely, the determination of the plane of mean low water at each cove, the establishment of a control for the survey of each, and the survey of the coves.

The best obtainable information for determining the planes of mean low water in these coves are from observations made by the Coast and Geodetic Survey at Wachapreague life-saving station, Cedar Island, between July 3 and 13, 1911, and at Hog Island lighthouse dock between June 5 and 25 of the same year. The bench marks established at those places are based on 18 high waters and 19 low waters at the former and 19 high waters and 21 low waters at the latter.

Tide staffs were set at Wachapreague Life-Saving Service dock and Hog Island lighthouse dock and connected by spirit leveling with the bench marks at each. Similar staffs were set in Stingray Point and in Little Beach Cove. Simultaneous observations of high and low waters were made of the four staffs during daylight of October 2 and 3, giving the staff readings of two high and four low waters. Light to moderate easterly winds prevailed during the times of these observations. Bench marks were established on the shores of both coves and were connected with the staffs by spirit levels.

The nearest stations or objects to the places for which surveys were desired which had been determined by triangulation were two objects on Wachapreague Island, northward of Parramore Island, a station about midway of that island and an object on Revel Island, near the southern end of Parramore Island. The last object had been determined by lines of sight which intersect at an angle of about 10°, and there was no check. As surveys were desired on a scale of not less than 1:5,000 more points were necessary unless base lines were measured. Accordingly, a plane-table triangulation was executed on the projection (1:10,000) which had been prepared at the office, and the doubtful position was verified and enough other objects were cut in to give sufficient control for the surveys of both coves. The coves were surveyed by plane table on separate sheets and on a scale of 1:5,000.

The low-water line was determined topographically, allowance being made for the height of the tide above mean low water at the time each point was located. The mean high-water line, or where that was indefinite or at a considerable distance from the plane table, the outer marsh line, was surveyed in the usual way. The work was begun September 30 and completed October 16.

EXHIBIT OF COAST AND GEODETIC SURVEY AT PANAMA-PACIFIC INTERNATIONAL EXPOSITION, SAN FRANCISCO.

[W. E. Parker and E. F. Dickins.]

The scope and character of the work of the Survey were shown by an exhibit forming part of the contribution of the Department of Commerce to the Panama-Pacific International Exposition. Navigational charts, coast pilots, and tide tables, which are the chief nautical publications of this Bureau, were given a prominent place. The geodetic, astronomical, and magnetic work of the Bureau was well represented by special publications and bulletins covering those subjects.

Surveying methods were illustrated by pictures and lantern slides, the latter shown from a projecting apparatus which rendered them clearly visible in a lighted room, and by a complete set of instruments and surveying appliances. The instruments were mounted as they are when in use, the idea being to show as faithfully as possible the special methods employed in the field by the surveyors of this Bureau.

Some of the interesting objects exhibited were a tide indicator, connected electrically with a sending apparatus and float on the water front so as to show the rise and fall of the tides at the Golden Gate, an exact model of a wire drag used in searching for submerged rocks in navigable waters, and a complete set of photographs of the Bureau's new tide-predicting machine, together with photographs of the tide-predicting machines of other nations. An officer of the Survey was detailed to explain the exhibits.

A special publication descriptive of the work of the Survey and a special chart of the Golden Gate and San Francisco were distributed without charge at the exhibition.

INTERNATIONAL BOUNDARIES—UNITED STATES AND CANADA BOUNDARY.

[E. C. BARNARD.]

SUMMARY OF RESULTS.—Base lines: 17 base lines measured, average length 344 meters. Triangulation: Distance along boundary 37 miles, 182 signals erected, 231 stations occupied for horizontal measures. Azimuth: 2 stations occupied for observations of azimuth. Leveling: 6 miles of levels run. Topography: 234 square miles of area covered (including water area), 929 miles of shore line surveyed, 767 islands located and mapped. Reference marks: 243 reference monuments set, distance along boundary 116.5 miles.

The party engaged in the survey of the international boundary on Rainy Lake and Rainy River was in the field at the beginning of the fiscal year. Progress made to June 30 is detailed in the last annual report.

The work of the season included the topographic survey of the shores and islands of Rainy Lake from Brule Narrows eastward to Kettle Falls and through International Falls westward to Baudette, as well as the tower construction and observation of angles on the scheme of triangulation laid out in the previous year to the head of Lake Namacan, and the extension of the small scheme of triangulation down Rainy River from Birchdale to Baudette; and also the location and setting of the necessary boundary reference marks.

To furnish control for the topographic work a separate party was engaged on triangulation of Rainy River, and this party afterwards was engaged in setting reference marks on this river.

Beginning at Birchdale, Minn., a small triangulation was carried down the river to Baudette, Minn., a distance of 28 miles. Azimuth was observed at stations Creamery and Oak, and 160 reference monuments were set on the banks of Rainy River between Baudette and International Falls. Twelve bases were measured in the triangulation. The small triangulation was controlled by the main scheme to which it was connected in five places.

One party was engaged in completing the topography, subsidiary triangulation, setting and numbering of boundary monuments on Rainy Lake from Brule Narrows to a point on Lake Namacan just west of Kettle Falls. A detailed map on a scale of 1:5,000 was made of Kettle Falls and Kettle River and the topography was extended to include the whole of Swell and Seine Bays.

The topographic work was on a scale of 1:20,000 and included all details within 1 mile from the shores of the lake or to the second 10-foot contour where it came within this distance. The elevations were taken from the water surface of the lake, the elevation of which was read each day on a water gauge, the zero of which was determined from bench marks established in 1912–13. The elevation of the lake varied from 1,105.3 to 1,108.1 feet above mean sea level.

Another party was engaged in topographic surveys on Rainy River. On July 1 this party was at work on the Canadian side opposite the mouth of the Big Fork River. On July 27 camp was made on Durand's farm on the American side, and on August 19 camp was established at a point three-fourths mile below Manitou post office. From this camp the mapping of the Indian Reservation on the Canadian side was done. Work was completed to the head of Long Sault Rapids by September 11 and the party

moved to a point on the Canadian side about 1¾ miles below Birchdale. The work was extended from this camp down the river to Frontier post office, where a junction was made with the work by another party. The mapping was afterwards extended from a point near Baudette where the Canadian parties had closed work at the end of the preceding season, to a junction with the surveys by the American party. A separate party took up the topography of Rainy River at Pinewood, extended it up the river to Frontier post office, and then down the river to connect with work by the Canadian party. Another party completed the mapping on the Canadian side of the river in the vicinity of Baudette.

In July Mr. Barnard visited the topographic party in camp near the mouth of Rat River and made a trip up the river to determine how far the topographic work should extend. A trip was made up Kettle River and the limits of the large-scale (1:5,000) map were determined upon.

A contract was made for a number of concrete blocks to be set in the earth for reference marks. These concrete blocks were set in a mass of concrete 16 by 16 inches by 4 feet, the concrete being tamped in around the side of the block so as to render the whole one solid mass. Where reference marks were in rock the marking was by holes drilled in the rock. As most of the reference-mark sites were triangulation stations already marked by bronze tablets the reference mark was usually set less than 1 foot distant from this mark in line with an adjacent triangulation station, and the distance to the triangulation tablet accurately measured.

In the latter part of July I. R. Pounder, the representative of the Canadian commissioner, who had been with the topographic party on Rainy Lake, joined the triangulation party on Rainy River and aided in the execution of the small scheme of triangulation between Birchdale and Baudette. At Rainer Mr. Pounder made the observations to locate additional reference marks that were found necessary: One of these was on the Canadian abutment of the Canadian Northern Railway bridge over the outlet of Rainy Lake and the other on a small island on the Canadian side a short distance below the dam.

On July 26 an examination was made of the field sheets of the Canadian party at work at Big Fork on Rainy River. With the aid of these sheets a curved midstream line was determined and by drawing straight lines to conform closely to this curve the points of change of direction on the boundary were determined and the sites where reference marks should be placed for these points of change of direction.

In the latter part of July an inspection was made of the work of the triangulation party then at Pinewood, Canada.

In August sites were selected for reference points in the vicinity of Kettle Falls, the plane-table sheets of the Canadian party were inspected, and a visit was made to a Canadian triangulation party then working in a narrow stream to the westward of White Sand Lake through which the boundary ran.

Descriptions and positions of triangulation stations in Black Bay and a copy of the survey of that Bay made in 1913 were furnished to the engineer of the International Joint Commission who was engaged in making a survey of the flooded areas on Rainy Lake.

In the early part of August an additional plane-table party began work on Rainy River in order to complete the survey of the river to Baudette, the point where the Canadian party had closed work at the end of the previous season. The triangulation on Rainy River was completed early in September.

On September 17 the work of the Canadian party at Boucherville was inspected and a tracing was made from their field sheets to aid in the location of reference marks in that vicinity. Sites were selected for all reference marks between Baudette and International Falls, and the numbers for these marks were decided upon so that the numbering might be done immediately after the marks were set.

Having determined the numbers of the reference marks as far as International Falls consecutive numbering was continued above the falls and through Rainy Lake.

Toward the close of the season the distance across the boundary narrows between reference marks 273 and 274 was accurately measured with a steel wire, the temperature of the wire being taken and the difference of elevation between the points determined. The length of the wire was afterwards determined by stretching it under similar conditions and like tension and transferring the position of the marks on the wire to a railroad track. The distances between the marks on the track were then measured with a 30-meter steel tape under tension and the temperature taken.

The distances between reference marks on the abutments of the bridge over the outlet of Rainy Lake and between reference marks just above the dam at International Falls were measured.

In October a trip was made down Rainy River from Fort Francis to Baudette on the steamer *Agwinda* in order to reinspect the completed topographic work, to note the sites of the reference marks and to mark on a map the navigable channel of the river.

All work on Rainy Lake was completed by October 13 and another party was sent to Baudette to expedite the completion of the survey of Rainy River by mapping the Canadian side of the river in that vicinity. Field work was closed for the season October 26.

The work at Baudette was practically completed by October 21, and the main party was then disbanded. A detached party was occupied in placing reference marks on Rainy River until November 10.

[W. B. FAIRFIELD.]

SUMMARY OF RESULTS.—Reconnoissance: 111 square miles of area covered, 16 points selected for scheme. Triangulation: 97 square miles of area covered, 192 signal poles erected, 20 stations in main scheme occupied for horizontal measures, 157 stations in supplemental schemes occupied for horizontal measures, 85 stations occupied for vertical measures, 182 geographic positions determined, 172 elevations determined trigonometrically. Topography: 58 square miles of area covered, 188 miles of shore line of rivers and lakes surveyed, 5 topographic sheets finished.

Progress made on the survey of the boundary between the United States and Canada in the section between the mouth of Pigeon River and Lake of the Woods, prior to June 30, 1914, is mentioned in the last annual report of the Superintendent. Work on this portion of the boundary was continued after July 1 until the close of the season on October 30.

Starting from the three points, Fourth, Fang, and Fent, of the previous season, all of which stations lie to the eastward of the east end of Basswood Lake, a main scheme of triangulation (larger than that of the previous season) was developed to the westward, covering Basswood Lake, Basswood River, and the greater part of Crooked Lake, two more figures being required to carry the work beyond Curtain Falls and into Iron Lake. Twenty-four stations were located for this, most of them being from 1 to 2 miles back from the lake shore and generally on the first high ridge or hill back from the lake. These high points are difficult of access and it was necessary in many instances to cut lines of sight through heavy timber.

Making the reconnoissance, occupying and marking the stations of the main scheme, and putting in the smaller triangulation from the falls at the east end of Crooked Lake to the wide part of the lake, occupied the time of the entire party from the beginning of the season until September 1, at which date the party was in camp near the east end of Crooked Lake.

On September 7 the plane-table work began at a point in the eastern part of Crooked Lake where it had terminated at the close of the previous season. By October 21 the topography of Crooked Lake, including that of Curtain Falls and part of the river below leading into Iron Lake, was completed.

The smaller triangulation was continued from the falls between Basswood River and Crooked Lake and was extended through the entire length of the lake to Curtain Falls, the last stations, Lure and Knab, being situated, one on the United States side and one on the Canadian side of the falls. Station Lure was marked by a brass plate on a solid rock ledge 8 feet from the south end of the falls.

A number of the stations of the smaller triangulation between the east end of Basswood Lake and the west end of Crooked Lake were tied to the larger scheme, and a connection was made giving a single determination of the short base measured at the Hoist during the preceding season.

Vertical angles were measured at enough stations to determine the elevations of nearly all of the triangulation stations.

All of the stations were marked either with a small brass plate set in the rock or by a drill hole with a triangle cut around it, 72 stations being marked by brass plates and 108 by drill holes.

Observations for azimuth were made at two stations, Igo and Exit, on two nights each, and both of these stations were connected with the main or larger scheme.

[E. R. MARTIN.]

SUMMARY OF RESULTS.—Triangulation: 225 square miles of area covered, 18 positions of monuments determined, 26 stations occupied for horizontal angles, 38.4 miles along boundary line included in triangulation. Inspection and numbering of monuments: 653 monuments inspected and numbered, 3 monuments repaired and foundations strengthened, 765 miles of boundary line covered.

A party was assigned in May, 1914, to the duty of determining the positions and inspecting and numbering the monuments on the United States and Canada boundary from the Continental Divide to the Lake of the Woods.

The main scheme of triangulation established by the boundary parties in 1909–10 was used, and by establishing 5 new stations the positions of the 19 stations were determined.

The monument numbering and inspection were carried on simultaneously with the triangulation from Monument 273 to Monument 295, and without any additional expense. On the completion of the triangulation the work of monument numbering and inspection alone was continued.

Every effort was made to cover as much of the boundary as possible each day. The number of monuments visited and numbered per day depended on the distance between the monuments and the character of the country. An average of about 200 monuments per month was maintained until the swamp section was reached.

The numbering of the monuments was accomplished by drilling holes three-sixteenths of an inch in diameter and one-sixteenth inch deep, close together, so as to outline the number desired. To expedite the numbering changeable plates perforated so as to outline the numbers, fitting into a frame adjustable to the section of the monument best suited to the numbers, were used as templates through which the holes were bored with a light drill.

In October five animals were lost by fire, after which time hired teams were used. The completion of the field work was delayed several weeks by flooded swamps, as the depth of the water in the muskegs made them impassable until ice formed in the month of December.

Measurements between Monument No. 852 and triangulation station Erca, and between Monuments Nos. 911 and 912 were made with an invar tape, using base-line methods. Field work was closed for the season on December 14.

[J. E. McGRATH.]

SUMMARY OF RESULTS.—Reconnoissance: 30 square miles of area covered, 104 points selected for scheme. Base lines: 1 secondary, 450 meters in length. Triangulation: 14 square miles of area covered, 101 signal poles erected, 72 stations occupied for horizontal measures, 59 stations occupied for vertical measures, 114 geographic positions determined. Leveling: 33 elevations determined by leveling, 35 miles of levels run. Azimuth: 1 azimuth station occupied. Topography: 20.41 square miles of area surveyed, 30.5 miles of shore line of creeks surveyed, 35.3 miles of roads surveyed, 3½ topographic sheets finished.

Work on the survey of the northeastern boundary between the United States and Canada in the valley of Hall's Stream was resumed at West Stewartstown, N. H., on July 27.

The work planned for the season was the resurvey, including triangulation and topography, and the re-marking of the international boundary line beginning at the eastern extremity of the section from the Connecticut River to the St. Lawrence River and extending northward along Hall's Stream to its junction with the section following the crest of the highlands that separate the drainage of the St. Lawrence River from that of the St. John River.

The topographic survey had for its southern limit the parallel of 45° as monumented by the boundary-survey parties operating in this section under the treaty of 1842 and was extended up the valley of Hall's Stream for 15 miles, the completed work being represented on

3½ standard topographic sheets on a scale of 1:5,000. For reference of elevations to sea level the height of a point on the railway track in front of Beecher Falls railroad station, based on a system of railroad levels, and stated to be 1,093 feet above sea level, was used. From this point a line of levels was extended northward connecting boundary Monuments 517, 518, 519, and 519a with all the triangulation points on the Canadian side and with the base stations on the American side of Hall's Stream. At all triangulation stations occupied vertical angles were observed on all visible triangulation signals and on the flags in trees erected for the use of the topographical party. The levels were run with a wye level and the main line was checked by running forward and back. A line of levels had been previously run through this valley by a Canadian party in 1914, and approximate connections were made with its elevations.

For the triangulation a base was measured near the mouth of the valley, and at one of the stations in a figure, of which the base forms a side, azimuth was observed on Polaris. The connection with Hertford Mount triangulation station, the nearest point in the Canadian Geodetic Survey, was made through a quadrilateral which included three points of the valley tringulation, and the angles were observed at all four stations. In addition to the stations selected for the regular triangulation scheme a number of high trees in commanding positions along the high hills surrounding the valley were marked with flags and then located by horizontal and vertical angle observations for the use of the topographic party. Many of the lines in the triangulation had to be cut through dense timber. Above Pacquetteville, where the valley is narrow, the scheme was restricted to small-sided figures and the rate of progress was reduced. Fog also interfered with observations in this portion of the work.

The character of the bottom of the valley, in the section below Malvina, through which Hall's Stream flows, is generally alluvial, with only occasional instances of rocky banks, and in consequence changes have occurred in the situation of the stream since the first survey under the Webster-Ashburton treaty, although these are not great, and seem to be the result of gradually operating natural forces. In one case the course of the stream has been deflected into the American shore for a maximum distance of 400 feet in the vicinity of a railroad bridge. The alterations in the stream have displaced all the monuments set by the Smith-Estcourt commission between the mouth of King Creek and Monument 518, and the only monument found standing in this section was one near the American end of the bridge which connects the road across Job Wheeler's farm with the main road in Canada. This monument was originally located near the mouth of West Branch and having been washed out of its previous position was set up in its present position by a former owner of this farm.

Seventeen monuments were set by the party along the stream, being disposed as equally along its length as conditions promising permanence and suitability for marking the location of the stream would permit. The monuments are either bronze boundary marks, cemented in bowlders or ledges of rock, or similar marks set in cement posts that were securely fixed in the ground or substantial beds of concrete. Six of the old monuments were reset in bases of concrete.

DETAILS OF OFFICE OPERATIONS.

The assistant in charge of the Coast and Geodetic Survey office has direct supervision over the work of the office. The miscellaneous section and the tidal research section are under his immediate direction.

Under an appropriation made by the last Congress two new buildings were erected for the accommodation of the chart printing office which have greatly improved the working facilities and the sanitary conditions in that branch of the office, but much work remains to be done in the older portions of the plate-printing offices.

An increase in the force of laborers is necessary to keep the workrooms and office rooms in sanitary condition.

It is recommended that the old wooden buildings in the grounds be removed and that the vaults under the ground in front of the Richards Building be made waterproof, thus providing for storage in a systematic, safe, and economical manner.

The installation of fire plugs and fire hose in the Butler Building and printing office is necessary to protect the valuable original records and engraved plates stored in those buildings against destruction by fire.

The wooden shelving in the library and archives should be replaced by steel shelving.

Furniture and drafting tables in use in the drawing section and in the computing and tidal divisions should be replaced by modern furniture and appliances.

The connection of the Survey buildings with the central power and heating plant is urged as a matter of convenience and economy.

The installation of direct-driven motors and modern machinery in the instrument shop is a much needed improvement and is earnestly recommended.

An offset press for chart printing is an urgent necessity. Without such a press it would be impossible to meet promptly an emergency demand for charts, even by working night and day.

A readjustment of the salaries of office employees and increases in the numbers and salaries of certain grades are needed in order that necessary work may be kept up to date and in order that the Survey may be able to retain the services of efficient employees who now often obtain transfers to other branches of the Government service where rates of compensation are higher and promotion more rapid.

A plan has been adopted of publishing all large-scale charts of the Atlantic coast, up to the scale of 1:80,000, with soundings in feet instead of fathoms. This has met with general approval.

A plan has been approved for greatly simplifying the information in regard to tides and currents published in the tide tables so as to make them most useful for practical purposes.

A new suboffice has been established at Galveston, Tex.; and at Boston, Mass., and New Orleans, La., offices supplied with charts and publications of the Survey have been established under the supervision of the Bureau of Foreign and Domestic Commerce. Arrangements have been made by which a stock of charts for sale to the public will be kept at the suboffices, and also on vessels of the Lighthouse Service.

COMPUTING DIVISION.

The most important work completed or in progress in the computing division during the year is as follows:

Computation and adjustment of the following pieces of triangulation: Along the thirty-ninth parallel between the western boundary of Missouri and the eastern boundary of West Virginia, including a spur from the main arc extending into Kentucky; the triangulation which controls the surveys of the Maryland Shellfish Commission; along the coast of Oregon and on the Columbia River; on the western coast of the Olympic Peninsula between the Strait of Juan de Fuca and Grays Harbor; along the coast of Maine; across the Kenai Peninsula in Alaska, joining Cook Inlet and Prince William Sound; the adjustment of the triangulation from Prince William Sound to the head of Cook Inlet to eliminate the error of closure of the loop, the Kenai Peninsula triangulation being the connecting link; along the St. Croix River in eastern Maine; along the Rainy River in northern Minnesota; the arc between Memphis, Tenn., and Huntsville, Ala.

The computation and adjustment of the following lines of precise leveling: From Crookston, Minn., to Butte, Mont., along the Great Northern Railway; from Butte, Mont., to Pasco, Wash., by way of Spokane, including a spur line from Sand Point, Idaho, to the Canadian boundary.

The computation and adjustment of latitude, the observations for which were made during the summer of 1914. These stations were established along the Texas-California arc of primary triangulation and along the oblique boundary between Nevada and California.

The computation and adjustment of the longitude, the observations for which were made during the summer of 1914, at the stations Far Rockaway, Long Island, Cambridge, Mass., and Naval Observatory, Washington, D. C. This work was done in connection with the determination of the difference in longitude between Far Rockaway, Long Island, and Borkum, Germany, in cooperation with the Royal Prussian Geodetic Institute.

The computation and adjustment of the longitude, the observations for which were made at stations along the Memphis-Huntsville arc of primary triangulation and at one of the stations of the triangulation made to connect a detached scheme near Louisville, Ky., with the transcontinental triangulation; the computation and adjustment of observations made for azimuth at stations on the Memphis-Huntsville arc of primary triangulation.

The computation and adjustment of observations made for the determination of the intensity of gravity at a number of stations; the computation of the effect of topography and isostatic compensation at a number of gravity stations; an investigation made in connection with a test of the formula which gives the variation in the intensity of gravity with the elevation of the station above sea level.

Three publications giving results of triangulation and leveling have been received from the printer during the fiscal year, namely, Special Publication No. 19, entitled "Primary triangulation on the one hundred and fourth meridian, and on the thirty-ninth parallel in Colorado, Utah, and Nevada"; Special Publication No. 22, entitled

"Precise leveling from Brigham, Utah, to San Francisco, Cal."; Special Publication No. 24, entitled "Triangulation in Alabama and Mississippi."

The manuscript of the following publications was prepared for the printer during the fiscal year: Special Publication No. 23, that part which dealt with the geodetic operations of the Survey; Special Publication No. 24, which gives the results of triangulation in Alabama and Mississippi; Special Publication No. 27, entitled "Latitude observations with the photographic zenith tube at Gaithersburg, Md.," by Dr. F. E. Ross; Special Publication No. 28, entitled "Application of the theory of least squares to the computation of triangulation"; Special Publication No. 30, entitled "Triangulation in West Virginia, Ohio, Indiana, Kentucky, Illinois, and Missouri"; Special Publication No. 31, entitled "Triangulation in Oregon, Washington, and California."

DIVISION OF TERRESTRIAL MAGNETISM.

The revision of the field observations on land and at sea was kept up to date.

Information in regard to the variation of the compass was supplied for 155 charts.

Special Publication No. 20, which contains the results of magnetic observations made in 1913, which was sent to the printer last year, was delivered July 29, 1914.

The Results of Observations made at the Tucson Magnetic Observatory in 1911 and 1912, sent to the printer in May, 1914, were delivered August 1, 1914.

Special Publication No. 25, containing the results of magnetic observations made in 1914, was completed and sent to the printer February 17, 1915, and was delivered early in May, 1915.

The manuscript for Special Publication No. 33, to take the place of Special Publication No. 9, has been prepared and is nearly ready for publication. For the 1915 isogonic chart, which will accompany the above and also be published separately, a new base map has been prepared, which contains about 1,200 names of places.

The 1915 magnetic tables are in course of preparation and are well advanced. All the magnetic elements have been tabulated but only the declinations have been reduced to the epoch, 1915.0.

The observatory results for 1913–14 for Cheltenham, Tucson, Porto Rico, Sitka, and Honolulu are all in preparation. The 1913 results for all are finished, and for Cheltenham and Tucson the 1914 results are about half done and for Honolulu about one-fourth done.

As usual, lists of the "magnetic character of days" at all of the magnetic observatories of the Coast and Geodetic Survey were prepared and furnished to Dr. van Everdingen, De Bilt, Holland, in accordance with a resolution of the International Commission for Terrestrial Magnetism, and quarterly reports of the principal magnetic storms recorded at the Cheltenham Observatory were supplied to the editor of the Journal of Terrestrial Magnetism for publication.

The tabulation of earthquakes recorded at the five magnetic observatories was made and two copies were furnished to Prof. Harry

Fielding Reid, one for transmission to the International Seismological Association and the other for his own use. Copies were also furnished to the United States Weather Bureau and to Prof. J. B. Woodworth, of the Harvard seismological station, at Cambridge, Mass.

Various miscellaneous computations and tabulations were made at various times; e. g., computation of moment of inertia for magnetometers, tabulation of results of magnetic observations in the vicinity of the United States and Canada boundary, etc.

The tabulation of data concerning observations at the five observatories in cooperation with the Australian antarctic expedition of 1912–13 was completed.

Revision was also made of the observations made at Cheltenham to standardize various instruments, including one for the United States Lake Survey and one for the Naval Observatory.

The number of requests for information received during the year was larger than for any previous fiscal years except 1912 and 1914.

TIDAL DIVISION.

The work of the tidal division for the year includes the preparation of the annual Tide Tables, with reprints for the Atlantic and Pacific coasts; harmonic analyses were completed for 3 stations of 1 year each, for 8 stations of 29 days each, and summations were made for an analysis for 2 other stations of 1 year each; nonharmonic reductions were made for 161 stations, with a combined length of 34 years, 5 months, and 19 days; mean sea level was computed for 46 stations, with a combined length of 15 years, 5 months, and 21 days; tabulations of high and low waters, and hourly heights of the sea, were made for 257 stations, with a combined length of 50 years, 9 months, and 22 days; monthly means and extremes for 12 stations, with a combined length of 88 years and 8 months; the diurnal inequality for 18 stations, with a combined length of 7 years, 5 months, and 28 days; the reduction of 374 volumes of soundings, involving the computation of the plane of reference for 159 stations, and the entering of many thousand tide reducers; registering and indexing tidal records received during the year; indexing and filing all tabulations and reductions made during the year.

The total number of calls upon the tidal division for work or information during the fiscal year ended June 30, 1915, was 1,138.

In accordance with an agreement made in former years, tidal predictions for five stations were made and sent to the Imperial Hydrographic Office at Wilhelmshaven, Germany.

At the request of the government of Western Australia, tidal predictions for Port Hedland were made and sent for the years 1914, 1915, and 1916; and for Fremantle for the year 1915.

The manuscript of the General Tide Tables for 1916 was completed, and the printed tables were received from the Printing Office in April, 1915, while the Atlantic and Pacific coast reprints were received in May, 1915. They are similar to the tide tables of preceding years, with corrected values where additional information has been received.

For the first time predicted tides were made for Seattle, Wash., for the year 1915, and sent to Capt. J. F. Pratt, inspector, Seattle,

Wash., for use in the Chamber of Commerce. The 1916 edition of the Tide Tables contains predictions for this station, making a total of 71 ports for which full predictions are given.

For Apokak, Kuskokwim River, Alaska, predicted tides were made for six months, May to October, 1915, printed and issued as a separate leaflet, being the first separate tide table printed for a single station.

The tide curves for predicted tides for Juneau and Ketchikan, Alaska, were prepared from April 1 to December 31, 1915, for use of wire-drag parties, who are at work in this part of Alaska.

Considerable time has been given to the consideration of the proposed changes to be made in the Tide Tables for 1917.

TIDE STATIONS IN THE UNITED STATES AND INSULAR POSSESSIONS, ALASKA, CANAL ZONE, AND WEST INDIES FOR WHICH THE COAST AND GEODETIC SURVEY HAS ONE YEAR OR MORE OF CONTINUOUS RECORD.

	Years.		Years.
Eastport, Me	4	Charlotte Harbor, Fla	1
Pulpit Harbor, Me	18	Egmont Keys, Fla	1
Portland, Me	5	Cedar Keys, Fla	3
Boston, Mass	31	St. Marks, Fla	1
Cape Cod Canal, East Entrance, Mass	2	St. Vincent Island, Fla	1
Cape Cod Canal, West Entrance, Mass	2	Pensacola, Fla	2
Newport, R. I	3	Mobile Point, Ala	5
Bristol, R. I	2	Biloxi, Miss	2
Providence, R. I	8	Cat Island, Miss	1
Block Island, R. I	1	Port Eads, La	1
New London, Conn	1	Weeks Island, La	7
Willets Point, N. Y	4	Galveston, Tex	9
Fort Hamilton, N. Y	22	Fort Point, Tex	4
Governors Island, N. Y	35	Morgans Point, Tex	1
Sandy Hook, N. J	17	Havana, Cuba	1
Atlantic City, N. J	4	Isabela de Sagua, Cuba	3
Cold Spring Harbor, N. J	3	Nassau, Bahamas	2
Reedy Island, Del	7	Colon, Canal Zone	10
Philadelphia, Pa	16	Balboa, Canal Zone	10
Fort Carroll, Md	4	Naos Island, Canal Zone	6
Baltimore, Md	13	San Diego, Cal	28
Washington, D. C	14	San Francisco, Cal	41
Colonial Beach, Va	4	Sausalito, Cal	20
Alexandria, Va	2	Mare Island, Cal	2
Tappahannock, Va	1	Collinsville, Cal	1
Old Point Comfort, Va	26	Humboldt Bay, South Jetty, Cal	1
Richmond, Va	3	Humboldt Bay, Hookton Slough, Cal	1
Wilmington, N. C	4	Astoria, Oreg	23
Georgetown, S. C	6	Port Townsend, Wash	3
Fort Sumter, S. C	23	Bremerton, Wash	3
Charleston, S. C	10	Seattle, Wash	16
Port Royal, S. C	1	Morford, Wash	2
Tybee Island, Savannah Entrance, Ga	2	Juneau, Alaska	3
Fort Clinch, Fla	5	Skagway, Alaska	3
Fernandina, Fla	18	Sitka, Alaska	1
Mayport, St. Johns River, Fla	3	Kodiak, Alaska	11
St. Augustine, Fla	2	Iloilo, P. I	6
Cape Florida, Fla	1	Cebu, P. I	4
Indian Key, Fla	1	San Pascual, P. I	1
Key West, Fla	4	Corregidor Island, P. I	3
Tortugas, Fla	4	Manila, P. I	9
		Grande Island, P. I	2
		Honolulu, Hawaii	31

CHART CONSTRUCTION DIVISION.

The aim of this division is to afford, by means of charts and Notices to Mariners, the latest information with respect to the navigable waters of our coasts with as little delay as possible, and to show this information on the charts in a manner by which it can be most clearly read and easily comprehended.

In carrying out this policy attention should be called to two important innovations, viz, the simplification of the information on the charts, which has been in progress during the past five years, and the adoption of aluminum plates in place of lithograph stones, which has occurred within the same period. Their effect has been the production of more serviceable charts for the mariner and in less time than by former methods. In fact, but for these changes the several branches of chart work would be hopelessly in arrears.

The old series of charts show a number of details, such as fences, woods, farm roads, individual houses, etc., which are not of importance to the navigator and are of a transitory character. Their omission, besides expediting the construction of the chart, has the effect of showing more clearly the prominent land marks needed by the navigator. In addition, on new charts, both the hachured land area and sanded water areas have been simplified, with the result that the original drawing and engraving is reduced and subsequent corrections more easily made.

Excepting the United States Lake Survey, all nautical chart-producing organizations construct their charts on the Mercator projection. There is no practical difference except in high latitudes between the Mercator projection and the Polyconic projection, in so far as the charts on a scale of 1:80,000 or larger are concerned, but the difference between the projections is appreciable for the smaller scales and is an objectionable feature of the old series of charts.

The substitution of the foot for the fathom as the unit for soundings on charts of 1:80,000 and larger scales which was decided upon during the past year has met with general approval.

Two other objectionable features will be eliminated by the new series of charts, viz, the lack of orientation with the meridian and the maintenance of two depth units on the same chart.

In planning the work of the division precedence has been given to new charts based on the new surveys of Alaskan waters, and in order to meet urgent demands preliminary charts have been issued. Next in importance has been the maintenance of existing charts up to date.

Besides the current corrections to the plates, the engraving section is engaged in engraving the new small scale series of charts, the 1:400,000 on the Atlantic and Gulf coast and the 1:200,000 on the Pacific coast, with a view of orienting them and putting them on the Mercator projection. Here also the policy of simplification has expedited the work with advantage to the charts in the way of clearness, by bringing into prominence the more important details.

The conditions of the printing section have been greatly improved. In the sundry civil act for 1915 Congress appropriated $12,500 for an extension and rebuilding of one of the buildings of this section. The bids on the first plans exceeded the amount appropriated and

new proposals had to be called for on revised plans. This caused a delay, so that construction was not started until November 12, 1914. On January 13, 1915, the one-story annex was completed and on April 7 the new two-story building was completed. We have as a result a well-arranged and well-lighted printing hall 150 feet in length by 18½ feet in width, in which are installed all the power presses now in use, with room for one or more additional offset presses, which it is hoped will be obtained in the near future. Above the west end of the printing hall is a second story, which affords a well-lighted room 78 by 18½ feet for the chief printer's office and the lithographic transfer presses and other transfer equipment. Opening out of this room is a lithographic dark room of ample dimensions.

There yet remains to be done the rearrangement and repair of the adjoining building, the installation of an elevator, and the purchase of some additional equipment.

The advantage of a metal plate in place of stone was recognized in this office for a number of years, but the experiments were interrupted by the current work. From April, 1911, the process was pursued more thoroughly with such successful progress that early in 1912 lithographic stones were entirely superseded by aluminum plates. Besides being cumbersome to handle, lithographic stones had the disadvantage of requiring for a reprint of a chart the repetition of the whole process of transferring in the same manner as for a new subject, whereas the aluminum plates can be filed away the same as engraved copper plates, and when required taken out and printed after changes have been made to utilize information received subsequent to the last printing.

The next advance will require the acquisition of an offset press, which has been recommended for several years past. With this press the quality of the prints will be improved, the printing expedited, and the surface of the chart paper will not be such an important consideration as it is with the flat-bed press. The increased information referred to in the preceding pages adds to the work of the lithographers in that before printing it has to be applied to the aluminum plates. As new charts are published each year, the lithographic work is being continuously increased from this source.

In the photograph section both the blue print and photostat work has exceeded that of past years. The difficulty which arises is to meet the demand when a large quantity of material for reproduction is received with the request that it be made special.

In order to obtain the best negatives for lithographs it is desirable to have an additional camera for negatives for bromide enlargements and restrict the present camera to large-scale work which will require a minimum of focal change.

The electrotype section has been charged with various duties. Besides the electrotyping, specifications have been prepared for repairs of buildings and for new equipment, the work of the contractors has been supervised, and the wiring of the buildings and other miscellaneous electrical work done.

CHART PREPARATION.

Schemes approved for new charts	18
Approved schemes on hand, charts not started	11

Drawings for new charts finished	18
Drawings for new charts in hand	8
New drawings for new editions finished	4
New drawings for new editions in hand	6
Extensive corrections finished	137
Extensive corrections in hand	18
Chart drawings from Manila for new charts finished	3
Chart drawings from Manila for new charts in hand	0
Chart drawings from Manila for new editions finished	4
Chart drawings from Manila for new editions in hand	0

Various miscellaneous drawings and tracings.

ENGRAVING.

New plates for new charts finished	3
New plates for new charts in hand	12
New plates for former lithographic charts finished	0
New plates for former lithographic charts in hand	1
New bassos for new editions finished	18
New bassos for new editions in hand	16
New bassos for reissues finished	16
New bassos for reissues in hand	6
New editions using current plate finished	18
New editions using current plate in hand	4
Extensive corrections applied to plates	286
Extensive corrections in hand	11
Miscellaneous plates engraved or corrected	11
Minor corrections applied to plates	1,245
Charts in section, engraving not started	0

PRINTING.

New subjects printed from aluminum plates	51
Reprints printed from aluminum plates	108
Reprints printed from stones	1
Total lithograph charts printed	160
Number of engraved charts printed	479
Miscellaneous lithographic publications	11
Miscellaneous engraved publications	1
Lithographic charts printed	62,036
Engraved charts printed	53,611
Miscellaneous lithographic prints	22,417
Miscellaneous engraved prints	25
Total	138,089
Lithographic impressions	243,031
Engraved impressions	61,768
Total	304,799

ELECTROTYPING.

Altos completed	47
Bassos completed	50
Total	97
Number of pounds of copper deposited	3,741

PHOTOGRAPHING.

Glass negatives made	1,189
Paper negatives made	9
Velox prints made	1,968
Vandyke prints made	64

Bromide prints made	259
Blue prints made	3,127
Photostat prints made	15,224
Lantern slides made	172
Matrices made	90
Prints mounted	18
Negatives developed	0
Photolithographic negatives, number of charts	49

CHART DIVISION.

The regular work of this division has been continued during the year. In order to keep the chart issues up to date with the force available, considerable overtime work has been necessary. Seven employees from other divisions have been detailed at different times during the year to aid in the work of the chart division.

The total issue of charts for the year was 119,387, an increase of 1,895 over the previous year. The total issue of Coast Pilots was 6,291, and of Tide Tables, Atlantic Coast, 2,050, Pacific Coast 10,775, General 2,206.

In addition to charts, Coast Pilots, and Tide Tables the following publications were received during the year:

Philippine Island map No. 14	200	Supplement to Chart Catalogue	2,600
Chart Catalogue, 1914	2,573	Supplement to Coast Pilot, Part III	1,000
Chart Catalogue of Philippine Islands	312	Supplement to Coast Pilot, Part V	1,480
Extract to Catalogue, New York and vicinity	451	Coast Pilot Notes, Kuskokwim Bay and River	500
Supplement to California, Oregon, and Washington	1,050		

The following Coast Pilots were issued during the year:

Part I–II	314	Inside Route, Coast of New Jersey	704
Part III	394	Porto Rico	47
Part IV	981	California, Oregon, and Washton	545
Part V	410	Alaska, Part I	321
Part VI	398		
Section D	349	Total	6,291
Part VIII	256		
Inside Route, New York to Key West	1,019		
Inside Route, Key West to New Orleans	553		

The following Tide Tables were issued during the year:

Atlantic coast:		General:	
1912	2	1898	1
1913	4	1899	1
1914	18	1900	1
1915	1,900	1911	2
1916	126	1912	1
Total	2,050	1913	3
		1914	210
Pacific coast:		1915	1,445
1911	1	1916	542
1914	338	Total	1,987
1915	10,181		
1916	255		
Total	10,775		

Charts were issued as follows:

Sales agents	52,855	Executive departments	7,077
Sales by office and chart division	2,645	Suboffice, Manila, P. I.	2,594
Congressional account	4,838	Foreign governments	318
Hydrographic Office	39,124	Miscellaneous	610
Bureau of Lighthouses	3,840	Total	119,387
Coast and Geodetic Survey	5,486		

Charts were issued at the suboffice, Manila, P. I., as follows:

Sales agents	274	United States Coast and Geodetic Survey suboffice	78
Military authorities	207	Miscellaneous	10
Naval authorities	158	Sold for cash	567
Civil authorities	211	Total	1,542
United States Coast and Geodetic Survey vessels	37		

INSTRUMENT DIVISION.

The annual report of the instrument division gives details of work accomplished in that division during the year, including the general office work, the instrument shop, and the carpenter shop.

The work of accounting for instruments, general property, and furniture has been attended to as heretofore, and, in addition, the necessary correspondence of the division has been kept up.

The scientific part of the work in designing and constructing new instruments, apparatus, and various kinds of special experiments, with a view to improving apparatus or methods of construction, has been conducted as usual.

The making and repairing of furniture, repairs to office buildings, packing and unpacking instruments and general property issued or received, and other special duties in connection therewith have been carefully attended to.

There have been unusual demands on the clerical force and on the carpenter shop in connection with repairs and changes in the Survey buildings.

The necessary work involved in preparing for condemnation and le or other disposition, instruments and general property worn out no longer needed in the Survey, was performed.

LIBRARY AND ARCHIVES.

The chief of the division of library and archives has charge of the general reference library maintained by the Survey and also is the custodian of the original sheets and field records.

An inventory of the books and pamphlets was taken in August, 1914, and the number of books and pamphlets on the shelves or charged out was 22,549.

Five hundred and seventy-five books were sent to the Government Printing Office for binding and 161 additional books were prepared for binding. The publications of the Survey were rearranged with a view to making them more accessible. Bibliographies on various subjects were prepared. Many books and maps were borrowed from the Library of Congress as required for the use of the Survey. Books

and maps were loaned to the Library of Congress, the Carnegie Institution, and other offices and institutions.

A list of all the maps in the library, arranged geographically, was prepared and a copy of this list was furnished to the map division of the Library of Congress. The atlases were examined and those of no value to the Survey offered to the Library of Congress for the selection of such items as may be of use to that library. Many maps and charts were eliminated from the files and those of value transferred to the Library of Congress.

The total number of charts on hand in October, 1914, was 11,181; the total number of maps on hand at the same date was 5,318; of blue prints 3,583.

It is recommended that metal shelving be provided for the valuable field, observatory, and office records, as a safeguard against fires. These records amounting to some 85,000 items are now arranged on wooden shelving.

ARCHIVES ACCESSIONS DURING THE YEAR.

Subject.	Volumes.	Cahiers.	Subject.	Volumes.	Cahiers.
Astronomy:			Pendulum:		
Observations	64	59	Observations	27	5
Computations—			Computations—		
Field	37	.....	Field	6	23
Office	3	.....	Office	.....	9
Geodesy:			Surveys: Soundings	525	.....
Observations	169	55	Tides and currents:		
Computations—			Tides	119	7
Field	.....	61	Currents	4	35
Office	.....	87	Levels	8	31
Hypsometry:			Densities	.....	1
Observations	17	13	Miscellany	20	54
Computations—					
Field	.....	8	Total[a]	999	1,81[a]
Office	.....	4			
Terrestrial magnetism:					
Magnetics	.....	382			
Absolute measures	.....	982			

[a] This statement does not include 108 hydrographic sheets, 85 topographic sheets, and 42 negative prints received during the year.

TIDAL RESEARCH SECTION.

The reduction and tabulation of hourly current observations ta from seven light vessels on the Atlantic were continued.

For the inside route pilot, Key West to New Orleans, tidal and c rent observations were reduced and results furnished. The curi tables contained in Part IV of the Atlantic Coast Pilot were par checked and revised. The tides at Port Simpson, British Columbia were predicted for the years 1916 and 1917 as a basis for current predictions for Seymour Narrows. Current predictions for Sergius Narrows, British Columbia, were furnished for use in the tide tables for 1916. A computation in reference to the number of hours of fog in certain localities for each month of the year for a number of years was made for the coast pilot section.

Short series of current observations for Florida Reefs, Kuskokwim Bay, and Cook Inlet were reduced.

A scheme was outlined and submitted for the observation of tidal currents, including the indication upon charts of proposed stations for a portion of the New England coast.

Various other reports and investigations were made, and information was furnished in reply to requests from outside sources on technical subjects relating to tides, currents, effect of winds, height of waves, densities and temperatures of sea water, and other subjects.

MISCELLANEOUS SECTION.

This section attends to the purchase and distribution of supplies and keeps accounts relating thereto, makes requisitions for printing and binding, issues stationery to field parties and office divisions, audits accounts payable from the appropriation for "Office expenses," conducts the correspondence relating thereto, and performs various other miscellaneous duties.

During the year the chief of this section represented the Department of Commerce on the General Supply Committee.

Respectfully,

E. LESTER JONES,
Superintendent.

To Hon. WILLIAM C. REDFIELD,
Secretary of Commerce.

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