ANNUAL REPORT

OF THE

SUPERINTENDENT, UNITED STATES COAST AND GEODETIC SURVEY

TO THE

SECRETARY OF COMMERCE

FOR THE

FISCAL YEAR ENDED JUNE 30, 1917

DEPARTMENT OF COMMERCE
UNITED STATES OF AMERICA

WASHINGTON
GOVERNMENT PRINTING OFFICE
1917

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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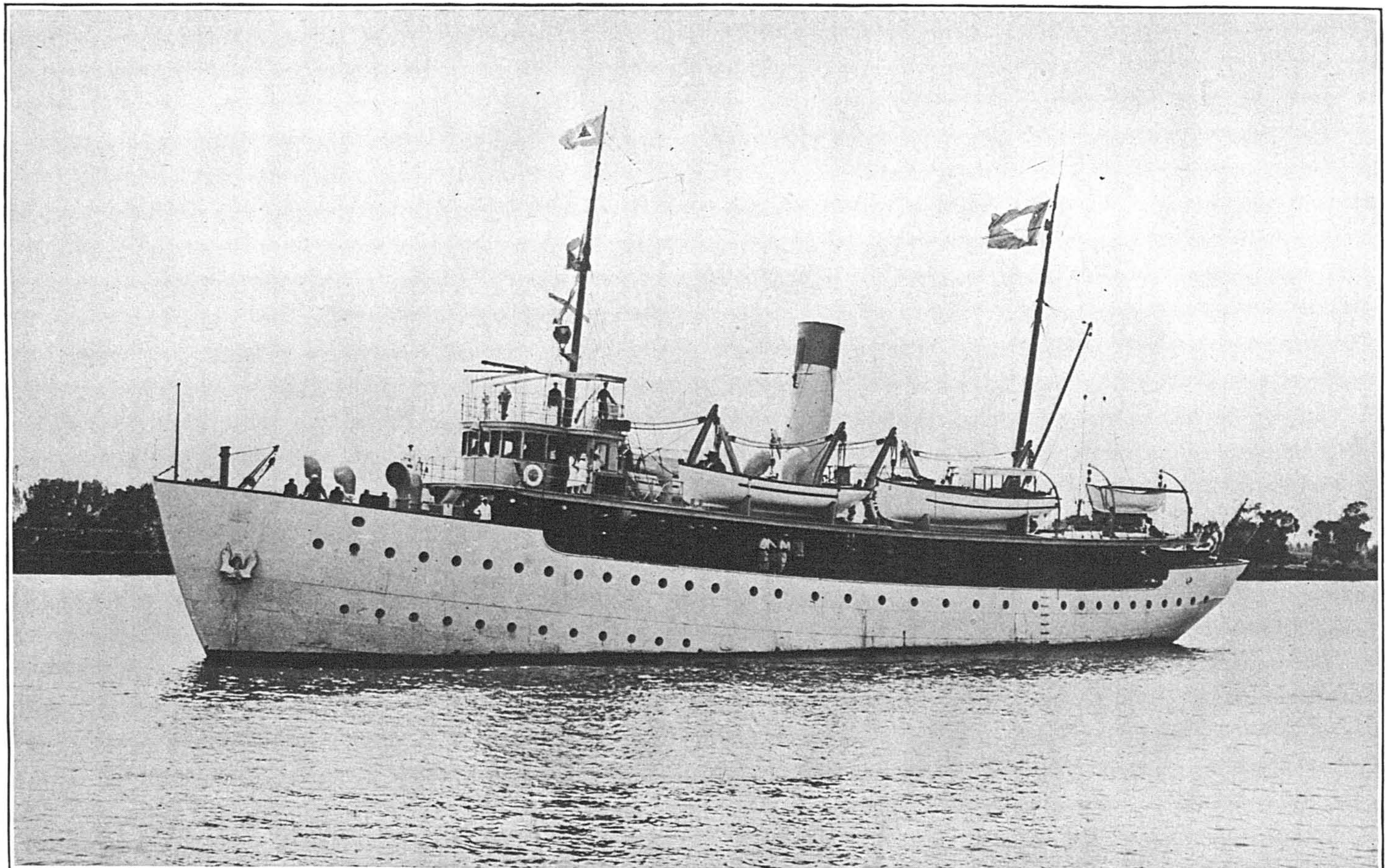


UNITED STATES COAST AND GEODETIC SURVEY STEAMER "SURVEYOR."

The most modern surveying ship, designed especially for work on the Pacific coast. Has a capacity of 75,000 gallons fuel oil and a cruising radius of 5,000 miles. Now temporarily in the United States Naval Service.

REPORT

OF THE

SUPERINTENDENT, U. S. COAST AND GEODETIC SURVEY.

DEPARTMENT OF COMMERCE,
COAST AND GEODETIC SURVEY,
Washington, October 5, 1917.

SIR: There is submitted herewith my annual report as Superintendent of the United States Coast and Geodetic Survey for the fiscal year ended June 30, 1917.

INTRODUCTION.

In my 1916 annual report consideration was given in detail to the office organization with its various divisions. It showed the functions of these divisions and gave such information as would enable the reader to become acquainted with the office procedure of the Bureau under the reorganization that had been recently put into effect.

That report gave a statement which showed the needs of the Bureau and what had been accomplished in the office and field during the year. The present report is divided into three parts, as follows:

Part I, Chapter I, is devoted to a general discussion of the plan of the field work of the Bureau along the coast and in the interior, what has been accomplished, and what remains to be done. Chapter II considers the needs of the field service in order that its work may be efficiently prosecuted.

Part II, Chapter I, is devoted to a discussion of what has been done at the Washington office of the Bureau, and in Chapter II are taken up some of the needs of the Washington office of the Bureau.

Part III gives a résumé of the work accomplished in the field and in the office during the year.

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

CHAPTER I.

PLAN OF THE FIELD WORK.

In the language of the organic act creating this Bureau, enacted during the administration of President Jefferson, its purpose was stated to be * * * "to cause a survey to be taken of the coasts of the United States * * * for completing an accurate chart of every part of the coasts within the extent aforesaid." From this origin, as modified and added to by subsequent legislation, the work of the Bureau, as is implied by its present name (United States *Coast* and *Geodetic* Survey) has been enlarged into what is generally spoken of as two distinct fields of activity. They are surveying of the coasts, generally spoken of as hydrographic surveys which ascertain the depths of our coastal waters, and surveying in the interior called geodetic surveys which consist of the establishment of the control or framework on which all land surveys, Federal, State, municipal, and industrial are or should be based.

GENERAL CHARACTER OF THE ATLANTIC COAST.

The nature of the coast largely determines the method of making the hydrographic surveys. Broadly speaking, along the coasts of the United States and throughout their possessions are to be found three general classes of shore formation, each presenting a different problem to the hydrographic surveyor.

From Maine to Sandy Hook, just south of the entrance to New York Harbor, the coastal formation is that of a rocky bluff, or shelving rocks extending to and beneath the waters, strewn with bowlders.

From Sandy Hook to as far south as the vicinity of Palm Beach, Fla., the shores are sandy, with an absence of prominent bluffs, rocks, and bowlders.

From Palm Beach around the southern shores of Florida, up to the neighborhood of Cedar Keys, coral reefs are characteristic of the coast line. Some of these reefs have taken the form of small islets, known locally as keys, while many others are entirely submerged but reach so close to the surface that they are grave menaces to navigation. (See fig. 3.)

THE GULF COAST.

Then, from Cedar Keys to the Mexican boundary line, the coasts are largely sandy, though presenting different characteristics from the sandy stretch between New York Harbor and Palm Beach in that immense sand bars have been thrown up, in places making great inland bodies or stretches of water through which commerce must travel to reach the Gulf. (See fig. 3.)

THE PORTO RICO COAST.

Leaving the shores of the continential United States, there remain long stretches of shore lines touched by the Atlantic Ocean and the Caribbean Sea. They are the coasts of Porto Rico and the outlying islands. Off these shores (with the exception of the north and northwest coasts of Porto Rico which face the open Atlantic Ocean) the depth increases gradually from the shores to the open waters and, as a rule, the bottom is covered with coral growths, and the chief dangers to navigation are the coral reefs as in that stretch of the coast of Florida from Palm Beach around to Cedar Keys. On the north and northwest coasts of the island of Porto Rico the shores are exposed to the open ocean, and the slopes are abrupt; therefore the coral growths along this stretch of the coast, considered from the standpoint of a danger to navigation, are negligible. (See fig. 5.)

THE PACIFIC COAST.

Passing now to the Pacific Ocean, the whole of the shores of the United States, from the Mexican boundary to the Canadian boundary, may generally be described as rocky, with stretches of beaches here and there resulting from coastal degradation. (See fig. 3.)

THE ALASKA COAST.

The shores of Alaska, from their southernmost point at Dixon Entrance, throughout southeastern, central, and western Alaska, along the northern Pacific Coast side and the Bering Sea side of the Aleutian Islands and back along the Alaska Peninsula to the neighborhood of Bristol Bay, are exceedingly rocky, with stretches of sandy beach here and there. In rapidly reviewing the nature of the coast of Alaska, emphasis must be placed on the precipitous rocky shores of southeastern Alaska, which consist almost entirely of elevated islands and peninsulas carved by glacial action and separated by narrow and deep fiords. Here was found the inspiration for that term "pinnacle rock" which aptly describes the dangerous instrument so well designed by nature to effectually tear a hole in the bottom of a vessel and send her to the bottom. (See fig. 4.)

Passing through these waters the traveler sees on every hand rugged mountain ranges whose profiles present a bewildering confusion of sharp, jagged peaks of various heights. Let him, then, imagine these same topographic features duplicated in the waters about him, the top of the highest peaks appearing above the surface in the form of precipitous rocky islets, those of slightly less elevation rising to within a few feet of the surface, while others, still lower, rise but slightly above the bottom.

With this picture in mind we have some conception of what a problem it is for the hydrographic engineer to discover and chart these hidden dangers rising from the great depth of the ocean waiting to rip open the bottom of the unfortunate ship that passes their way. To make matters worse, the navigator who can detect other dangers to his vessel with some accuracy is yet groping in the dark with no means of divining the presence of this hidden danger of the sea. There is no break in the water and no ripple on the surface above it. There is absolutely no indication of this concealed menace.

From Bristol Bay to the north and around east to the one hundred and forty-first meridian, the northeastern point of Alaska, the coast line is generally composed of sand beaches and mud flats.

THE PACIFIC ISLANDS.

Going now to the islands in the Pacific Ocean we have the coasts of the Hawaiian and Philippine Islands which are surveyed by this Bureau.

The various islands of each of these groups came into existence through volcanic action, and therefore they have abrupt shores which drop off into great depths. The water has a temperature which promotes coral growth where great depths do not occur. There are extensive stretches of these island shores where the coral reefs require the same close surveys that are necessary along the coral coasts of Florida and Porto Rico. This is a general statement which suffices now, but the coasts of the Hawaiian and Philippine Islands will be discussed in detail later on.

Besides these two main groups in the Pacific, there is the little island of Guam, also of volcanic origin, with its shores and coral beds to be surveyed, and on the Atlantic coast the newly acquired Virgin Islands of the United States. (See fig. 5.)

THE PANAMA CANAL REGION.

There yet remain, before we have completed a hurried review of the coast lines that fall to the lot of this Bureau to survey, two other areas, one on the Pacific coast and the other on the Atlantic coast. They are the approaches to the Panama Canal. While these are not extensive in area, they are doubtless destined, through the great amount of steamship traffic that will pass through the canal, to become of the utmost importance and will require searching examinations. (See fig. 5.)

As to the character of these two approaches: That on the Atlantic side presents no great problem. There are some coral reefs, where conditions are favorable to their growth, and there are also, here and there, beds of rocks protruding above the sediment from the Chagres River that has in the course of time spread a mantle over the hard bed of the approach to the canal.

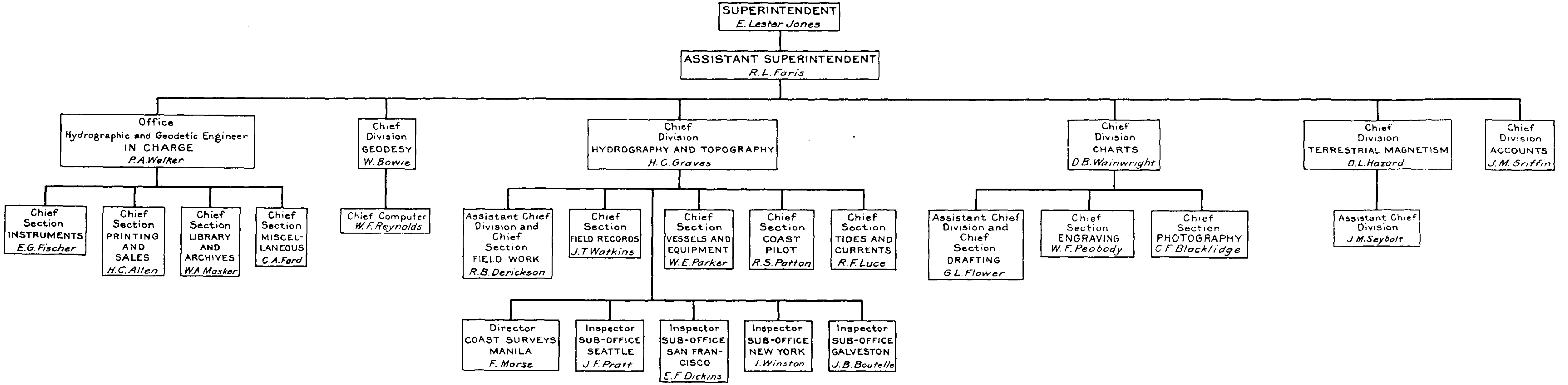
That of the Pacific entrance to the canal is a more serious and difficult problem for the hydrographic engineer. Here are found conditions not very different from those of southeastern Alaska, except that the unexpected isolated peaks of rocks found in the ocean bed at the entrance to the canal, and for a considerable distance seaward, had their origin in a volcanic activity, and the conformation of the bed of this approach permits a fairly accurate prediction that dangers may be found.

No. 2.

ORGANIZATION CHART.

Effective Oct. 15, 1915
Revised to Oct. 1, 1917.

CHART SHOWING ORGANIZATION OF THE
U.S. COAST AND GEODETIC SURVEY
1917



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EXTENT OF THE GENERAL COAST LINES.

The lineal extent of each kind of coast line included under the classifications according to formation is given below. That a wrong impression may not be conveyed as to the magnitude of the hydrographic area requiring the attention of this Bureau, it is proper to say here that the lineal extent of these shores under these classifications only partly states the situation, for the very patent reason that much depends upon how quickly these shores drop off to great depths free from obstructions to navigation. If the water is comparatively shallow for great distances toward the sea, dotted with islands, a lineal extent of a few miles of shore line embraces great areas to be surveyed, whereas if the shore drops off to great depths free from pinnacle rocks, the area necessary to be covered is small.

The lineal extent of our general coast lines, classified according to formation, is as follows:

	Miles.
Rocky formation (generally fixed and unchanged by the action of tides and currents):	
From the northern coast boundary of Maine to the entrance to New York Harbor	600
The Pacific coast of continental United States	1,366
The coast of Alaska from Dixon Entrance to Bristol Bay	3,850
The approaches to the Panama Canal	71
Porto Rico	122
	6,009
Coral formation:	
From Palm Beach, Fla., around Cedar Keys, Fla.	567
All of the coasts of Porto Rico except part of the northern and part of the western shores of the main island of Porto Rico	189
The coasts of Guam, Hawaii, and the Philippine Islands	4,923
	5,679
Sand or mud flat formation (subject to change from the action of tides and currents):	
From New York Harbor to Palm Beach, Fla.	1,194
From Cedar Keys around the coast of the Gulf of Mexico to the Mexican boundary	1,156
From Bristol Bay around the Alaska coast to the one hundred and forty-first meridian	2,790
	5,140

METHODS OF HYDROGRAPHIC SURVEYING.

It is my purpose to discuss in detail the coast line of each of the coastal States of continental United States, and our other coast lines, both with reference to what has been accomplished and what remains to be done, but if, before doing this, we consider briefly something of the history of the methods of making the hydrographic surveys, I am sure it will lead to a better grasp of the problem that is before us.

Happily for the coordination of surveys made of the coast, whether contiguous or separated by thousands of miles, the original plan adopted by the Bureau and the one which has been followed throughout its existence, was laid by an eminent scientist who conceived that the survey of the country should be controlled by a connected system of triangulation in order that the position of any selected point in a surveyed area might readily be determined with relation to any other point or points on the surface of the earth which had been previously connected with the triangulation.

With this accurate control, the position of a newly surveyed area can be determined with exactness with relation to completed surveys, and little or no confusion will result.

If the same admirable foresight could have been exercised in planning the means of making surveys as was exercised in coordinating the relation of the positions of the different surveys, then we would have been far more advanced at the present day with less expenditure of energy. Unfortunately, however, there are phases of human activity in which the method of procedure must be learned by practical experience and in which the problem is so intricate that advancement is slow.

This has been the shortcoming, if such it may be termed, of the Bureau in making the hydrographic surveys. Or, better said, human foresight had not the power to conceive the ultimate needs that would arise, because it could not be foreseen what strides marine commerce would make.

An examination of the records of the surveys by the Bureau of any given important harbor where the areas are unchangeable will show that generally at least two different surveys have been made, each adequately meeting the needs of the day when made, and each insufficient for the needs of succeeding eras of ships and shipping.

For example, the deepest draft of merchant vessels ranged from 12 feet in 1825 to 20 feet in 1850. These vessels were sailing ships which, in order to enter any harbor against an adverse wind, must beat back and forth across the harbor. Therefore, they did not require one deep, clearly defined channel so much as the knowledge of the dangerous shoal areas over the entire harbor.

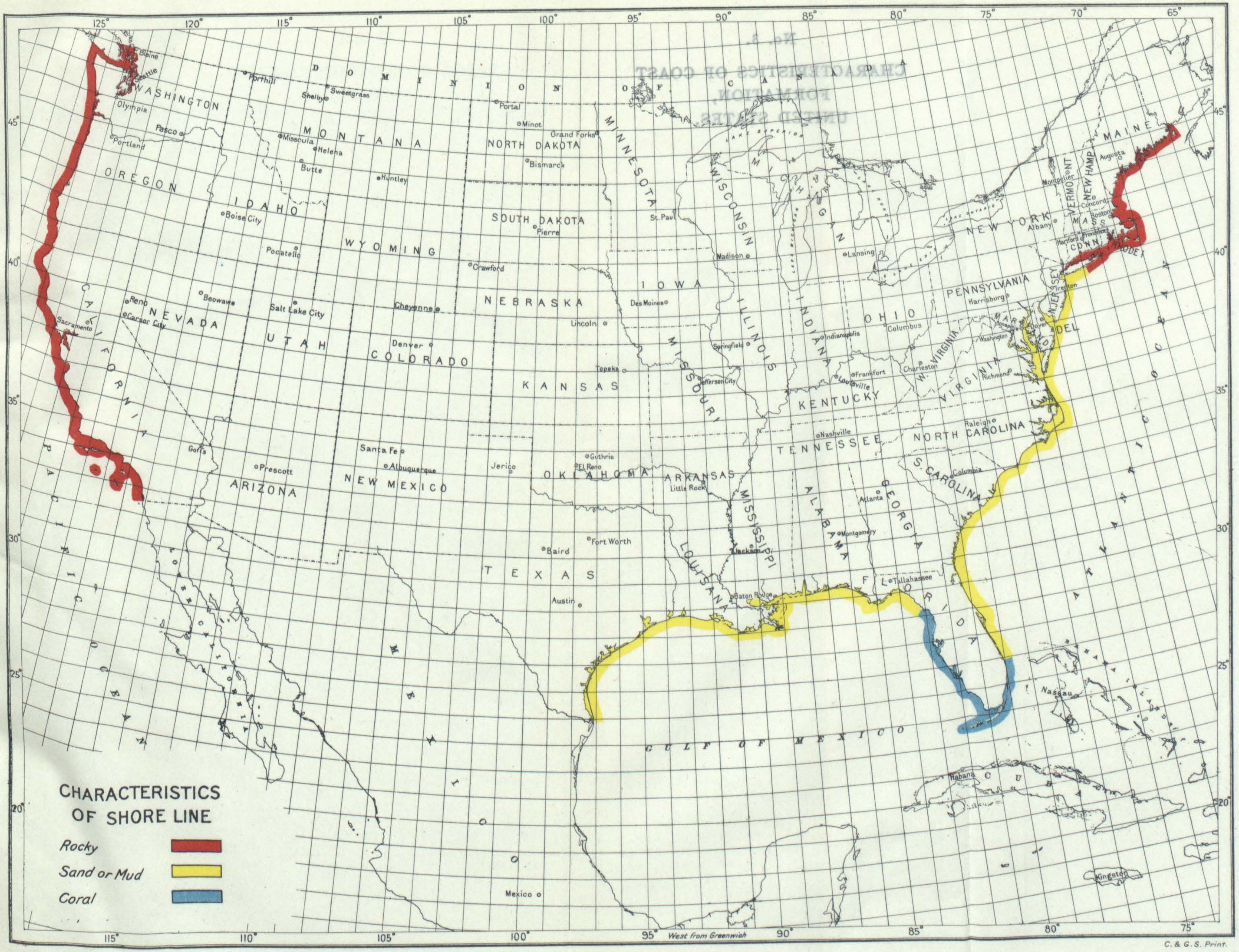
Then, from 1850 to 1895 the draft of the merchant vessels increased from 20 feet to about 30 feet, and most of the commerce was carried in steam-powered vessels that were not dependent on the wind for motive power and could keep to a defined channel.

Now, if we examine these old surveys of the important harbors, we will find that as the draft of the vessels increased there was a seeking out in each harbor of the deepest channel available in the harbor, and of course commerce favored that harbor with the deepest channel. In fact, it is related that in the case of ports less favored with natural channels deep enough to allow a large vessel to pass in and out with a full cargo, the full cargo freight rate was charged before a large vessel would go into such a port for such cargo as she could carry over the bar or shoalest part of the harbor. As this competition sprung up in commerce, resurveys made were not so much of the entire harbors as closer examinations to locate and define these channels.

The draft of merchant vessels has continued to increase until now a depth of 40 feet is required for some of them, and long ago the

No. 3.

CHARACTERISTICS OF COAST FORMATION, UNITED STATES.


CHARACTERISTICS
OF SHORE LINE
Rocky
Sand or Mud
Coral
DOMINION OF CANADA
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
S. CAROLINA
NORTH CAROLINA
VIRGINIA
W. VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VERMONT
NEW HAMP
MASS
CONN
N.JERSEY
DEL
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
CUBA
West from Greenwich
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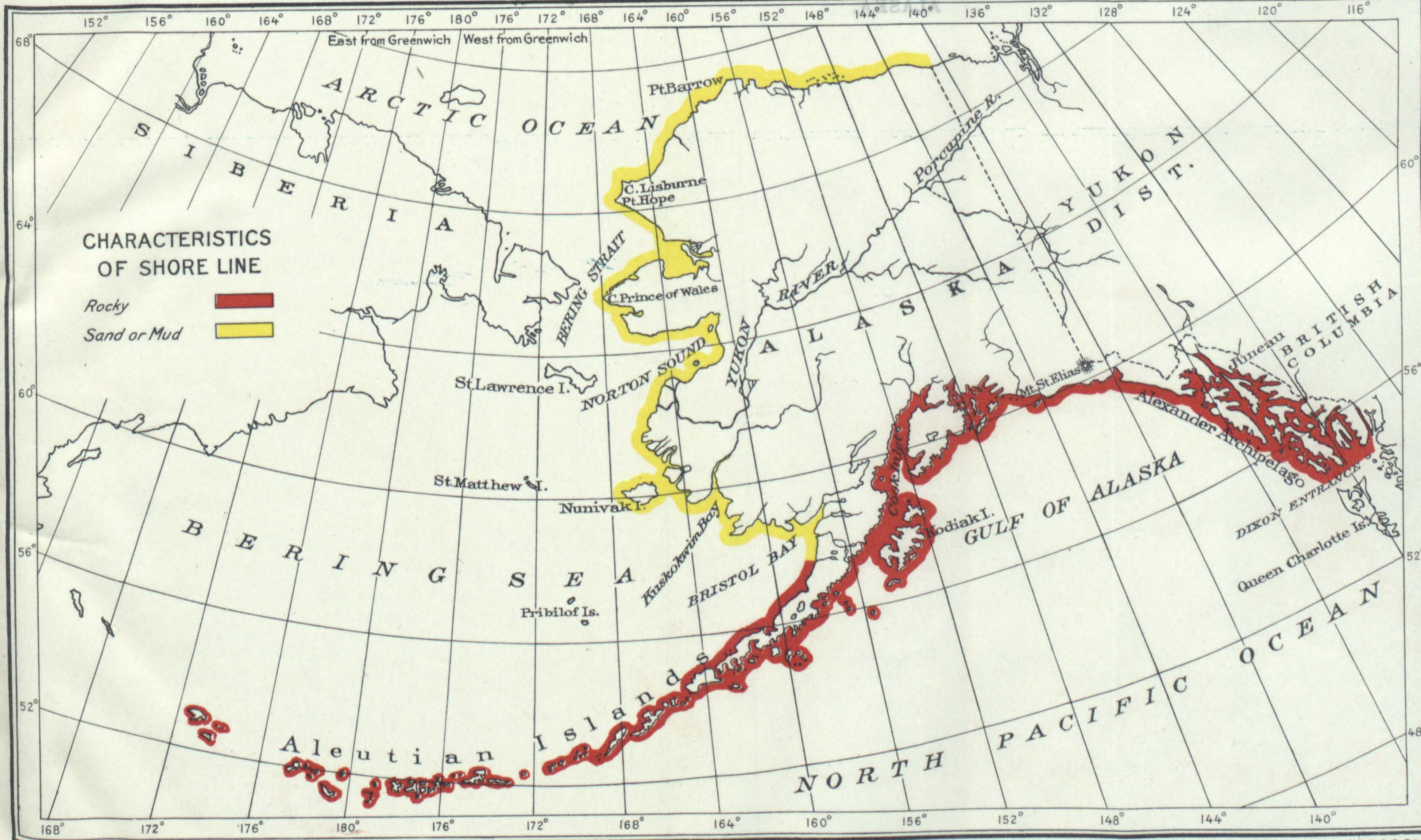
No. 4.

CHARACTERISTICS OF COAST FORMATION, ALASKA.


CHARACTERISTICS OF SHORE LINE
Rocky
Sand or Mud
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt.Barrow
C.Lisburne
Pt.Hope
BERING STRAIT
C.Prince of Wales
NORTON SOUND
St.Lawrence I.
St.Matthew I.
Nunivak I.
Kuskokwim Bay
BRISTOL BAY
Pribilof Is.
BERING SEA
YUKON RIVER
ALASKA
Porcupine R.
YUKON DIST.
Mt.St.Elias
Juneau
BRITISH COLUMBIA
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
Cook Inlet
Kodiak I.
GULF OF ALASKA
Aleutian Islands
NORTH PACIFIC OCEAN
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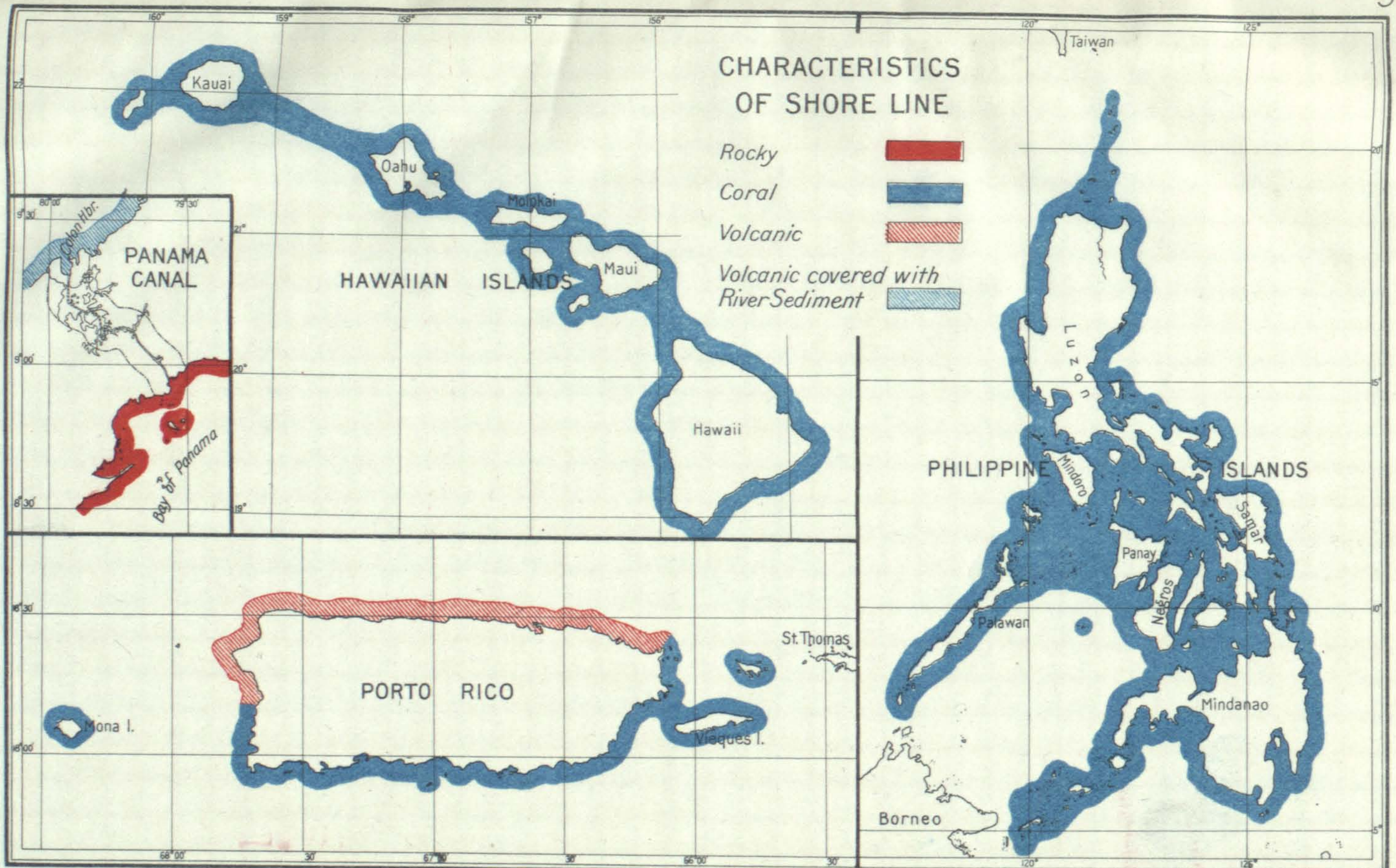

CHARACTERISTICS OF SHORE LINE
Rocky
Coral
Volcanic
Volcanic covered with River Sediment
HAWAIIAN ISLANDS
Kauai
Oahu
Molokai
Maui
Hawaii
PANAMA CANAL
Colon Hbr.
Bay of Panama
PORTO RICO
Mona I.
Vieques I.
St. Thomas
PHILIPPINE ISLANDS
Taiwan
Luzon
Mindoro
Panay
Samar
Negros
Palawan
Mindanao
Borneo

C. & G. S. Print.

natural channels that existed in and to most of the harbors have been either deepened by dredging or abandoned, and entirely new channels dredged. (See fig. 6.)

During this development the methods of making hydrographic surveys have been as follows: During the sailing-ship period, the surveys consisted of a system of widely spaced sounding lines over the entire harbor, with many additional closely spaced soundings at any place on those lines when depths of about 20 feet or less had been found. In other words, the object of the survey was to locate the shoal areas rather than the deep ones. Then, when the commerce was carried in steam vessels that could follow a definite course and which required greater depths, the critical examination with the hand lead line extended not over the entire harbor but along the course of the deep channels, and these examinations show close lines of soundings in finding these channels, but no close examination of the entire area of the harbor.

As indicated above, these hydrographic surveys have been advanced sufficiently to show where the deepest channels are in all the harbors; and, in fact, in the important harbors artificial channels have been dredged, and the acute problem now before the hydrographic engineer is to find, both in the deep channels and the shoaler areas, those obstructions which, consisting of isolated rocks or bowlders, are of such limited extent that they have been missed by all previous surveys made with the lead line. (See figs. 21 to 24.)

LIMITATIONS OF LEAD-LINE SURVEYS.

It is difficult to explain in words how elusive these dangers are when sought with the hand lead. Even in cases where vessels have struck such rocks, so that their existence is known and their location so closely fixed that the field of search is limited to an area perhaps 100 yards square, it has sometimes taken days of search to find the least water on them. How much more difficult, then—in fact, how utterly impossible it is—to know that in any survey made with the hand lead every danger has been discovered when it is not even known that such dangers exist.

Consider for a moment how surveys with the hand lead are made. The hand lead consists of a line marked in fathoms and feet, to which is attached a piece of lead about 2 inches in diameter and 10 inches long. As the sounding boat moves along on a straight line the leadsman casts the lead ahead of the boat, reading the depth from the line as the lead strikes the bottom and the line becomes vertical. The point where each sounding was taken is accurately located by observers in the boat who, with sextants, measure the angles between known objects on shore.

The sounding lines are closely parallel to one another, the boat moves slowly, and the soundings are taken as rapidly as the depths permit, but even so the area of the space included between any four soundings is comparatively large. Take the case of lines spaced 20 yards apart, with soundings 10 yards apart in each line. This would be considered a close survey, yet the area bounded by two soundings on each of two adjacent lines is 200 square yards, which is ample to contain a bowlder or pinnacle rock 10 yards in diameter and permit it to remain undetected by the soundings.

Finally, when it is remembered that the work must commonly be done in a choppy sea or in currents, so that the boat can not always be kept on the line, and that the lead will strike a steep-sided rock and slide to the bottom undetected, it becomes obvious that it is utterly impossible to think of finding every hidden danger by means of the lead. (See fig. 7.)

In Buzzards Bay, Mass., over an area slightly in excess of 21 square miles, 91,000 soundings had been taken with the hand lead line, and from these soundings a chart had been issued which declared to the world that in this region the mariner might expect to find no less than 31 feet of water. But in this very area the cruiser *Brooklyn* touched a rock that reached up to within 18 feet of the surface, and which had been missed by the hand lead line. (See fig. 8.)

Out of this and like experiences confidence was badly shaken in the reliance to be placed on surveys made with the hand lead line in regions where pinnacle rocks, isolated bowlders, and coral reefs rise abruptly from the general contour of the bottom.

DEVELOPMENT AND USE OF THE WIRE DRAG.

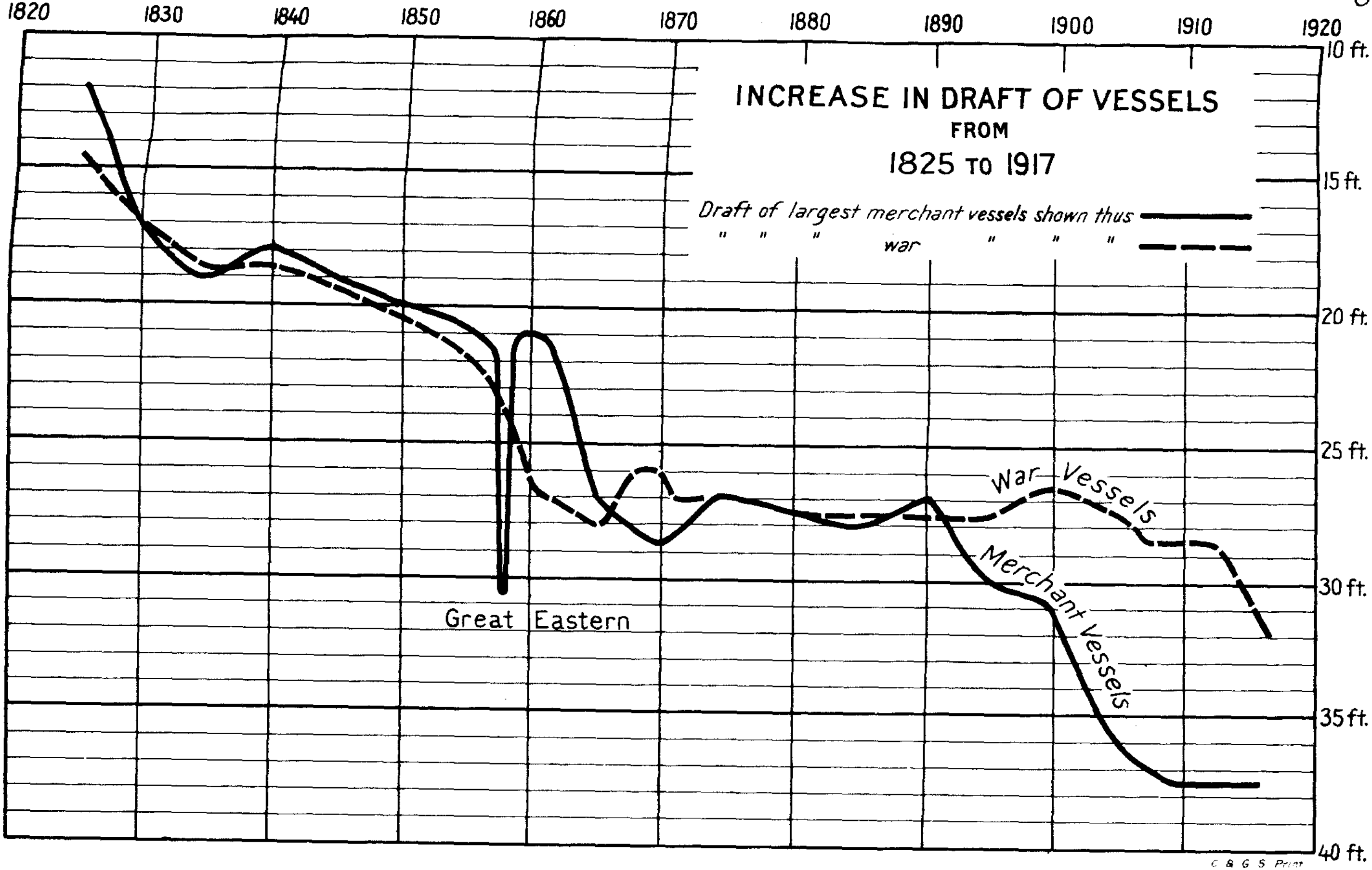
It was then realized that some more certain method than the lead must be used in such areas. This brought to mind the method of dragging a wire or rope through the water as had been first employed by French engineers and later by the United States Army Engineers. From this beginning the Bureau has developed the modern wire drag which, though simple in conception, has become a wonderful mechanism for rapidly covering extensive areas and yet finding within the area covered every existing pinnacle rock, bowlder, or coral reef.

The purpose of the wire-drag survey, then, is to examine areas where dangers in the form of pinnacle rocks, bowlders, and coral reefs are suspected to exist, and therefore when the shores, under the classifications as outlined before, are shown to be rocky, or there are coral reefs, the survey must be made with the wire drag to insure finding all dangers. Where the shore is of sandy formation, the wire drag is unnecessary and the lead line survey is sufficient.

However, there is this to be said about both the wire-drag survey and the lead and line survey: Each has its limitations. As the lead and line survey is ineffectual in finding pinnacle rocks and coral reefs, so is the wire drag ineffectual in determining the contour of the bottom beneath the waters surveyed. The horizontal bottom wire of the wire drag when drawn through the water is supported at certain depths by floats on the surface of the water, and thus it will catch on any obstruction coming above the depth to which it is set, but it furnishes no information of the depth of water below the bottom of the drag. This is only learned by making soundings with the lead and line. Therefore, each method must to some extent supplement the other.

NEED OF OFFSHORE SOUNDINGS.

Now, while soundings may be made with the hand lead line to a greater depth than 100 to 120 feet, yet this depth is probably the limit of the practical application of this method of making surveys.


INCREASE IN DRAFT OF VESSELS
FROM
1825 TO 1917
Draft of largest merchant vessels shown thus
" " " war " " "
1820
1830
1840
1850
1860
1870
1880
1890
1900
1910
1920
10 ft.
15 ft.
20 ft.
25 ft.
30 ft.
35 ft.
40 ft.
Great Eastern
War Vessels
Merchant Vessels
C & G S Print

It might be thought that as no vessel requires a depth of much over 37 feet, it is unnecessary to sound for depths in excess of 100 to 120 feet. This, however, is not the case, as it is necessary for many purposes to know the depths for great distances from the shores. Take the case of a vessel crossing the Atlantic for an American port. She has met with rough weather, and she is off her course and her position is not known. If she takes no soundings to locate herself until she reaches water that is only 100 to 120 feet deep, she is well-nigh lost. As a matter of fact, vessels with modern devices can sound without stopping in depths up to 100 fathoms, and it is therefore imperative that the surveys should extend at least to that depth.

To provide for such emergencies and to fill many other needs of navigators, soundings are taken for many miles out from the shore. An examination of any general sailing chart will show that from these soundings it has been found that as our continental shores drop off under the sea a definite point can be determined where the gradually deepening waters reach 5, 10, 20, and 100 fathoms, and therefore, what would be countour lines on the land are shown on the chart, only on the chart they are called the 5, 10, 20, and 100 fathom curves.

DEEP-SEA SOUNDING.

As it is impracticable to use the hand lead line for sounding where the depth is much in excess of 100 feet, below this depth soundings are made with a machine devised for the purpose. A much heavier lead is used and the line is replaced by wire wound on a drum operated by steam or electricity. When it is desired to take a sounding, the weight is released and the wire unwinds from the drum until the bottom is reached and the depth is recorded, then the drum is reversed and the wire wound in. When the ship has proceeded the desired interval, this process is repeated and another sounding recorded.

CLASSES OF HYDROGRAPHIC SURVEYS.

There are then three different classes of hydrographic surveys:

1. *Inshore hydrography*, used in bays, estuaries, etc., and along the coasts as far offshore as the surveyor can see the shore objects necessary for locating his position.

2. *Offshore hydrography*, when the surveying vessel starts at a known point situated at the limit of visibility of objects on shore, proceeds seaward the necessary distance, and returns shoreward until the shores can again be seen and the position located.

3. *Wire-drag surveys* in areas where the soundings indicate the possible existence of pinnacle rocks, bowlders, or coral reefs undetected by the lead.

The necessary combinations of these three classes of work constitute a complete hydrographic survey.

PROBLEMS OF THE HYDROGRAPHIC ENGINEER.

Having thus given a review of the changing aims of the hydrographic surveyor from period to period during the existence of the Bureau, and having roughly divided our coasts into classifications with respect to the different formations of the shore lines, it is here proper to say something of the problem now before the hydrographic engineer resulting from these different characteristics of the coastal formations, to what extent the old surveys can be utilized, and where they must be rejected as entirely inadequate and new surveys made.

In the very general classifications we have heretofore given of our coast lines, we have said that there are 11,649 lineal miles of general coast line of rocky or coral formation, and therefore fixed and unchanging, with the saving clause that in the shore lines included within this general classification would be found here and there stretches of considerable length of formations different therefrom.

With respect to coasts of fixed character the following remarks apply:

Where complete hydrographic surveys are made to a depth sufficient to safeguard any future increase in the draft of vessels the results are good for all time.

It is sometimes a matter of nice perception and judgment for the hydrographic engineer to decide the amount and character of the work necessary to insure the completeness of the survey. Along the Florida Keys the problem is plain. It requires only a few soundings taken at the beginning of the survey to indicate that this is an area which must be dragged before the survey can be considered complete. Knowing that such drag work must follow, the surveyor does not waste time using his lead in an attempt to locate every coral head, as he knows that the drag will later locate all such obstructions much more quickly and cheaply than could possibly be done with the lead.

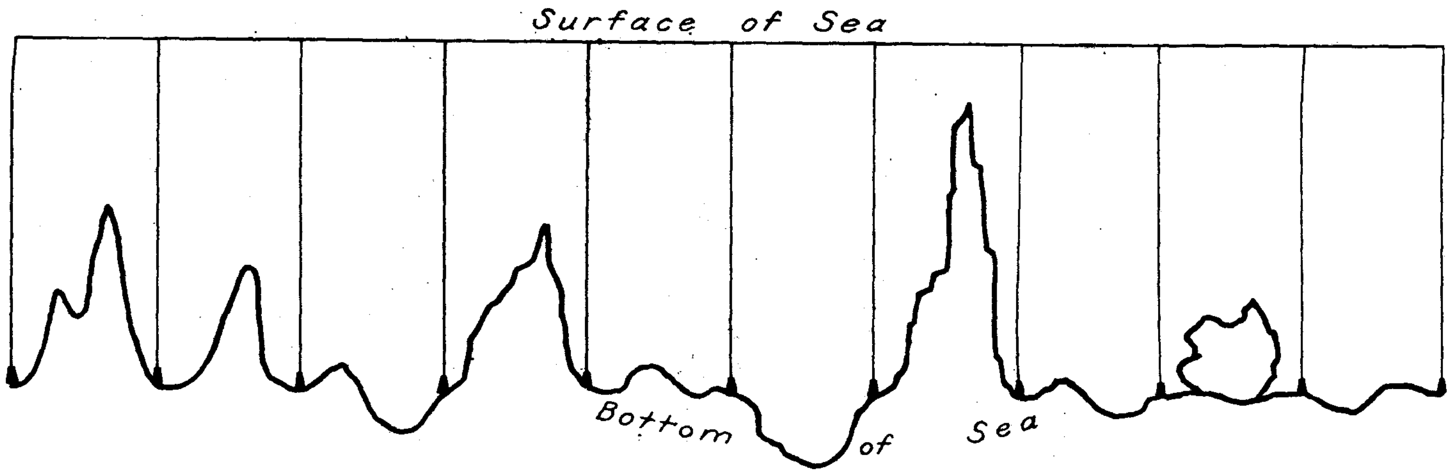
Conversely, on the exposed coasts of California, Oregon, or Washington, where the waters deepen rapidly seaward and where there are no narrow, restricted waters that vessels must follow but everywhere plenty of sea room, it is obvious that wire-drag work is unnecessary and impracticable except in a few restricted areas in the vicinity of harbors. Here, therefore, the surveyor must make sure that sufficient soundings are taken to make the surveys complete. Although these waters are deep, there are also great inequalities in depth. Wherever the lead gives an indication of such inequalities by giving a sounding either materially deeper or shoaler than the surrounding ones, a further investigation must be made to trace out fully the differences in depth and make sure that none are so shoal as to constitute a menace to navigation.

It will thus be seen that a certain amount of information regarding any particular region is necessary before the Bureau can decide what work should be included in its survey, and the problem confronting the Bureau may be stated as follows:

1. Of the surveys made to date, decide which are adequate, and which should be supplemented by additional work.

2. Where the surveys are inadequate they should be supplemented by additional soundings, and where such soundings indicate the necessity, by wire-drag work.

3. In regions as yet unsurveyed, begin with the soundings, and as the work progresses decide what wire-drag work is necessary, and in



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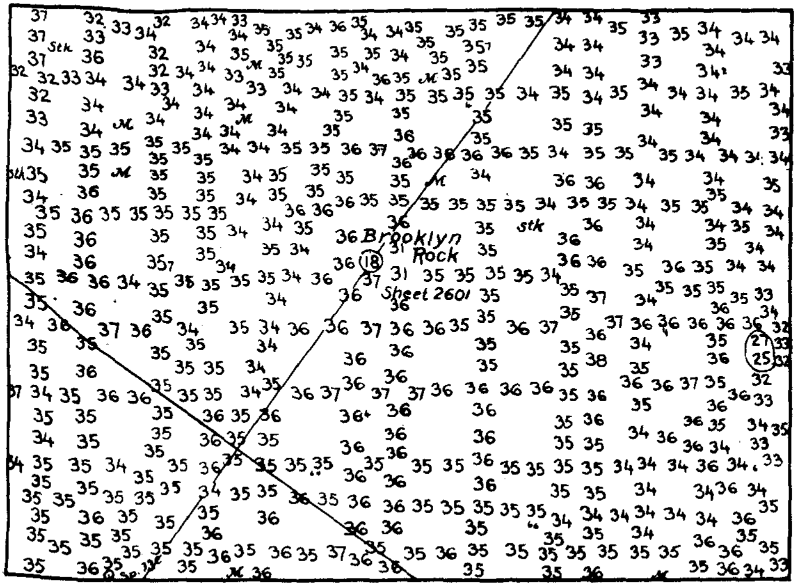
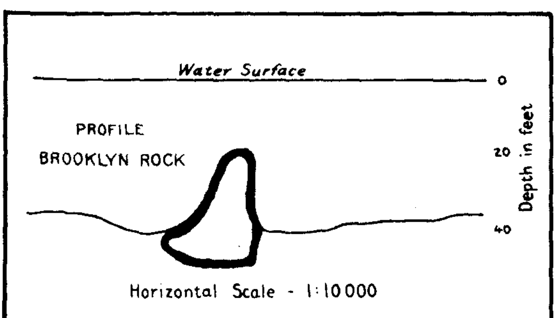
PORTION OF ORIGINAL HYDROGRAPHIC SHEET, BUZZARDS BAY, ON SCALE 1-10000, SHOWING AREA CLOSELY SOUNDED IN 1895, WHERE THE *BROOKLYN* STRUCK IN 1902.





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sounding be guided by the knowledge of whether or not such drag work is to follow.

In changeable areas the following remarks apply:

Experience has enabled the hydrographic engineer to judge quite definitely how often resurveys of such areas are required, and there are some general known natural laws that can be relied on. For instance, every inlet has its sand bar across its mouth, and the frequency of the necessity of resurveys of the bar is determined by local conditions. Such inlets as Absecon Inlet on the coast of New Jersey, or Grays Harbor on the coast of Washington where the bars lie inshore, require resurveys every year after the winter storms to keep the charts up to date.

Then, where waters such as Chesapeake and Delaware Bays have broad, open entrances and the deposit carried to the sea is diffused over large areas, the surveys at the entrances are required only about every 10 years.

Further, where we have large areas of protected interior waters such as Chesapeake Bay, Delaware Bay, and Mississippi Sound, surveys are required only about every 50 years.

Another feature of these sandy coasts is the result of the action of the sea waves and currents on the outlying shores. Here there is continual activity, with the result that where this year we find open waters sufficient for any steamer, next year we may find a sandy coast fully as substantial for all intents and purposes as is the land on which are built many of our coast cities.

CHANGEABLE COAST LINES.

An example of two of these changes may be of interest. There is shown opposite in black the shore line of Rockaway Inlet according to the survey of 1835, and superimposed on it, in red, the shore line of this inlet according to the survey of 1914. (See fig. 9.) There the shore has advanced 3¼ miles during a period of 79 years, and this is not given as an example of the speediest growth of the coast but more as an example of a rapid change in a locality that is commercially important, the Federal Government having under consideration the spending of nearly 7½ million dollars for the improvement of Jamaica Bay, and the city of New York upward of 70 million dollars for the same purpose.

Another example of these changes is Assateague Anchorage about midway between the entrances to Delaware and Chesapeake Bays. This is at present extensively used as an anchorage by schooners, tows, and other small vessels, usually in heavy northerly weather. Sixty-eight years ago there was no anchorage there. In 1849 Fishing Point, a bare sand spit, began to extend southward from the then existing southern point of Assateague Island, and since then a protected anchorage ground has been formed. From 1908 to 1911 the rate of growth of this spit was 200 yards per year, and from 1911 to 1915 it was about 100 yards per year. Fifteen different surveys have been made of this locality. (See fig. 10.)

There is one other circumstance that may make immediately necessary a resurvey of large sections of those of our coasts that are of sandy formation. That is an unusually severe hurricane. Not long after the hurricane along the coast of the Gulf of Mexico in 1915, this Bureau was importuned by the chamber of commerce of nearly every important city on the Gulf coast to make immediate resurveys of the entire coast, because the accustomed steamship routes had been entirely obstructed by the shifting of the sandy bottom of the Gulf. This resurvey was taken up as soon as our funds and facilities at hand would permit, though we are equipped only to determine the new channels for commerce and not to make the needed resurvey of the entire region. So far as this determination has proceeded it has been found that the changes are so great that the old surveys are valueless.

OFFSHORE SOUNDINGS.

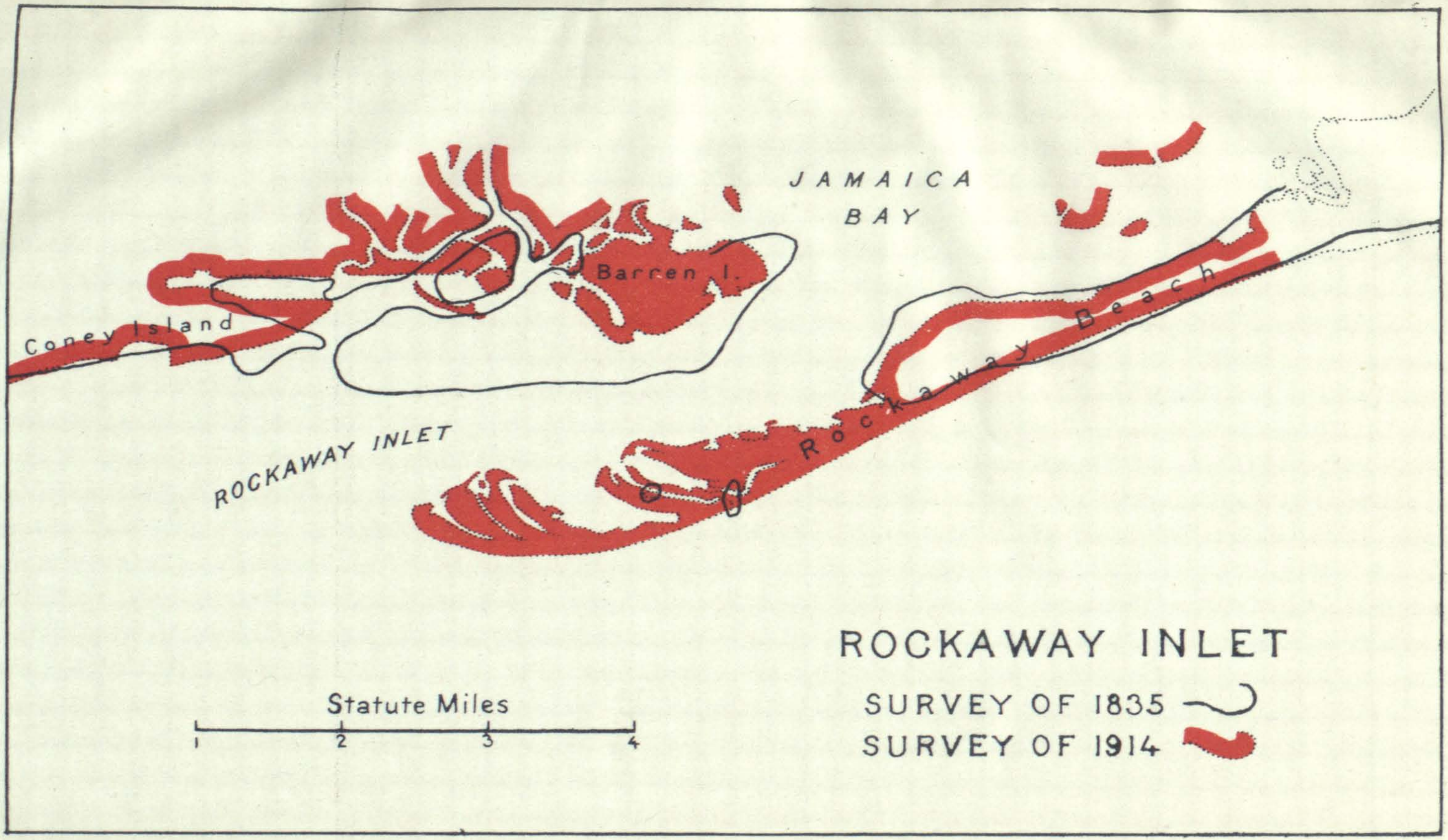
As has been intimated, both for the determination of dangers to navigation and to enable masters of vessels to check their positions by taking soundings and comparing them with those on the chart, it is necessary to make surveys and determine the depth of water when the survey vessel making such soundings is so far at sea that she is out of sight of land.

Previous to the season of 1915 these surveys were taken in this wise: Signals were established along the coast where the survey was made. The surveying vessel would start directly to sea, making soundings at desired intervals and determining her position for each sounding by taking angle observations on the shore signals. So long as the signals were in sight and the angles could be observed on them, the positions of the soundings were accurately determined. So far the results of these surveys were and are of value.

However, when the vessel had reached a point where the shore signals were no longer visible, her position (and therefore the positions of the soundings taken) was estimated as follows: Her position was known at the time she left the sight of the shore signals and was plotted on the survey sheet at this point. Say, then, that she was run on a certain course for a certain length of time with her engines running at a known speed. Taking into consideration these two factors, it was then reckoned that she had reached a certain point, when she was stopped and a sounding taken, the position of the sounding being plotted on the survey sheet at the point that she was reckoned to have reached. Then she was put under way with the compass as a guide and run another period of time and a sounding taken, the sounding being plotted on the survey sheet at the position where the vessel was estimated to be. This was continued until she had proceeded the requisite distance to sea, which for the Atlantic coast is generally determined by the 100-fathom curve or where the depths drop off to 600 feet. Then she was put about, and in a like manner soundings were taken and plotted until she reached sight of the shore signals again.

OCEAN CURRENTS AND OFFSHORE SOUNDINGS.

The one element that was not sufficiently taken into consideration in the old method of making these offshore surveys was the effect of the ocean currents on the vessel throughout the run. In making


JAMAICA
BAY
Barren I.
Coney Island
Rockaway Beach
ROCKAWAY INLET
Statute Miles
1
2
3
4
ROCKAWAY INLET
SURVEY OF 1835
SURVEY OF 1914

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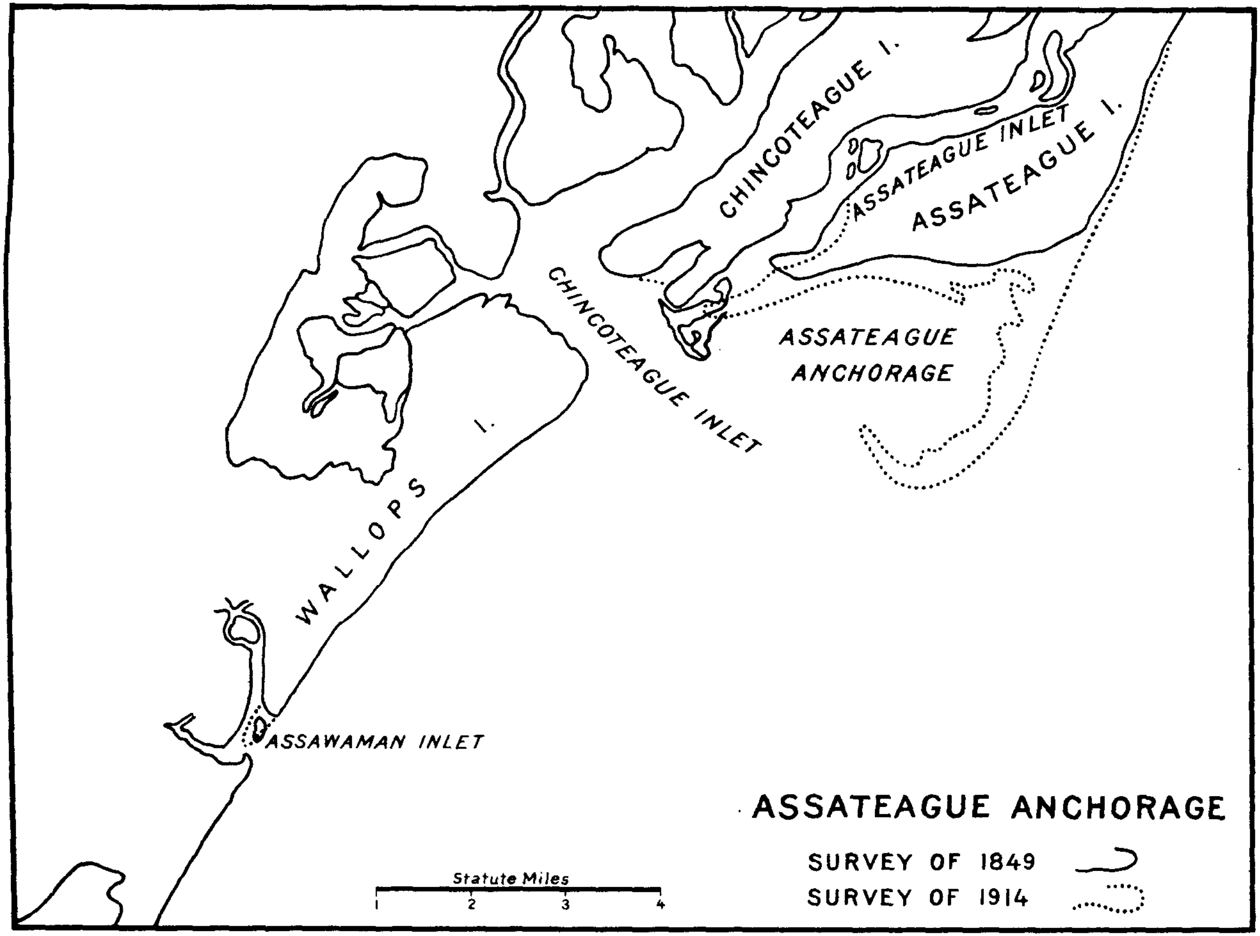
CHINCOTEAGUE I.
ASSATEAGUE INLET
ASSATEAGUE I.
CHINCOTEAGUE INLET
ASSATEAGUE ANCHORAGE
WALLOPS I.
ASSAWAMAN INLET
Statute Miles
1
2
3
4
ASSATEAGUE ANCHORAGE
SURVEY OF 1849
SURVEY OF 1914

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these soundings the vessel travels at the slow rate of about 3 or 4 knots an hour, and therefore whatever current there is has a greater effect in altering her position than if she had a speed of 18 or 20 knots an hour, because she is longer exposed to the action of the current.

PRESENT METHOD OF OFFSHORE SOUNDING.

Under the present system the offshore work is done as follows: First, high shore-signals are built; then buoys with signals that extend as far as practicable above the water are anchored just within the limit of visibility from the shore signals. This gives the added advantage of having the position of the vessel known not just as far offshore as the shore signals are visible but as far as the signals on the buoys are visible.

Before the vessel starts her run from the known position, current observations are taken and the direction and strength of the current are noted. We will say that her predetermined course was due east. Suppose when the current observation is made it is found that a current is running to the north. Then instead of heading the vessel due east, she is headed enough south of due east to counteract the effects of the current and held on that course for two hours, stopping to make soundings at the required intervals. After running this course for two hours, she is stopped and anchored and the direction and strength of the current determined. Suppose from this second current observation it is found that the current is running due east. Then instead of diverting the vessel from her course, the current is accelerating her speed, and she can be headed due east, but to the position that she would have attained by the speed of her engines must be added that of the force of the current. Thus it is that at each step of the journey account is taken of the direction and strength of the current and the course of the vessel altered to counteract the force of the current and keep her on her predetermined course.

Taking into consideration these elements and altering the course of the vessel to counteract the influence of the observed currents, the actual plotted course of one of our surveying vessels is shown on the diagram (see fig. 11) by the full line from "start" to "finish—observed currents applied." The actual position of the vessel when she came in sight of the moored buoys and determined it exactly was at the point "True finish." It will therefore be seen that where the vessel was thought to be when she finished her run was only about 5 miles from where she actually was, and consequently there was required only an adjustment of 5 miles over a course of about 130 miles, whereas plotting positions by "dead reckoning" there was an actual error of about 32½ miles in a run of about 140 miles, and therefore a readjustment was required throughout the course to distribute this error of 32½ miles over the course. As a matter of actual practice the error of 5 miles in the illustration is not characteristic, but the average error is generally not more than 1 or 2 miles, and in many instances the plotted position of the finish of the run and the actual position determined by angles on the moored buoys have been almost identical.

CONDITION OF THE HYDROGRAPHIC SURVEYS.

With the foregoing in mind, I shall now attempt to discuss the condition of the hydrographic surveys with respect to the shores of each of our coastal States, and of Alaska, Porto Rico, the Panama Canal approaches, Hawaii, Guam, and the Philippine Islands.

However, before doing this, it will perhaps facilitate the centering of the attention of those interested in any particular section of our coasts if this discussion is prefaced by a few notes giving the plan followed.

First, we will discuss the coasts of those States bordering on the Atlantic Ocean, beginning at the State of Maine, and taking up each feature of the coast of this State in its order as we proceed south. Likewise, each State in order touching the Atlantic Ocean and its tributaries to the south of the State of Maine will be taken up.

For general offshore work, where the same remarks apply to the coasts of several States, those sections of the coasts where the conditions are the same will be discussed as a unit.

Geographically, the different sections of our coasts will be taken up in the following order: (1) The States bordering on the Atlantic Ocean and the Gulf of Mexico, (2) Porto Rico, (3) the Atlantic approach to the Panama Canal, (4) the Pacific approach to the Panama Canal, (5) States bordering on the Pacific Ocean, (6) Alaska, (7) Hawaii, (8) Guam, and (9) Philippine Islands.

SYSTEM OF CLASSIFICATION.

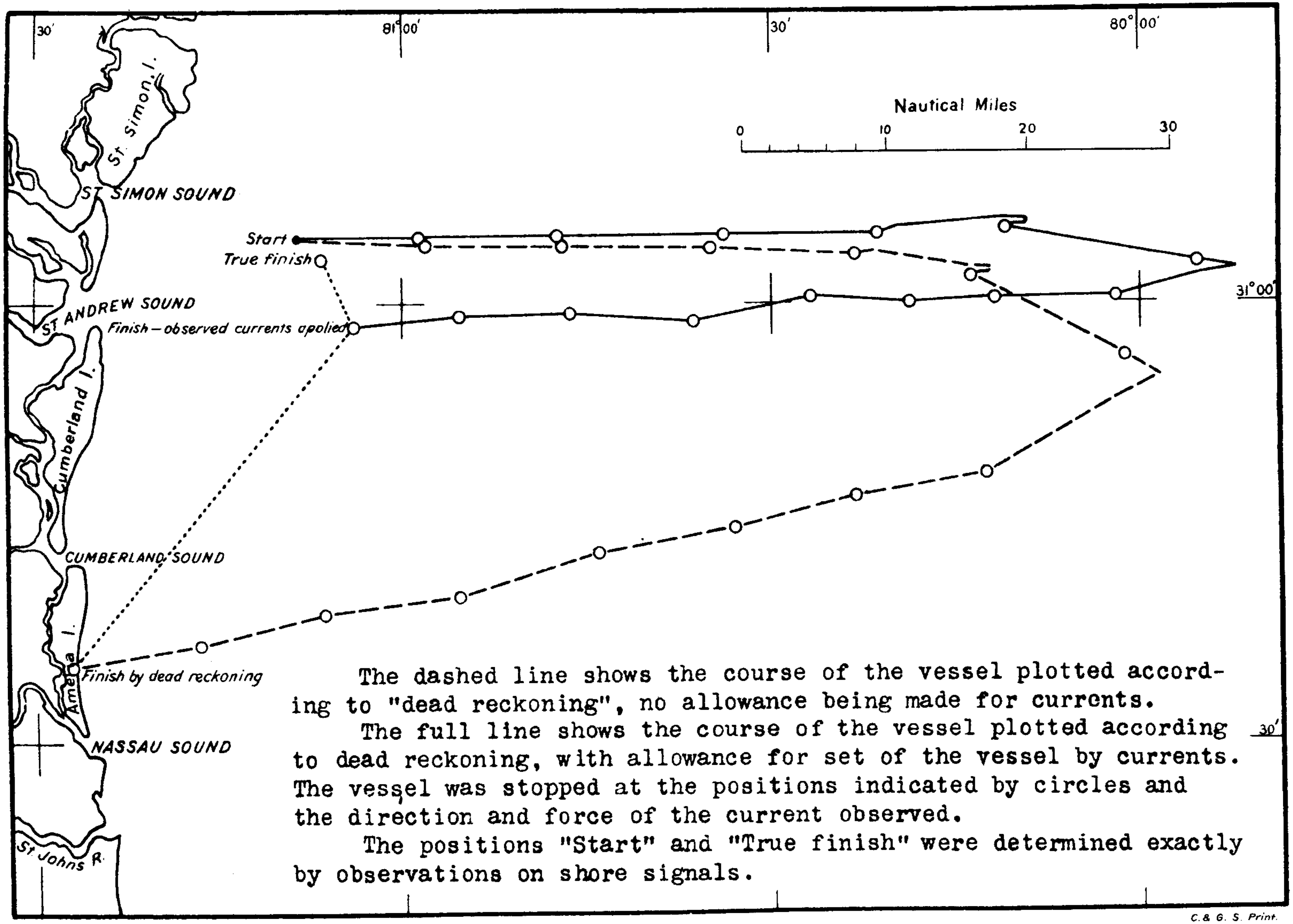
The system followed for the entire Atlantic coast is to divide the waters into three classes, inshore, inland, and offshore, and these will be taken up in the order named for well-defined sections of the coast. The terms are defined as follows: Inshore waters include all areas of moderate depth on the outside coast, from a depth curve arbitrarily adopted outside of which no dangerous shoals are believed to exist to the heads of navigation of all bays, sounds, and tidal rivers that have a navigable connection with the sea. The only exceptions are Nantucket Shoals, Georges Bank, and Cashes Ledge, which have moderate depths but which extend or lie far from the land and are included under offshore areas. Inland waters include shoal bays, sounds, and tidal rivers that can be used for through traffic by boats drawing not more than 10 and in most cases not more than 4 feet. Such waters are usually connected with the sea by shoal inlets and with other inside waters or with each other by canals, cuts, or dredged channels. Offshore areas extend from the outer limit adopted for inshore areas to a depth curve generally fixed at 100 fathoms on the Atlantic coast, which for most of the coast is near the edge of the continental shelf. (See fig. 53.)

INSHORE WATERS OF NEW ENGLAND, CANADIAN BORDER TO NEW YORK.

The coast of New England throughout its length presents practically one uniform problem to the hydrographic engineer. Surveys of varying degrees of completeness have been made of the entire area,

No. 11.

OFFSHORE SOUNDINGS.



The dashed line shows the course of the vessel plotted according to "dead reckoning", no allowance being made for currents.

The full line shows the course of the vessel plotted according to dead reckoning, with allowance for set of the vessel by currents. The vessel was stopped at the positions indicated by circles and the direction and force of the current observed.

The positions "Start" and "True finish" were determined exactly by observations on shore signals.

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and it is possible for navigators to select channels which are apparently safe. They would be of ample depth if it were not for the ice-worn granite rocks of Maine and the large bowlders deposited by the great ice fields from Buzzards Bay to New York, which alike form menaces to navigation. The lead line is not adapted to find without assistance dangers of this character. The wire drag alone is able to locate all these obstructions.

Ultimately, every bay and river must be surveyed by this method. For the present it will be necessary to continue the practice of confining the work to the important channels and approaches to the chief ports. Even this represents an immense amount of work, much of which should be finished now. (See fig. 12.)

COAST OF MAINE.

The long stretch of Maine coast from the Canadian border to Frenchmans Bay is as yet untouched by the wire drag. There are a number of towns, however, that depend largely on water-borne traffic for their supplies. The exceptionally rocky coast makes it certain that a wire-drag survey will result in the discovery of many rocks which now endanger the safety of their commerce.

Frenchmans Bay.—Frenchmans Bay, with Bar Harbor and its other resorts frequented by yachts during the summer season, has been dragged, though not to the depth now considered necessary. The value of the work is further impaired by the necessity of passing over not less than 14 miles of undragged doubtful area in order to reach the bay from the open sea.

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

There is a series of valuable inside passages along the Maine coast that are very narrow in places and wind between rocky ledges. Owing to the nature of the bottom they are particularly likely to be obstructed by pinnacle rocks or the extension of narrow ridges out into the channel. The only part of these channels which has been dragged lies between Blue Hill Bay and the western entrance of Penobscot Bay. The results obtained have been so startling that they clearly indicate the danger in the use of channels that have not been dragged.

The Penobscot River provides, by giving access to Bangor for vessels of moderate draft, an important means of communication with the interior of Maine, and it should be dragged.

From the western entrance of Penobscot Bay to Casco Bay there has been no wire-drag work done. The inside route is constantly used by coasting steamers, but it is certain that it has within its limits many uncharted rocks, some known locally and some unknown. The Kennebec River to Bath and Augusta and Boothbay Harbor and its approaches are in urgent need of a wire-drag survey.

Casco Bay and Portland.—The approaches to Portland have been dragged with the result of finding numerous uncharted shoals, thereby furnishing important evidence of the need of completing the survey to the eastward and westward. The resurvey of inner Casco Bay where the glacial age has left a series of several hundred long narrow islands and ledges has not yet begun.

Westward of Portland the succession of sand beaches, of which Old Orchard is the best known, might appear to indicate an absence of rock in this region. The depth of sand above the underlying rock is not great, however, and pinnacle rocks occur outside these beaches. Westward of Cape Porpoise the surveys are entirely inadequate, and the need of immediate surveys is evidenced by the appearance on the chart of a rocky shoal with 5 fathoms or less, marked position doubtful. This was recently reported by a fisherman, but it has not yet been practicable to locate it.

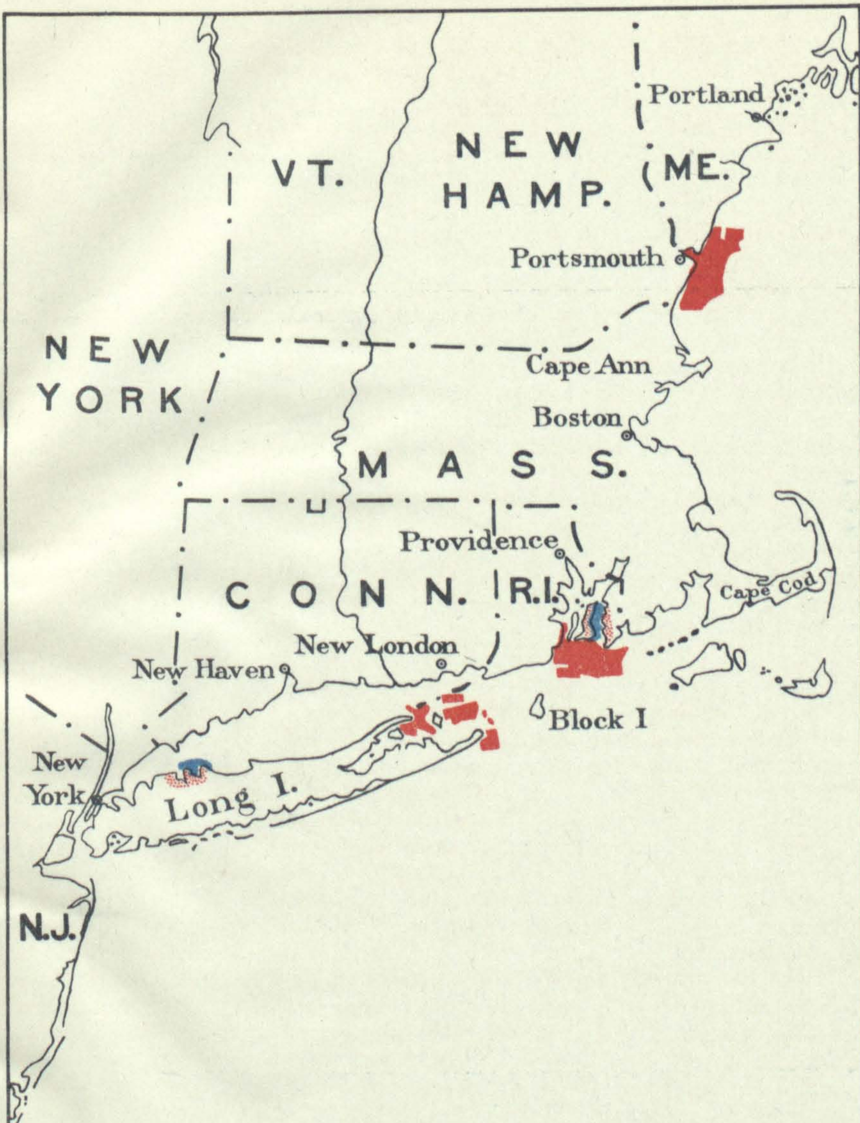
The region from Boon Island to Isle of Shoals is very rocky and its importance as the approach to Portsmouth is so well recognized that a wire-drag survey is in progress. Many rocks have been located and the safest course for battleships is now known.

COAST OF MASSACHUSETTS.

From the north border of Massachusetts to Cape Ann the shores are entirely different from those to north or south. There are high sand bluffs in places and low sandy shores in others. As a result the waters along the shore are changeable, and though they have been recently surveyed, they will need further attention in the future.

The most complete extent of dragged area extends from Cape Ann to the Cape Cod Canal and from the head of Buzzards Bay to Sakonnet Point, R. I. With the exception of the inner part of Boston Bay and areas near the shores of Buzzards Bay, this important survey is complete. This work was made especially necessary by the opening of the Cape Cod Canal in 1915, as the original surveys had been made when the commerce of this region was relatively unimportant. Not only were a number of shoals found of less depth than that proposed for the canal, so that the system of buoying had to be changed, but it was realized that commercial needs may at some future date make it necessary to deepen this canal to take care of the largest vessels, and provision was made for such deepening. Even should a depth of 40 feet be adopted the present surveys will be found adequate, and where the depths are less the information will be invaluable to the engineers making the improvements.

Much of the traffic between eastern New England and points west and south passes outside of Cape Cod, most of it through Nantucket and Vineyard Sounds. Off the northern part of Cape Cod recent surveys are available, but in Nantucket Sound the entire route is through channels bounded by shifting sands. In one part of the most used channel, through Pollock Rip Slue, a shoal has formed in the last few years that has been steadily narrowing and decreasing



FIELD OPERATIONS
During 1917

Wire drag surveys
Unchangeable areas surveyed
Topographic surveys

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the depth of the available channel. A resurvey of parts of this route is needed every few years to insure safety of navigation. No rocks are found eastward of Cape Cod, but in the north half of Nantucket Sound and the western part of Vineyard Sound large bowlders occur and wire-drag work is needed. At present vessels must pass over 10 miles of undragged area in following the best channel through Vineyard Sound.

COAST OF NEW YORK.

From Point Judith to New York it is almost unnecessary to go into particulars except to make it clear that other than in part of Block Island Sound practically no wire-drag work has been done and a complete wire-drag survey of all of Long Island Sound, including Fishers Island Sound, is required. The project to deepen East River to 40 feet makes it necessary to be certain where the channels with such depths are located in Long Island Sound. The work done in Block Island Sound has defined the limits of such depth in the eastern approach to Long Island Sound, and it is urgent that the rest of it should be undertaken without delay. The approaches to all the harbors on Long Island Sound should be dragged. Even the shoaler bays are filled with motor boats and the number of boats in operation for a given area is probably greater than anywhere else in the United States.

The Hudson River is a valuable waterway between New York and Albany and is a part of the canal system of the State. A few years ago a dangerous rock was found directly in the path of steamers between New York and Albany. With such a possibility all the doubtful parts of the Hudson should be dragged.

INLAND WATERS, MAINE TO NEW YORK.

There are a few inland waterways of minor importance, particularly Plum Island Sound on the Massachusetts coast, which have been recently surveyed. The Merrimac, Piscataqua, and Connecticut Rivers need additional surveys where not covered by the surveys of the United States Engineers in connection with improvements. There is a series of bays on the south side of Long Island Sound which either have been or are about to be connected one to the other so as to form a through channel from Jamaica Bay east of Coney Island to Peconic Bay at the eastern end of Long Island. There are two important inlets, Rockaway and Fire Island, that are subject to extremely rapid change, and these will require frequent resurveys.

OFFSHORE WATERS, MAINE TO NEW YORK.

The Gulf of Maine is a large body of water, a portion of the Atlantic Ocean, which so far as Coast Survey operations are concerned, may be considered as lying to the westward of meridian 67° 00′ and extending to the Nantucket Shoals. This entire area has been surveyed but the surveys are inadequate. Not only are the soundings obtained insufficient, but many of them are not located correctly on the charts. A good example of this is the discovery several years ago that only one shoal rock exists on Cashes Ledge, where two were charted, and that Sigsbee and Ammen Rocks formerly shown 4 miles apart are really the same rock.

These defects in the chart are serious for two reasons. The trans-Atlantic steamers approaching the ports of northern New England, especially Portland and Boston, are unable to depend on the charts sufficiently to locate themselves accurately by sounding. This is particularly serious during the fogs of summer which often extend far out to sea and last for days, and during the winter snowstorms.

In addition to this, the fisheries of the Gulf of Maine are an important national asset. The captains of fishing vessels were invited last year to furnish information in regard to uncharted shoals in the Gulf of Maine and to express their opinion as to the needs of the charts. Valuable information was obtained in regard to fishing banks not shown on the charts, and there was an almost unanimous expression of opinion that the present charts do not meet the needs of fishermen. Not only are many important fishing banks not shown, but the limits and depths of known banks are not correctly given. Besides, there is not at present enough information available as to the character of the bottom. The known existence of rocky bottom may lead to the discovery of good fishing grounds.

Extending eastward from Nantucket Sound there is an immense shoal area, consisting of sand ridges which are shifted by the waves and currents. Nantucket Shoals extend about 50 miles offshore, then there is a deep channel, and then comes the great shoal area of Georges Bank, which has several very shoal ridges. It is readily seen that it is important to keep the channels surveyed and to examine the adjacent shoals to detect changes, but it might readily be asked what is the use of surveying such areas as Nantucket Shoals which vessels are most careful to avoid. First, it is necessary to be certain that the outer limits of these shoals are clearly shown so that they can be avoided. Second, the shoals are important fishing grounds. Third, more careful surveys may develop safe channels for coastwise navigation, channels which are already indicated on the charts but are unsafe to use because of inadequate surveys.

The existing surveys are nowhere adequate and are particularly subject to wrong locations because of the strong and variable currents. The shoals are so numerous and the channels so intricate that a difficult problem is presented in their examination by sufficiently accurate methods. The ground fishing industry, especially for flounders, which has in recent years assumed large proportions, is steadily moving seaward, as an area once fished over has to be left for years to recover. Nantucket Island is during the winter the headquarters of this industry. Not only do the present charts not give the needed information in the search for new grounds, but the absence from the chart of existing shoals is a source of danger to the boats running to and from the harbor. Breakers often occur where there is ample depth for boats when the water is smooth. This is an excellent example of how a region usually avoided by commerce may be of importance to an industry which furnishes part of the food supply of the nation.

There is scarcely any part of our coast where correct soundings are of more importance than in the approach to New York from the eastward, as all trans-Atlantic steamers bound to that port pass over this area. Many of them have to depend on soundings for safety. A fairly good survey of this area is available, but additional work should be done by modern methods in the portion out of sight of land so that the needs of the enormous traffic will be met. An especially important feature of trans-Atlantic commerce is the high proportion of large vessels and the consequent importance of their loss.

INSHORE WATERS, NEW YORK TO THE FLORIDA REEFS.

New York Harbor has had a recent survey, but as it is an area subject to change, it will require a survey, at least in part, every few years.

Along most of the coast of New Jersey the character of the bottom is such that the exact existing depths should be ascertained beyond all doubt, particularly as shoals dangerous to coastwise traffic have been reported from time to time. The only reliable surveys along this stretch of coast have been made in connection with searches for these reported shoals. Eastward of Cape May there are shoals that need a resurvey. (See fig. 13.)

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

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

Chesapeake Bay and tributaries have been extensively surveyed in recent years, and a large part of them will not require resurvey for many years. This is also true of the Potomac River. The parts which need resurvey are the deep parts of the bay from Cape Charles to a point opposite Annapolis, part of the James River, and the Rappahannock and Susquehanna Rivers. This means that the intricate system of channels on the eastern side and the upper and lower ends of the bay are completed. The entrance has been recently surveyed, but another survey will probably be needed in 10 years.

From Chesapeake Bay entrance to Cape Hatteras there are only a few places where the shoals extend far from the shore. While a resurvey is needed, the most pressing need is that the limits of these shoal areas be accurately determined. (See fig. 13.)

Diamond Shoals off Hatteras should be resurveyed chiefly to determine changes in their extent, and particularly to obtain a knowledge of the correct depths on the seaward side, so that vessels passing too close may be warned in time.

From Cape Hatteras to Winyah Bay, S. C., the conditions are somewhat different. The changeable area along the coast is very narrow and existing surveys of the adjoining area of moderate depth are good enough for all requirements. Two areas are exceptions, the Cape Lookout Shoals and the Frying Pan Shoals, to which the remarks made in regard to Diamond Shoals apply, except that there is less traffic passing them. (See fig. 14.)

From Winyah Bay to Fernandina, Fla., the chief characteristic is the distance from the shore to the outer edge of the shoal banks fringing it. Outside of these banks the water is fairly deep, and this region has been recently surveyed. (See fig. 14.)

From Fernandina to the Florida Reefs, the area of moderate depths continually narrows until at Palm Beach the distance to the 100-fathom curve is very small. The completed survey extends southward to a little beyond St. Augustine. South of St. Augustine, the bottom is probably not subject to change except as noted below, and the surveys, while by no means complete, are fair. Off Cape Canaveral and outside the southern half of the Indian River there are extensive banks and ridges in urgent need of resurvey and which will have to be resurveyed at intervals. Known depths of 11 to 16 feet a long way offshore show the need of further surveys to make certain that all the shoals are correctly charted.

From Jupiter Inlet to Fowey Rocks, where the Florida Reefs begin, the deep water approaches so close to the shore that it will be a slight task to do the inshore work in connection with the offshore.

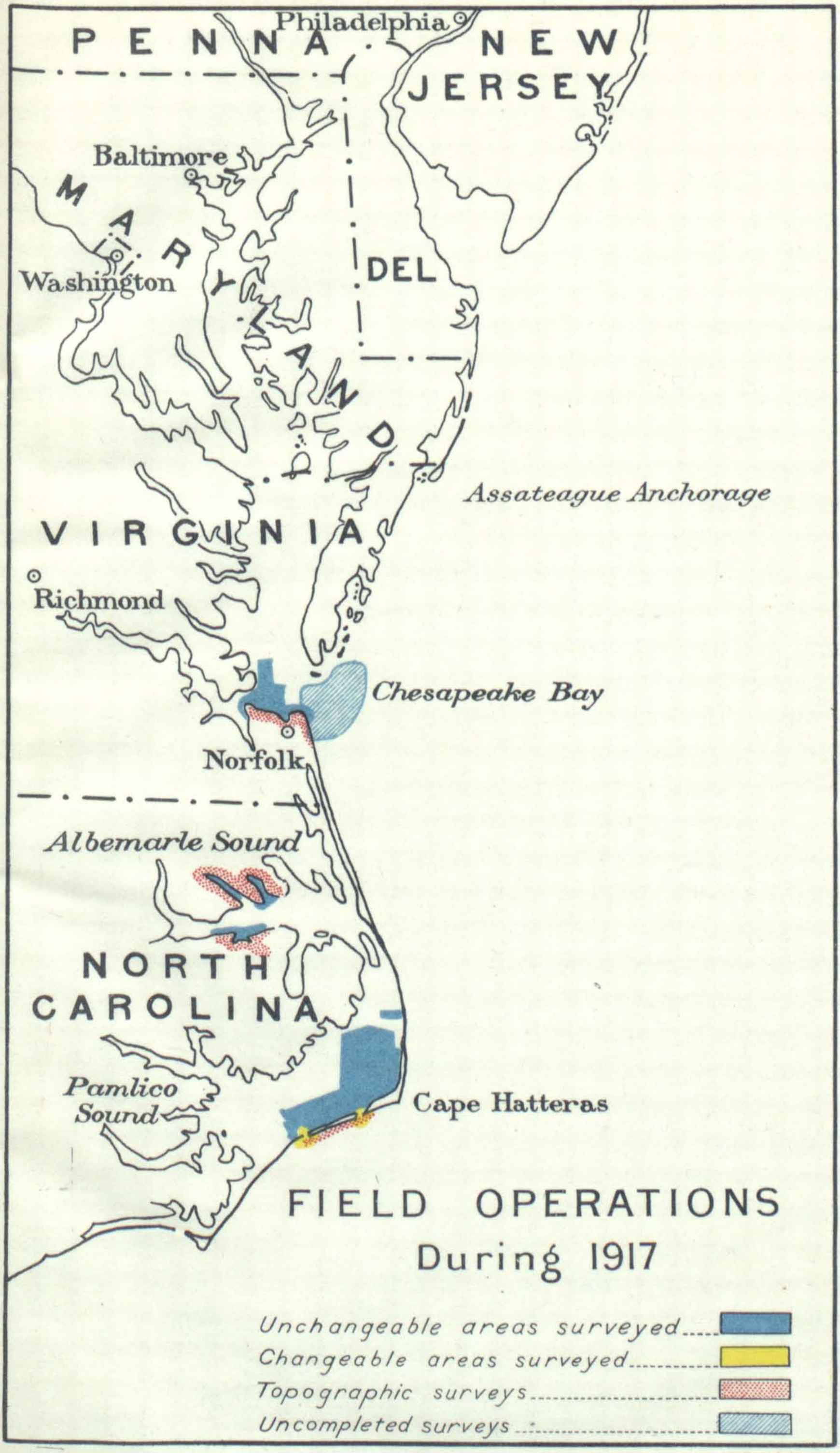
INLAND WATERS, NEW YORK TO THE FLORIDA REEFS.

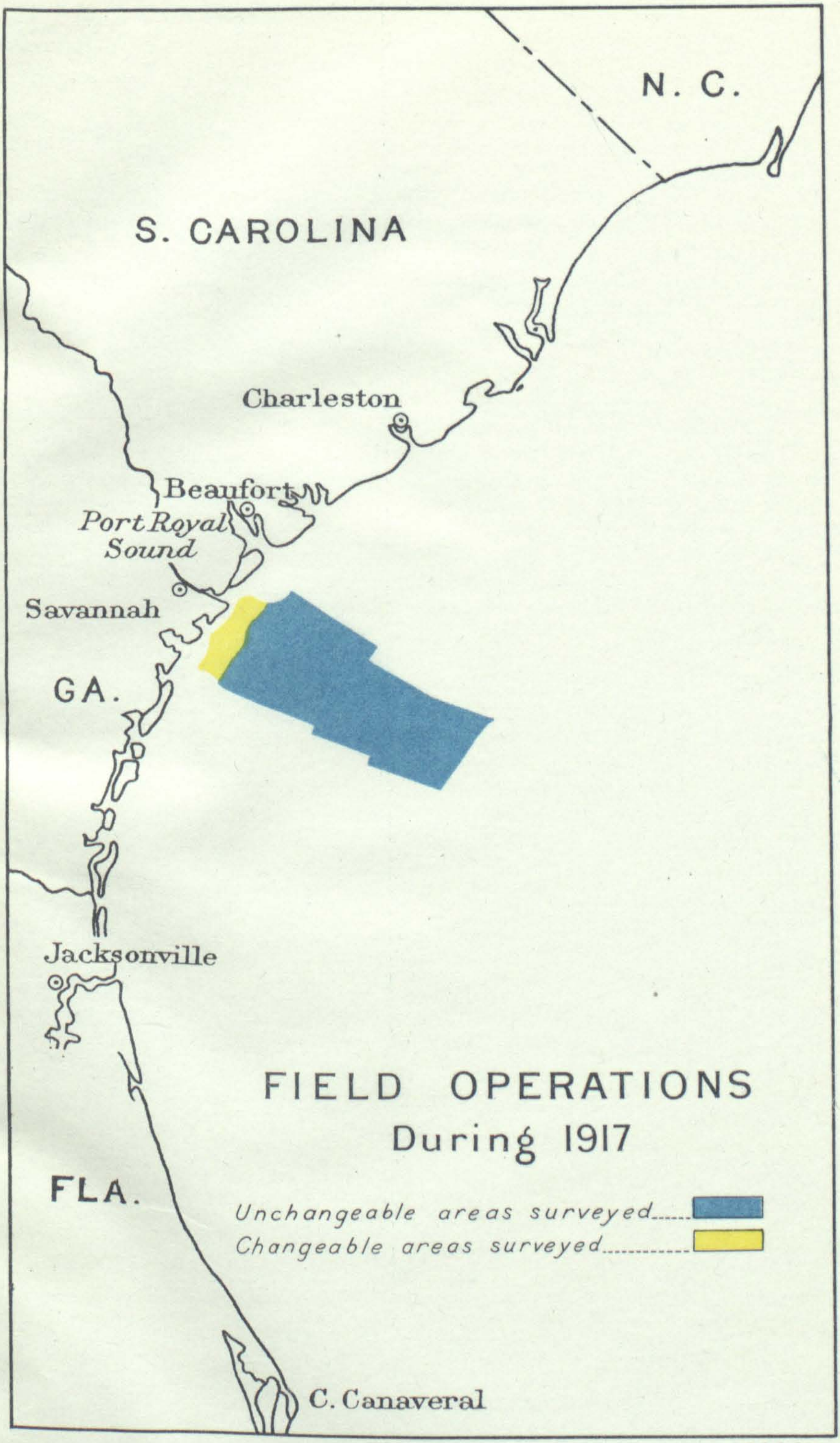
This subject is usually considered from the point of view of the expense necessary to deepen channels so that small launches and even vessels of moderate size may traverse this inland route without being subject to the dangers of the open sea which may even prevent the passage of the smaller launches.

There is another important phase. These inland waterways are largely natural, and the use of the waters requires that correct charts be available. In fact, very often the chart furnishes the only means of finding the channels that have been deepened. It is evident that the Coast Survey should keep the charts up to date, not only for the larger boats which are now able to pass from New York to Beaufort, N. C., without going outside, but for the small launches which can go from New York to southern Florida through inside channels except for 150 miles of the North and South Carolina coasts.

The great interest that has been taken in this subject, its importance in relation to the national defense, and the amounts that have been expended in improvements emphasize the increasing need for charts based on surveys made with an understanding of present needs rather than on those made when it appeared that these waters would in many cases never be used.

While many portions of the 10-foot route from New York to Beaufort have not been recently surveyed, so much of it is through canals and through the deeper portions of the bays and sounds that it


Philadelphia
PENNA
NEW JERSEY
Baltimore
MARYLAND
Washington
DEL
Assateague Anchorage
VIRGINIA
Richmond
Chesapeake Bay
Norfolk
Albemarle Sound
NORTH CAROLINA
Pamlico Sound
Cape Hatteras
FIELD OPERATIONS
During 1917
Unchangeable areas surveyed
Changeable areas surveyed
Topographic surveys
Uncompleted surveys
C. & G. S. Print.


N. C.
S. CAROLINA
Charleston
Beaufort
Port Royal Sound
Savannah
GA.
Jacksonville
FLA.
C. Canaveral
FIELD OPERATIONS
During 1917
Unchangeable areas surveyed
Changeable areas surveyed

C. & G. S. Print.

is probably safe through most of its length. As soon, however, as the main route is left the defects of the charts become apparent.

The through route for small launches following the coast is in need of resurvey for practically its entire length. Several conditions exist. The main routes are probably over permanent bottom through most of the way, but the number of soundings in many cases is not sufficient to show exactly where the most water can be obtained. Where a few inches in depth may make the difference between a comfortable rate of progress and being stuck on a mud flat, the need for correct charts is self-evident.

THE INLETS.

The various inlets from the sea to these inland waters are subject to constant change, and usually this change extends for some distance both inside and outside of the inlet. These inlets are of such character that correct charts are impossible to maintain except with frequent surveys. Many of them should be surveyed every spring, after the winter storms, which would enable the Bureau to issue a fairly dependable chart of such inlets through the following summer. The Bureau of Lighthouses on each visit finds out where the deepest channel is and shifts the buoys to correspond, and it is important that the channels as shown on the chart be correct with reference to the buoys. Without such surveys the chart at times may not suffice even to find the buoyed entrance. Entering inlets always involves a certain amount of unavoidable hazard; but as it has to be done and often under the most dangerous conditions, with an approaching storm making it the only hope of safety, the charts should render all the assistance possible.

It is unnecessary to particularize the different waters of this through route along the coast, except the more important ones, as the same conditions occur throughout. New Jersey, Delaware, Maryland and Virginia (Eastern Shore), South Carolina, Georgia, and Florida, and portions of North Carolina are repetitions of the same story—bays and sounds of moderate depth connected by canals and dredged channels wherever the natural depths are insufficient.

NORTH CAROLINA.

The important inland waters of North Carolina are particularly valuable to this State because water transportation is possible over large areas where there are no railroads. Over much of the eastern part of the State lumber is either rafted or shipped by water to the distributing points. Agricultural products reach the market by boat, and the fisheries depend entirely on water transportation.

As a result of these varied uses in addition to the through traffic to the south, the entire area should be correctly charted.

Albemarle Sound.—Albemarle Sound and its tributaries, with a few exceptions, have been resurveyed within the last few years and will not require resurvey for a long time. The uncompleted portions, including the North and Alligator Rivers, should be finished in the near future as they form part of the through 10-foot channel system. The Chowan River, the western extension of the sound, should also be finished, and this region would then be in a most satisfactory state.

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

Pamlico Sound.—Pamlico Sound is chiefly important as a through channel. The eastern half of the sound is fairly well surveyed, and the work is now in progress. The entire western half and the Neuse River, which in addition to its local use is part of the through 10-foot channel, have not been resurveyed.

After passing through Pamlico Sound and part of the Neuse River, a narrow channel crosses to Beaufort where all vessels up to 10 feet draft go to sea. Small launches, however, may pass through Bogue Inlet and even farther to New River Inlet, if they wish to take chances in passing through the very shoal inlets.

From New River Inlet to Winyah Bay, S. C., all boats must pass outside, but from Winyah Bay to Key West there is an inside channel. Through South Carolina, Georgia, and Florida, the inside waters consist of rivers, sounds normal to the coast, and bayous. These waters are in urgent need of work to revise the older surveys, which were made from 30 to 60 years ago, and larger charts based on these resurveys are an urgent necessity.

OFFSHORE WATERS, NEW YORK TO THE FLORIDA REEFS.

Nature has provided for New York an approach which is nearly as easy to follow as a well-buoyed channel. The drowned valley of the Hudson extends as a well-marked depression for nearly 100 miles out to sea. The navigator who is uncertain of his position simply steers a course to cross this depression and when his soundings tell him that he has reached it, he changes course and follows it to the harbor. The absence of complete and accurate development of this channel, however, leads to some uncertainty as to its position especially at its outer end, and some of its possible value is destroyed by lack of sufficient soundings. (See figs. 13 and 14.)

An explanation of the method used in locating a vessel by soundings will show why accurate charts are particularly needed from New York to Palm Beach and from Key West to the Mexican border.

At fixed intervals the vessel takes soundings, which are plotted to the scale of the chart on tracing paper, and this is moved over the chart keeping the line joining the soundings parallel to the course of the vessel until the soundings agree with those shown on the chart. If the charts are correct and based on a sufficiently modern survey, the method is the best known for locating the position when out of sight of land or when the weather conditions shut out the aids. If, on the other hand, the soundings are few and far apart so that the ship's soundings fall between them, and if those on the chart are wrongly placed, this method becomes much more difficult and an accidental agreement may lead the vessel into danger.

From New York to Cape Hatteras the charts are only fairly good, by no means good enough to meet the full needs of navigation, but this work has been postponed as the need for resurvey has been so much more urgent farther south. Up to a few years ago the offshore surveys from Cape Hatteras to the Florida Reefs were almost unbelievably deficient. This condition is being remedied as rapidly as possible, and between Winyah Bay, S. C., and St. Augustine, Fla., the offshore work out to the Gulf Stream is complete.

It is important that this work be extended both north and south from its present limits as rapidly as possible. With adequate funds full advantage can be taken of the seasons, and by working in the north in the summer and south in the winter the cost of the work will be greatly reduced. (See fig. 15.)

INSHORE WATERS, FLORIDA REEFS TO MEXICO BORDER.

If the wire drag is needed to make New England waters safe, it is indispensable in the region of the Florida Reefs. Coral rocks are not the result of a breaking-down process but of building up by the activity of animal life. The absence of weathering has resulted in a great variety of form and vast numbers of sharp projections from the general bottom where the conditions are favorable for the growth of coral.

While we are sure that an enormous number of uncharted rocks exist in this region, the fact that they are so numerous, that the region is so large, and that there is little navigation over much of it makes it practically impossible to drag the entire area, because of both the time and cost involved. Wire-drag work is accordingly recommended at present only where there is navigation by commercial and naval vessels or where maneuvering ground for naval vessels is required, and localities not now used but likely to be useful when dragged are included. Even this minimum represents many years' work. Areas that need wire-drag work, but where the cost is prohibitive, will have to be resurveyed by other methods, which will result in finding many though of course not all of the uncharted rocks. Some areas are considered as completed even if they are not surveyed by the standard applied to the more navigated regions, and the present surveys meet all the present requirements. (See fig. 53.)

WIRE-DRAG WORK.

Vessels entering the Straits of Florida from the eastward have to force their way against the strong current of the Gulf Stream, which in places attains a velocity of 5 miles per hour. It is known that along the northerly edge of the stream and close to the reefs the current is very weak and at times runs to the westward. There is a strong temptation to keep dangerously close to the reefs and save fuel, and this is the cause of frequent wrecks. Aside from the danger of running onto the known reefs, which are in many places bare and are of no great depth throughout their length, another source of danger, the extent of which is not yet entirely known, has been discovered. A secondary reef, parallel to the main reef and about one-half mile outside of it, is found to approach the surface in places as a narrow ridge with depths as little as 25 feet. Over 20 miles along the reef have been examined, but nearly 200 remain. This work should not be delayed, as it is of importance to nearly all of the great traffic entering the Gulf of Mexico.

Vessels bound for eastern Gulf ports naturally wish to take the shortest route. If of light draft, they can cross the Florida Reefs at Key West. The next channel is between Rebecca Shoal and Dry Tortugas, and if this is not used vessels must pass well to the westward of Dry Tortugas to avoid a shoal bank west of it. The Rebecca Shoal channel apparently has ample depth of water, but has a bad reputation among mariners, as several vessels have reported striking shoals in it. Part of this channel is now being dragged, and when completed a marked saving of time to vessels will result. The bank west of Tortugas should be dragged, especially as vessels making land from the westward may have to cross part of it.

Northward of the keys from Key West to Tortugas a doubtful area should be dragged. Several shoals have been found by the old method of striking them with vessels.

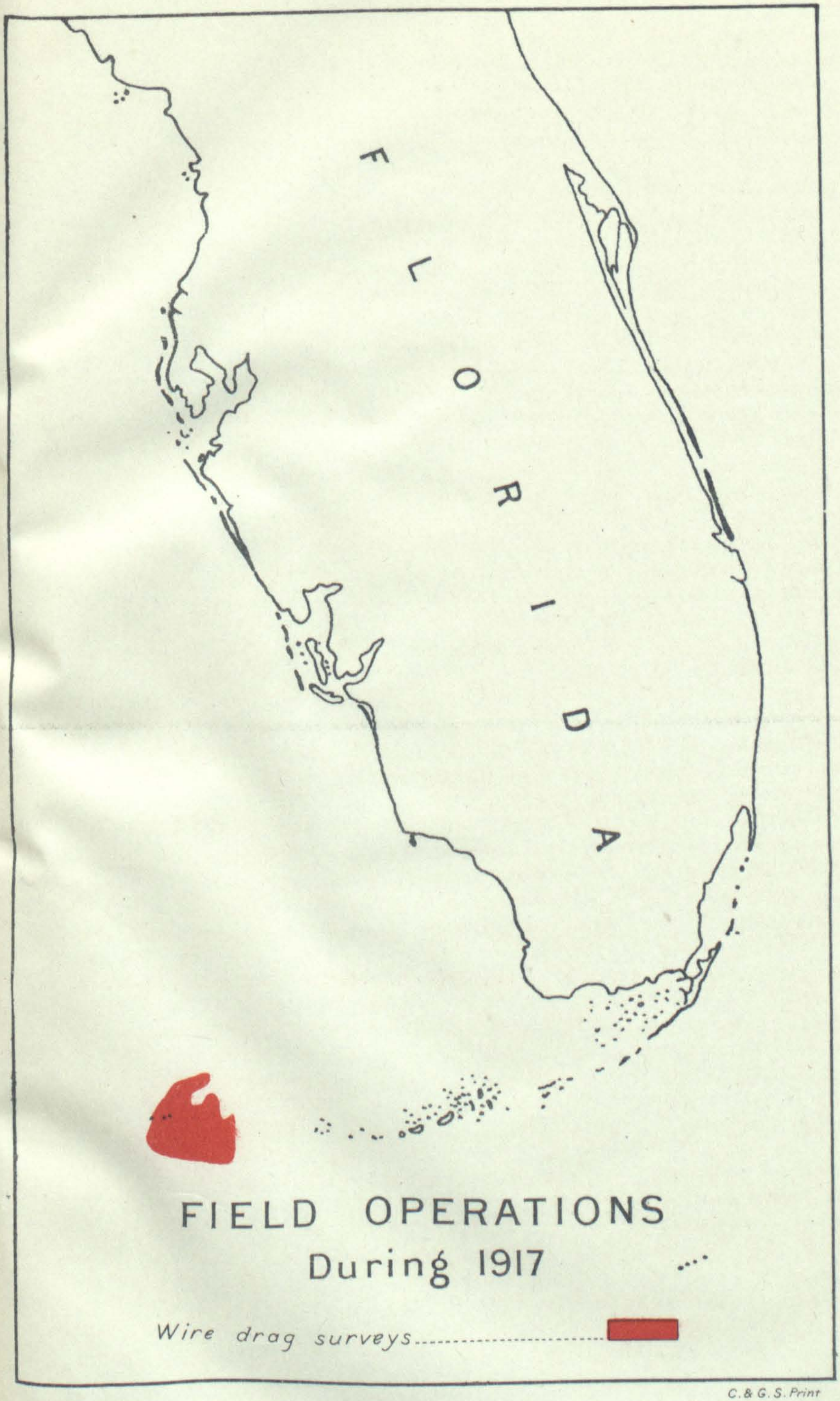
The channel between the keys and the reef known as the Hawk Channel is important for moderate-draft vessels. While it is not at present planned to drag it, it may be found necessary to drag the axis of the channel. Florida Bay has an excellent survey, though coral heads are very likely to exist here and there. The activity of coral growth does not appear to have been nearly so great on this side of the keys however.

CHARACTERISTICS OF THE GULF COAST.

The chief characteristics of the west coast of Florida are the distance to which shoal water extends offshore between Cape Sable and Cape Romano and from Tampa Bay to Apalachicola, and the existence of a number of large bays connected with the sea by deep channels either natural or dredged.

Comparatively few additional inshore surveys are needed, as the existing surveys, while perhaps not up to the standard of some other parts of the coast, meet the needs of existing and probable future navigation very well. Charlotte Harbor and Tampa Bay and their approaches are in need of resurveys. There is also a strip of sandy islands in each case which are subject to change and will need resurvey from time to time.

Off the Withlacoochee River a condition exists which, while common in other parts of the world, is otherwise unknown in the waters of the United States. Vessels approach this part of the coast to load phosphate rock, and as there are no harbors and the shallow water extends a long distance offshore they are compelled to anchor nearly out of sight of land, and their cargoes are lightered from the shore. A number of rocks have been struck in this region and additional surveys are needed. The anchorages commonly used and their approaches should be dragged. In stating that the inshore surveys of the west coast of Florida are generally complete, it should be realized that any commercial development that makes it necessary for large vessels to approach the shore will almost certainly result in rocks being found which do not interfere with existing navigation, and it will be the duty of the Coast Survey to make additional surveys wherever such development occurs.


FLORIDA
FIELD OPERATIONS
During 1917
Wire drag surveys
C. & G. S. Print

From Apalachee Bay to Cape San Blas the coast begins to assume a character more like the south Atlantic coast, and coral bottom is no longer found. This stretch of coast is sandy, and sand shoals extend off some distance, especially in the vicinity of Cape San Blas. This region needs a resurvey and like other sandy portions of the coast will need resurvey from time to time. (See fig. 16.)

The Florida and Alabama coast is somewhat different as deep water approaches close to the shore and the inshore surveys are considered complete except in Pensacola and Mobile Bays. All of the entrances, however, require frequent resurveys.

The coast of Mississippi and Louisiana has a very large proportion of changeable area, and resurveys are needed now and will be needed from time to time from Mobile Bay to the end of the offshore shoals south of Vermilion Bay. The immense load of sediment carried by the Mississippi River, especially in time of flood, causes constant changes in the Delta. The deposit of sediment and the action of the waves on the deposit results in rapid growth in some places and erosion in others.

Off the southern coast of Louisiana there is an extensive shoal region which is in need of survey.

The inshore waters along the rest of the Louisiana coast and the Texas coast with an important exception have deep water fairly close to the shore, and no additional surveys are needed. The exception is along the eastern part of the Texas coast from Sabine Pass to Galveston.

Sabine Bank and Heald Bank have shoal depths at a considerable distance from the shore, and they should have a thorough resurvey. Galveston Bay also needs resurvey.

INLAND WATERS, FLORIDA REEFS TO THE MEXICO BORDER.

Key Biscayne Bay, especially in the vicinity of Miami, is in urgent need of a resurvey. While the surveys of the shoal water between Cape Sable and the keys and among the keys are old they meet the demands fairly well and are not considered as needing resurvey. In most of this area the water is very shoal, and even light-draft launches require local knowledge.

From Key West to New Orleans the system of inland waterways is not nearly so continuous as on the Atlantic coast, but from New Orleans to the Texas border there is no break in them. Most of the breaks occur on the west coast of Florida where fortunately the inshore waters are shoal, and accordingly, there is not much swell or heavy breakers to fear. All the channels are in need of resurvey. Eastward of Pensacola there is a long stretch of inside channel through Santa Rosa Sound which needs resurvey.

From Mobile Bay to New Orleans there is one of the finest protected channels on the coast, Mississippi Sound. The line of islands on the outside is continuous except for the inlets, and protected waters for light-draft vessels make the water communication between Mobile and New Orleans exceptionally fine.

In this area the survey has been largely completed along the coast of Mississippi and when extended to Mobile Bay will be completed for a long time to come except at the inlets.

From New Orleans westward the inland route passes through a series of canals to Cote Blanche Bay. This bay is somewhat exposed to the sea, and its bottom is subject to change. A resurvey is needed now, and it will have to be repeated at intervals in the future. The remainder of the route is through canals and shoal bays to the Mexican border, and all the bays and sounds need resurvey.

OFFSHORE WATERS, FLORIDA REEFS TO THE MEXICAN BORDER.

Along the northern edge of the Straits of Florida the soundings are insufficient and they will have to be carried out somewhat beyond the 100-fathom curve.

The distance from the west coast of Florida to the 100-fathom curve is nearly 100 miles. Over much of this area the depths are moderate and the charts are based on reconnoissance surveys only. The bottom is coral rock in many places, and projections may arise sufficiently near the surface to be dangers to navigation. Fishermen have reported several uncharted ridges, and while the somewhat incomplete surveys which it has been possible to make so far of the reported localities have not confirmed all the details of their report, important differences from the charted depths were found.

The 100-fathom curve approaches fairly close to the Mississippi Delta; then swings offshore again so that it is about 60 miles south of Sabine Pass. It then swings to the southward in a curve which brings it within about 18 miles of shore at the Mexican border.

In surveying this area, it will be necessary to use particular care in the vicinity of the 100-fathom curve. There are authentic reports of shoals with 26 to 35 fathoms, with coral bottom very close to the 100-fathom curve, and one report states that a shoal with 11 fathoms exists very close to the 100-fathom curve southeastward from Galveston.

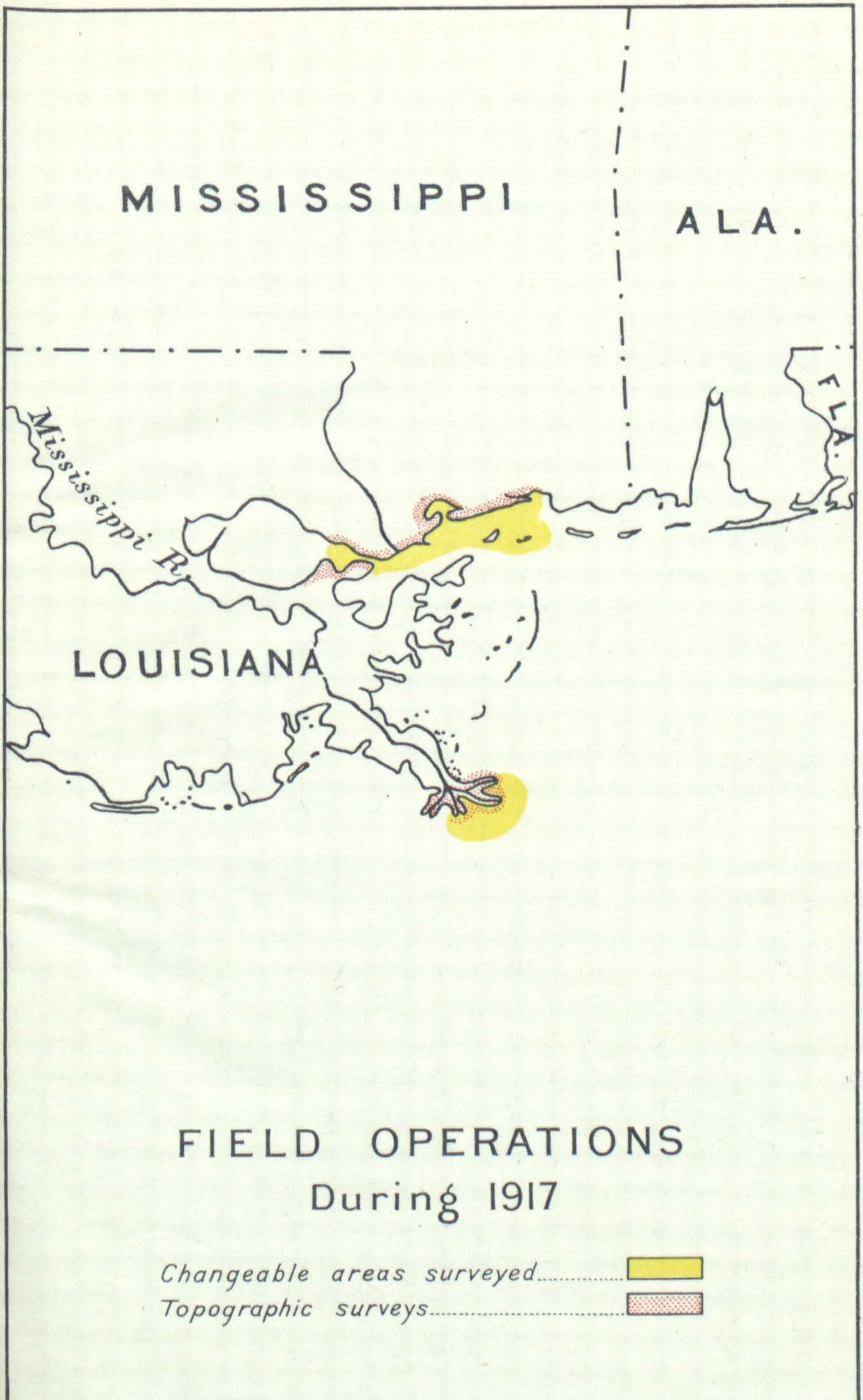
This whole offshore area is badly in need of a thorough resurvey, and there is no other part of the work in offshore waters that is so likely to be productive in furnishing important changes in existing charts. (See fig. 16.)

PACIFIC COAST OF THE UNITED STATES.

The western coast of the United States is very different from the eastern. Generally mountainous, with comparatively few harbors or inside waterways and with comparatively deep water close to the shore, it presents little resemblance to the low shores and wide continental shelf of the Atlantic. (See fig. 53.)

The purpose of the surveys is, then, to meet the needs of vessels approaching from seaward and of coasting vessels which keep to a few comparatively narrow tracks, to insure up-to-date charts of the various harbors, and to make soundings offshore to develop fishing banks that are known to exist.

The weather is an important factor in increasing the importance of the charts of this coast. From Los Angeles Harbor northward fog is very common in the summer time, and in the winter gales accompanied by thick weather are of frequent occurrence. On the coast in the vicinity of San Francisco thick weather is prevalent for perhaps 25 per cent of the time. Under such conditions the navigator must rely entirely upon his chart, and it is essential that detailed



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surveys be made to beyond the limit of soundings taken by merchant vessels, which is the 100-fathom curve.

Along the shore of southern California much work was done up to 1895, and some of the surveys then made may be accepted as final. In the vicinity of the outer islands, surveys extend only a little way from the shore, and the deep waters between and outside of them are unsurveyed. The few soundings taken show irregular bottom and breakers have been reported in places where the chart shows 600 fathoms. These waters therefore should be surveyed out to the 1,000-fathom depth. (See fig. 17.)

Los Angeles Harbor.—Los Angeles Harbor should be dragged, and minor local surveys are needed at a number of places along this coast.

From the western end of the Santa Barbara Channel to Monterey Bay the surveys as a rule extend only to the 50-fathom curve, which lies but a short distance offshore. These surveys should be extended seaward to include the usual track of coastwise vessels, which lies an average distance of about 10 miles from shore.

As an example of the need for wire-drag work, the results of the survey of San Luis Obispo Bay are striking. It was found that the large oil vessels entering this harbor were attempting to follow a channel with several dangerous rocks in its center. In fact, had the survey with the wire drag been made before the port was used by large vessels, the saving represented by the amount actually lost through strandings would have paid with a good margin the cost of all needed wire-drag surveys of the Pacific coast, exclusive of Alaska.

San Francisco Bay.—San Francisco Bay is of varied character of bottom and the needed surveys vary to correspond. The outer approaches are complete except in the vicinity of the Farallones. Here additional sounding is needed, and an investigation should be made with the wire drag to verify the existence of other rocks than those charted.

The bar outside the Golden Gate needs a resurvey. Wire-drag work has been carried through Golden Gate and inside both northward and southward from San Francisco to the limits of the rocky area. The southern part of the bay where the bottom is subject to change by the currents is in need of resurvey.

From San Francisco Bay to Point Arena a widely spaced system of sounding lines has been carried out to the 100-fathom curve. Here, an additional amount of work, about equal to that already accomplished, is necessary before the survey can be considered complete.

Between Point Arena and Cape Mendocino the surveys extend a uniform distance of 6 miles from shore, reaching depths varying from 50 to 200 fathoms. Additional detailed surveys should be made in the vicinity of each cape, and between them the work should be carried seaward to beyond the steamer track.

From Cape Mendocino northward to the Oregon boundary the limited surveys existing were made many years ago and are entirely inadequate. A complete resurvey should be made at the earliest possible date.

COAST OF OREGON.

One word describes the condition of the Oregon coast—UNSURVEYED. A limited amount of work was done years ago south of Cape Blanco and in the vicinity of the Columbia River, but this was not more than a reconnoissance and does not extend out far enough to be of practical value to navigators. Elsewhere, no surveys have ever been undertaken. (See fig. 18.)

Even in such an important locality as Cape Blanco, which must be rounded by all vessels plying between the Columbia River and San Francisco, there are no soundings to serve as a guide in thick weather, and vessels have been lost solely on account of this lack of surveys.

On the coast of Oregon are eight important harbors, on which the Government and private interests have expended approximately $40,250,000 in improvements designed to facilitate navigation. One of these is the Columbia River, the gateway to one of the most important transportation centers on the entire coast.

Yet in spite of these immense expenditures for improvements, there is not a single one of these harbors the approaches to which have been adequately surveyed. The approaches to the Columbia have been sounded for a short distance offshore, but even in this area the soundings are too far apart to do more than indicate in a general way the depths which may be expected.

This partial survey extends southward along the coast to include the approaches to two other harbors. The approaches to the remaining five, on which $3,826,000 have been expended in improvements, are entirely unsurveyed.

Perhaps the best comment on the condition of surveys on the Pacific coast is contained in the recent edition of the Coast Pilot, a publication of the Coast and Geodetic Survey, which with the charts forms the chief guide to navigators:

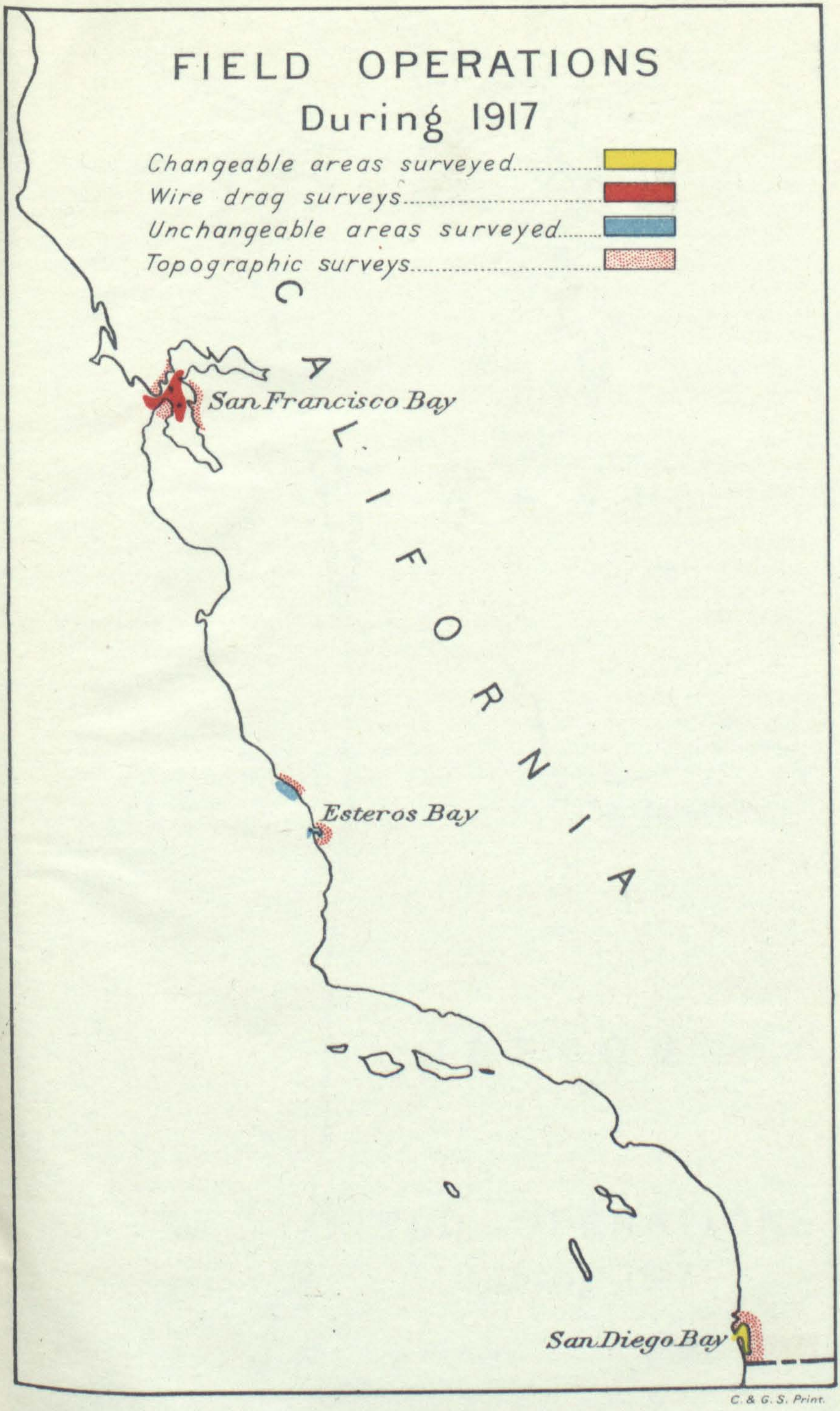
> In using the charts it is well to remember that the surveys on which they are based were made many years ago, and are, in some localities, incomplete. The absence of soundings on charts of any given locality is an indication of lack of survey, and not that the locality is free from danger.

COAST OF WASHINGTON.

The statement just made regarding the Oregon coast applies equally to the Washington coast. The entire coast stands in urgent need of a first survey, except in the approach to the Straits of Juan de Fuca and in the straits themselves, where the present work is adequate. Willapa Bay and Grays Harbor have both been recently surveyed, but they both are of changeable bottom and resurveys will be required at intervals. (See fig. 18.)

The interior waters of the State of Washington represent the point of change from a practically straight coast line to the broken formation of the coast of British Columbia and southeastern Alaska. There are many channels of importance leading to Seattle, Tacoma, Everett, Bellingham, and Olympia, and connecting with the inside passage to southeastern Alaska. All these waters should be dragged wherever there is the slightest doubt as to the presence of dangers to navigation.

Of the inside waters off the northern part of the Pacific coast little is known except that the Bureau of Fisheries, acting on the information obtained from fishermen, has located certain fishing banks. These banks should be surveyed to determine their depth and extent,


FIELD OPERATIONS
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Changeable areas surveyed
Wire drag surveys
Unchangeable areas surveyed
Topographic surveys
CALIFORNIA
San Francisco Bay
Esteros Bay
San Diego Bay
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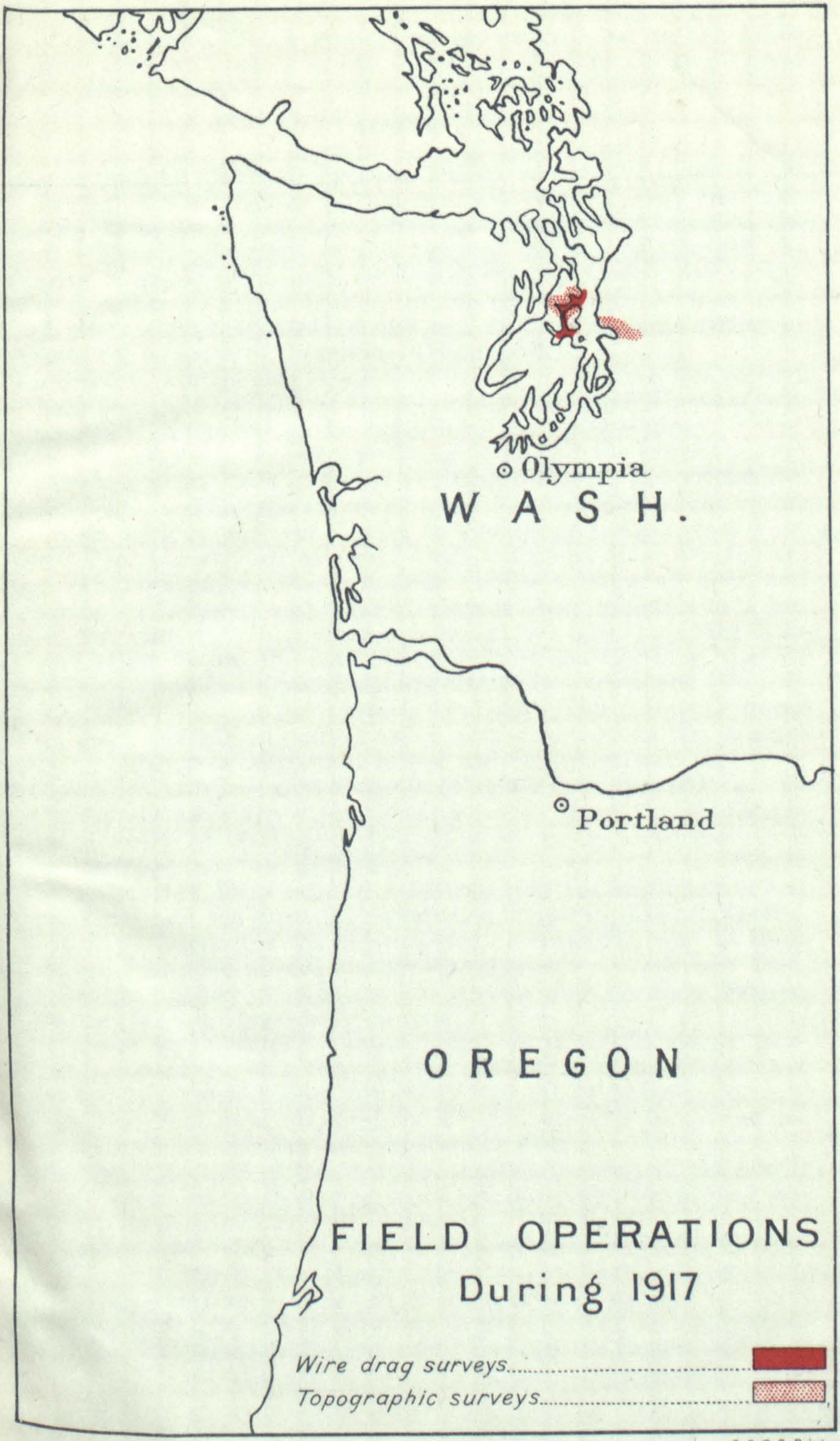

Olympia
WASH.
Portland
OREGON
FIELD OPERATIONS
During 1917
Wire drag surveys
Topographic surveys
C & G.S. Print.

and it is believed that a general survey carried out to the 1,000-fathom curve will result in the discovery of other banks of great value. (See fig. 53.)

ALASKA.

An important difference between Alaska waters and those of the continental United States is that scarcely enough work has been done to let us know just how much must be done to complete the charts. The development of the country has far outstripped the progress of surveys, not only because of the few vessels and parties engaged in the work but because of the great length of coast over which the various activities are scattered and the intricate system of channels for so much of its extent. (See fig. 54.)

In order to appreciate the need of rapidly extending the surveys of these waters, it should be clearly understood that Alaska's only connection with the rest of the world is by the water routes.

The Government railroad now being built and the other existing lines are not trunk lines in so far as connection with the continental United States and Canada are concerned. The trunk line is the waterway from various ports in Alaska to Seattle and other west coast ports. The Alaska railroads and local steamboat lines are feeders only. The industries, which include chiefly mining of gold and copper on an immense scale and of various other minerals to a less extent, fisheries, especially salmon canning, but also supplying halibut and other fish to the market, agriculture and grazing, now of minor importance but developing, are scattered everywhere, and connection with the principal ports is by boat. The principal towns are on good harbors suitably located with reference to the steamer routes and the more important mines and canneries, and any town that loses any of these advantages soon declines in importance. In practically all cases the canneries and mines along the shores are visited directly by steamers. The value of water-borne commerce during the past year was $110,368,178.

The amount of these natural resources ripe for exploitation has been so great and the prize they offered so tempting that transportation could not wait for the Government to make the way to them secure. It has gone ahead, finding its own path to each new field, suffering great losses in so doing, but content to suffer them because the returns were so immensely greater.

The Coast and Geodetic Survey, which in this field should have been the pioneer showing the way for commerce to reach each new enterprise, has, instead, been following impotently behind, charting dangers less from data obtained by its own surveys than from reports of vessels which have been wrecked on them.

It is high time that such a state of affairs be corrected, yet it will now take years before the surveys can reach a point where they can even meet the needs of present commerce. (See fig. 19.)

In southeastern Alaska the first and most obvious need is to complete the wire-drag work. Most of these waters have been sounded, so that only dragging is necessary to complete this survey.

This drag work should be taken up in the order of its importance, beginning with the main steamer route through the region and then taking up the various tributary waters leading to areas of commercial importance.

For some years past, two parties have been actively engaged in dragging the main steamer route, and this work is now about 55 per cent complete.

The outside coast of the islands bordering on the open Pacific and their connecting channels are largely unsurveyed, and have to be navigated with great caution. A navigator seeing a chart on which the shore line is sketched, no soundings, several rocks and shoal banks, notes as to rocks and breakers reported, and a statement on the chart to the effect that the area is unsurveyed is, to say the least, unable to proceed with confidence; and this situation is by no means unusual. The most pressing need of such regions is a complete hydrographic survey followed later in places by wire-drag work. The rapidly increasing commercial importance of this region and the exceptionally dangerous character of the waters through which traffic must pass, render surveys in the near future imperative.

Cross Sound to Prince William Sound.—From Cross Sound, the northernmost channel from the inside waters to the sea, to Prince William Sound the coast has few features of present or prospective importance. There is, however, urgent need for surveys to insure the safety of vessels approaching and passing along this coast. In this region the charts are very defective in the matter of showing soundings and prominent coastal mountain peaks and headlands that would enable the navigator to obtain his position on approaching from seaward. The only important break on this coast, Yakutat Bay, has some canneries, and additional surveys are needed here on this account.

Prince William Sound to Unimak Pass.—A very important section of the Alaska coast extends from the waters of Prince William Sound westward to Unimak Pass. Not only are the industries of present importance, but there are extensive mineral resources, largely undeveloped through lack of cheaper transportation. The point to be emphasized is that this is not an old, settled country with its needs in the matter of transportation fixed, but it is still capable of great future development, and in considering the needed surveys this future must be taken into account.

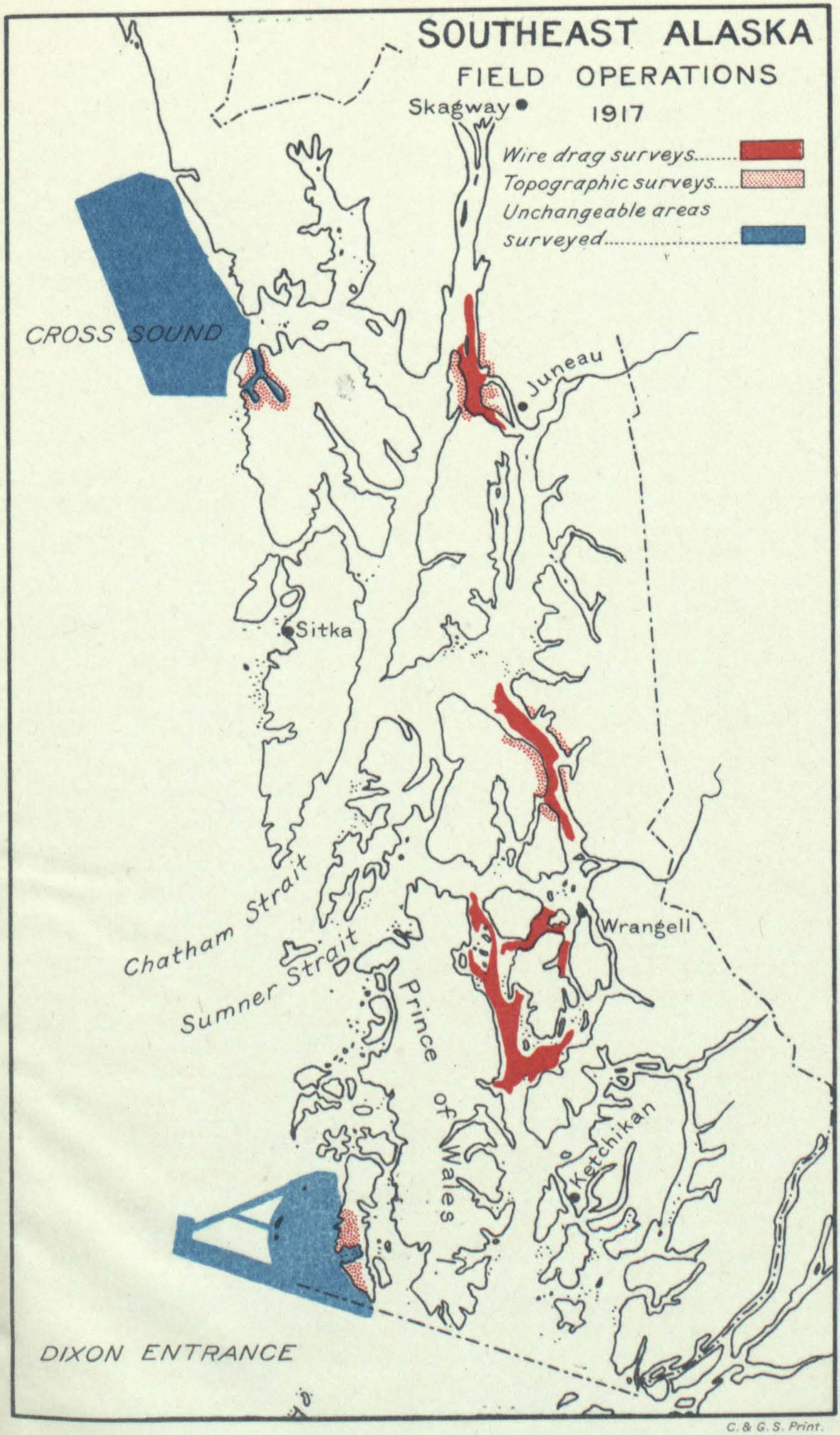
The approaches to Prince William Sound have been surveyed and need no resurveys for the present except in the vicinity of Cape St. Elias and Middleton Island. Wire-drag work will be needed in both these localities as reefs and pinnacle rocks exist.

Prince William Sound needs additional soundings over most of its area, and many of its branches need original survey. (See fig. 20.)

Cordova is the terminus of the Copper River & Northwestern Railway which gives access to the important copper mines on the Copper River. The approaches to Cordova have been surveyed except for wire-drag surveys needed to insure complete safety.

Seward, on Resurrection Bay, is the terminus of the Alaska railroad now being built by th. Government. The surveys of its approach are completed except for wire-drag work.

It is probable that much of the freight originating along the line of the Government railway will be transshipped at Anchorage at the head of Cook Inlet. Not only will this make it necessary for many


SOUTHEAST ALASKA
FIELD OPERATIONS
1917
Wire drag surveys
Topographic surveys
Unchangeable areas surveyed
Skagway
CROSS SOUND
Juneau
Sitka
Chatham Strait
Sumner Strait
Prince of Wales
Wrangell
Ketchikan
DIXON ENTRANCE

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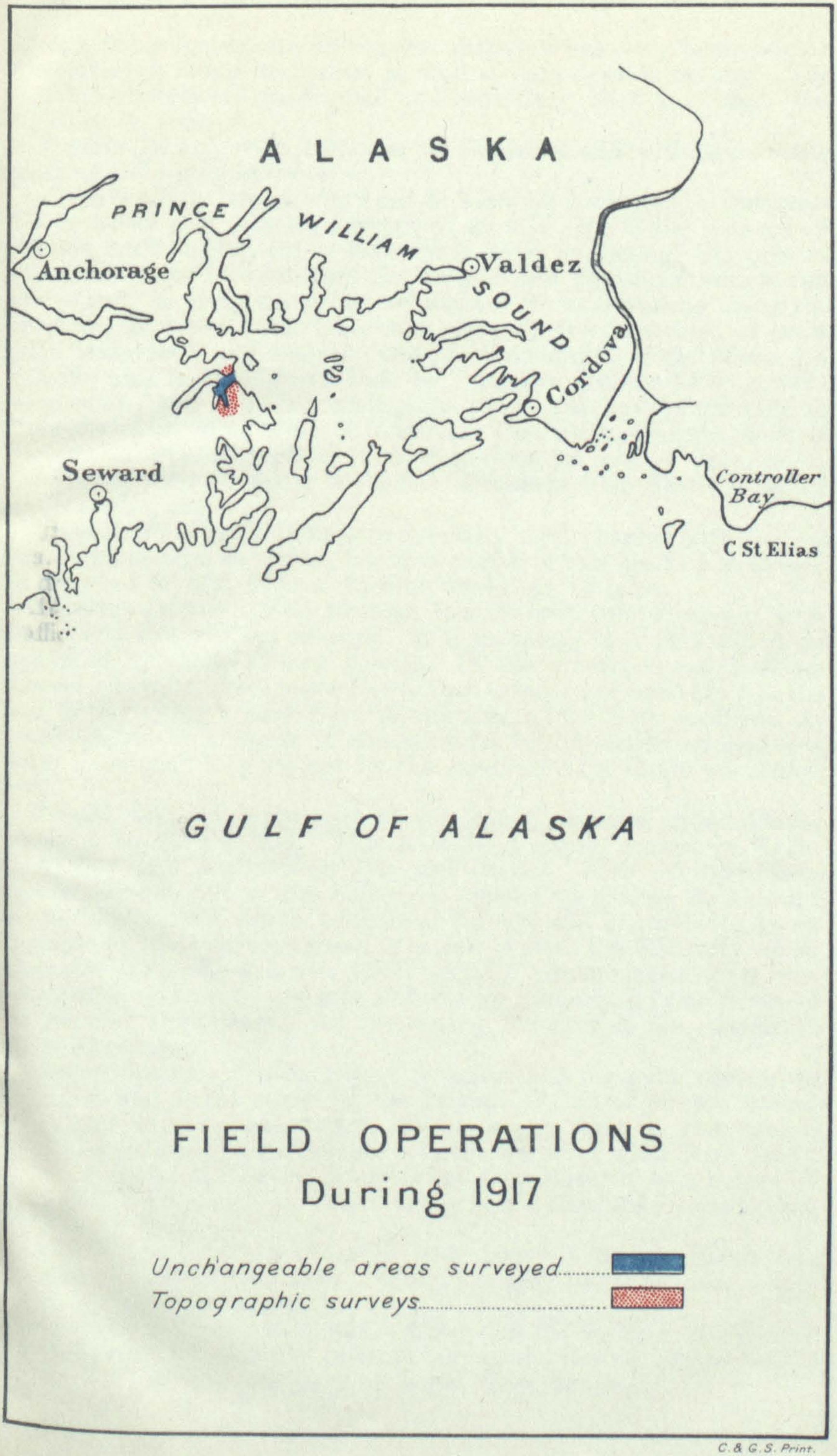

ALASKA
PRINCE WILLIAM SOUND
Anchorage
Valdez
Cordova
Seward
Controller Bay
C St Elias
GULF OF ALASKA
FIELD OPERATIONS
During 1917
Unchangeable areas surveyed
Topographic surveys

C. & G. S. Print.

vessels to navigate these waters, but there are now very large salmon canneries all along its shores, as well as considerable mining. The present surveys are inadequate and wire-drag work is needed over much of its area.

Kodiak Island, with a number of canneries and with some cattle grazing, is largely unsurveyed.

From Kodiak Island westward to Unimak Pass only a comparatively small part has been surveyed at all. While the amount of present traffic is small it is sufficient to need protection. At present the Coast Guard vessels and the freight and passenger vessels run grave risks in using the protected natural channel leading along the coast inside the islands. This is a particularly bad stretch of coast with many reefs and islands. Only in the vicinity of the Shumagin Islands and from Unimak Pass to Unalaska Islands have surveys been made, and they are inadequate. It is not now practicable to drag the entire area, but it is important that the immediate needs of navigation, even though of limited amount, be met by dragging a selected channel to insure the safety of vessels from Shelikof Strait to Unimak Pass.

Unimak Pass is the almost universally used channel into Bering Sea. It has been surveyed, but it is probable that part of it should be dragged or that at least further soundings be taken.

Aleutian Islands.—The Aleutian Islands have comparatively little traffic and are without surveys. It is necessary that this region be patrolled by Coast Guard vessels. In the wreck of the *Tahoma* several years ago there was a loss to the Government equivalent to the cost of surveying a large part of this area. This is an excellent example of how in a region of almost no traffic the needed surveys cost little more than may be lost by the existence of a single uncharted reef.

Bristol Bay.—A large part of the salmon shipped from Alaska comes from Bristol Bay. This is without survey except in Nushagak Bay and Kuskokwim Bay and River. Both of these have recent surveys, but as the bottom is subject to change on account of the large rivers, future additional surveys will be needed. As an example of what surveys mean in a new region, the discovery of an entrance to the Kuskokwim River suitable for moderate-draft vessels opened up an immense area suitable for grazing and also in places for general agriculture. An interesting industry is the raising of herds of reindeer.

Norton Sound.—Norton Sound is important for gold mining on its shores and as the mouth of the Yukon. In all of Norton Sound additional surveys are needed. It is curious that in this sound, which according to all available information is of quite level sandy or muddy bottom, Besboro Island, rises very abruptly to a height of 1,012 feet. With such an occurrence it is not absolutely certain that no pinnacle rocks exist.

Port Clarence.—Port Clarence just south of Bering Strait has canneries of some importance. While a survey has been made, additional surveys are needed.

Bering Sea and Arctic Ocean.—Except in the vicinity of Pribilof Islands, there are no other existing surveys in Bering Sea or to the north which can be considered of value. (See fig. 54.)

OUTLYING ISLANDS.

PORTO RICO.

When Porto Rico came under the jurisdiction of the United States as a result of the Spanish-American War, one of the pressing needs was an adequate survey, in spite of the fact that it was among the first discovered and settled of the West Indies. This work was intrusted to the Coast Survey, and the surveys were begun without delay. By 1910, the survey was completed and a sufficient number of deep-sea soundings were taken around the island.

There are, however, extending to the eastward and westward of the island and along the south coast, extensive areas where the bottom is of coral formation. There are also reefs along the north coast, but as they are close to shore and must be avoided by vessels, it is only important to know their location, and no extensive surveys are needed in their vicinity. The other areas mentioned above are different in that there is traffic between the reefs and over areas where the depth is little greater than the draft of the vessels, and the existence of uncharted projections can cause wrecks. Vieques Sound between Culebra and Vieques Island east of Porto Rico, Virgin Passage, and the approaches to the harbors of the American Virgin Islands are in need of wire-drag work. The only work of this character that has been done was in the vicinity of Mayaguez. This work resulted in the abandonment of one channel and the rebuoying of another.

Wire-drag work should be in progress now, and it is only delayed by the lack of launches that can do the work in the rough water caused by the trade winds.

GUAM.

The present chart of the island of Guam is compiled from Spanish and British charts and some harbor surveys by the United States Navy. No attempt at a comprehensive survey has been made. A complete survey should be made, not only including the harbors, but the surrounding waters, carrying the survey out to a depth that will be certain to include all dangers. In these waters shoals rise abruptly from great depths, and the absence of soundings on the charts does not imply safety but simply absence of surveys.

HAWAIIAN ISLANDS.

There are only two good harbors in all the Hawaiian Islands and both of these are on Oahu Island. All of the islands except Hawaii have coral reefs around at least part of them. In the vicinity of Oahu, Maui, Kahoolawe, and the south coast of Molokai the surveys are fairly complete. In the vicinity of Hawaii, the surveys are very inadequate except in the only harbor, Hilo Bay. The west coast of Lanai and the vicinity of the two westernmost islands, Kauai and Niihau, are practically unsurveyed. The various channels between the islands from Maui to Oahu are fairly well surveyed. The others are practically without survey.

PANAMA CANAL APPROACHES.

The Atlantic approach to the Panama Canal has been surveyed since work started on the canal construction. Limon Bay is, however, a region where pinnacle rocks occur, and one of these was struck by the U. S. S. *South Carolina.* All the anchorages should be dragged, and the work should be carried a short distance outside.

The Pacific approach to the canal has had a recent survey and has been dragged. No further surveys are needed at present.

PHILIPPINE ISLANDS.

Active work was commenced by the United States Coast and Geodetic Survey in the Philippine Islands on January 1, 1901, and it has been prosecuted continuously since that time.

On September 3, 1901, a proposed plan for the division of expenses between the Governments of the United States and the Philippine Islands, which had been approved by the Secretary of the Treasury of the United States, was submitted to the United States Philippine Commission for consideration and was later approved. On January 1, 1902, the plan of cooperation, as submitted, was carried into effect.

Since January 1, 1902, the work has been conducted under the joint agreement, which provides that it shall be under the general supervision of the Superintendent of the Coast and Geodetic Survey, at Washington, D. C., represented by an officer of the regular field force of the service designated as Director of Coast Surveys, Philippine Islands, who shall, however, report to the head of the Insular Government, so far as concerns the expenditure of funds furnished by that Government. It also provides for a specified division of expenses, which has resulted in the payment of 35 per cent of the total expenses by the Government of the Philippine Islands.

The details of the work are arranged through a suboffice established at Manila, where all records are received, computations are made, charts and sailing directions are prepared, and information is supplied to navigators, engineers, and others.

Five steamers fitted out for making complete surveys, including triangulation, topography, and hydrography, are employed in the field work, while in addition, working parties are sometimes established in quarters on shore, with launches and small boats equipped for use in making surveys.

The Philippine Islands are composed of not less than 3,000 islands and islets covering an area of approximately 115,000 square miles, about the same as that of the five New England States and the State of New York combined.

The total length of the general coast line, measured on small scale charts (1:400,000) using 3 mile spaces of dividers and omitting islands and bays less than 3 miles long is approximately 10,850 miles, or about the same as that for the entire Atlantic coast of the United States, including the islands. About 75 per cent of this shore line has been completed.

The unsurveyed hydrography covers a large area on account of the necessity of extending this work, in some localities, for many miles offshore, and on account of the very extensive area of the

Sulu Sea. It is estimated that about 50 per cent of this class of work has been completed.

The triangulation has been carried over the greater part of the coasts of the islands, there remaining a few scattered localities where only tertiary triangulation will be necessary, all of the triangulation of a secondary class required for the coasts having been completed. There is a connected system over the greater part of the coast and the adjustment to a uniform datum can proceed without interruption.

It is estimated that 64 per cent of the entire work of surveying the islands was completed at the close of the fiscal year 1917.

The surveys of the coasts of the Philippine Islands have covered all of the localities that are at present of any commercial importance, the remainder of the work being in localities many of which are dangerous to navigators, but which, at the present date, are seldom visited by vessels engaged in trade.

The unsurveyed regions are as follows: The northeast coast of Luzon from Polillo Island northward to Aparri; the region off the north coast of Luzon, including the Babuyan Islands, Balintang Channel, the Batan Islands, and Bashi Channel; the entire west coast of the island of Palawan and about one-half of the east coast of the same island; the west coast of Mindanao, from Blanca Point, south to Zamboanga; the south coast of Mindanao, from Pola Point to Malita, in Davao Gulf; the Sulu Archipelago and the Sulu Sea from Cuyos, south to the limits of our possessions off the coast of Borneo.

Northeast coast of Luzon.—This entire unsurveyed region, from Polillo Island on the south to Aparri on the north, is of little commercial importance, and being quite free from dangers to navigation, the execution of the work is being delayed until more important sections are completed.

Little reliable information relating to this region is available, but a number of good anchorages have been reported. Among these are the inner harbor at Port San Vincente, Casiguran Bay, Dilasac Bay, and Dingalan Bay. The first two mentioned are excellent typhoon harbors, and as the greatest distance to one or the other could not exceed 100 miles, there is no reason why this work can not be executed with safety and dispatch, although it must be done during the season of frequent typhoons, it being impossible to work at any other time of the year on account of the heavy sea.

Off north coast of Luzon.—A survey should be made of the islands and the waters to the northward of Luzon as far as Bashi Channel, as, in accordance with the numerous reports, there is considerable uncertainty in regard to the true location of the islands, and the rocks and dangers to navigation in the locality. As it is in the region visited by frequent typhoons, the work should be undertaken during the period when typhoons are less frequent.

West and east coasts of Palawan.—The coast line of the island of Palawan is very irregular, indented with deep bays forming some of the finest harbors in the archipelago. The whole region about the island and extending southward to Balabac Island, Banguey Island to Cagayan Sulu, and off the north coast of Borneo, consists of coral reefs, many small islets, and innumerable hidden dangers to navigation. To the westward of Palawan, reefs and dangers extend to over

100 miles offshore. The hydrographic survey of this region involves an immense amount of labor. A preliminary survey for the location of channels through the reefs and entrances to harbors will first be necessary, after which these localities must be swept with the wire drag.

West coast of Mindanao.—The necessity for the survey of this unfinished portion of Mindanao, from Blanca Point to Zamboanga, a stretch of about 150 miles, is not urgent, as the region is of no commercial importance and is known to be free from dangers to navigation. It is the intention, however, to take it up as soon as there is a favorable opportunity in order that the circuit of the island of Mindanao may be completed. The coast is bold and rocky, exposed to both the northeast and southwest monsoons, and there are only a few months in the year, before the change in the monsoons, that are favorable for work in this region. April, May, and June are probably the most favorable, as during these months the winds are usually light and at times variable.

South coast of Mindanao.—This stretch of about 160 miles, from Pola Point to Malta in Davao Gulf, involves no great difficulties and will be taken up as soon as the surveys in other localities of greater importance for the safety of navigation have been completed. The coast, in general, is bold and steep, with numerous outlying reefs which, however, do not extend a great distance from shore.

Sulu Archipelago.—This region, about 75 miles wide, extending in a southwesterly direction from Zamboanga on the southern coast of Mindanao, to the coast of Borneo, a distance of about 180 miles, has scattered over it about 300 islands and islets and numerous hidden dangers to navigation. It requires a survey of the most careful and intricate character, and much of the locality must be swept with the wire drag. The formation is coral and dangerous to navigation, as rocks are frequently found in localities where they are least expected to exist. The currents in the region are very strong. The physical conditions are such that excellent control can be obtained and little traverse work will be necessary.

For many years the pirates of this locality have been a terrible scourge, and unless conditions change, military protection will be necessary during the execution of the surveys.

Sulu Sea.—This body of water, averaging 350 miles in length and 300 miles in width, is located between the islands of Mindoro on the north, Panay, Negros, and Mindanao on the east, Sulu Archipelago on the south, and Palawan on the west.

The northern end, as far south as the Cuyos has been surveyed with a fair degree of accuracy, but owing to the coral formation, where hidden dangers frequently exist, wire-drag sweeping will be necessary in selected passages.

The entire region to the south of the Cuyos remains unsurveyed except for a reconnoissance and approximate locations by navigational methods.

Numerous rocks and reefs dangerous to navigators are scattered throughout the sea, but certain well-defined passages have been examined with sufficient accuracy to make navigation through them reasonably safe. The survey of the entire region south of the Cuyos will be taken up as soon as work in more important localities has been completed.

OCEAN CURRENTS.

No discussion of means designed to safeguard navigation is complete without a consideration of the subject of currents, since it is to their action, occurring unseen and unsuspected, that so many disasters are due.

To this subject the Survey has devoted a great deal of attention in recent years and at present publishes current tables for a number of localities, giving information of great value to the navigator. It hopes, however, to prosecute its studies still more vigorously in the future, so that the scope of the information so furnished can be materially expanded.

While it would be an interesting inquiry to determine, if possible, the mooted question of whether currents have their origin in prevailing winds, the difference in salinity and therefore difference in density of the ocean waters, or rainfall and evaporation, such is not the business of the Bureau.

Our duty is confined to the more practical subject of determining where and under what conditions currents exist and their strength and direction, and these are not so much the result of scientific research as of direct practical observations of the actual currents themselves.

From the practical standpoint of the navigator; currents may be divided into three classes.

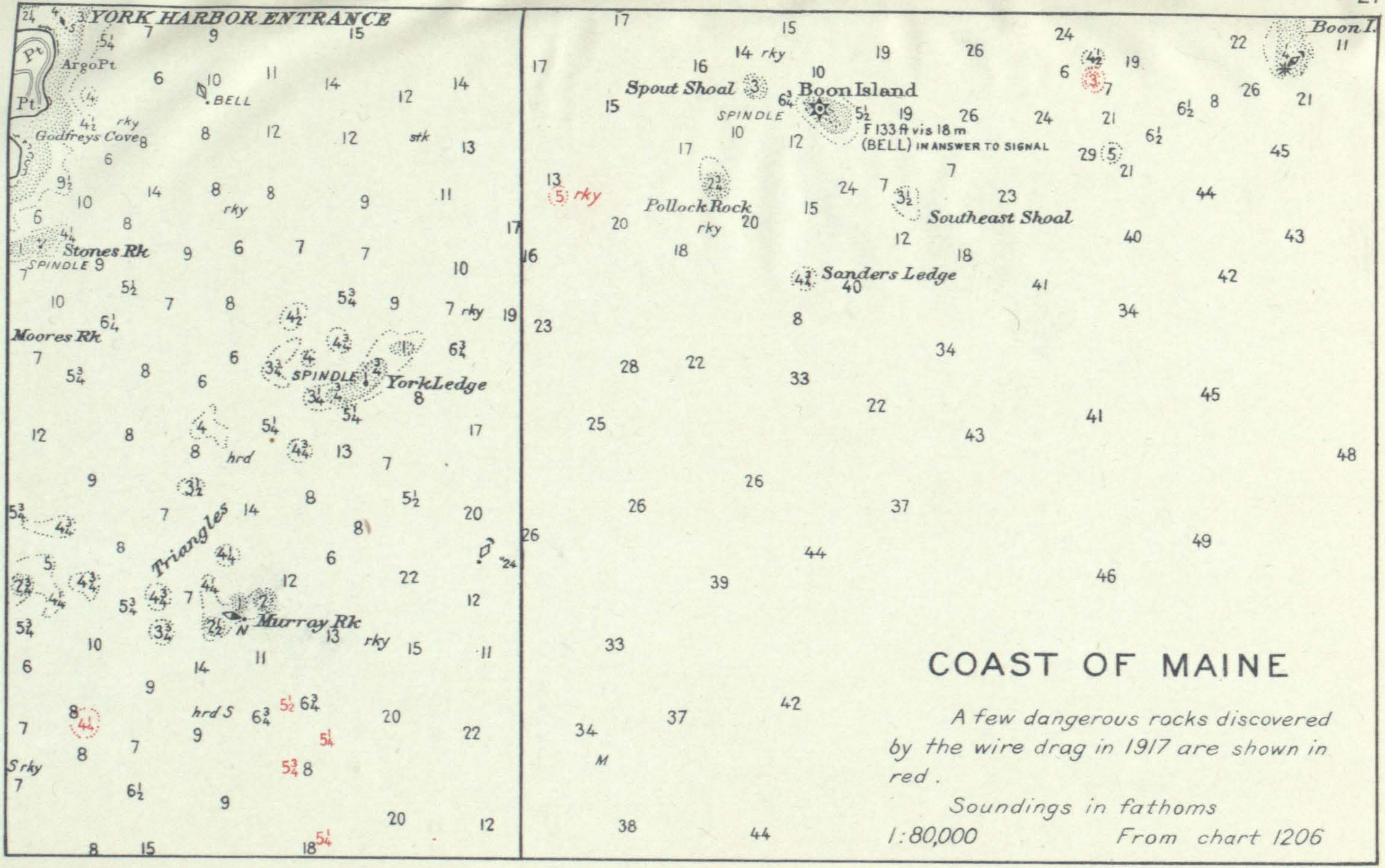
1. Tidal currents: Since these are the result of known forces, acting under known conditions, their prediction offers no difficulty.

It is well known that the principal tide-producing force is the combined attraction of the sun and moon. Since the relation of these two heavenly bodies to each other is constantly changing, passing through a complete cycle once every lunar month, their combined attraction, and consequently the tides themselves, pass through similar monthly cycles. In order, therefore, to secure data on which to base predictions of the tidal currents at any given point, it is only necessary to take continuous measurements of the velocities and directions of the currents actually existing and to note the times of slack water as the current turns from flood to ebb or from ebb to flood.

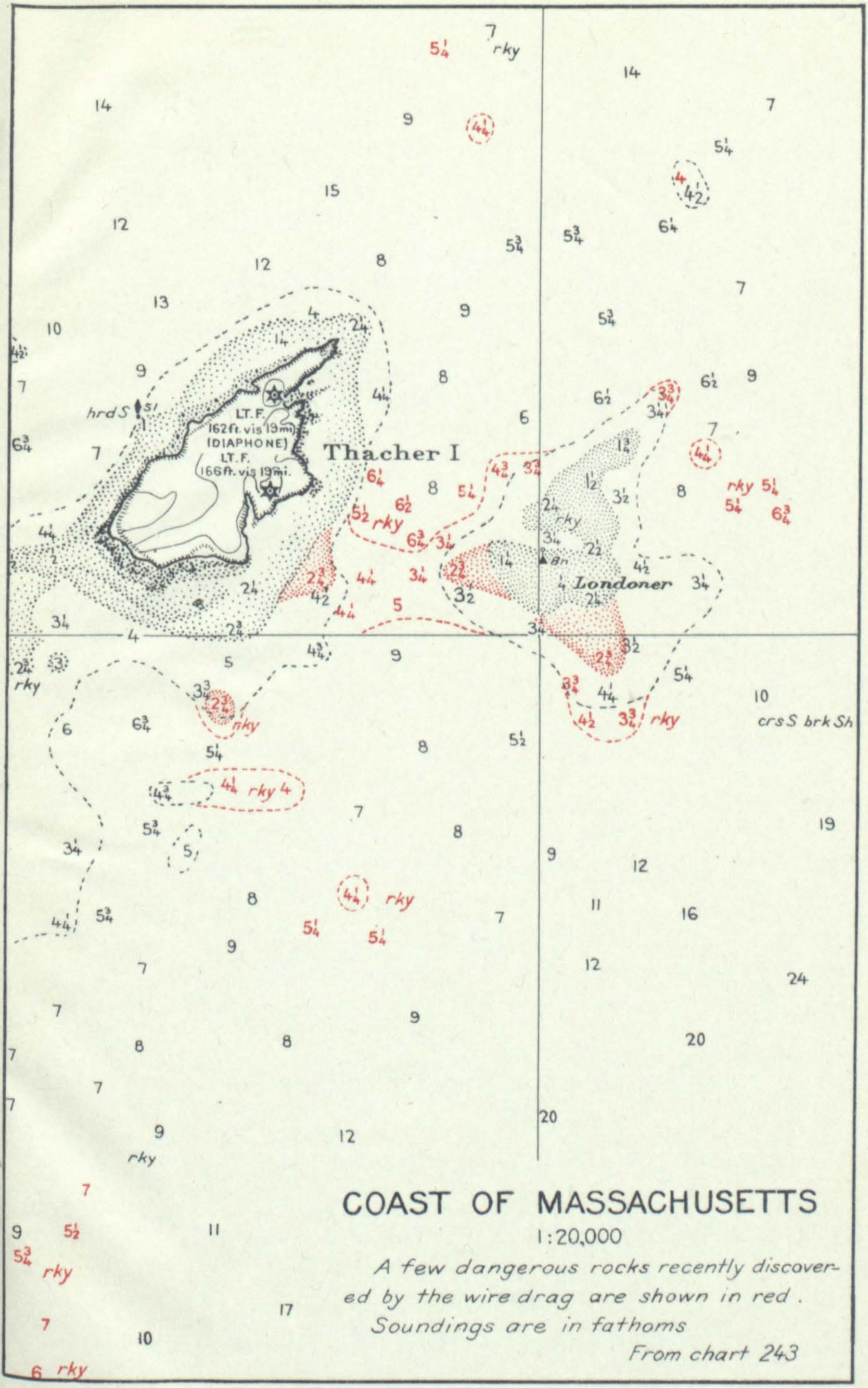
From the data thus obtained for any one lunar month, the currents which will occur during any other month can be predicted, with the understanding of course, that there may be temporary fluctuations due to storms, freshets, etc. In fact, fairly accurate predictions can be made from observations taken during a period of considerably less than a month's duration.

2. Currents of the type exemplified by the Gulf Stream, where the occurrence is continuous, the flow always in one direction, and the velocity at any point fairly constant except when temporarily modified by weather conditions.

The study of such a current must include the determination of its velocity at different points under normal conditions, and also the determination of the amount by which that velocity is affected by different weather conditions. For this purpose, the method used may be that already described, but it is obvious that the observations must extend over a longer period in order to include the effect of varying weather conditions.


YORK HARBOR ENTRANCE
Argo Pt
Godfreys Cove
BELL
Stones Rk
SPINDLE
Moores Rk
York Ledge
Triangles
Murray Rk
Spout Shoal
Boon Island
F 133 ft vis 18 m
(BELL) IN ANSWER TO SIGNAL
Pollock Rock
Southeast Shoal
Sanders Ledge
Boon I.
COAST OF MAINE
A few dangerous rocks discovered by the wire drag in 1917 are shown in red.
Soundings in fathoms
1:80,000
From chart 1206

C. & G. S. Print.


Thacher I
LT.F.
162 ft. vis 19 mi.
(DIAPHONE)
LT.F.
166 ft. vis 19 mi.
hrd S
Londoner
Bn
rky
crs S brk Sh
COAST OF MASSACHUSETTS
1:20,000
A few dangerous rocks recently discovered by the wire drag are shown in red.
Soundings are in fathoms
From chart 243

C. & G. S. Print.

SAN FRANCISCO BAY

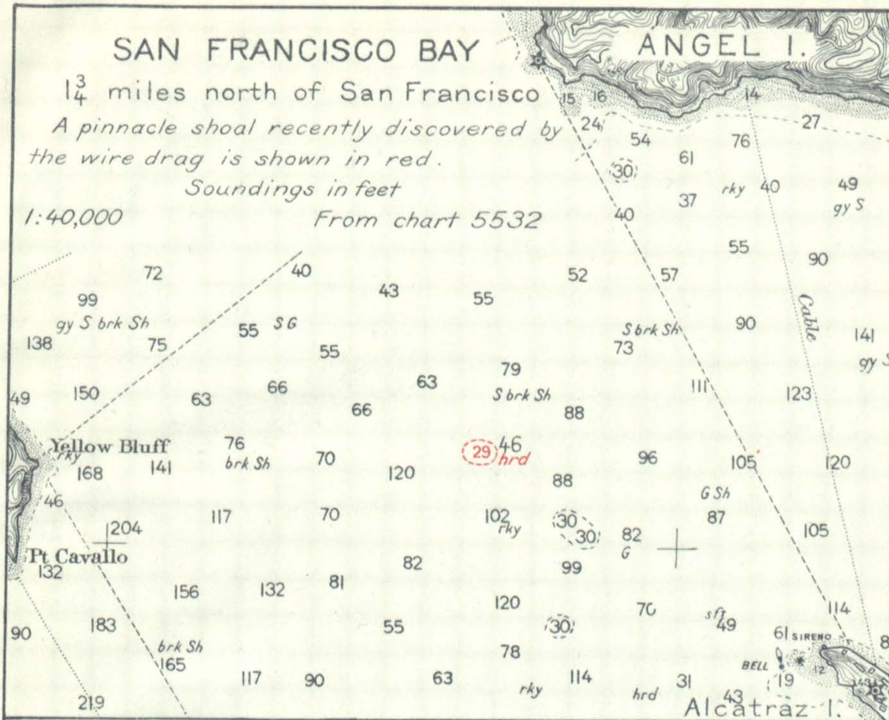
$1\frac{3}{4}$ miles north of San Francisco

A pinnacle shoal recently discovered by the wire drag is shown in red.

Soundings in feet

1:40,000

From chart 5532



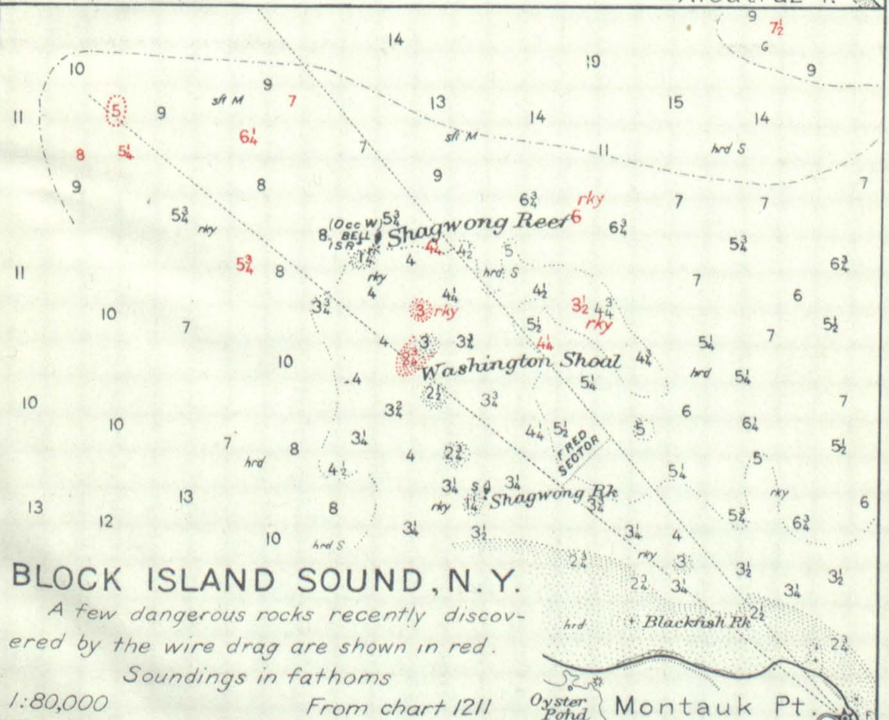
BLOCK ISLAND SOUND, N. Y.

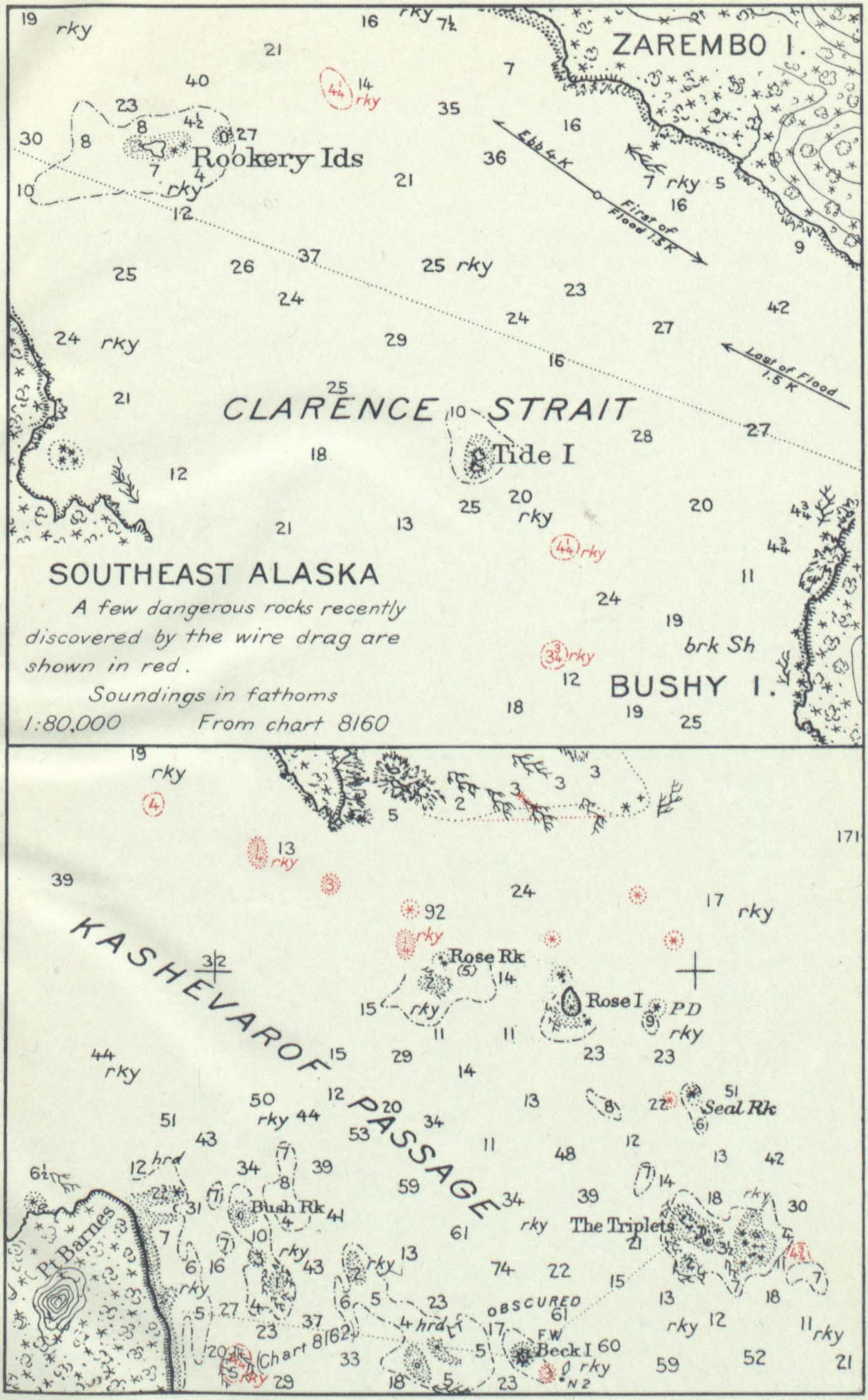
A few dangerous rocks recently discovered by the wire drag are shown in red.

Soundings in fathoms

1:80,000

From chart 1211




ZAREMBO I.
Rookery Ids
Ebb 4 K
First of Flood 1.5 K
Last of Flood 1.5 K
CLARENCE STRAIT
Tide I
SOUTHEAST ALASKA
A few dangerous rocks recently discovered by the wire drag are shown in red.
Soundings in fathoms
1:80,000 From chart 8160
BUSHY I.
brk Sh
KASHEVAROF PASSAGE
Rose Rk
Rose I
PD
Seal Rk
Bush Rk
Pt Barnes
The Triplets
OBSCURED
FW
Beck I
Chart 8162
LT

C. & G. S. Print.

3. Currents which may be described as accidental in character. These occur apparently as a result of certain transitory localized causes, and in consequence, are shifting and variable.

The dangerous currents of the Pacific coast of continental United States are of this character. These may be flowing north one week and south the next, or they may die out entirely; but as they have been known to attain velocities of from 2 to 3 miles per hour, it is of the utmost importance that they be carefully studied and a method found for informing navigators when they will be encountered.

Obviously, this is a different problem and one that will require a long period of observations to solve. Such studies as have been made, however, have indicated a practical way of solving it, provided the necessary observations can be obtained.

Thus, it appears that the chief essential necessary for furnishing navigators with information regarding the currents is a series of actual measurements of the currents themselves, extending over periods of varying length, depending on the character of the currents.

In the inland waters where shelter is afforded and where the currents are tidal, necessitating observations over short periods only, it is practicable to use small launches, so that the necessary results can be obtained at a moderate cost. But in the open unprotected waters of the outside coasts, where observations must be taken continuously over long periods and where it is particularly important to obtain such observations during periods of stormy weather, a staunch seaworthy vessel must be provided.

To build or charter a vessel solely for this purpose would make the cost very great, and it is for this reason that in the past we have had to be content with the meager current information that was obtained during the course of the various hydrographic surveys.

However, this matter has been given serious consideration, and some years ago a plan was evolved through which it was hoped to remedy this defect, which plan has, however, through lack of sufficient legislation, been thus far unexecuted.

Briefly, the plan contemplated was this: The Bureau of Lighthouses maintains along our coasts anchored lightships that serve as aids to navigation. These ships are for the most part at points on the tracks of vessels where it is desirable to have information regarding the currents. As these ships are anchored (and therefore confined to a limited area), the plan was to have continuous current and meteorological observations made from these ships throughout the year. From the data thus obtained it should be possible to derive general laws on which reliable predictions can be made as to the direction and strength of currents under all conditions. With the aid of these general laws predictions could be made for the occupied stations, and actual observations made at points between the lightships would then enable us to secure data on which to base predictions for all our coasts.

However, this matter will be discussed further under the head of "Needs of the field service" in Chapter II.

GEODETIC WORK.

Every civilized nation recognizes the need for having geodetic surveys that are used to control the detailed mapping and surveying and its engineering work.

The geodetic work that is of the greatest economic and commercial value is primarily triangulation and precise leveling. In order that these may be better understood, there will be given a brief explanation of the problems that confront a surveyor when he is making a map over an extended portion of the earth's surface.

As is well known the earth's surface is spherical and not plane. In the surveying with which most of us are familiar, the area over which operations are carried is so limited that it may be considered as lying in a plane. This condition may be assumed for areas of even several hundred square miles. When such an area is surveyed, for purely local purposes, an initial point may be assumed for the operations. Then, by measuring distances with a tape or chain and getting angles with a small engineer's transit, control points are established into which are tied the various lines and points of which the survey is composed. Such a survey might be that of a park where the object to be accomplished is to show on a map the boundary of the area covered by the park, the roads, streams, hills, woods, buildings of various kinds, and any other natural or artificial features whose positions relative to the boundary lines are needed.

The average farm survey is similar. Here we would have some starting point, such as a tree or a rock or a concrete monument, and from this point a traverse by compass and chain, or by some other plane surveying method, is extended around the whole farm. Following this, various topographic features on the farm would be tied in to the boundary lines by distances and angles measured on the ground.

In such areas as we have been considering there has been no necessity to treat the earth's surface as being curved, but suppose it is desired to cover an area as large as that of a State, say 100,000 square miles in area. Such an area would have such a large curvature, since it is a large section of the surface of the sphere representing the earth's figure, that special methods must be employed to avoid distortions and to make it possible for the surveyor properly to determine directions and distances between various points within the area considered.

When we take into consideration the shape and size of the earth, and of course its curvature, in making a survey, such a survey is called a geodetic one. All of the surveying operations by the Federal Government, with few exceptions, are geodetic in the sense that the curvature of the earth is taken into consideration. This applies especially to the work of the Coast and Geodetic Survey, the topographic mapping by the Geological Survey, and much of the work of the General Land Office.

In order to make surveys over large areas and to have the results harmonious, it is absolutely necessary that some method be employed to locate very accurately some points that can be used to control the position of the surveys. Such a method is that of triangulation. This may be described briefly as a series of points located on the most prominent mountain peaks and hills, or in the case of a flat country, points on which towers are erected in order to raise the instruments with which observations are made above woods, houses, and other obstructions. Two of these points are selected as the ends of a base line, and the distance between them is measured very accurately with a metal tapeline.

Each of the points is permanently marked by a tablet set in a concrete block or in solid rock. Over each one of these points is erected a stand if on a mountain peak, or a tower if on a wooded hill or in a flat country. These stands and towers are accurately centered over the tablet in the concrete or stone monument. The next step in the process of carrying on triangulation is to observe with a theodolite, which is a very high grade engineer's transit, angles at each of these points between each two of the points that are near it. In this way a series of triangles is formed.

It is a well-known mathematical principle that if any three elements of a triangle are known (the elements being the three sides and the three angles), one of which is a side, the other elements can be computed. In the present illustration, we would have one side known in what may be called the first triangle. This is the side which is measured directly with the metal tape. We also have the three angles of the first triangle. With these angles and the one side which was measured directly we can compute the other two sides of the first triangle. The next step would be to compute the lengths of the sides of the contiguous triangles using the two computed sides of the first triangle as bases. As the triangles are in a connected system, there will be many lines which are common to two triangles and we can, therefore, use the computed sides of some of the triangles as bases from which to compute the sides of the other triangles and so on throughout the scheme.

Before the triangulation can be utilized to the best advantage, some system of coordinates must be adopted in order that a point of the triangulation may be given a position that will harmonize with the position of the other triangulation points or stations. The origin of coordinates adopted by the United States and by nearly all other countries is the intersection of the meridian (the true north and south line) which passes through the observatory at Greenwich, England, and the earth's equator This intersection of the meridian and the equator has a zero latitude and zero longitude. All points in the United States, which are referred to these two lines, will have north latitude and west longitude.

It is a comparatively simple matter to find the coordinates of a point with relation to these two lines by making observations on the stars by which are determined the latitude or distance above the equator and the longitude or distance west of the meridian of Greenwich. The determination of the latitude and longitude of such a point can be made with almost any degree of accuracy that is required. Such a point can be used as the initial point for the triangulation of the whole country. A point like this would be included in the triangulation scheme mentioned above. At such a point there would also be observed the true direction of the line joining one of the other points that are near by.

With the latitude and longitude of the initial point, the true bearing of one of the lines radiating from this point, and the distances and angles of the various triangles, one is in a position to be able to compute the latitude and longitude of each of the other points in the scheme of triangulation and the true bearing of each of the lines.

One can readily see that, in the area of 100,000 square miles of which we spoke above, many surveyors could begin operations if the whole area were covered by a triangulation and the longitude and latitude of many points had been determined. The position of the map made by each of the surveyors with relation to the system of coordinates could be accurately determined and when all of the maps were joined to make a single map of the whole area there would not be any distortion in it, nor would there be overlaps, gaps, or offsets where any two maps of small areas were brought together. We should find that the longitude and latitude of a topographic feature shown by one surveyor would correspond to the longitude and latitude of that feature as shown by the other surveyor.

The area of the United States is approximately three million square miles and the extent of its coast line is many thousands of miles. It was soon found in making the charts along the coasts in the early part of the last century that when two systems of triangulation were joined there was developed a discrepancy that was troublesome to the chart makers. For instance, the triangulation stations that had been established along the coasts of the New England States and the maps based upon them were harmonious among themselves, but they did not agree exactly in latitude and longitude with the triangulation made along the coast of New York and New Jersey. In other words, the longitude and latitude given for the stations where the two systems joined, were not exactly the same as computed through the two separate schemes of triangulation.

It was early discovered that the reason for this discrepancy was due not to errors in the observations in the astronomic stations, which were used as the initial points of the triangulation, but it was that the unevenness in the surface of the continent caused the plumb line, to which all astronomic observations must be referred, to deflect toward the mountains or high ground and away from the valleys or low ground. As a concrete example of this deflection, we may cite the case of the triangulation in Porto Rico.

Before the Spanish War an astronomic station had been established at San Juan on the north coast of the island, and another astronomic station near Ponce on the south coast. Shortly after the war a triangulation was extended across the island between these two places, and it was found that the distance across Porto Rico as given on the map constructed upon the two astronomic stations was about 1 mile greater than the actual width of the island. The true distance was given by the triangulation.

It was at once concluded that the reason for this discrepancy was the presence of the mass of the mountains on the island, which attracted the plumb line at both Ponce and San Juan, and the presence of deep water in the Atlantic Ocean and the Caribbean Sea which, on account of the deficiency of density, as compared with the base of the island, repelled the plumb line away from the water and toward the island. The cumulative effect was that the plumb lines, instead of pointing in what might be called the normal positions at the two stations, were drawn toward each other, and thus during the observations on the stars, a greater angle in the heavens was subtended by the two plumb lines than there would have been had there been no abnormal conditions present near the astronomic stations.

In the United States there have been observed a number of cases where the so-called deflection of the vertical was large. Had the stations at which these deflections were found been used as the starting points for triangulation, then large discrepancies would have been found when the various separate schemes of triangulation were joined. As a matter of fact, there were discrepancies found when each two separate schemes of triangulation of the country were connected.

In order to eliminate the effect of the deflection of the vertical, strong schemes of primary triangulation were extended along the Atlantic coast from the eastern part of Maine to Pamlico Sound, N. C. A branch from this triangulation was also extended along the eastern slope of the Appalachians to Mobile, Ala. When this arc was completed, it was possible to strengthen and connect the separate sections of triangulation that had been made along the Atlantic and Gulf coasts for the purpose of controlling the topographic and hydrographic surveys that were made to furnish sailing charts of our coasts.

It was later found necessary to connect the Atlantic and the Pacific coasts with a strong arc of primary triangulation, which was run along the thirty-ninth parallel of latitude. When this triangulation was done, it was possible to coordinate the surveys that had been made for charting purposes along the Pacific coast with those along the Atlantic and Gulf coasts. A strong arc of primary triangulation has also been extended along the entire Pacific coast of the country, in order to coordinate and strengthen the separate schemes of tertiary triangulation that had been done for the control of the hydrographic and topographic surveys. These surveys had been made to furnish data for sailing charts of the Pacific. This work was similar to that done on the Atlantic and Gulf coasts, mentioned above.

In order that the triangulation stations of a country may be located most nearly in the ideal places on the earth's surface, a number of astronomical stations must be connected with the triangulation scheme and an average position assumed which will be most nearly freed from the effect of the deflection of the vertical at the separate astronomical stations. This was done in the United States with the result that our whole system of maps is in nearly the ideal position.

The advantage of having a primary triangulation covering the whole country is very great, for it enables engineers and surveyors to coordinate all of the public and private surveys throughout the country. It is also important that a whole continent be covered by a continuous network of primary triangulation all based upon the same initial point in order to avoid the errors due to the deflection of the plumb line at the various stations.

The situation in North America is unique, for the United States, Canada, and Mexico have decided to extend their primary triangulation in such a way as to have it continuous over the whole continent. This makes it possible to obtain accurate distances and directions between points of one country and those of another. It also insures harmony in the maps on the international boundaries where ordinarily there is much confusion resulting in misunderstandings and trouble along the borders.

One might think, when the primary triangulation had been done that controls the positions along the Atlantic and Gulf coasts and along the Pacific coast and the primary triangulation had been extended across the country to join the eastern and western coasts of the United States, that the geodetic work of the Coast and Geodetic Survey would be complete, as far as the needs of this Bureau are concerned. This is largely true, but after having met the demands of the Bureau for controlling the sailing charts along the coasts, it is found that there is hardly an area of any size in the whole United States, in the interior of the country, that is not dependent on geodetic control for maps and surveys. For a number of years this Bureau has been extending other arcs of primary triangulation in the interior of the country, and its present plan, which may, of course, be greatly modified in the future, is to extend rapidly the triangulation in order that there may be no place more than about 100 miles from a primary triangulation station. There will be many parts of the country where the distances to primary triangulation stations will be much less than this. (See figs. 25 and 26.)

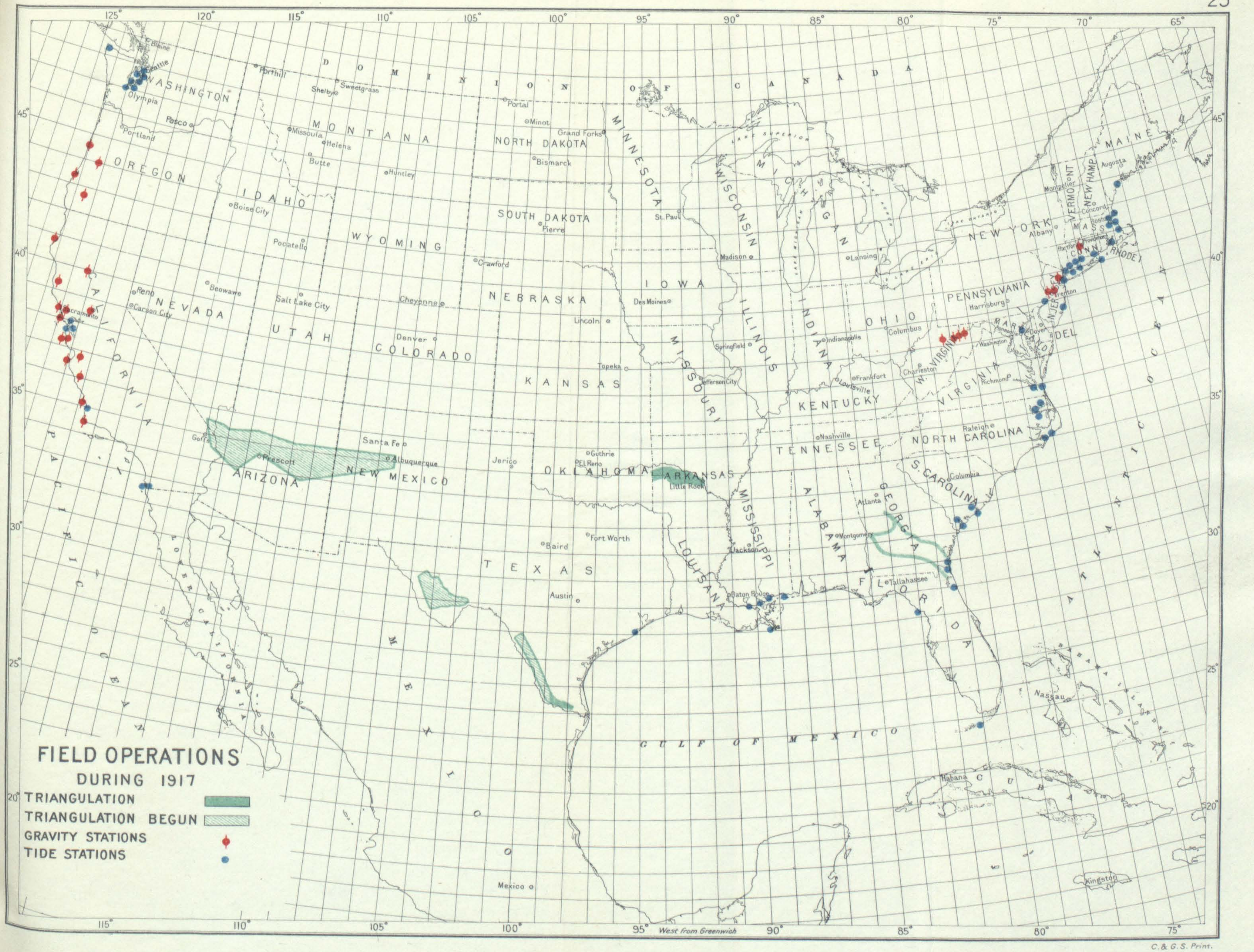
The Survey must also extend arcs of primary triangulation throughout the area of Alaska, including that portion of Alaska which extends between Dixon Entrance and the head of Lynn Canal, in the vicinity of Skagway. The Geodetic Survey of Canada plans to extend a primary triangulation from the vicinity of the Straits of Fuca to Dixon Entrance and from the head of Lynn Canal to the intersection of the Yukon River and the one hundred and forty-first meridian of longitude. This meridian is the boundary between Alaska and Canada. The Geodetic Survey of Canada and the Coast and Geodetic Survey of the United States would thus cooperate in connecting Alaska and western Canada by triangulation with the primary triangulation of the United States and eastern Canada. A small amount of this Alaska triangulation has already been done, and it is hoped to extend it rapidly in the near future. (See fig. 27.)

For the actual progress of the primary triangulation to date, see figure 53. For precise levels needed in Alaska, see figure 28.

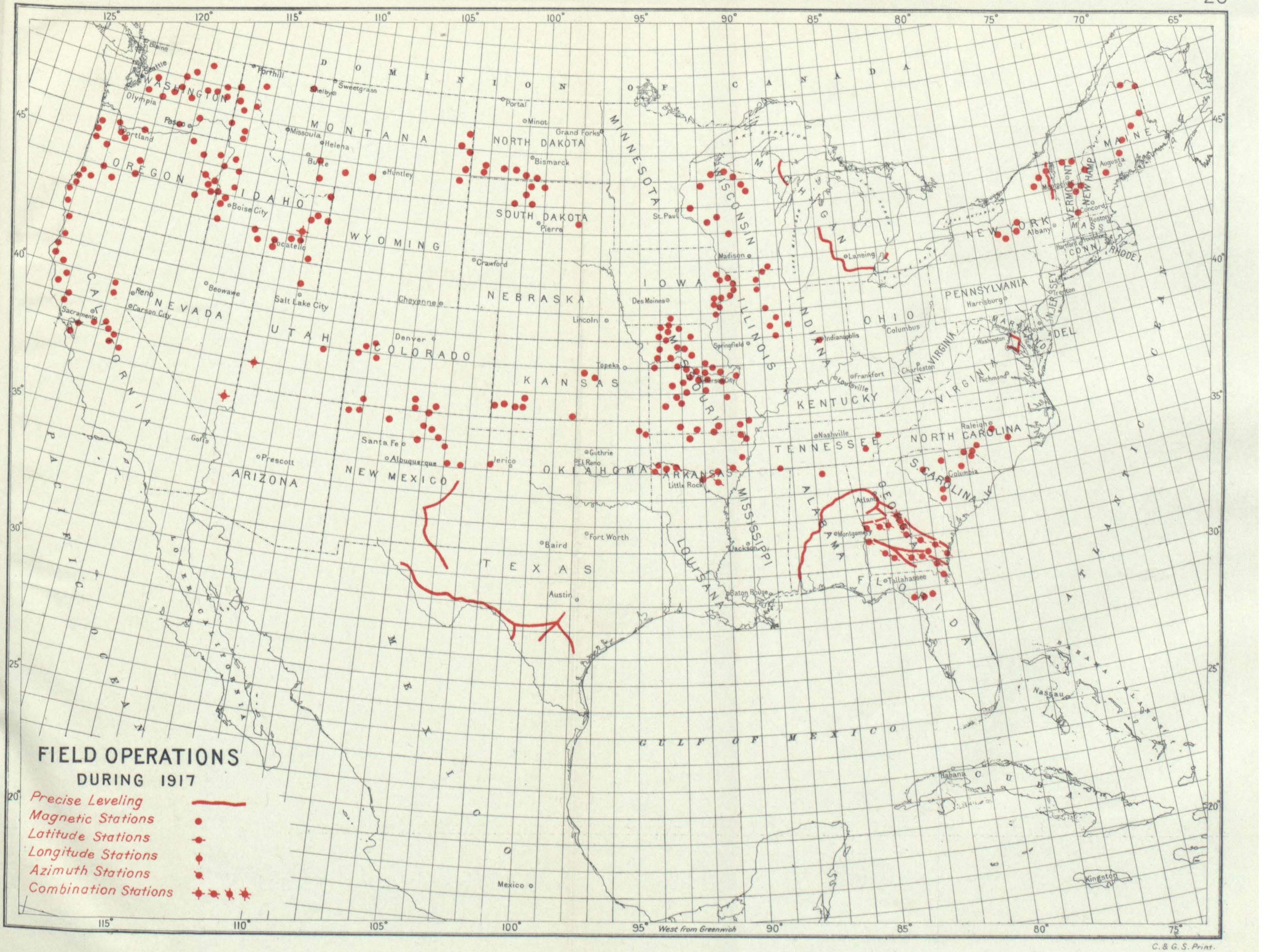
In addition to the triangulation done by the Coast and Geodetic Survey for the control of maps, surveys, and engineering work of various kinds, it is engaged in extending a network of precise leveling throughout the country in order to furnish to engineers and others accurate elevations on which to base their operations. It can readily be seen that it is as important, in many cases, to know the elevation of a point on the ground or of some object above a certain plane as it is to know the horizontal position of the point or object.

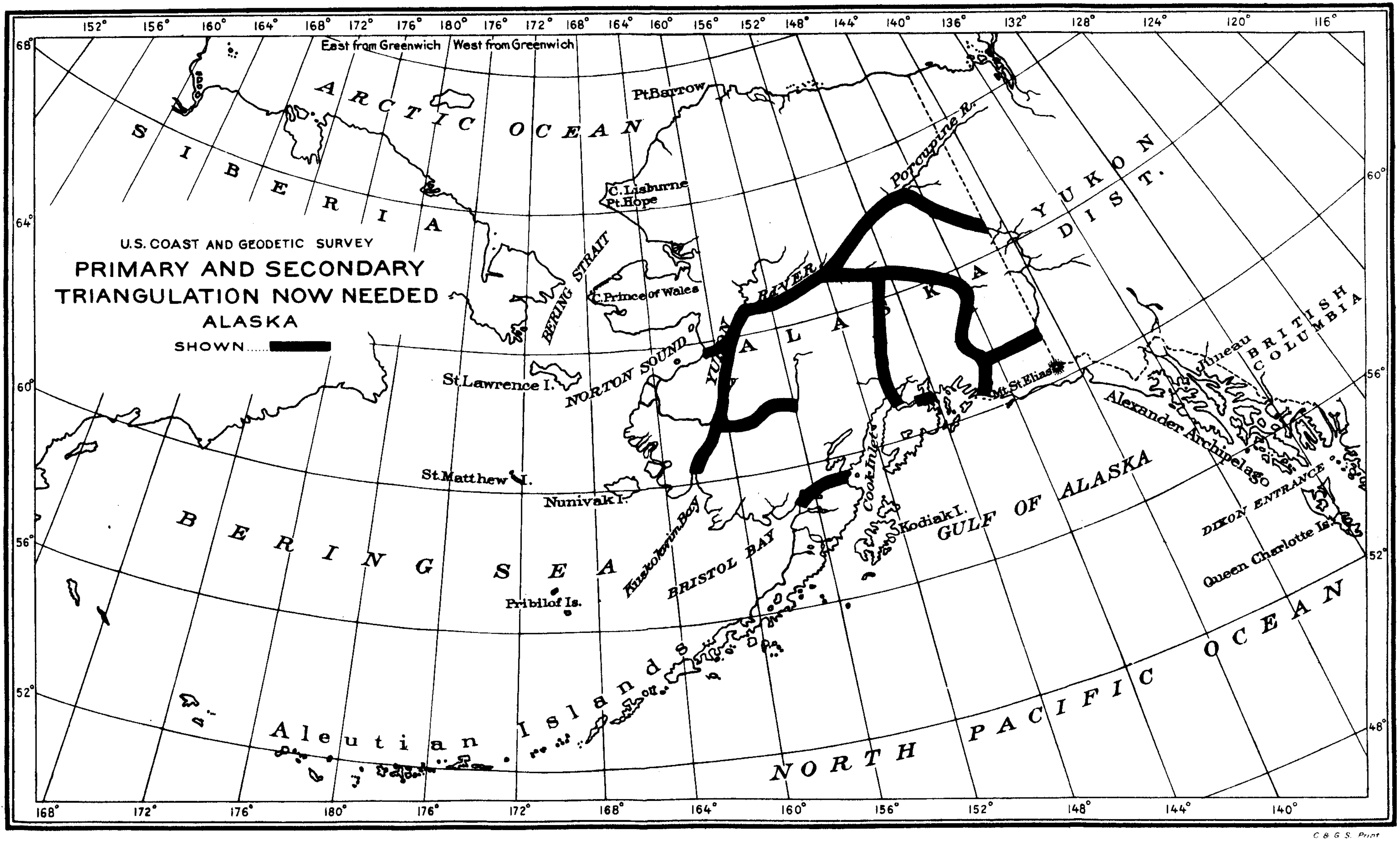
It is especially desirable to know the contour of the ground in laying out drainage and irrigation projects, in extending railroad lines, and in many other industrial and commercial enterprises.

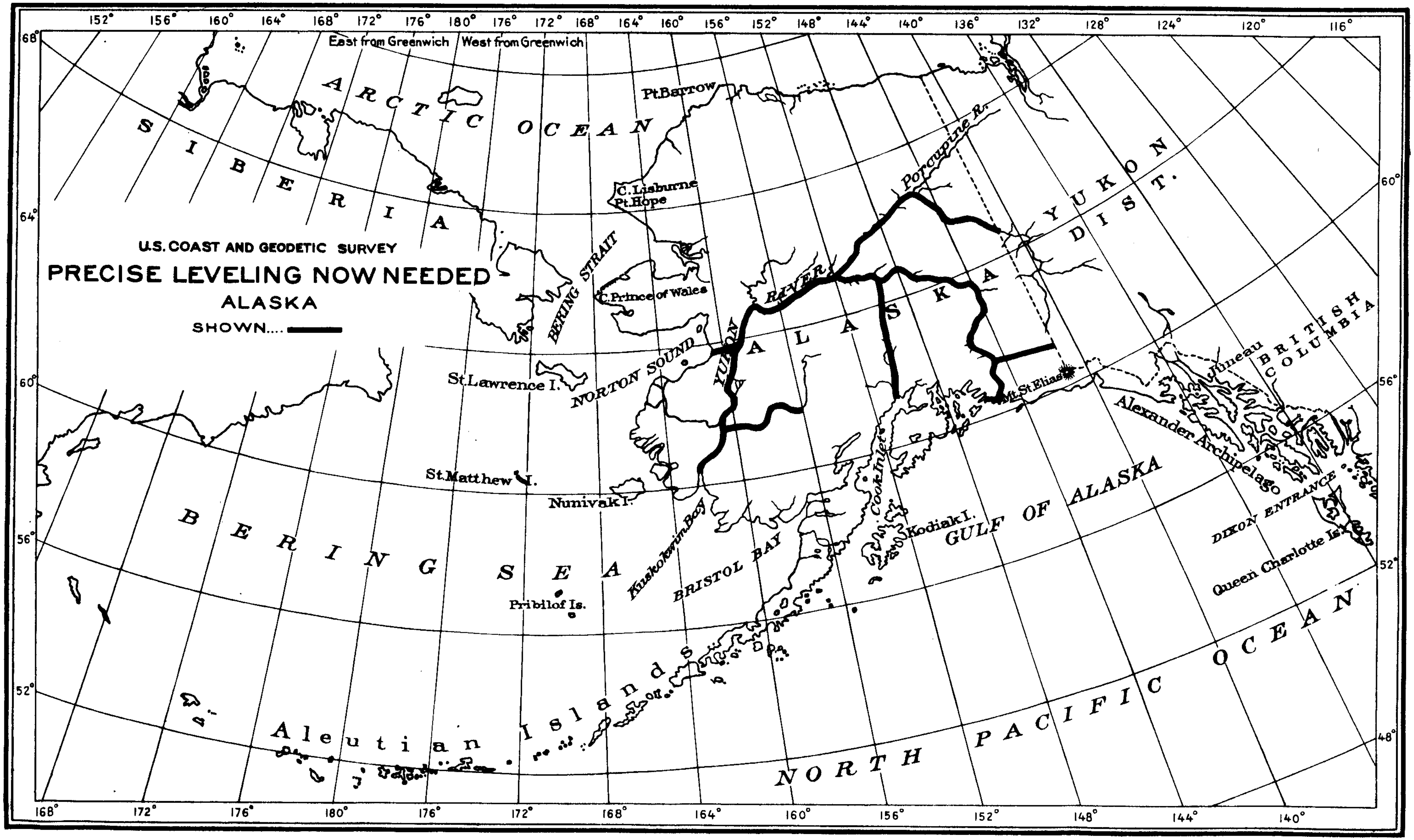
While everyone will agree that it is necessary to know the elevations of the ground in many of our daily occupations, it has not always been recognized as essential to have elevations at each place referred to the same surface or datum. For instance, two cities not very far distant from each other will have different datums on which their elevations are based. One may be the surface of a lake near it,


FIELD OPERATIONS
DURING 1917
TRIANGULATION
TRIANGULATION BEGUN
GRAVITY STATIONS
TIDE STATIONS
DOMINION OF CANADA
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
NEW MEXICO
COLORADO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
S. CAROLINA
NORTH CAROLINA
VIRGINIA
W. VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
ATLANTIC OCEAN
PACIFIC OCEAN
GULF OF MEXICO
MEXICO
CUBA
LOWER CALIFORNIA
West from Greenwich

C. & G. S. Print.


FIELD OPERATIONS
DURING 1917
Precise Leveling
Magnetic Stations
Latitude Stations
Longitude Stations
Azimuth Stations
Combination Stations
West from Greenwich
C. & G. S. Print.


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


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

C. & G. S. Print

the other an arbitrarily assumed elevation for a bench mark. In some cases—in fact, most cases now—mean sea level is used as the datum for elevations. This datum has been universally adopted by the Coast and Geodetic Survey in all of its land operations and also by the United States Geological Survey in all of its topographic work. It will no doubt be adopted in the very near future by all cities, States, and countries, and by private corporations and individuals.

Mean sea level is the only datum that is a universal one; that is, it is the only datum that may be used for many detached pieces of leveling at different parts of our coasts. For instance, mean sea level may be determined at New York City by tidal observations, and elevations may be extended from that point. Likewise, mean sea level may be obtained at Norfolk and levels started from there; also at Galveston and on the Pacific coast, at places like San Diego, San Francisco, etc. There is no limit to the places along the coast at which mean sea level may be determined and be considered as having zero elevations for any line of levels starting inland from them. When leveling has been started at a number of places along the coast and lines extended inland from them, it is reasonably certain that when these lines join in the interior of the country the elevations of a common point, as given by the several lines, will agree almost exactly. Of course such elevations determined will be subject to the unavoidable small errors incident to the precise leveling.

To show the great need for primary triangulation and precise leveling for industrial and economic purposes, there are quoted below portions of letters, pamphlets, and books that have been received at this office from various sources.

A letter from the Director of the United States Geological Survey, addressed to the Superintendent of the Coast and Geodetic Survey, states:

I am pleased to see that the approved estimates for the fiscal year 1913 include an increase for the work of your Bureau in determining geographic positions and more especially because they provide for the extension of a triangulation in Alaska from the international boundary to Bering Sea. I need hardly tell you how valuable the results obtained by the Coast and Geodetic Survey in the States are to this service. * * *

The special purpose of this letter is to direct your attention to the urgent need of a general system of triangulation in Alaska and especially in the Yukon Valley. The accurate location of areas under survey in this northern region will only be possible on the basis of a triangulation. If this is understood now it will settle the problem of location for all time to come. If the triangulation is not made, endless work and much expense will be involved in the adjustment of future surveys and maps.

As the Geological Survey is engaged in the preparation of base maps necessary to the study of the mineral resources of Alaska, it is vitally interested in having the triangulation extended over the more important parts of the Territory as soon as possible. Such a triangulation would also be the first step towards the setting in each mining district of one or more monuments whose positions have been exactly determined. This would give an accurately located tie point for every mineral survey, and by absolutely fixing the position of each survey, would avoid endless disputes in the future. In my opinion great economics will be made in the future by starting this work at once. I therefore urge you to undertake it as soon as means permit.

A report was received at this office giving the results of a triangulation made by a private mining company in Alaska in which a statement was made that it was found necessary for a triangulation to be extended over a certain mining district in order that the initial mineral monuments which had been in general use should have their relative positions determined. It was stated that before the triangulation had been made, there was great confusion in regard to the location of certain mineral claims. When a claim had been located from several mineral monuments, no two locations agreed. When, however, the triangulation had been carried over the area and the relative positions of the initial mineral monuments had been determined, the locations of a claim from several monuments would agree, and there were no confusion and litigation as a result.

Several of the larger cities of the United States, notably New York, Cincinnati, and Los Angeles, have found that it was necessary to extend a primary triangulation over their areas in order that control points might be furnished for the various surveying, engineering and mapping work done within them. It is evident that where such work is done by a city the results should be possible of coordination with maps made by the Federal Government and by the States near them. The only way in which this is possible is for the triangulation to be extended to the vicinity of each of the large cities of the country.

It might be argued that each State should extend its own triangulation within its borders, but when we consider that this would practically mean the organization of 48 geodetic surveys in the country, it is realized that it would be more efficient and cost the people less in the end if a Federal organization should execute practically all of the primary triangulation that is needed by the States and cities. This also applies to a great extent to the precise leveling, and this is largely because, to add to the primary triangulation and precise leveling schemes, lines would have to be added which would lie in several States, in many cases. When the network of arcs of primary triangulation and lines of precise leveling have been extended by the Coast and Geodetic Survey to a far greater extent than is now the case, then it may be best for the States to supplement what has already been done. This is a matter, however, that will adjust itself as the work develops.

The value of primary triangulation in controlling local surveys is illustrated by the experience of the Clinchfield Coal & Coke Co., whose property lies in the States of Tennessee and West Virginia. Extensive plane surveying had been carried on by this company, but it was found that the results were not satisfactory. It was then decided that there should be extended over the area controlled by this company, a primary triangulation to furnish the framework on which detailed topographic and other surveys might be based. The results met fully the expectations of the engineers who planned to have the area controlled in this way.

The State of Massachusetts is now using the triangulation that was executed within its area by the Coast and Geodetic Survey and by the State itself in controlling the surveys of many of its farms. Each farm survey is, if possible, tied into a triangulation station in order that the geographic position of at least one of the boundary corners of the farm may be determined. When a survey of that character is tied into the triangulation, it will be possible to recover the boundary corners of the farm at any future time, even though all marks defining the boundary on the ground may be destroyed.

It is no doubt true that, in the future, other States will adopt the plan of having farm surveys and other private land surveys connected with the triangulation system of the country.

Triangulation was used by the States of Maryland and Delaware when laying out their oyster beds in the Chesapeake Bay and the Delaware Bay, in recent years. In the report of the Maryland Oyster Survey is the following statement:

There is one point in the methods not adequately explained elsewhere in the publication of the Maryland Oyster Survey which, it is believed, should be emphasized. That point relates to the advantages of the use of geographic coordinates in technically and legally defining boundaries of natural oyster bars and leased oyster bottoms. This method of defining property lines under water was also used in the survey of the leased oyster bottoms of Delaware.

The difficulties of accurately locating and permanently defining the boundaries of a farmer's plantation on land, even with the aid of monuments, public roads, streams of water, and other points of reference, are often great, judging from the disputes arising from this source. But be that as it may, there can be no doubt as to the difficulties of accurately locating and permanently defining the boundaries of an oysterman's plantation situated under the water and at a distance offshore from 1 to 6 miles.

There is only one point on the earth's surface at the intersection of any one parallel of latitude and any one meridian of longitude. Therefore there can be no dispute as to the meaning of such a geographic definition of the location of a point even though all of the original triangulation station marks used in its determination, together with the chart on which the position was originally plotted, have been totally destroyed.

In the case of the destruction of an original triangulation station mark or any other point defined by geographic positions, a competent geodetic engineer can reestablish its exact location by means of a new system of triangulation connected with other distant triangulation station marks which have not been destroyed. In the case of the destruction of the chart on which the position of any such point on the earth's surface was originally plotted, this point can be replotted in its geographic position with any degree of accuracy permitted by the scale of any new chart constructed for that purpose.

If there be no question at the time of the original location and legal adoption of a definition of the location of a point by given latitude and longitude, there can be no technical or legal question afterwards as to its exact meaning, or as to the exact redetermination of the location of this point, be it either on land or water, at its newly determined position or on a new chart in its newly plotted position.

For these reasons the method of defining the location of boundary points by latitude and longitude (geographic positions) was adopted in the survey of the leased oyster bottoms of Delaware. This method is more or less of an innovation in oyster surveys, which was first used in connection with the work of the Maryland Oyster Survey. It possesses so many undoubted advantages and at the same time it is so simple in principle and application when once understood, that its adoption by oyster surveys of States other than Maryland and Delaware seems probable.

The above quotation describes admirably the advantages obtained when oyster surveys are based on triangulation. It may not be quite so simple to apply triangulation to farm surveys because of the obstruction to observations by forests, etc., but it undoubtedly is true that the principle could be used to advantage and profit when lands become valuable as in the case of the State of Massachusetts.

An article entitled, "Expedite the map," by a distinguished geographer of the United States appeared in Science, in October, 1916. In this article it was stated that a committee had been organized by the writer of the article to expedite the completion of the topographic map of the United States. The article said in part:

Every industry, art, and science which demands a knowledge of the lay of the land is benefited by good maps of the area in which it is carried on. The general location of railways and highways, the planning of water supplies, irrigation and drainage projects, the prosecution of geological, soil, and forest surveys, the development of water powers, and the installation of electric transmission lines, the promotion of large-scale realty transactions, such as are common in less settled parts of the country, are all aided immensely if good topographic maps of their areas are available, and they are correspondingly embarrassed if such maps are wanting. Practical men who have had experience in mapped and unmapped areas can testify to the ease and the difficulty of the work in the two cases.

It is true that maps are needed in all the areas covered by the country for our industry and commerce. Therefore, it would seem to be necessary, in order to mobilize the resources of the country for the purposes of war and peace, that accurate topographic maps should be extended over the country as rapidly as the forces of the Government having such work in charge may be expanded sufficiently to undertake them.

The great need for topographic maps in the commercial and industrial development of the country is shown also by an article which recently appeared in one of the Washington newspapers. It says:

That Uncle Sam's topographic maps are appreciated by public corporations is shown by the fact that telephone companies throughout the United States are constant purchasers. These companies send frequent orders to the Geological Survey, Department of the Interior, for maps in lots of 250 or 500, and occasionally when some big contract has been landed, as many as 1,000 maps are ordered at a time for the use of the engineers and linemen.

Some electric supply companies keep complete sets of the maps of areas in States where they expect to do extended work, and when they hear that contracts are to be let for such work, they refer to these maps and with the "lay of the land" before them, they can tell at a glance the character of the work that may be required and can make their bids promptly and intelligibly.

Telephone officials who are using the maps extensively state to the Survey that they are of indispensible value in their work.

It is no doubt true that the experience of the telephone and electric supply companies is the same as that of many other industrial enterprises and companies. While the Coast and Geodetic Survey does not make the topographic maps in the interior, at the same time the Survey's primary triangulation and precise leveling are needed in order to insure accuracy in the maps in their elevations and geographic positions, and with the primary control as given by the triangulation and leveling, the topographic mapping can be done more expeditiously and at less cost.

A letter received recently from the Director of the Geological Survey gives the following statement:

I wish again to express my thanks to you for so arranging a portion of your field work as to meet the immediate needs of this Survey. The various geographers of this Survey take great interest in watching the progress of the Coast and Geodetic Survey triangulation and precise leveling from year to year and hope to see the plans, as set forth in your annual report and elsewhere, carried rapidly forward to completion.

The results of the triangulation of the Coast and Geodetic Survey are used wherever they are available by the officials of the Federal

Forest Service in locating the boundaries of reservations and other points for which exact positions are needed within the reservations. Letters received from that service by the Coast and Geodetic Survey indicate the extent to which our results are used by their officials.

Triangulation has been used extensively in the Commonwealth of Australia for the surveys of public lands preparatory to their allotment to settlers. It has been impossible in the United States to delay the settlement of public lands until the triangulation could be carried over the areas to be settled, but it is hoped that this may be done in the Territory of Alaska.

In 1912 a conference of surveyors general of the various States of Australia was held at Melbourne. Resolutions were adopted which expressed the opinion of the conference that a geodetic survey of Australia should be undertaken and that such a survey should be conducted by the Commonwealth Government. Among the reasons why such a survey should be made, as expressed by the conference, are the following:

(*a*) 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.

(*b*) That such surveys are absolutely necessary for the production of accurate maps, will be of high value in connection with cadastral and geological surveys, and form a basis for topographical work for defense and other purposes. It will, moreover, provide a standard of accuracy for surveys of every description throughout the Commonwealth.

(*c*) That it will afford an invaluable base to which settlement surveys already effected can be connected, providing data for reestablishing boundaries which with increasing density of settlement, becomes a matter of great importance. Further, as regards the sparsely occupied areas of Australia, such a survey if carried out in advance of settlement, will be of the greatest utility and assistance in effecting the settlement surveys which can at any future time be reproduced with a minimum error and at a relatively low cost, preventing litigation consequent upon other methods.

The problem which confronts Australia is identical with that which confronts this country in Alaska, and to a certain extent we have a similar problem in the United States which is to control existing public-land surveys by triangulation.

In a report of the Trigonometric Survey of India of 1905, there is a statement by the superintendent of the value of primary triangulation. He states that the principal triangulation of India was executed for the control of topographic surveys and that its first great practical use has been the prevention of embarrassing accumulation of errors in the surveys at the borders of India. Its second use has been to unify and coordinate all the separate surveys of the various States to give them one origin, combine them into one harmonious whole, get rid of gaps and overlaps from the interior mapping of India, and to free India from the internal boundary disputes that have so troubled other countries. Another use has been to furnish perpetual points for the use of posterity, without which the revisions of maps would be impossible.

The primary triangulation in the United States has been found to be of as great use as that in India although it has not been so greatly extended as in that country. Much more will have to be done in the United States before we shall have as much triangulation in proportion to our area as India has.

It is most important that primary triangulation be connected with all of the State boundaries in this country in order that there should be known the latitude and longitude of the boundary monuments. This will make it possible to relocate any monuments in the future that may be destroyed, thus avoiding long and expensive litigation over the boundaries of contiguous States.

In one of the best textbooks on higher surveying there is a statement that indicates the great value of the primary triangulation to the Nation. It says in part:

> The main object of a geodetic survey is to furnish the necessary control for all other surveys. This control includes the determination of relative positions of a comparatively few widely separated points on the earth's surface and the directions and lengths of the lines joining them. Without such accurate locations the errors of ordinary surveys would accumulate until they vitiated the needed accuracy of the survey and map. Indeed, the primary triangulation of the United States Coast and Geodetic Survey by its corrective functions stands in the same relation to other surveys as the United States Supreme Court stands to all lesser courts. In fact, during the past few years this primary triangulation has been the means of settling boundary line disputes between more than 10 States.

The opinion of the editors of the Engineering News as to the value of precise leveling is expressed by them in a review of a precise leveling report issued by the Coast and Geodetic Survey. This review states, in part:

> This is the authority on precise spirit leveling and should be included in the library of every engineer interested in this branch of engineering. * * * The advantages of tying local survey nets into the national precise leveling net is not fully appreciated by many engineers and surveyors, yet it is the only way in which a city datum may be settled once and for all.

The advantages of having precise leveling cover the whole country and of having all the elevations of the country referred to a single surface, which, of course, should be mean sea level, and the disadvantages of not having this leveling and a single surface for reference, are expressed in a number of letters received at this office from prominent engineers of the United States. Extracts from some of these letters are given below.

The chief engineer of the topographical survey commission of the city of Baltimore wrote, in part, as follows:

> The city of Baltimore in 1893 established a series of precise level bench marks which have been used since that time in connection with all engineering work carried on by the municipality. This survey has for its datum the mean low tide at Baltimore.
>
> The Pennsylvania Railroad, as well as other organizations, used still a different datum, so one can see that, although the city's precise level work has been carried out to a degree of precision equal to that adopted by your Survey and is satisfactory for all city work, it would have been much better if the datum adopted for Baltimore had been that of mean sea level. This, I am sure, would have been done if at the time this survey was started a Government bench mark had been available. This would, to a certain extent, have done away with certain confusions which now exist.
>
> We believe that the plan for the United States Government to establish bench marks throughout the country, based on mean sea level datum, would encourage the use of that datum by all who wish to carry on any extensive system of leveling and would prove a great convenience and eliminate many errors and much confusion.

The chief engineer of the Chicago & North Western Railway Co. said:

I thoroughly agree with you that this precise leveling is essential in the surveying and engineering work done in this country by various public and private agencies.

We endeavor to base our elevations upon mean sea level wherever possible, but find that the use of various datums by cities, counties, and States results in considerable confusion and arguments. I am of the opinion that if we had but one datum all of our work would be more easily coordinated and would result in less confusion and waste than at present.

The chief engineer of the Missouri Pacific Railway Co. wrote as follows:

It is very desirable, though not absolutely essential, to use one datum plane for all engineering elevations, as with conditions as at present existing there is a great deal of confusion and time lost in looking up proper equations to change from one datum plane to another.

In getting rough approximations of the discharge of streams it is necessary to know the approximate slope, and to get this it is necessary to know the elevations of crossings of the river at different points on its course. Where elevations of these crossings are referred to different datums it is frequently impossible to get more than a very rough approximation of the difference of elevations, which results in a corresponding approximation of the discharge. This also very frequently happens in connection with drainage work.

The use of various arbitrary datums by States, counties, cities, and private organizations is becoming more and more a serious problem, for the reason that it requires considerable research or investigation to determine whether the elevations used are referred to sea level or other datum planes and then to ascertain the correct equations.

I do not know of any one thing which the Coast Survey has undertaken which will be of greater benefit to the engineering profession of the country at large, in so far as all engineering operations are concerned—and by this one can almost say all industrial development of the country—than to promote and secure the adoption of mean sea level as the datum for all elevations.

For the precise leveling already done in the United States by the Coast and Geodetic Survey and by other organizations, see figure 53.

While the principal object of the geodetic work of the Coast and Geodetic Survey is that of furnishing data with which geographic positions and elevations may be determined, at the same time there is another phase of the work that should be mentioned. This is the observations with pendulums to determine the value of the intensity of gravity at places throughout the United States. The value of this work is largely scientific, though it is possible that it may have considerable economic value. Its scientific value consists principally in making it possible to obtain a more correct formula by which the value of the intensity of gravity may be computed at a physical laboratory or some other place where it is desired to know such value. Again, the results of gravity work are of considerable worth in making it possible to study the distribution of materials in the outer portions of the earth. Researches carried on in the Coast and Geodetic Survey in recent years have proved conclusively that under great mountain masses the material in the outer portions of the earth, say, to the depth of 60 miles, is less dense on an average than that of the material in the same zone under the coastal plains. It is also found that the materials at the bottoms of the oceans are, in general, more dense than is the material under the coastal plains. These facts are of great value to geologists and others in what may be called general world science. The subject is a very new one and the Coast and Geodetic Survey expects to make many more observations with the pendulum and continue its investigations relating to the densities of the material of the earth. It may be added that it is impossible to tell what is the absolute density of the material at any place down in the earth, but it is possible to arrive at an approximate value of the difference between the actual density and what might be called the normal density. (See fig. 53.)

We may summarize the situation in regard to the geodetic work in the United States somewhat as follows:

The primary triangulation and the precise leveling that have been done are excellent in quality and form the basis from which other primary triangulation and precise leveling may be extended. We should probably have as much more primary triangulation and precise leveling done in the very near future as there is now in existence. It is all the more necessary that this work be extended very rapidly on account of the great development that is going on in the industries and commerce of the country and especially in the extension of its roads, railroads, river control, and other public works. Hundreds of millions of dollars are expended on roads alone each year in the United States. Each road that is built within an area not covered by a topographic map costs more in labor and material than if a topographic map were in existence for the area in question. It may be said that this applies to all extensive pieces of engineering work. In order that the topographic mapping of the country may be done accurately and economically, the primary triangulation and precise leveling should be rapidly extended into those areas that are to be mapped.

The lack of sufficient geodetic work in the form of primary triangulation and precise leveling is not due to negligence on the part of anyone, for it is only recently that engineers and surveyors have recognized the necessity for this geodetic control for maps and engineering work and have made heavy demands upon the Coast and Geodetic Survey to furnish it. With increased demand upon the Survey for this geodetic work it is naturally to be expected that funds will be provided to meet such needs.

This Survey realizes the necessity of publishing the results of its primary triangulation and precise leveling in order that they may be the more readily available for use by engineer, surveyors, and others. It may be said that material which is only in manuscript form is almost as valueless as if it did not exist at all. The members of the Survey who work in the division of geodesy at the office at Washington are almost exclusively engaged upon furnishing information principally to engineers and surveyors who are in the Coast and Geodetic Survey and other Government bureaus and to those in private life. With increased activities in the field in extending primary triangulation and precise leveling there will be needed additional mathematicians and clerks in the office to compute and adjust the field observations and prepare the results for publication.

MAGNETIC WORK.

There yet remains a phase of geodetic work which has had no mention—that of magnetic observations. The popular notion is that the magnetic needle always points to the geographical North Pole, while as a scientific fact, there are fewer places on the earth's surface where it does point directly to the geographical North Pole than where it does not. While the compass needle varies widely from west of north at certain parts of the earth to east of north at other parts of the earth, it is not constant at any place. That is to say, at a locality selected at random, the compass may this year point 1° west of north, and a year hence point 1½° west of north. While the cause of this change is yet unknown, by observations from year to year it has been pretty definitely determined what the rate of these changes are. The information regarding these changes is very essential to the land surveyor. If a survey was made 40 years ago running due north by the compass from a certain mark and the variation of the compass has changed 2° to the west since 40 years, if we are going to run a line due north by the compass to-day, we must allow for this deviation of 2°. For this reason magnetic observations are made with standardized instruments at selected stations throughout the country to determine what the deviation is at their localities from period to period so that the results may be published for the information of the engineering profession.

While the making of magnetic observations was recognized as one of the functions of the Coast Survey at the time of its reorganization in 1843, it was not until 1899 that it became possible to undertake a systematic magnetic survey of the country. Up to 1877 the magnetic work was confined almost entirely to the coast States and was in most cases executed in conjunction with other branches of the Survey work, and although some observations were made in the interior States in subsequent years, the progress was very slow up to 1899.

The plan for the magnetic survey of the United States, as laid down in 1899, provided for a first general survey with stations 30 to 40 miles apart, to be followed by a more detailed investigation of regions where the general survey indicated irregular distribution of the earth's magnetism. The plan also included the reoccupation at intervals of about five years of a sufficient number of "repeat" stations to determine the change of the magnetic elements with lapse of time, and the operation of magnetic observatories for determining in more detail the changes in the direction and intensity of the earth's magnetic field.

Following this general plan, the distribution of stations has been based largely upon the county subdivision of the States, the idea being to have at least one magnetic station in each county so that the necessary data might be available for the use of the county surveyors in testing their compasses. With this end in view most of the stations have been marked in a permanent manner, and the true bearings of prominent objects have been determined. In many cases meridian lines have been established for greater convenience of the local surveyors.

Observations have been made at all but about 150 of the county seats and a number of areas of marked local disturbances have been examined in more detail. The density of distribution of the stations corresponds in a general way with the density of the population, so that in the unsettled and less accessible portions of the country they are widely scattered, but for the whole United States the average distance between stations is 25 to 30 miles. About 75 " repeat " stations a year have been occupied. Magnetic observatories have been in continuous operation at Cheltenham, Md., since 1901; at Sitka, Alaska, and near Honolulu, Hawaii, since 1902; at Vieques, P. R., since 1905; at Baldwin, Kans, from 1900 to 1909; and near Tuscon, Ariz., since 1909. (See figs. 26 and 53.)

In Alaska the magnetic survey has gone on in conjunction with other branches of the work of the Bureau, so that the observations have been for the most part confined to the seacoast, except for a string of stations along the Yukon River. A general magnetic survey of Porto Rico, Hawaii, and the Philippine Islands has been completed and some observations have been made in Guam and on the Canal Zone.

In the United States proper there still remain many locally disturbed areas which require investigation, the extent to which the investigation should be carried in any particular case being a question which can not be determined in advance. There are other regions where more stations will be required as they become settled. In addition, in order that the accumulated results may continue to be of use, observations at " repeat " stations must be kept up regularly.

Most of the leading nations of the world are cooperating in a study of the earth's magnetism in an effort to determine its origin, the causes of its many fluctuations, and the laws which govern them. In order that accurate data may be available for these investigations, many magnetic observatories are kept in continuous operation recording every change in the direction and intensity of the earth's magnetic field. As the changes are found to be different in different parts of the earth, it is important to have the observatories as widely distributed as possible. The United States, by reason of its wide extent of territory, is very favorably situated for carrying on a large share of this work, and the sites of the five observatories now in operation were chosen with this object in view.

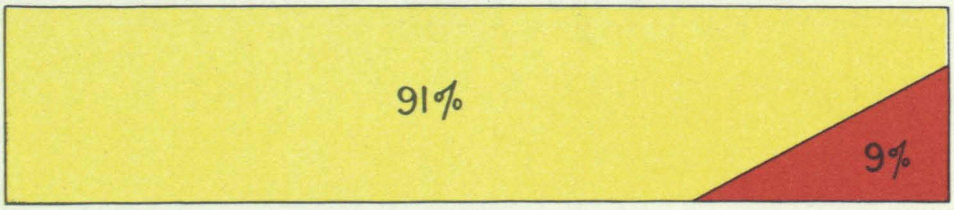
For the success of these investigations it is important that our five observatories should continue for many years, and that in addition observatories should be established on the Canal Zone and on the island of Guam. With these additions we should have a chain of stations extending nearly halfway around the globe, from longitude 65° to 216° west, and extending from latitude 9° to 57° north. These would be supplemented by the observatory near Manila now being maintained by the Jesuits.

Condition of water surveys, Pacific Coast and Alaska, 1917, as compared to the Philippine Islands

United States Coast and Geodetic Survey

Alaska

Owned by the United States since 1867 (50 years)

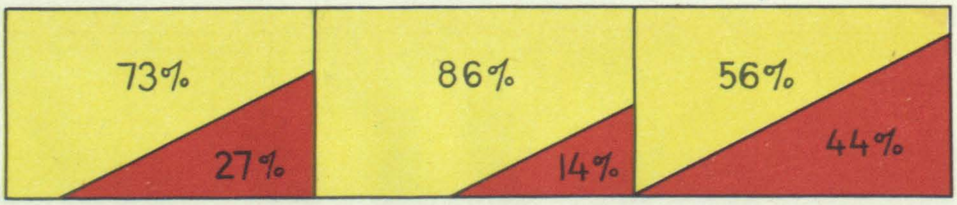


Yellow (91%) - represents unsurveyed water areas.
Red (9%) - represents water areas surveyed in past 31 years.

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

California Oregon Washington

Part of continental U. S. since 1848 (69 years)



Yellow (73%, 86% and 56%) - represents unsurveyed water areas.
Red (27%, 14%, and 44%) - represents water areas surveyed in past 67 years.

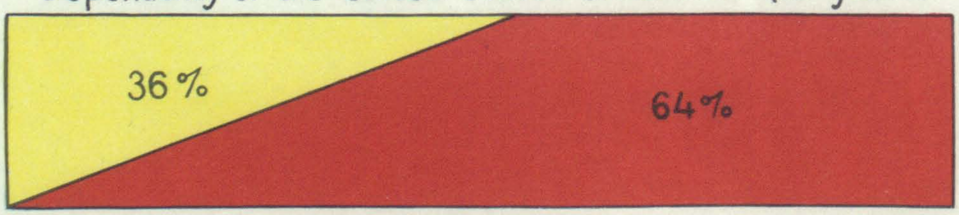
One vessel of the Surveyor type will require 20 years to complete a first survey of the navigable waters of this coast.

For 20 years no systematic survey of water areas has been made on account of lack of vessels.

Now compare work done in the

Philippine Islands

Dependency of the United States since 1898 (19 years)



Yellow (36%) - represents unsurveyed water areas.
Red (64%) - represents water areas surveyed in past 17 years.

Philippine surveys have progressed more rapidly in 17 years than in the other regions shown on this sheet due to the funds and four (4) ships supplied by the Philippine Government.

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CHAPTER II.

NEEDS OF THE FIELD SERVICE.

In speaking of the needs of the Bureau with respect to the hydrographic work, so vast is the task remaining to be done and so limited the equipment with which to accomplish it that it is vain to suggest the enlargement and more rapid extension of one phase of the work without a corresponding acceleration of another phase. (See fig. 29.)

I have tried in the preceding chapter to give a clear idea of the condition of the surveys of each section of our coasts, and where and what kind of surveys are urgently needed. Leaving out of the discussion for the present the equipment for surveys in the Philippine Islands, where vessels and funds are supplied in part by appropriations for the purpose by the Philippine Government, this Bureau has for the survey of the Atlantic and Pacific coasts of continental United States, the waters of Alaska, Guam, Porto Rico, Hawaii, Virgin Islands of the United States, and the approaches to the Panama Canal, the following small and more or less superannuated fleet:

VESSELS.

1. The *Surveyor*, newly built and just from the shipyard. This vessel is the result of the sum of the past experience of the officers of the Bureau in designing a vessel adapted in every possible way for the attainment of the maximum results with the least expense. She is a steel steam vessel of 1,000 tons displacement; 186 feet in length over all, 34 feet in breadth, 12 feet draft; indicated horsepower 1,000; speed 11.5 knots; fuel capacity 75,000 gallons fuel oil; complement 11 officers and 58 men; built at Manitowoc, Wis., in 1917. See fig. 1.)

2. The *Isis*. She is a steel steam vessel of 377 gross tons and 256 net tons; registered length 180.4 feet, breadth 24.8 feet, draft 11.7 feet; indicated horsepower 2,000; speed 16 knots; coal capacity 120 tons; complement 8 officers and 44 men. Purchased by the United States Coast and Geodetic Survey July 1, 1915. She was built for a yacht, but was the best adapted for the needs of the Bureau of any vessel on the market at the time funds were available for her purchase, and while not so admirably fitted for the purpose as the *Surveyor*, the money expended for her purchase could not have been better placed for the needs of the Survey.

3. The *Bache*. A composite steam vessel of 472 tons displacement, 370 gross tons, and 252 net tons; registered length 153.2 feet, breadth 26.2 feet, draft 10 feet; indicated horsepower 400; speed 10.5 knots; coal capacity 96 tons; complement 9 officers and 42 men. Built at Shooters Island, N. Y., in the year 1901.

4. The *Explorer*. A wooden steam vessel of 450 tons displacement, 335 gross tons, and 228 net tons; registered length 135 feet, breadth 27 feet, draft 10 feet; indicated horsepower 400; speed 10.3 knots; coal capacity 85 tons; complement 7 officers and 40 men. Built at Wilmington, Del., in the year 1904. In the design and construction of this vessel, it was endeavored to provide for the utmost space in her. To provide this space, some of the strengthening members usually provided in a vessel were omitted. While no weakness was noticed in consequence of the absence of these strengthening members during her earlier work, she is now showing their absence, and in rough seas her sides are pliable to the extent that the bolts holding them together are subject to shearing stresses, and if she is continually employed in rough seas, it means that she will ultimately become too weak to be of any service.

5. The *Hydrographer*. A wooden steam vessel of 146 tons displacement, 116 gross tons, and 79 net tons; registered length 101 feet, breadth 19.5 feet, draft 6.8 feet; indicated horsepower 250; speed 10 knots; coal capacity 22 tons; complement 5 officers and 18 men. Built at Port Jefferson, N. Y., in the year 1901.

6. The *Yukon*. A composite steam vessel of 38 gross tons and 25 net tons; registered length 75 feet, breadth 15.7 feet, draft 5 feet; indicated horsepower 100; speed 7.5 knots; coal capacity 16 tons; complement 4 officers and 13 men.

7. The *Patterson*. A wooden auxiliary steam barkentine of 719 tons displacement, 500 gross tons, and 453 net tons; registered length 163 feet, breadth 27.3 feet, draft 14.2 feet; indicated horsepower 215; speed, steaming, 8 knots; coal capacity 133 tons; complement 12 officers and 49 men. Built at Brooklyn, N. Y., in the year 1882.

8. The *Matchless*. A wooden two-masted schooner of 118 gross tons and 94 net tons; registered length 91 feet, breadth 25 feet, draft 8 feet; complement 6 officers and 16 men. Built at Key West, Fla., in the year 1859.

While we have six so-called steam vessels, one barkentine, and one schooner for surveying the Atlantic and Pacific coasts of continental United States, the waters of Alaska, Hawaii, Guam, Porto Rico, the Virgin Islands of the United States, and the approaches to the Panama Canal, if we examine into the condition of these vessels and their suitableness for the work to be performed, we will find that there is not even strength in numbers.

The *Surveyor* is of course the best-equipped vessel for our work. She is stable enough to work in the most exposed waters and endure the roughest seas and has fuel capacity to enable her to remain at the field of operations for a protracted period. (See fig. 1.)

The *Isis* and the *Bache* are sufficiently seaworthy for offshore work during favorable seasons of the year, but they are hardly staunch enough for making surveys of the exposed waters of California, Oregon, and Washington, and the outside waters of the Alaskan coast. Again, they have not the fuel capacity to make it profitable to employ them on this work, while the *Surveyor* is the ideal in respect to her fuel capacity, using fuel oil instead of coal and therefore being able to remain at sea almost the entire season. With her as a basis of comparison, it is correct to say that for offshore work 20 per cent of the time of the coal-burning vessels is required to replenish their fuel supply. The percentage of the time lost is of course modified by the locality in which the vessel is working; for instance, if the vessel is working off the coast where there are many supply stations where coal can be secured, not so much time is lost, but if she is working off a coast where supply stations are few and far between, then even more than 20 per cent of time is lost. There is, however, much more of the class of work which the *Isis* and *Bache* are suited to do than can ever be done by them.

The *Explorer*, through the faulty construction mentioned above, is too weak to be exposed to the rough waters of outside surveys and must operate in protected waters.

The *Hydrographer* and the *Yukon* are, of course, too small for any outside work, and they must be employed on inside work in less exposed waters.

The barkentine *Patterson* is structurally too weak to be used in exposed waters and too expensive of operation to be used as a house boat for inside surveys. She has lately been employed in making surveys of the inside Alaskan waters, but is such an antiquated craft that the overhead cost of operation makes the results far less in quantity and more costly than they would be with a modern vessel. The *Patterson* was built 35 years ago.

The schooner *Matchless* was built 58 years ago and of course can serve no purpose now except as a house boat from which parties can operate in making surveys of inland waters.

From the above it will be seen that we have but one vessel (the *Surveyor*) suitable for outside work in all kinds of weather; two vessels (the *Isis* and the *Bache*) suitable for certain outside work but without the fuel capacity of the *Surveyor* and therefore more economically operated in localities where fuel stations are easily available; two small vessels for inside work (the *Hydrographer* and the *Yukon*); one old barkentine, too weak for outside work and too expensive in maintenance to use for a house boat and one old schooner that can only be used as a house boat.

The result is that no concerted scheme of surveying operation for all our waters can be put into effect, but we are compelled to dissipate our appropriations here and there in making needed detached surveys as industry and commerce develop in one section after another of Alaskan waters, or in making examinations here and there for reported dangers.

It therefore follows that the vessels provided are entirely insufficient in number of the various classes to meet the situation at a time when our merchant marine is being enlarged to such an extent that our hydrographic surveys have more attention than at any time in the history of the country.

Considered from the standpoint of insurance, the appropriations expended by this Bureau in providing nautical data for use in making nautical charts is probably the least expensive of any Government venture. During the past fiscal year there were expended by this Bureau in making hydrographic surveys of our Atlantic, Pacific, and Alaskan coasts $210,410 for field expenses, while over these waters during that period Government statistics show, excluding coastwise trade, $8,089,318,107 in value of property carried by water. There are many commercial activities in Alaskan and other waters awaiting the day when we can make the surveys and issue charts containing sufficient data to enable vessels safely to navigate those waters, but until we have the adequate number of vessels and funds for carrying on this work, the full development of the country will be retarded.

WIRE-DRAG LAUNCHES.

Something has already been said in this report about wire-drag work, but those remarks were incidental to the discussion of other subjects, and therefore no mention was made of the problem involved in the effort to more efficiently carry on the surveys by this method. However, I did explain the general principles upon which the wire drag is based and how impossible it is to locate all dangers by any other method. (See fig. 7.)

Though it has been used in an earlier publication, it will throw light on the present subject to again print the illustration (fig. 30), representing the wire drag in operation. It was pointed out earlier in this report that by the subsequent use of the wire drag over areas where very close surveys had been made with the lead and line, pinnacle rocks and bowlders were found which only needed a vessel to collide with them to cause a wreck. This, however, was a general statement in connection with remarks on another subject and it may bring the point home more forcibly to cite an instance characteristic of any rocky or coral region.

Prior to 1916 Salem Harbor and approaches (Massachusetts) had been covered by three hydrographic surveys, one in 1850, one in 1858, and one in 1894-5. Then, in 1916 a wire-drag survey was made. While such a subject does not lend itself well to illustration by views, I have tried to show by two drawings just what this wire-drag survey disclosed. One of these drawings (fig. 31) is of Salem Harbor and approaches. On it are shown in red 45 numbered shoals and rocks that were found. Then on the other drawing (fig. 32) I have attempted to show how far below the surface was the bottom of the harbor and approaches as the depths were previously published on our charts, and how much above this general bottom the wire-drag survey showed that these rocks and bowlders really extended. The fact that some of them rise only a short distance above the bottom does not necessarily reduce the hazard involved in their unsuspected existence. If the chart shows 18 feet of water where traffic must pass, and a vessel draws 15 feet of water, then she clears the bottom by only 3 feet. If, then, there is an isolated bowlder in this area, though only rising 5 feet above the bottom, trouble is imminent. As stated above, this survey of Salem Harbor is only characteristic of the "finds" of this kind wherever the wire drag has gone.

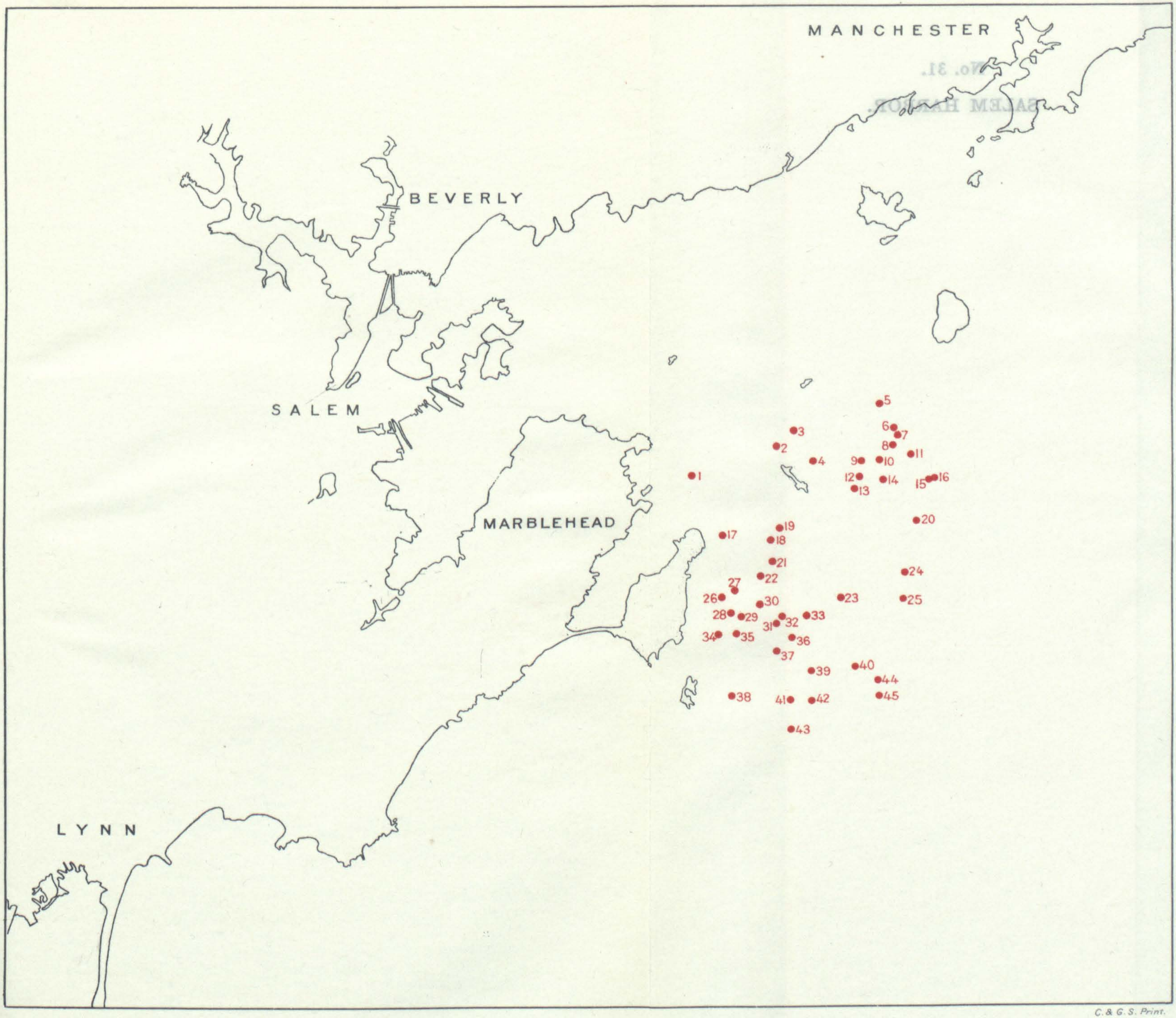
Figure 33 shows all the essential units and members that are required to make up a wire-drag outfit for the coast of New England. It will be noted that four power boats are required.

1. The guiding launch, which is the largest, tows one end of the drag, and determines its course through the water. On this launch

WIRE DRAG IN OPERATION.

No. 31.

SALEM HARBOR.


MANCHESTER
BEVERLY
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are carried the machinery for winding in the drag when it is taken up, and the semaphore by means of which all operations are directed.

2. The end launch, which is the next in size, tows the other end of the drag, following instructions signalled from the guiding launch.

3. The large tender patrols the drag when in operation, changing the depths at which the drag is operated, in order to conform to known differences in depth or the rise and fall of the tides, to clear the drag when aground, and to remove lobster pots or other fishing gear in the path of the drag.

4. The sounding tender sounds around and determines the position of menaces to navigation that are found, allows the drag to proceed ahead, and at other times assists in the work of the large tender.

Because of the fact that heretofore there have been no funds appropriated for the purchase of these power launches, they have been rented from private parties.

Now, the purpose of this statement is to show how much more efficiently and economically this work could be carried on if the Government furnished its own launches, designed specifically for this work, instead of following the present practice of renting them from private parties.

Past experience has shown conclusively that the rental which the Government must pay each season for chartered launches amounts to an average of one-fifth of their cost. In other words 5 years rental would purchase the boats outright. As the average life of such launches is at least 10 years, the Government, by building its own boats could get 10 years of service for 5 years rental. This, of course, does not take into consideration the cost of upkeep, but for boats of this character, properly cared for, that cost is trifling, and would be more than offset by other present costs which will be mentioned later.

Launch rentals are high for the following reasons:

1. Owners of launches that have never been used for wire-drag work are unfamiliar with conditions, and have no means of estimating the probable cost of repairs or deterioration.

2. The risk of loss or damage must be assumed by the owner, though he has no voice in the matter of how and when the launches will be used, and insurance rates are high, especially in Alaska.

Heavy-powered, staunch fishing boats are best suited for wire-drag work, and owners of such boats are fairly sure of generous earnings from fishing. Therefore, they will rent only at a figure high enough to insure equal returns.

Launches suitable for wire-drag work are scarce at any price for the following reasons:

1. Pleasure launches usually have enough power for the work, but their hulls are too weak.

2. Fishing and working launches are generally of sturdy construction but are usually low powered.

3. It is impracticable to use launches with two-cycle engines for wire-drag tenders, but launches of a suitable size equipped with four-cycle engines are few in number.

This difficulty in securing suitable launches results in a considerable additional delay and expense. When it is desired to secure the launch equipment for a new season's work it is not sufficient to send out specifications and proposals to the owners, and when the bids are returned, to examine them and accept the lowest submitted.

Instead, the descriptions furnished must be carefully studied, eliminating those which are clearly unsuited for the intended use, and an officer must then be sent out to personally inspect the remainder and choose the ones which afford the most advantageous combination of adaptability and low rental.

Finally, it is never possible to secure launches suited in all respects to the work. Alterations, more or less extensive, must invariably be made. These alterations are those necessary to strengthen the decks sufficiently to carry the weight of the heavy machinery and gear, to provide for the installation of the auxiliary engines, reels, signalling system, etc., used, to clear away rails, awnings, and obstructions on deck, and to suitably protect woodwork or fittings from damage in the handling of heavy buoys or weights. All expenses so incurred must be borne by the Government, and at the end of the season they must be duplicated in restoring the launch to its original condition.

These extra expenses of inspection and alteration would more than pay for the upkeep of Government-owned launches.

For example, the yearly average cost to the Government for installing the wire-drag machinery on the rented launches and removing it at the close of the season, taking into consideration the time of the field officers utilized for this purpose, was, for each of the four parties in the field, about $850, or a total of $3,300.

There is this further thing to be said about renting launches for wire-drag work. There are localities in which the wire-drag work must be done where launches can not be hired for the purpose because they are not there to be hired. This is true of Porto Rico. Likewise, the few launches available in the region of Key West are wholly unsuited for wire-drag work.

While this report was being prepared, there has been received from the Secretary of the Navy a letter as follows:

NAVY DEPARTMENT,
Washington, September 26, 1917.

SIR: I have the honor to forward herewith a paraphrase of a cablegram received from the governor of the Virgin Islands of the United States relative to the inquiries contained in your letter of 6 September:

"It is recommended that a wire-drag survey be taken of the waters between the Islands of St. Thomas and St. John in addition to the vicinity of Vieques Sound. It is regretted that there are no motor boats available in this locality for this work. The general conditions of St. Thomas and St. John are mountainous, rugged, dense undergrowth, sloping, thinly populated, and arid. In connection with the topographical survey, the location of property boundaries is most important. It is also recommended that a geological survey, with special reference to the location of suitable sites for artesian wells, be made."

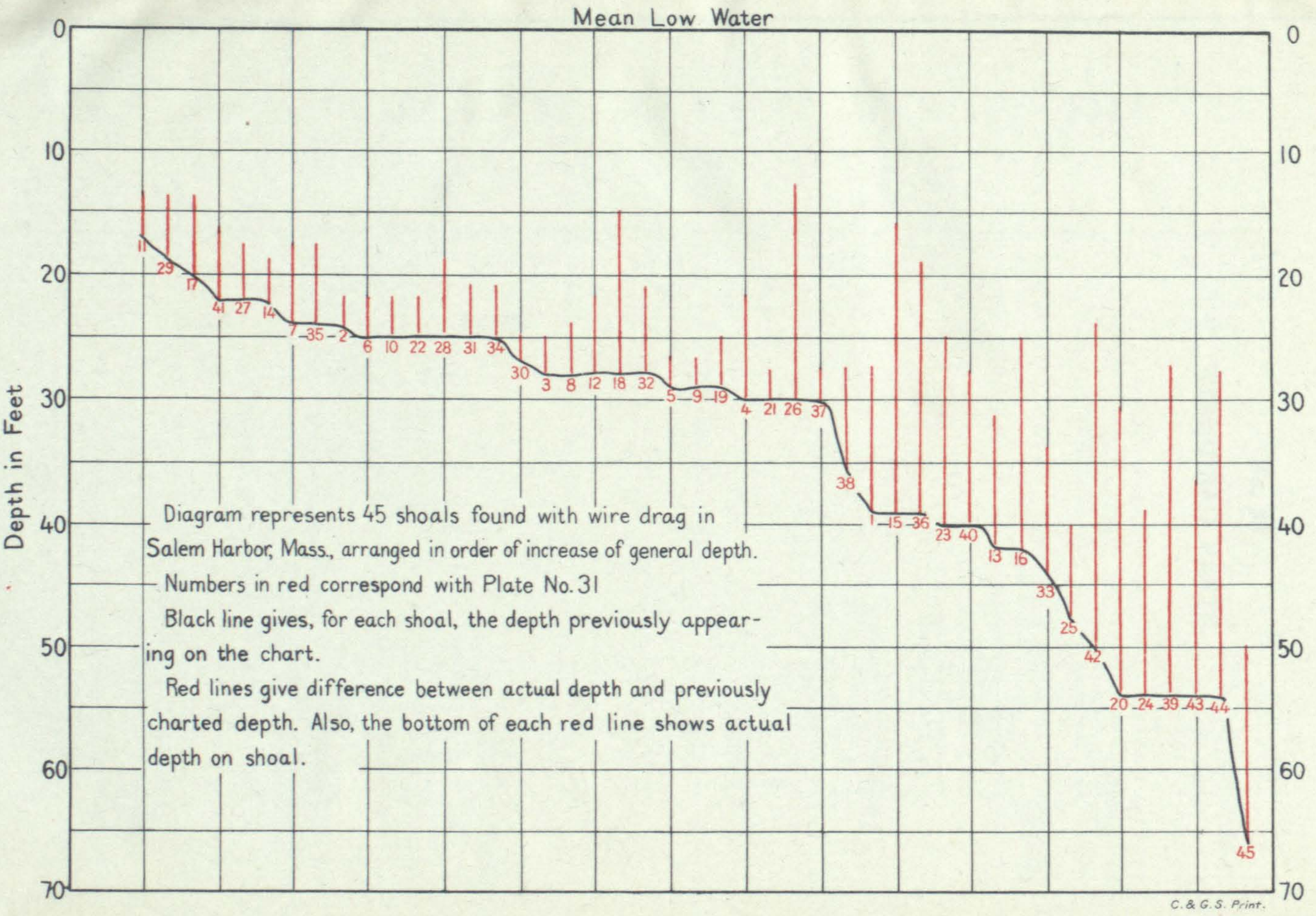
The Navy Department regrets that there are no boats available for assistance in the making of this wire-drag survey, but should a vessel be stationed in that vicinity which carries appropriate boats for this service, orders will be issued for her to assist in every way possible.

The Department will be pleased to be informed as to the action taken relative to the survey of these islands, and to assist in any manner which may be possible.

Sincerely yours,

JOSEPHUS DANIELS.

The honorable the SECRETARY OF COMMERCE.


Mean Low Water
Depth in Feet
0
10
20
30
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50
60
70
11 29 17 41 27 14 7 35 2 6 10 22 28 31 34 30 3 8 12 18 32 5 9 19 4 21 26 37 38 1 15 36 23 40 13 16 33 25 42 20 24 39 43 44 45
Diagram represents 45 shoals found with wire drag in Salem Harbor, Mass., arranged in order of increase of general depth.
Numbers in red correspond with Plate No. 31
Black line gives, for each shoal, the depth previously appearing on the chart.
Red lines give difference between actual depth and previously charted depth. Also, the bottom of each red line shows actual depth on shoal.

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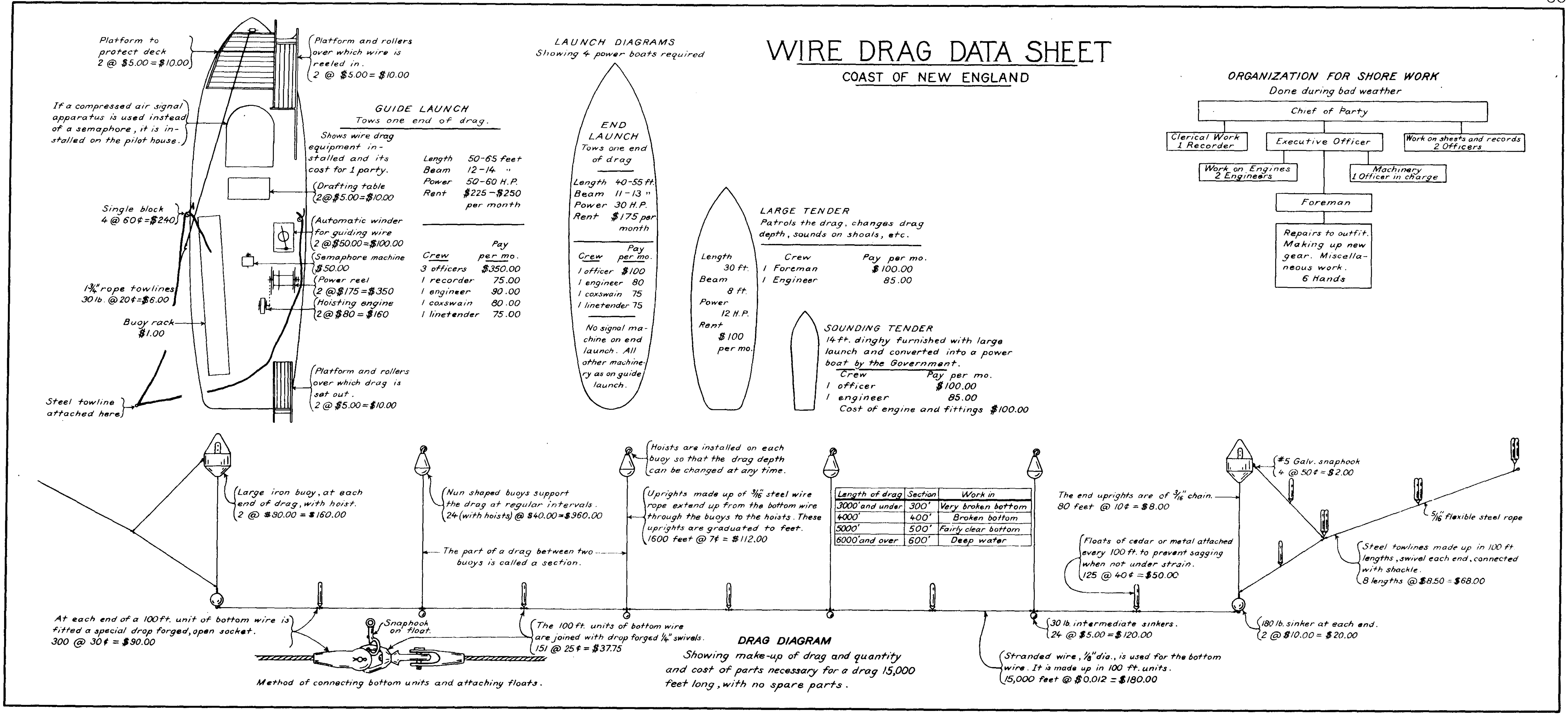
No. 33.

WIRE-DRAG PARTS.



Length of drag	Section	Work in
3000' and under	300'	Very broken bottom
4000'	400'	Broken bottom
5000'	500'	Fairly clear bottom
6000' and over	600'	Deep water

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To this letter reply was made as follows:

DEPARTMENT OF COMMERCE,
OFFICE OF THE SECRETARY,
September 29, 1917.

SIR: The receipt of your letter, dated September 26. 1917, relative to surveys in the Virgin Islands, is acknowledged.

I regret to learn that the Navy Department will be unable to furnish the necessary launches for the wire-drag work in the vicinity of the islands of St. Thomas and St. John and Vieques Sound, as it is understood that no suitable launches can be obtained locally for this work.

Under these circumstances, it appears that the hydrographic work in general will necessarily have to be postponed until the return of the Coast and Geodetic Survey vessels from duty under the Navy Department or until suitable launches can be obtained from other sources.

As stated in previous correspondence from the Coast and Geodetic Survey, officers and equipment for the shore work of the survey of the islands will be sent to St. Thomas at the earliest practicable date. They will be instructed to use any of the small launches that may be found suitable for the local hydrography, upon arrival in the islands, and it is probable that the hydrographic surveys of the bays and harbors can be made during the winter.

Respectfully,

WILLIAM C. REDFIELD.

The SECRETARY OF THE NAVY,
Washington, D. C.

In concluding this matter, I can not better express conditions than to quote from a letter just received from one of our engineers in charge of a wire-drag party that has this season been operating in the vicinity of Key West, Fla.:

According to all reports we have been fortunate in having an unusually favorable season for work but I am afraid that it is about over, for heavy squalls and rain are beginning to make things interesting and the weather seems to be getting generally unfavorable.

It would not be so bad if our end launch could only take care of herself, but it is asking almost too much of a 25-horsepower guiding launch to take up the drag in a heavy squall, that may last five minutes or five hours, and then get a line to the end launch and furnish enough power to give her steerage way.

I wish that the opponents of Government-owned wire-drag boats could have spent the season with us and personally experienced the constant annoyance and obtained an idea of the inefficiency of the present system of chartering boats, especially in regions where suitable launches are few and far between. I believe that this is the first wire-drag work that has been done almost entirely out of sight of land and in what, because of strong currents, is even worse than the average open sea; and it has been necessary to do it with launches that we would hardly consider adequate for work in Cape Cod Bay.

In the four months of actual field work to date we have covered about 225 square miles. Our guiding launch is the most able sea boat for her size that I have ever seen and I am sure that, with an end launch that could even equal her power and slow speed of 6 or 7 knots, we could easily have covered 100 square miles more.

Of course the present conditions and demands of the Navy for numerous motor boats have increased our difficulty in obtaining suitable launches but they are not too plentiful in this region at any time.

NEED AND IMPORTANCE OF CURRENT OBSERVATIONS.

Earlier in this report I described the nature of the data that must be gathered by the Bureau to enable it to furnish predictions of the currents, and the reasons why a special arrangement was necessary before such data for the outside coasts could be secured in adequate amount and at reasonable cost.

In this chapter it is my purpose to explain the importance of securing more information regarding ocean currents and to make a plea for authority to expend funds for that purpose in a manner that will secure the best results with the least expenditure of money.

I have explained how it is possible through hourly current observations made at different lightships maintained by the Bureau of Lighthouses on the Atlantic, Gulf, and Pacific coasts to obtain data which would be basic for the localities where the lightships are stationed and the more valuable because these lightships are generally stationed near the tracks of marine commerce, and therefore, if the data obtained from current observations at these ships do not form the premises from which other conclusions can be drawn, they would be of the utmost importance as a basis for predictions in the localities where the lightships were stationed. However, based on our present knowledge of current phenomena there is no hesitation in making the assertion that hourly current observations made at advantageously located lightships would form a basis that would go far toward solving the problem of current predictions.

If, then, these current observations at lightships will result in such beneficial data, the question may rightly be asked, why are not these observations made? The reasons are that the funds available for carrying on the work of the Coast and Geodetic Survey under the wording of the present appropriations can not legally be expended to remunerate the crews of these various lightships for making these observations; that the employees on the light vessels will not, nor should they, be expected to make the necessary continuous day and night observations without being compensated for so doing, and that it is impracticable to station on the light vessel extra men employed for this specific duty. I am advised by the Commissioner of Lighthouses that as the crews of the various lightships are only paid fair wages for the services they now perform, it is extremely difficult to keep men in the service. It would be not only unfair to impose the extra duty of making these observations on the crews of the lightships without extra pay for the services but, if this were done and the observations were made indifferently and without a spirit of cooperation, the results would be unreliable, and predictions made from them might be so wholly erroneous as to be harmful rather than helpful.

This matter has had deep consideration both by the members of this Bureau and by the officers of the Bureau of Lighthouses, and the following plan is looked upon with favor by all concerned, namely, to pay out of the appropriations for the Coast and Geodetic Survey into the mess fund of each lightship where current observations are made $1 for each day that observations are made. Under existing laws there is a prohibition against such a method of carrying on this work, and it would require a provision in the bill making appropriations for the Coast and Geodetic Survey authorizing such payments before this could be done. It would thus cost but $365 a year to make continuous hourly current observations at any selected lightship, and there is every reason to believe that by such cooperation the results would be reliable.

The question may now have arisen as to whether these current data are really of more than theoretical importance. To show that they are of practical importance, I could cite numerous instances where wrecks have been the result of the lack of knowledge of the direction and strength of currents, but shall confine myself to two:

The steamer *Lugano* was at a point 2¼ miles off Great Isaac Light at the northern extremity of the Bahama Islands, bound for a port in the Gulf of Mexico. Figure 34 shows, by a blue line, the track which the master laid down on the chart for his vessel to follow and which he actually believed it was following. No allowance was made for the northerly set of the vessel due to the Gulf Stream, however, and as a result the vessel was wrecked on Long Reef, 17½ miles north of her supposed position. In other words, the vessel, instead of following the track as shown in blue, had actually followed the track shown in red.

As the vessel was 7¾ hours making this run, and during that time was set 17½ miles off her course, it follows that the average velocity of the current to which she was subject was 2¼ miles per hour; but as these velocities vary greatly for different parts of the Gulf Stream, it is probable that during part of the run she was subject to a current of at least 3 knots.

A case of even greater interest, since it illustrates not only the disaster which may occur from a lack of current predictions but, also, the way in which lack of adequate surveys may contribute to such losses, is that of the steamer *Bear* which, in June, 1916, stranded on the coast of California and became a total loss.

The *Bear* was bound from the Columbia River to San Francisco. The weather was foggy; since passing Cape Blanco, 10 hours before the disaster, they had been unable to see the land and determine their position. Therefore, as they approached Cape Mendocino they began to take soundings to locate the position, using the method described earlier in this report.

In this locality the danger line is the 30-fathom curve. Figure 35 shows that according to the chart, if a vessel keeps in depths of 30 fathoms or more, she will be in no danger. In fact, it is a common practice for vessels in this locality, uncertain of their position, to feel their way carefully in to a depth of 30 fathoms and then follow that depth, which leads within easy hearing distance of the fog signal on Blunts Reef Light Vessel. When they hear that signal they knew where they are and can proceed with confidence.

When they began sounding they were in deep water. They let out 1,200 feet of sounding wire without reaching bottom, which meant that they were in depths of over 100 fathoms, or, according to the chart, somewhere outside the 100-fathom curve. They took a number of such soundings, no bottom at 100 fathoms. Then they got bottom, about 80 fathoms. They felt their way along, sounding as they went, getting bottom in depths which shoaled gradually from 80 to 34 fathoms. In other words, according to the chart they were always outside their danger line, the 30-fathom curve.

The next sounding reported again gave deep water—80 fathoms, and after that no bottom at 100 fathoms. According to the chart, there was only one place where such a series of soundings could have been obtained. The vessel must have crossed the shoal plateau which extends westward from Cape Mendocino and entered the deep submarine valley which makes in toward the beach about 3 miles southwestward from the cape.

In other words, the vessel must safely have passed the dangerous reefs off Cape Mendocino. The commander assumed that such was the case, and changed his course for Point Arena. About an hour later the vessel stranded near the mouth of Bear River, 2 miles northward of the cape. Instead of following, approximately, the track shown on the chart in black, it had actually followed the one shown in red.

Here is a disaster which cost six lives and a vessel valued at $1,000,000, which occurred as a direct result of the navigator not having the information essential to the safety of his passengers, his ship, and himself. It is true that the official investigation of the disaster proved that the officers in charge had been guilty of what might be called contributory negligence and that had it not been for such negligence the disaster might not have occurred.

However, it is just this information of the currents and the ocean depths, which this navigator did not have, that should be obtained and put in practicable form as soon as possible so that navigation may be adequtely safeguarded and the recurrence of such fatalities prevented.

CREWS OF VESSELS.

Another need in connection with the hydrographic work is to remedy the situation with regard to crews on the vessels of the Coast and Geodetic Survey, which has long been a serious one and this year became so acute that a number of the vessels had to be laid up as a result of the impossibility of getting and keeping sufficient men to enable them to operate efficiently.

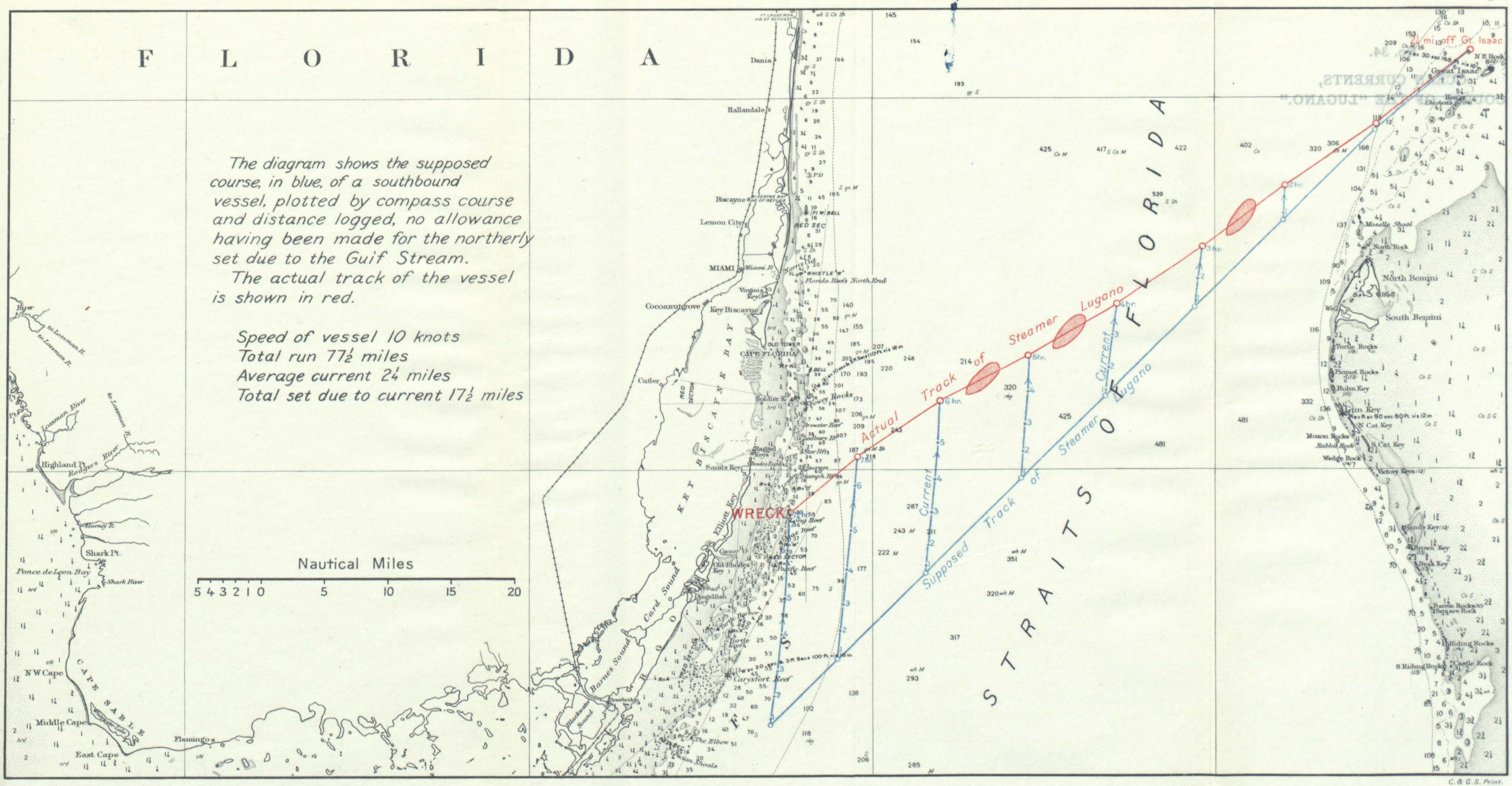
The conditions of labor in the United States have undergone an enormous change in the past few years. Labor has demanded and received higher wages and better working conditions. The Coast and Geodetic Survey, however, among other Government institutions, has been unable to keep pace with that change, and the result has been that just in proportion as it failed to do so its efficiency has been reduced.

There are a number of factors which make service in the Coast and Geodetic Survey undesirable from the point of view of the enlisted man. The pay is less than he can earn elsewhere, either in the merchant marine or in various industries ashore; the work is of more than average difficulty and must sometimes be continued through much longer hours than the 8 to 10 hours to which he is accustomed elsewhere; the living conditions in the crowded forecastles of small and antiquated wooden vessels are anything but attractive; and, finally, his employment is only temporary and may be terminated at any time, so that he has not even the incentive of a permanent position to compensate him for the other undesirable features enumerated.

The result of these conditions is that the Coast Survey has earned the reputation, among seafaring men, of being an undesirable service. Men will come to it only as a last resort, when out of work, out of money, and with no chance to find employment in other lines of work.

No. 34.

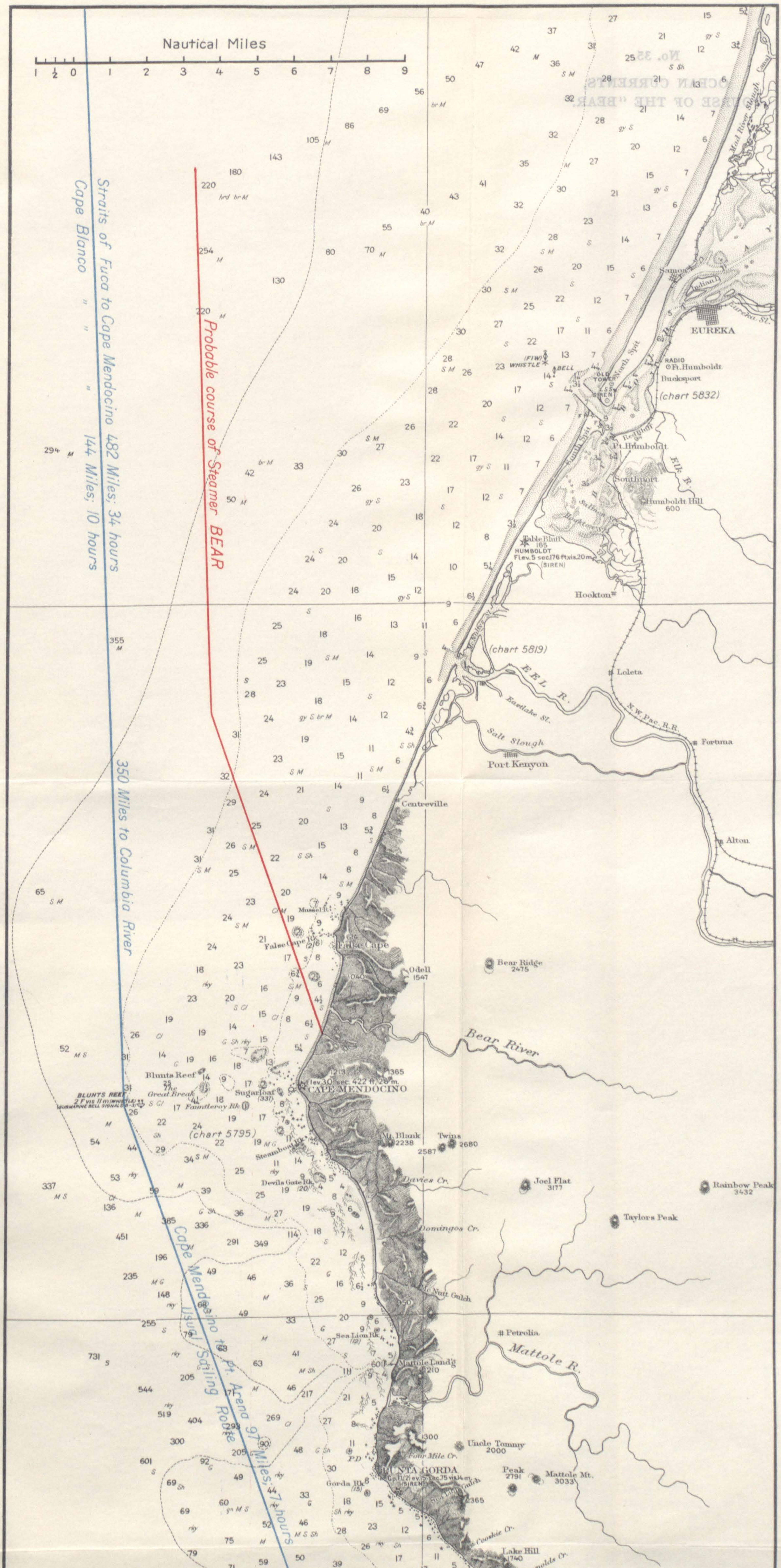
OCEAN CURRENTS,
COURSE OF THE "LUGANO."



FLORIDA
The diagram shows the supposed course, in blue, of a southbound vessel, plotted by compass course and distance logged, no allowance having been made for the northerly set due to the Guif Stream.
The actual track of the vessel is shown in red.
Speed of vessel 10 knots
Total run 77½ miles
Average current 2¼ miles
Total set due to current 17½ miles
Nautical Miles
5 4 3 2 1 0 5 10 15 20
STRAITS OF FLORIDA
Actual Track of Steamer Lugano
Supposed Track of Steamer Lugano
Current
WRECK
2¼ mi off Gt. Isaac
Great Isaac
North Bemini
South Bemini
KEY BISCAYNE BAY
MIAMI
Dania
Hallandale
Biscayne
Lemon City
Cocoanutgrove
Key Biscayne
Cutler
Elliott Key
Card Sound
Barnes Sound
Carysfort Reef
The Elbow
Flamingo
CAPE SABLE
East Cape
Middle Cape
NW Cape
Ponce de Leon Bay
Shark Pt.
Shark River
Highland Pt.
Rodgers River
Lossman River
C. & G. S. Print.

No. 35.

OCEAN CURRENTS,
COURSE OF THE "BEAR."


Nautical Miles
No. 35
OCEAN CURRENTS
COURSE OF THE "BEAR."
Straits of Fuca to Cape Mendocino 482 Miles; 34 hours
Cape Blanco " " 144 Miles; 10 hours
Probable course of Steamer BEAR
350 Miles to Columbia River
Cape Mendocino to Pt. Arena 97 Miles; 7 hours
Usual Sailing Route
EUREKA
Samoa
Mad River Slough
Eureka Sl.
North Spit
South Spit
Ft. Humboldt
Bucksport
Pt. Humboldt
Southport
Humboldt Hill
Elk R.
Table Bluff
HUMBOLDT
Hookton
Loleta
EEL R.
Eastlake Sl.
Salt Slough
Port Kenyon
Fortuna
N.W. Pac. R.R.
Alton
Centreville
(chart 5832)
(chart 5819)
(chart 5795)
Mussel Rk.
False Cape
False Cape Rk.
Odell
Bear Ridge
Bear River
Blunts Reef
The Great Break
Sugarloaf
Fauntleroy Rk.
CAPE MENDOCINO
Steamboat
Devils Gate Rk.
Mt. Blank
Twins
Davies Cr.
Joel Flat
Rainbow Peak
Taylors Peak
Domingos Cr.
McNutt Gulch
Petrolia
Mattole R.
Sea Lion Rk.
Mattole Land'g
Uncle Tommy
PUNTA GORDA
Four Mile Cr.
Gorda Rk.
Peak
Mattole Mt.
Cooskie Cr.
Lake Hill
Reynolds Cr.
Spanish Hill
Spanish Cr.
Oak Hill
Rodgers Break
Reynolds Rk.
Kinseys Cr.
Frasers Cr.
North Slide
Spanish Flat
Hadleys Peak

C. & G. S. Print.

This means, of course, that the Survey gets the most undesirable type of men on the water front—the misfits, those who in the process of selection have been refused for other more desirable occupations.

Such men seldom remain on one job long enough to become of value. When they have earned a few dollars they want to quit; if they can not obtain their discharge upon request, they either desert or by refusing duty, drunkenness, and general misconduct compel the commanding officer to get rid of them.

The constant change and upheaval in the crews which result from these conditions are strikingly portrayed in the following table, which shows for each Coast Survey vessel in the United States waters the complement allowed and the number of persons in the complement during the fiscal year, 1917:

Vessel.	Station.	Complement.	Persons in complement.
Surveyor	Atlantic coast	58	[a] 85
Bache	.....do	42	129
Isis	.....do	44	171
Matchless	.....do	16	54
Hydrographer	Gulf coast	18	51
Patterson	Pacific coast	49	[b] 132
Explorer	.....do	39	[b] 124

[a] In commission only since June 11, 1917.
[b] In commission only about seven to eight months of the year.

Even this table does not tell the whole story, as there is not one of these vessels which has not been continuously shorthanded, through inability to obtain recruits.

These factors, the undesirable type of men which alone can be obtained and the inability to keep men even of this type, result in a great loss in efficiency.

The Coast Survey ships, as surveying units, are carefully planned, and their equipment and personnel are arranged so as to provide for the most efficient and economical operation of three to five surveying parties. In these parties the enlisted men form an integral part. They are not there merely to man the ship; they take an active part in the surveying work. They are the recorders, rodmen, leadsmen, tide observers, coxswains or engineers of the surveying launches, operators of the sounding machines, etc. There are no idlers or supernumeraries; each man (with the possible exception of the mess force) has his definite place in the organization, and so the shortage of a single man means a loss in efficiency, while a shortage of three to five men means that one less party can be worked. This means that in return for the saving in the wages of these men (a negligible quantity) the efficiency of the vessel, which must be measured by the amount of work accomplished, is reduced from one-third to one-fifth.

It costs from $30,000 to $60,000 a year to operate one of these ships, depending on size and location, and it follows that a shortage of a few men in the complement will, for a ship engaged in combined operations, result in a loss of $6,000 to $20,000 a year.

Losses occur as a result of the lack of training of the men in the specialized work which they are required to perform. The enlisted men in the Coast Survey require such training quite as much as do the men in the Army or Navy. As already indicated, in the former service these men do not merely shovel coal, scrub decks, or clean brass; they take an active part in the surveying operations, only a little less important than that of the officers, and no amount of efficiency on the part of the officers can compensate for their failure to perform their work properly. In these days of increased draft, ships must pass close to the bottom, particularly along the Atlantic coast. The officers may properly find and locate the channels or shoals, but if the leadsman does not read the depths correctly, if the recorder does not record them properly, or if the tide observer goes to sleep or goes off somewhere for the day and then "fakes" the record of his staff readings, the result may be the loss of a vessel through an error in the chart.

At least a season's work is necessary to properly train these men in such duties. Yet, the record of changes in complement above quoted shows that the complements change on an average of two to three times a year. Furthermore, the men that present conditions enable the Survey to obtain are, as a rule, of a type that have no desire to become proficient in the work. Their thoughts center on spending their pay, not on earning it fairly, so that too often their efforts are concentrated on performing the minimum amount of labor that can be forced out of them.

Losses occur as a result of the effect of these conditions upon the officers. Officers, who year after year are compelled to operate under such discouraging conditions, who are continually harassed by their inability to obtain good men or to enforce discipline over bad ones, and who have appealed to the office again and again for relief, without obtaining it, become discouraged and lose their enthusiasm and ambition for accomplishment. Inevitably, they come finally to take things easy, to humor the crews, to making concessions before an issue is forced. Their first thought is not the accomplishment of the work with which they are charged but rather to so operate as to avoid a rupture which they are powerless to control.

It must be clearly understood that these conditions are not merely the result of the present world conflict. They existed in a serious degree before that conflict began, and the war has merely exaggerated them to such an extent that, as already stated, it has become necessary to lay up certain ships which could no longer be operated efficiently.

An effort has been made to compute the cost of these losses in efficiency, and from the best data available it appears that the loss by the seven vessels operating in the United States during the past year is about $82,000. One case, that of the *Patterson*, may be cited as typical.

The *Patterson* works in Alaska in the summer, and winters in Seattle. Last spring she was detained 20 days in Seattle through inability to obtain men. She finally sailed with a shortage of 5 men. After working for about 6 weeks with this reduced complement and its resultant loss of efficiency, the ship was compelled to go to port. Here 5 days were lost through drunkenness among the crew and their refusal of duty. She finally got away with a shortage of

7 men. Efforts to recruit men in Seattle to fill these vacancies were unavailing; men would not consider the $60 a month offered when they could readily earn $100 or over elsewhere.

Work was continued with this reduced complement, therefore, until early in August when the situation was relieved by discontinuing the work of another vessel, the *Explorer*, which had been operating under conditions equally unsatisfactory. Enough men were kept aboard the *Explorer* to bring her to Seattle, where she was laid up; the remainder of her crew was transferred to the *Patterson*.

The estimated cost of this decreased efficiency on the *Patterson*, alone, is $24,500.

All possible means have been used by the Survey to improve these conditions. The pay of the crews has been increased to an amount considerably beyond that available under the existing appropriation. If the ships were operated during the 1918 fiscal year on the same basis as they have been for some years past, there would be a deficiency of $30,000 in the appropriation for pay of crews. The fact that officers and vessels of the Survey have been taken over by the Navy relieves the situation; otherwise, it would have been necessary either to obtain a deficiency appropriation from Congress, or to lay up at least part of the ships in the spring of 1918.

For this situation there are two possible remedies, one partial and one complete.

The partial remedy is to allow the present status of the crews to remain unchanged, employing them for the duration of the season, and paying them a wage as high or slightly higher than they would obtain elsewhere.

This plan, in a modified form, has already been adopted by the Bureau, and in the 1919 estimates the fund for pay of crews is based on the wage scale recently adopted for the governmental and private merchant fleets by representatives of the Department of Commerce, the Department of Labor, the Shipping Board, employers, and employees.

There are, however, a number of reasons why this increase in wages will not completely solve the problem under consideration.

1. The equality in wages is only apparent, for the earnings of merchant seamen are materially increased by overtime pay, which it is impracticable to grant employees in the Coast and Geodetic Survey.

2. The Survey vessels, working near ports, must compete not only with the merchant marine but also with the labor markets ashore. These latter are glad to pay $75 to $100 per month for the men to whom the Survey can offer only $60.

3. Employing men for the season only, even if they could be induced to remain for that period, will not afford a complete solution. As has already been shown, the maximum effectiveness in the work of the Survey can be obtained only with trained crews. It requires a season to train these men, and under the above plan they would be discharged just when they were beginning to be effective and the following season the same training process would be begun anew.

The truth is that increased pay is only one element entering into the final solution of the problem. The final solution rests on a complete readjustment of present conditions.

The men must eventually be given permanent employment at a fair wage and under comfortable living conditions. They must have before them some prospect of advancement for faithful service, and their rights must be fully safeguarded. In return, they must be required to live up to the terms of an equitable contract, and there must be authority for dealing effectively with the occasional undesirable who refuses to do so.

Such a readjustment will make it possible to build up a permanent organization of sober, industrious men, devoted to the Survey and its interests through long association, and will result in an increase of 20 to 25 per cent in the efficiency of every vessel.

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

CHAPTER I.

WORK OF THE WASHINGTON OFFICE.

Last year, in my annual report, I gave a synopsis of the duties of the various divisions and sections of the Washington office of this Bureau; and as the organization and duties have remained the same, though there have been a few changes in the personnel, it is unnecessary to again enumerate their duties, but I will state in general terms the nature of the work of the Washington office and then more particularly what each division and section has accomplished.

In addition to the administrative direction of the work of the Bureau being centered at the Washington office, it is the repository for all original notes, survey sketches, and books of record made in the field, whether on land or at sea, in the process of carrying on the surveys which it is the function of the Bureau to make. It is through this office that data from these surveys are handled and finally issued in the form of charts, tide tables, coast pilots, magnetic tables, and special publications containing geodetic and other information of value to the navigator and the engineering profession.

It would not be of general interest to give in detail all the activities of the different divisions and sections of the office in compiling, drafting, computing, preparing for printing, printing, and in carrying on correspondence incident to the issuing of the charts and publications of this Bureau, but it seems well to show a comparison of this year's issue of charts and coast pilots with that of last year and previous years, and for the purpose of record to give a résumé of the accomplishments of each of the divisions of the office.

A brief summary of the work accomplished by the different divisions of the office during the fiscal year is as follows:

OFFICE OF THE HYDROGRAPHIC AND GEODETIC ENGINEER IN CHARGE OF OFFICE.

General routine office work incident to the maintenance and upkeep of the buildings occupied by the Bureau. In this connection, the old boilers that supplied heat for the buildings, and which had been condemned by inspectors under the Engineer of the United States Navy Yard, were removed and two new boilers installed. Extensive improvements were made throughout the various sections of the office in an effort to place them in a sanitary and orderly condition, in order to fulfill the requirements of the Public Health Service.

Under a rearrangement of the sales office, bookkeeping room, chart-correcting room, and the printing rooms the transaction of business has been greatly facilitated. The production of charts has been greatly increased by printing a large number of them by lithography rather than from the engraved copper plates. Receipts from the sale of charts and publications, etc., during the year were $21,018.58.

A new spring balance for applying the exact required tension to invar base tapes in measuring primary base lines was designed, as was also a new sounding tube.

During the fiscal year 1,668 instruments, apparatus, tools, etc., were repaired in the shops; 1,534 instruments, apparatus, tools, etc., were made, and 707 instruments purchased.

Instruments shipped to the field during the year	3, 790
Instruments received from the field during the year	2, 545
Articles of general property shipped to the field during year	6, 717
Articles of general property received from field during year	1, 257

The expenditures for the purchase of items of various kinds for the office amounted to $89,985. By improving the methods of handling this business, the section handling the expenditure of these moneys has been able, though short handed, to keep pace with the needs of the Bureau. The war situation has made very difficult the purchasing of supplies. Delinquency on the part of contractors in the delivery of supplies is becoming more and more frequent, thus necessitating extra work and correspondence.

During the year 58 new original topographic sheets and 70 new hydrographic sheets were added to our archives, as were also numerous original records made during the course of surveys in the field. These were all properly accessioned and filed for future reference.

DIVISION OF GEODESY.

The most important pieces of work which were completed during the past fiscal year or which were in progress during that time are the following, some of which may have been begun during the previous fiscal year:

Computation and adjustment of the following pieces of triangulation: (1) The triangulation which controls the survey of the Maryland Shellfish Commission; (2) along the coast of Maine; (3) Utah-Washington arc of primary triangulation; (4) Lake Washington and Seattle; (5) ninety-eighth meridian south, connecting with Mexican triangulation; (6) St. Vincents Sound, Fla.; (7) Boston Bay, Mass.; (8) along the coast of Georgia; (9) Tampa Bay, Fla.; (10) Pasquotank River, N. C.; (11) Lake Borgne and Lake Pontchartrain, La.; and (12) in Rhode Island.

The field computation was made of the following pieces of triangulation: (1) Arthur Kill, N. J.; (2) in the District of Columbia and suburbs, for the Washington Suburban Sanitary Commission; and (3) Memphis-Little Rock (traverse).

The computation and adjustment of the following lines of precise leveling: (1) In Michigan and Indiana; (2) from boundary to Vanceboro, Me.; (3) from Clovis to Pecos, Tex.; (4) from Cedar Keys, Fla., to Birmingham, Ala.; (5) from Washington, D. C., to Indian Head, Md.; and (6) from Birmingham to Mobile, Ala.

The computation of azimuth, the observations for which were made by Hydrographic and Geodetic Engineer C. V. Hodgson in 1915–16.

The computation of latitude and longitude, the observations for which were made by Hydrographic and Geodetic Engineers J. E. McGrath and W. B. Fairfield in 1916.

The computation of various latitudes, the observations for which were made a number of years ago.

The computation and adjustment of latitude and longitude for Rochester, N. Y., the observations for which were made by Hydrographic and Geodetic Engineer C. H. Sinclair.

The computation and adjustment of observations for the determination of the intensity of gravity at a number of stations established by Messrs. Garner and Steinberg.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY.

In this division was planned the details of carrying on the hydrographic work and preparing instructions to the various field parties for its execution. This included instructions to the parties on the various vessels of the Bureau, the wire-drag parties, and the revision parties.

In respect to the locality where the work has been done, investigations have been made with regard to the different existing surveys, the character of the locality, the nature of the bottom, and the required closeness of the work to be done. By a careful study of conditions surrounding the area to be surveyed, and reviewing former survey records, data and results were placed before each chief of party that assisted him to efficiently direct his operations.

The office work of this division further consisted of reviewing and passing upon the plans and specifications of the new vessel of the Bureau, the *Surveyor*, which has recently been completed. Repairs to vessels have also been supervised from this division.

Two coast pilots and one inside route pilot were prepared for the printer during the year; also, the tide tables for 1918.

DIVISION OF CHARTS.

The following statistics show the accomplishments of this division in the way of drafting, engraving, and photographic work for the past year, as well as the accomplishments for 1913, 1914, 1915, and 1916:

Work done.	1913	1914	1915	1916	1917
DRAFTING.					
Schemes approved for new charts	15	20	18	4	8
Approved schemes on hand, charts not started	5	4	11	5	5
Drawings for new charts finished	23	18	18	4	11
Drawings for new charts in hand	13	16	8	10	10
New drawings for new editions finished	5	7	4	10	11
New drawings for new editions in hand	2	....	6	10	4
Extensive corrections finished	121	87	137	157	151
Extensive corrections in hand	5	9	18	11	14
Chart drawings from Manila, for new charts finished	12	8	3	2	3
Chart drawings from Manila, for new editions finished	1	10	4	5	14

Work done.	1913	1914	1915	1916	1917
ENGRAVING.					
New plates for new charts finished	9	6	3	2	8
New plates for new charts in hand	10	7	12	11	6
New plates for former lithograph charts in hand	....	....	1	3	2
New bassos for new editions finished	15	18	19	11	16
New bassos for new editions in hand	14	13	16	16	3
New editions using current plate finished	21	14	18	24	32
New editions using current plate in hand	2	6	4	2	2
Extensive corrections applied to plates	258	239	286	316	269
Extensive corrections applied to plates in hand	13	9	11	14	7
Miscellaneous plates engraved or corrected	8	11	11	22	21
Minor corrections applied to plates	1,315	1,198	1,245	1,158	696
Charts in section, engraving not started	2	....	....	....	....
PHOTOGRAPHING.					
Glass negatives made	992	1,184	1,189	1,225	1,109
Paper negatives made	32	30	9	11	....
Velox prints made	1,215	1,903	1,968	4,313	3,413
Vandyke prints made	135	244	64	52	36
Bromide prints made	340	317	259	500	391
Blue prints made	2,123	1,937	3,127	2,411	1,921
Photostat prints made	11,240	11,381	15,224	18,549	19,017
Lantern slides made	1	11	172	354	208
Matrices made	74	101	90	43	96
Redeveloped prints made	....	....	....	....	197
Prints mounted	23	19	18	39	63
Negatives developed	6	....	....	22	41
Photolithograph negatives, number of charts	76	52	49	30	29

DIVISION OF TERRESTRIAL MAGNETISM.

The office work accomplished by this division during the year is as follows:

The results of field work executed during 1916 were computed and prepared for publication as Special Publication No. 42.

Magnetic Tables and Magnetic Charts for 1915 was completed and submitted for publication as Special Publication No. 44. It contains the latest values of declination, dip, and horizontal intensity for all places in the United States and adjacent foreign countries at which magnetic observations had been made up to the end of 1915, together with corresponding reduced values for January 1, 1915; tables used in reducing the results to 1915; tables giving the values of the magnetic elements and components for each full degree of latitude and longitude in the United States; maps showing the lines of equal declination, dip, horizontal intensity, vertical intensity, and total intensity as well as lines of equal annual change of the first three.

The reduction of the observations made at the five magnetic observatories during 1915 was completed and progress was made with the 1916 observations.

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

Observatory data for August 26, 1917, were prepared at the request of Prof. R. F. Stupart, to be used in a study of the severe magnetic storm which accompanied the auroral display of that date.

An isogonic chart of the State of Washington and a collection of the results of declination observations in that State were prepared for Henry Landes for publication in a geographical dictionary of the State.

A table giving the values of the magnetic declination at numerous places in the United States for 1917 was prepared for insertion in the World Almanac.

The results of magnetic observations along the forty-ninth parallel Canadian boundary were tabulated for publication with the report of the Boundary Survey.

Compass data were supplied for 146 charts.

ISSUE OF CHARTS AND COAST PILOTS.

Figure 36 shows graphically how the issue of charts has increased. In actual figures, the number of charts issued during the fiscal year 1916 was 158,303, while the number issued during the fiscal year 1917 was 203,506.

Figure 37 shows graphically how the issue of coast pilots has increased. The number of coast pilots issued during the fiscal year 1916 was 5,602 while the number issued during the fiscal year 1917 was 7,935.

PUBLICATIONS ISSUED DURING THE YEAR.

Serial 32. United States coast pilot, Atlantic coast: Section C, Sandy Hook to Cape Henry, including Delaware and Chesapeake Bays. 284 p., 1 map. 8vo.

Serial 33. Results of observations made at United States Coast and Geodetic magnetic observatory at Vieques, P. R., 1913–14; by Daniel L. Hazard. 102 p., 7 charts. 4to.

Serial 36. Results of magnetic observations made by United States Coast and Geodetic Survey in 1915; by Daniel L. Hazard. 80 p. 4to.

Serial 42. General tide tables for 1917. 489 p., 13 text fig. 8vo.

Serial 43. Atlantic coast tide tables for eastern North America, 1917. 195 p., 13 text fig. 8vo.

Serial 44. Pacific coast tide tables for western North America, eastern Asia, and many island groups, 1917. 144 p. 8vo.

Serial 45. United States coast pilot, Atlantic coast, section E, Gulf of Mexico from Key West to Rio Grande. 169 p., 1 map. 8vo.

Serial 47. Elements of chart making; by E. Lester Jones, Superintendent. (Special publication 38.) 15 p., 20 pl., 12 charts. 8vo.

Serial 48. Supplement to regulations and instructions, January 1, 1913–June 30, 1916. 20 p. 8vo.

Serial 49. Precise leveling from Reno to Las Vegas, Nev., and from Tonopah Junction, Nev., to Laws, Cal.; by H. G. Avers and G. D. Cowie. (Special publication 39.) 49 p., 5 text fig. 8vo.

Serial 50. Investigation of gravity and isostasy; by William Bowie. (Special publication 20.) 196 p., 1 pl., 4 p. of pl., 9 charts in pocket. 4to.

Serial 51. Supplement to United States Coast and Geodetic Survey catalogue of charts, coast pilots, and tide tables, 1916. August 30, 1916. 6 p. 4to.

Serial 52. Inside route pilot: New York to Key West. 3d ed., September 15, 1916. 94 p., 8 litho. 8vo.

Serial 53. Rules governing the issue of original sheets and records. 2 p. 8vo.

Serial 54. Supplement to United States Coast and Geodetic Survey catalogue of charts, coast pilots, and tide tables, 1916. January 2, 1917. 7 p. 4to.

Serial 55. Supplement to regulations and instructions for government of United States Coast and Geodetic Survey. 9 p. 8vo.

Serial 56. Supplement to third edition United States coast pilot, Atlantic coast, part III, from Cape Ann to Point Judith, February 1, 1917. 21 leaves. 8vo.

Serial 57. Supplement to United States coast pilot, Atlantic coast, parts I–II, March 9, 1917. 13 leaves, 8vo.

Serial 58. Supplement to United States coast pilot, Atlantic coast, section D, March 16, 1917. 22 leaves. 8vo.

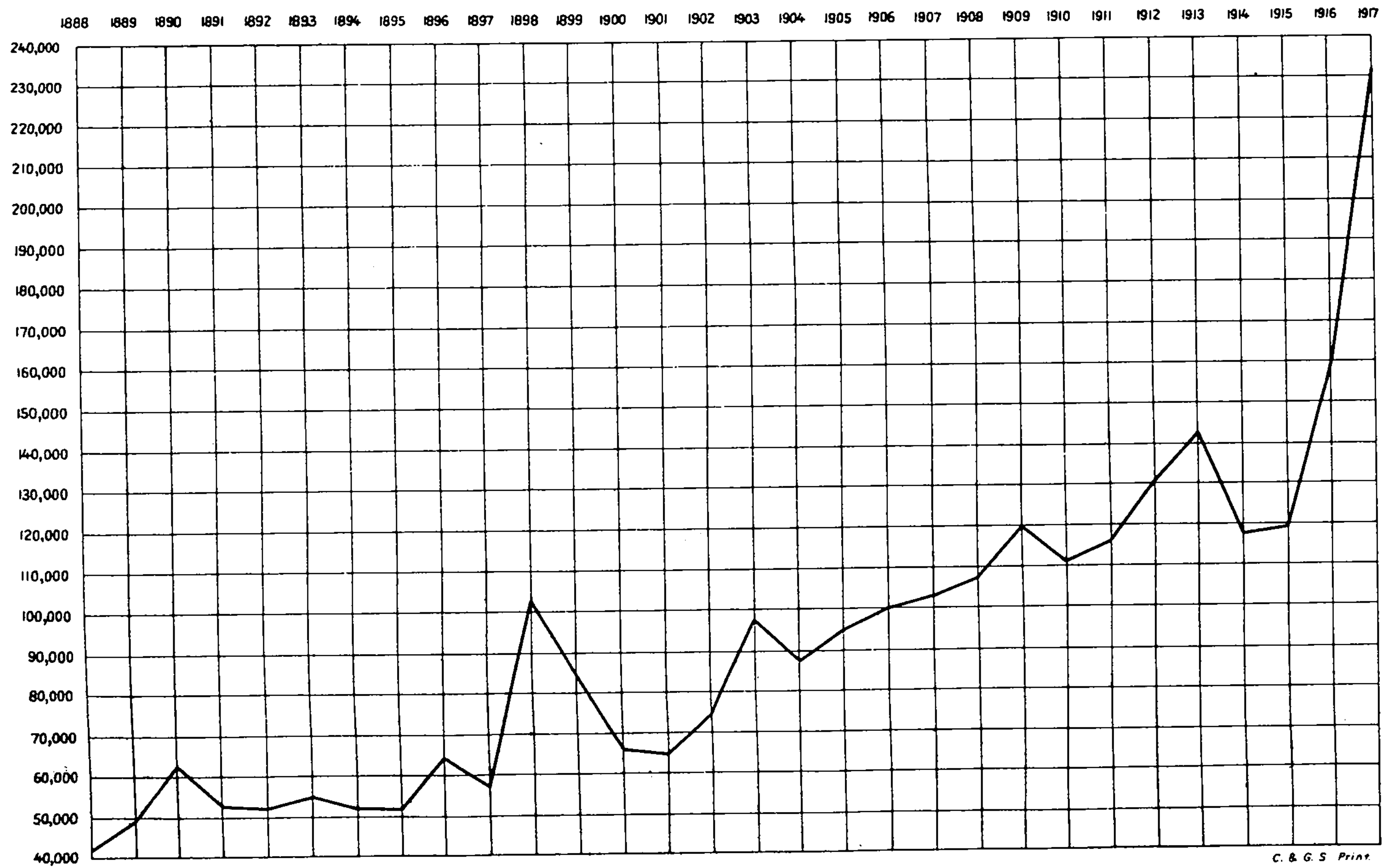
Serial 60. Use of mean sea level as the datum for elevations; by E. Lester Jones, superintendent. (Special publication 41.) 21 p. 8vo.

Annual Report of Superintendent, 1916. 164 p., 20 litho., 33 pl. [Printed also as H. doc. 1489, 64th Cong., 2d sess.] 8vo.

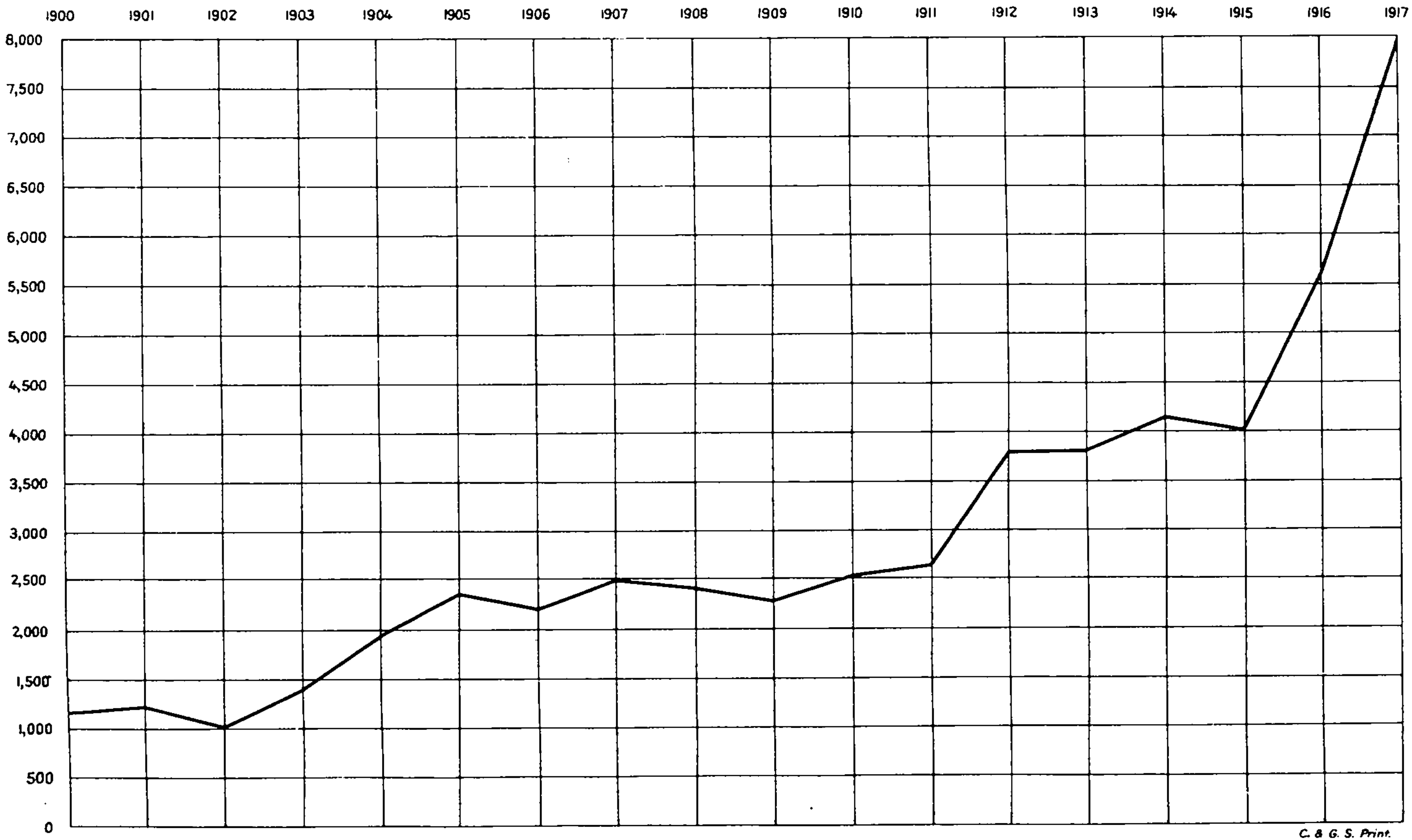
Centennial celebration of United States Coast and Geodetic Survey. 196 p., 42 text fig., 3 pasters. 4to.

Supplement to United States coast pilot, Atlantic coast, section D, Cape Henry to Key West. September 22, 1916. 19 leaves. 8vo.

Tables for a polyconic projection of maps. (Special publication 5, rev. 4th ed., 1917.) 189 p., 1 text fig. 4to.



ISSUE OF CHARTS FROM 1888 TO 1917



ANNUAL DISTRIBUTION OF COAST PILOTS

CHAPTER II.

NEEDS OF THE WASHINGTON OFFICE.

CLERICAL FORCE.

The following are needed:

1. Increase in number of clerks.
2. Increase in entrance salary for clerks.

In the report of the Bureau for 1916 emphasis was laid on the fact that the work is greatly handicapped because of the lack of clerical help. It was also explained that though there is a total of 40 clerks in the Bureau, so many of these are assigned to special duties that the persons really doing clerical work are but 25 in number. Conditions in this respect are the same this year as they were last year. The work of many divisions in the office is seriously handicapped because of the lack of clerical help. In some of the divisions, because this clerical work must be done, it has been necessary to assign other employees to it, with the result that higher salaried employees, with technical qualifications, are performing duties that a clerk at much less salary could do better.

The entrance salary for clerks in this Bureau is $720 per annum. There are six positions at this salary. From the fact that entrance salaries are higher in most other bureaus and departments, a clerk that comes to this Bureau at $720 per annum only remains long enough to qualify for a better-paying position in another bureau or department. The tabulation below shows how this Bureau has lost the services of low-salaried clerks over a period of 11 years, and how conditions in this respect are bettered as the salary scale increases. This table should be carefully studied.

Fiscal year.	Salary, $720.			Salary, $900.			Salary, $1,000.			Salary, $1,200.		
	Appropriated for.	Resigned.	Per cent resigned.	Appropriated for.	Resigned.	Per cent resigned.	Appropriated for.	Resigned.	Per cent resigned.	Appropriated for.	Rseigned.	Per cent resigned.
1907	9	2	22 2/9	3	0	0	3	0	0	8	0	0
1908	7	3	42 6/7	6	0	0	3	0	0	8	0	0
1909	7	1	14 2/7	6	3	50	3	0	0	8	0	0
1910	7	1	14 2/7	6	1	16 2/3	3	0	0	8	0	0
1911	7	2	28 4/7	6	2	33 1/3	3	0	0	8	2	25
1912	6	6	100	10	0	0	5	0	0	8	0	0
1913	6	3	50	10	5	50	5	1	20	8	1	12 1/2
1914	6	2	33 1/3	10	0	0	5	0	0	8	0	0
1915	6	0	0	10	4	40	5	1	20	8	0	0
1916	6	1	16 2/3	10	2	20	5	0	0	8	1	12 1/2
1917	6	4	66 2/3	10	3	30	5	1	20	8	0	0
Average	....	....	35.33+	....	....	21.81+	....	....	5.45+	....	....	4.54+

Fiscal year.	Salary, $1,400.			Salary, $1,650.			Salary, $1,800.		
	Appropriated for.	Resigned.	Per cent resigned.	Appropriated for.	Resigned.	Per cent resigned.	Appropriated for.	Resigned.	Per cent resigned.
1907	4	1	25	3	0	0	2	0	0
1908	4	0	0	3	0	0	2	0	0
1909	4	0	0	3	0	0	2	0	0
1910	4	0	0	3	0	0	2	0	0
1911	4	1	25	3	0	0	2	0	0
1912	4	0	0	3	0	0	2	0	0
1913	4	0	0	3	0	0	2	0	0
1914	4	0	0	3	1	33 1/3	2	0	0
1915	4	0	0	3	0	0	3	0	0
1916	4	0	0	3	0	0	3	0	0
1917	4	0	0	3	0	0	4	0	0
Average	......	......	4.54+	......	......	3.03+	......	......	0

From the foregoing it is evident that the $1,800 positions are the only ones from which there are no resignations; and that inexperienced clerks are constantly coming into the service. After they have been trained by older clerks and chiefs of divisions, and reach a point where they are fairly able to work alone and without constant guidance they become restless and discouraged by the stagnation in promotions and the results are resignations, to enter more promising fields.

It takes a long time and a great deal of instruction to develop the average incoming clerk to the point where he can transact independently the duties assigned him. A large amount of skilled help is wasted in training the novice. The Bureau is crippled and work is retarded as follows:

1. Loss of time in training the new clerk.
2. Loss of time which a trained clerk would give in the same position.
3. Loss of time where the position is vacant and awaiting an incumbent.

It is further evident that to maintain a reasonable degree of permanence in the trained clerical force obstacles to meritorious advancement should be removed, and encouragement to greater efforts to attain the highest specialization should be given. The figures show that now the chance to advance above $1,000 per annum is almost nil, and that painstaking effort is not rewarded.

The great amount of overtime by the clerical force does not make up for the lack of numbers, and many details in the line of efficiency, economy, and output of product have to be either abandoned or partly lost in generalization. The field force has been increased but the clerical force has had no additions which are necessary to dispose of the increased output from the field. Overtime by the clerks for the fiscal year ended June 30, 1917, was 619 days, or an average for each one who worked overtime of 19 days.

Furthermore, the cost of living as well as salaries in commercial life have risen to such an extent that the point has been reached when it is hardly possible to induce anyone to accept one of these positions at $720 per annum.

PRINTERS.

Salaries for the printers in this Bureau are unusually low, and we must obtain better positions in order to retain competent men in the service. Our lithographic draftsmen receive only from $1,200 to $1,400 as compared to the $1,380 to $2,100 paid in the United States Geological Survey. Our lithographic transferrers are paid $1,000 to $1,200, while in the Geological Survey they receive up to $1,920.

Plate printers in the Coast Survey are paid $1,200 per annum. In the Bureau of Engraving and Printing they earn from $3.07 to $9.97 per day.

This great disparity in the salaries paid in this Bureau compared with the higher salaries paid in other technical bureaus has made of our service a training school for other departments. They have drawn on us liberally. This is complimentary but discouraging. We have a force of trained enthusiastic men whom we desire to retain in the service, but by reason of the small salaries we are permitted to pay them they are continually dropping out. Figure 38 graphically expresses conditions.

INSTRUMENT MAKERS.

The art of constructing instruments and apparatus used by geodesists, astronomers, hydrographers, and others engaged in the work of the Coast Survey is one requiring years of training, and at least an elementary knowledge of mathematics, mechanics, physics, etc.

The work is never specialized, such apparatus never being produced in numbers. Each artisan, therefore, must be fully skilled in all branches of the profession.

The instrument makers of the Coast Survey have been much underpaid, as compared with employees in practically all the crafts short of mere factory hands and laborers in private life. This condition also obtained for many years prior to the present war. Under conditions now prevailing, they may be expected to remain in their positions only as various private reasons prevent them from accepting better salaries elsewhere.

For months it has been impossible to fill a vacancy in our force of instrument makers at $1,200 per annum.

NEED FOR HIGHER SALARIES FOR HYDROGRAPHIC AND GEODETIC ENGINEERS.

In my report for 1916 several tables and one diagram shown, contained data comparing the compensation of the hydrographic and geodetic engineers of the Coast and Geodetic Survey, with that of engineers in the Government service elsewhere and in private life.

The appropriation for the fiscal year 1918 made a slight increase in the average compensation of the hydrographic and geodetic engineers, but there is still the necessity for further increase in order that the positions may be made sufficiently attractive to draw young engineers and to hold them after they have been in the Survey a few years and have become familiar with our operations and methods.

For a number of years every man who has passed the aid examination of the Civil Service Commission has been offered a position in the field force of the Coast and Geodetic Survey. Most of them have accepted such positions. It would add to the efficiency of the Survey if, instead of having to offer every one on the civil-service register a position, the appointing officer had a choice of three names from which to select an eligible for the position in question.

There are several reasons why there are not more names on the eligible register for the field positions in the Coast and Geodetic Survey. One is the hardships which must be endured by all who enter the field force. Our engineers must serve anywhere in the United States, Alaska, Hawaii, the Philippines, or our other possessions; it is seldom they have the opportunity to visit their homes more than once a year and then only for a few weeks. When they are in distant parts of the country, it may be several years before they are able to visit their homes. In no case can they expect to have the home life that most men desire. The work done by the engineers is generally in out-of-the-way places, where the surroundings are not such as would appeal to the average engineer.

Promotion is slow in the service and our engineers are inclined to leave the Government service after a few years to seek employment in more remunerative fields. In nearly all cases those who have left the Survey have in a very short time increased their compensation beyond what would have been possible had they remained in the service. Another reason for dissatisfaction among our engineers is that, while promotion is slow, they can not look forward even after many years' service to a compensation which is comparable to that paid by other engineering bureaus of the Government, for the maximum compensation is far below that received by engineers of equal training and experience. (See fig. 39.) The two upper curves of this diagram are copied from an illustration which appeared in a report dated December, 1916, of the American Society of Civil Engineers. All of the engineers of the Coast and Geodetic Survey who have had a few years' experience in its service are eligible for membership in the American Society of Civil Engineers, and therefore it is just to compare the salaries received by our engineers with those received by members of the American Society of Civil Engineers in other branches of the Federal service and in private life.

Still another reason for dissatisfaction among our engineers is the fact that they are not able, during their active service in the Government, on account of the small compensation received, to lay by a competency for their old age. There is yet no provision of law which makes it possible to place our engineers on a waiting list with pay, such as is done in some services, and therefore our engineers as they become old and incapable of performing field work efficiently are reduced in salaries and placed on work which, though light, is still more than men of advanced years should be required to do. If they are unable to do any work, they are dropped from the service without any further pay.

After considering some of the causes for our engineers leaving the service, it is evident that some measures should be provided to add to the stability of the engineering force of the Survey and thereby increase its efficiency. The remedies appear to be increased average compensation and more rapid promotions, also some provision for compensation after the active years of their life have passed. I expect to treat of the matter of more rapid promotion and retirement

Comparison of Salaries

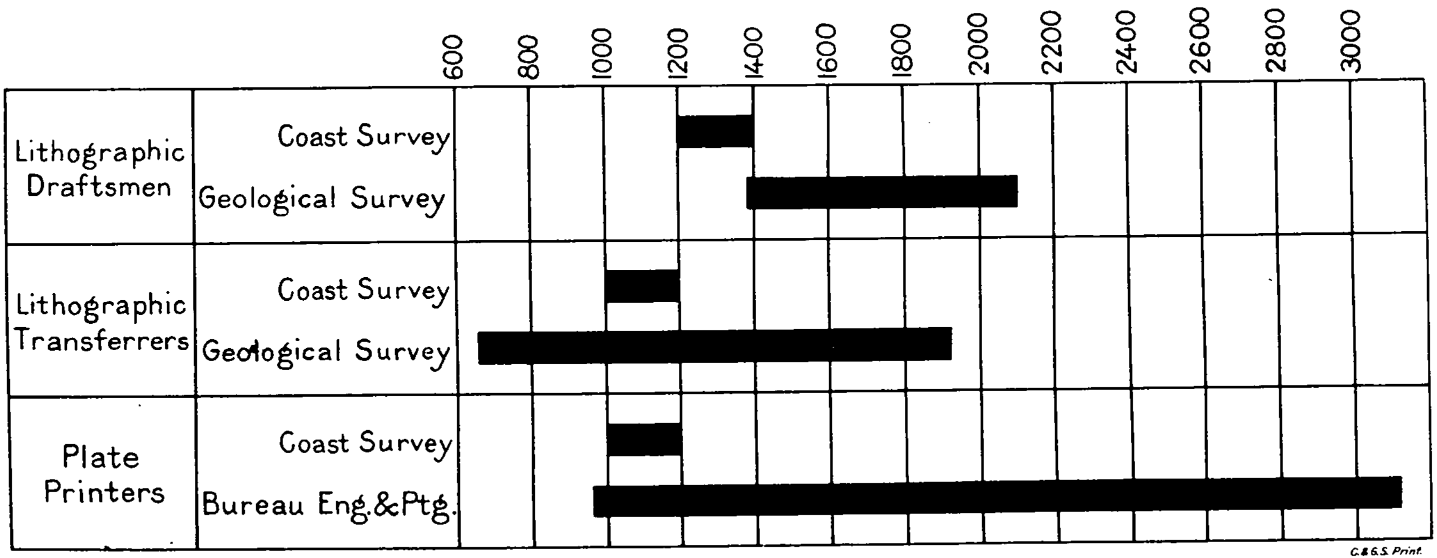
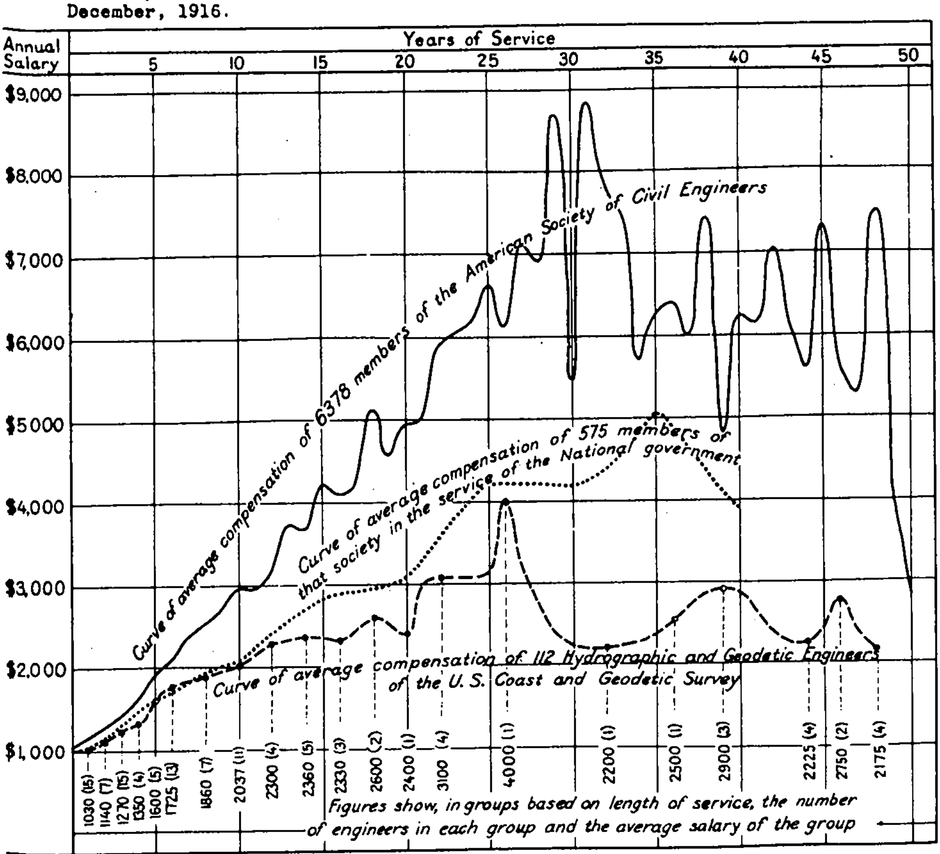


Diagram of average compensation of hydrographic and geodetic engineers of the United States Coast and Geodetic Survey, compared with the average compensation of 6,378 members of the American Society of Civil Engineers, as analyzed in a report of a committee of that Society, published in December, 1916.



The requirements for admission into the U. S. Coast and Geodetic Survey are such that practically every officer of the engineering force of that service is eligible for membership in the American Society of Civil Engineers. Therefore, the compensation of the hydrographic and geodetic engineers of the Coast and Geodetic Survey is fairly comparable with the compensation of the members of the American Society as analyzed graphically.

C. & G. S. Print

pay in a later report. Here, I am placing emphasis on the necessity of providing, at the coming session of Congress, for additional positions which will slightly increase the average compensation of the engineers. There is no doubt whatever of the necessity for having more engineers in order to carry on efficiently the work of the Bureau, which is so vital to the industrial and commercial development of the country. When additional places are provided for, the new positions should be placed in the higher salaries, rather than in the lower ones which are now overloaded.

NEED FOR ADDITIONAL DRAFTSMEN.

I laid great emphasis in my last annual report on the statement that the need of additional draftsmen was more pronounced than ever before. As no additional draftsmen have been provided, this statement is still true, but the situation is more serious on account of the accumulation of another year's results to be handled by an entirely inadequate force already in arrears.

It is thought that the failure to obtain an increased force of draftsmen arises from a misconception of the amount and character of chart construction work and the qualifications required of the men who do it.

The impression which prevails to a large extent that when the field results are received in the office they need little more than fine penmanship to make them ready for publication, is not correct. In most cases the plotting and verification of the results of a hydrographic survey requires as much time by an expert in the office as is required in the actual soundings in the field. For wire-drag work the office work consumes more time. Nor is the field sheet when completed in a form suitable for publication for two reasons: The soundings are too numerous and the scale too large for convenient use by the navigator. In fact, a chart contains the information compiled from a number of field sheets, both hydrographic and topographic. The selection of the proper soundings to adequately represent the underwater features of the chart, to emphasize the important features on land, and to generalize the less important, is the work of an expert who has had years of training based on a thorough technical education.

The fine penmanship is the final step in chart construction. It is employed in making a smooth copy of the compiled drawing, if it is decided not to reproduce the latter by an engraved plate. Twenty per cent of the drafting force is assigned to complete and verify the hydrographic sheets of the field parties, whereas double the number are necessary to keep from being in arrears. With the increase of the field force and increased appropriations for field work the disparity between the results to be charted and the draftsmen available to handle it will be greater than ever.

Besides the compilation of new charts for hitherto unsurveyed areas, there is a great mass of material which has to be handled to keep the existing charts up to date. The importance of this new information will be recognized when it is understood that it includes the data concerning the changes caused by all the vast river and harbor improvements in tidal waters, the changes which occur in the great system of lights and buoys on our coasts, and the numerous reports from other sources of changes in our navigable waters. With respect to the river and harbor improvements, the average number of blue prints received from the United States Engineers in 1915–16, each one the result of a survey, amounted to 475 a year.

Reports from other sources of changes in navigable waters include the surveys from State and municipal engineers.

In 1916 the United States Lighthouse Service maintained in the tidal waters of our coasts over 10,000 lights, beacons, and buoys. Besides keeping track of the constant changes incident to such a large system, our charts are affected by the changes occurring in the Philippine Islands, Canada, Mexico, Central America, and Cuba.

The compilations and drawings of the corrections for keeping the charts up to date require the service of 25 to 30 per cent of the drafting force. Only 10 per cent of the force can be assigned to the preparation of the smooth chart drawings.

What may be termed the "miscellaneous work," which includes constructing field projections, the preparation of original sheets for photographic reproductions, miscellaneous tracings and diagrams, occupies on an average of 20 per cent of the drafting force.

When it is understood that there are between 400 and 500 chart proofs verified a month, in the course of their being printed, it will be recognized that there are few men available for the preparation of new charts, or the reconstruction of our older series of charts which have such objectionable features as two-depth units and skew projections. Also the series of southeastern Alaskan charts are based on very imperfect control.

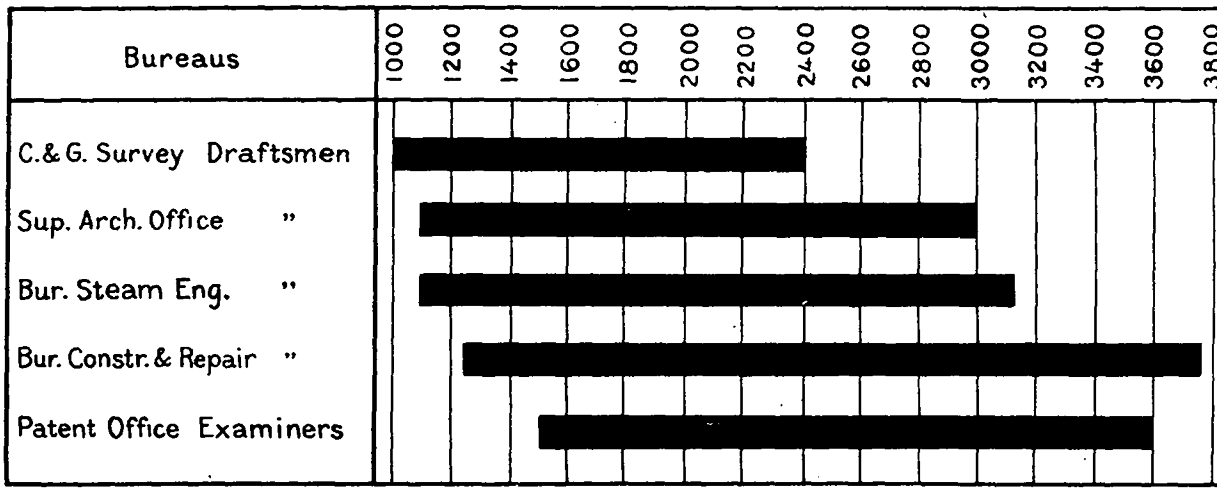
The question of salaries is closely bound up with that of increases of force. Without adequate entrance salaries and a reasonable prospect of promotion, we can not obtain or retain men who have had the requisite technical training to comprehend the operations in the field and to interpret and combine the results of field operations.

To state the foregoing in briefer form, the drafting section digests and prepares for publication the information which appears on new charts, new editions of charts, or as corrections to new prints to keep them up to date. Its work, therefore, is one of the most important links in the chain of operations required for chart production. A chain is no stronger than its weakest link, and the present force of draftsmen has been inadequate to handle the material directly affecting our charts so as to place it before the navigator with the expedition which its importance demands.

As stated, the present force was inadequate under former conditions. The increase in the field force and the increased appropriations for field work provided for the present fiscal year will render still greater the disparity between the information to be charted and the draftsmen available to handle it.

In order that our draftsmen may fill their positions successfully, besides the necessary manual skill, they must have the technical training comparable to that of a civil engineer. This technical training is necessary for them to comprehend the methods employed by the parties in the field, so that they can interpret the results furnished by the triangulation, the topographic and hydrographic parties, and from this complex mass of material extract the essential data which, when skillfully combined, produce the nautical chart. (See fig. 40.)

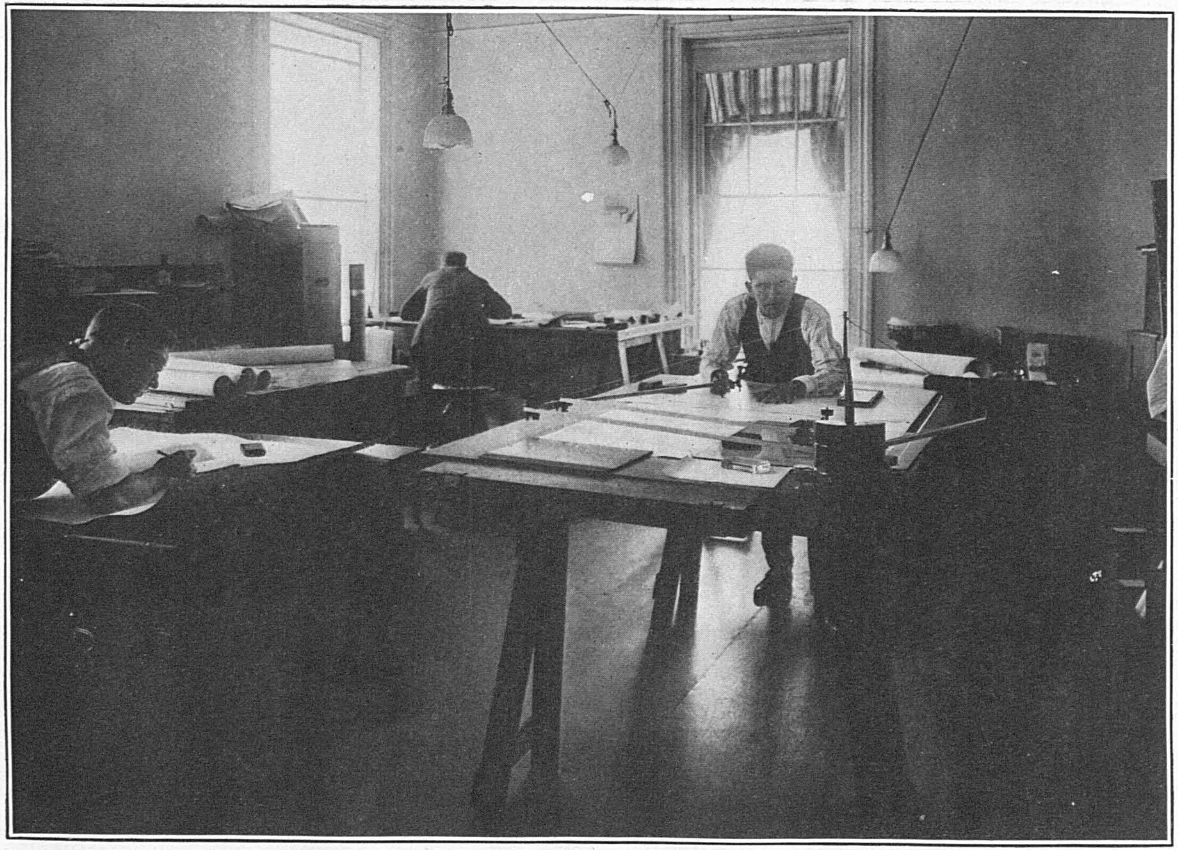
Comparison of Salaries of C. & G. Survey Draftsmen with Salaries paid Employes of similar technical requirements in other Bureaus. Entrance and Maximum Salaries shown in each case.



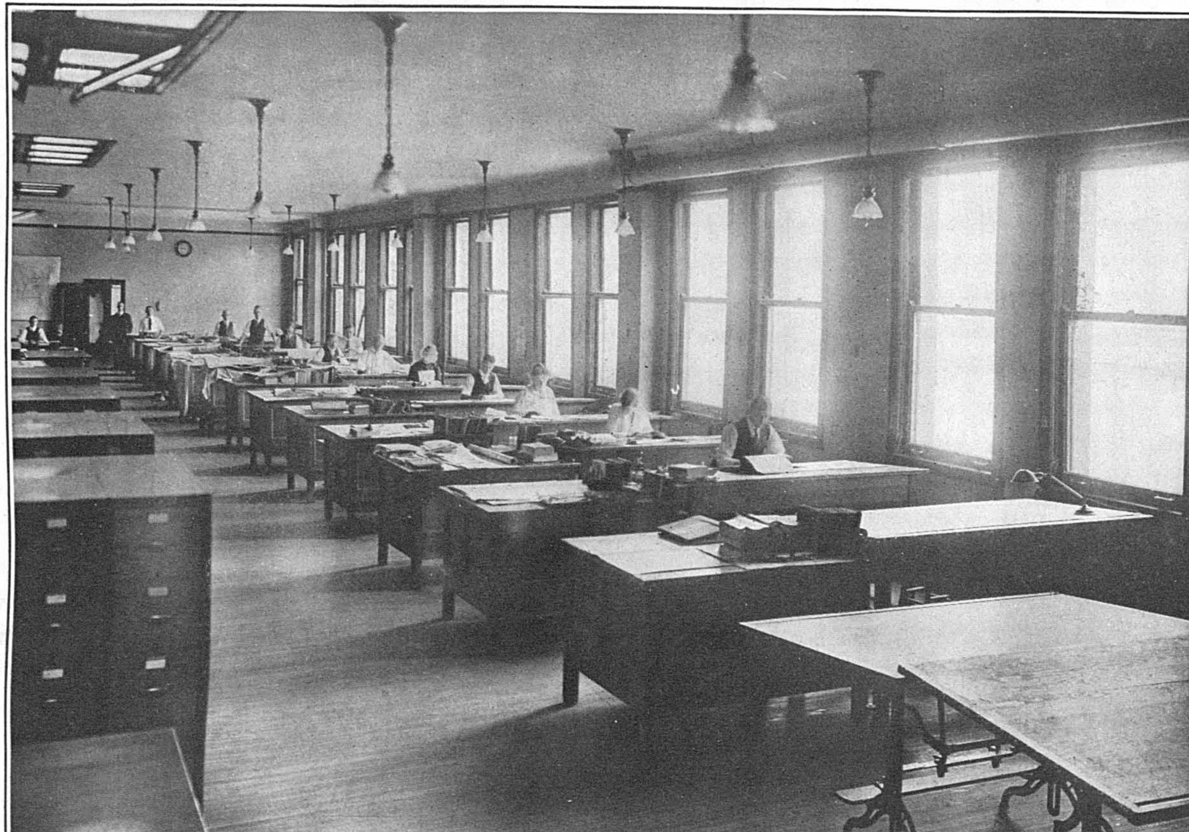
Average salary of C. & G. Survey draftsmen – $1700

Average salary of the others shown in this diagram – $1957

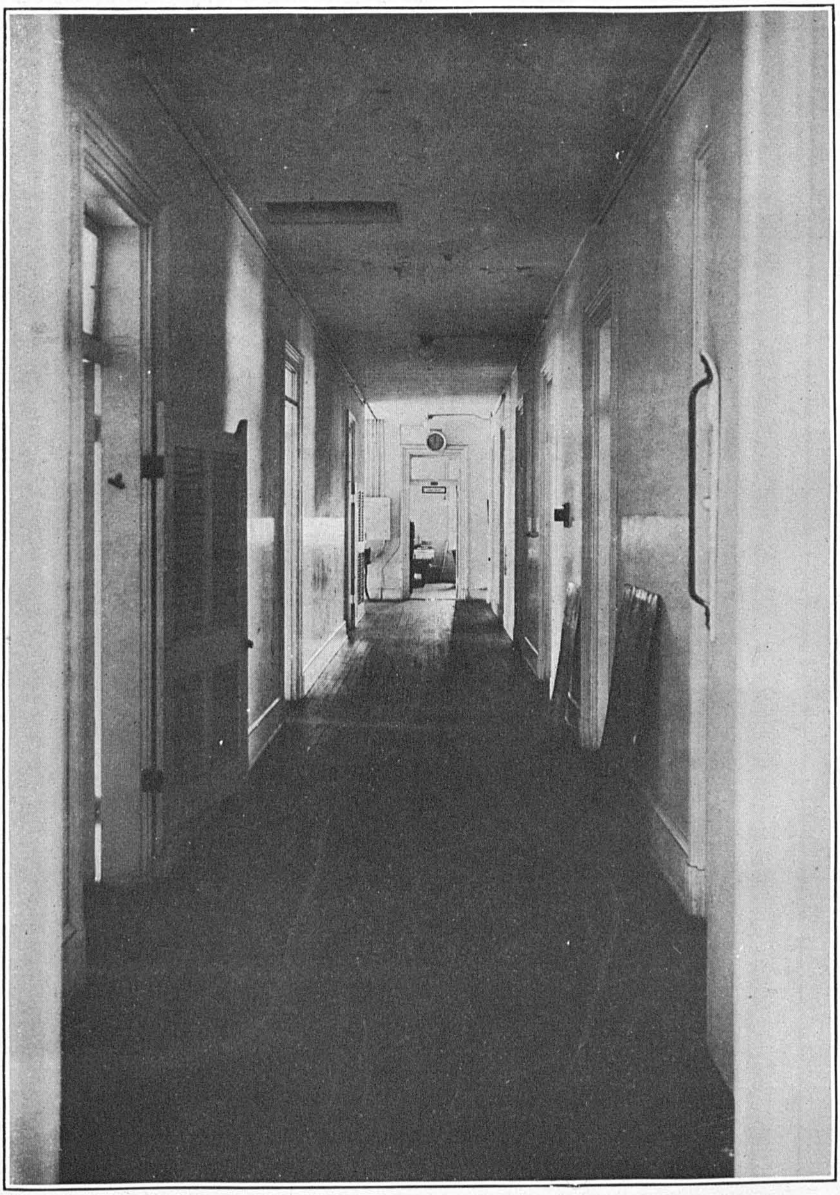
C. & G. S. Print.



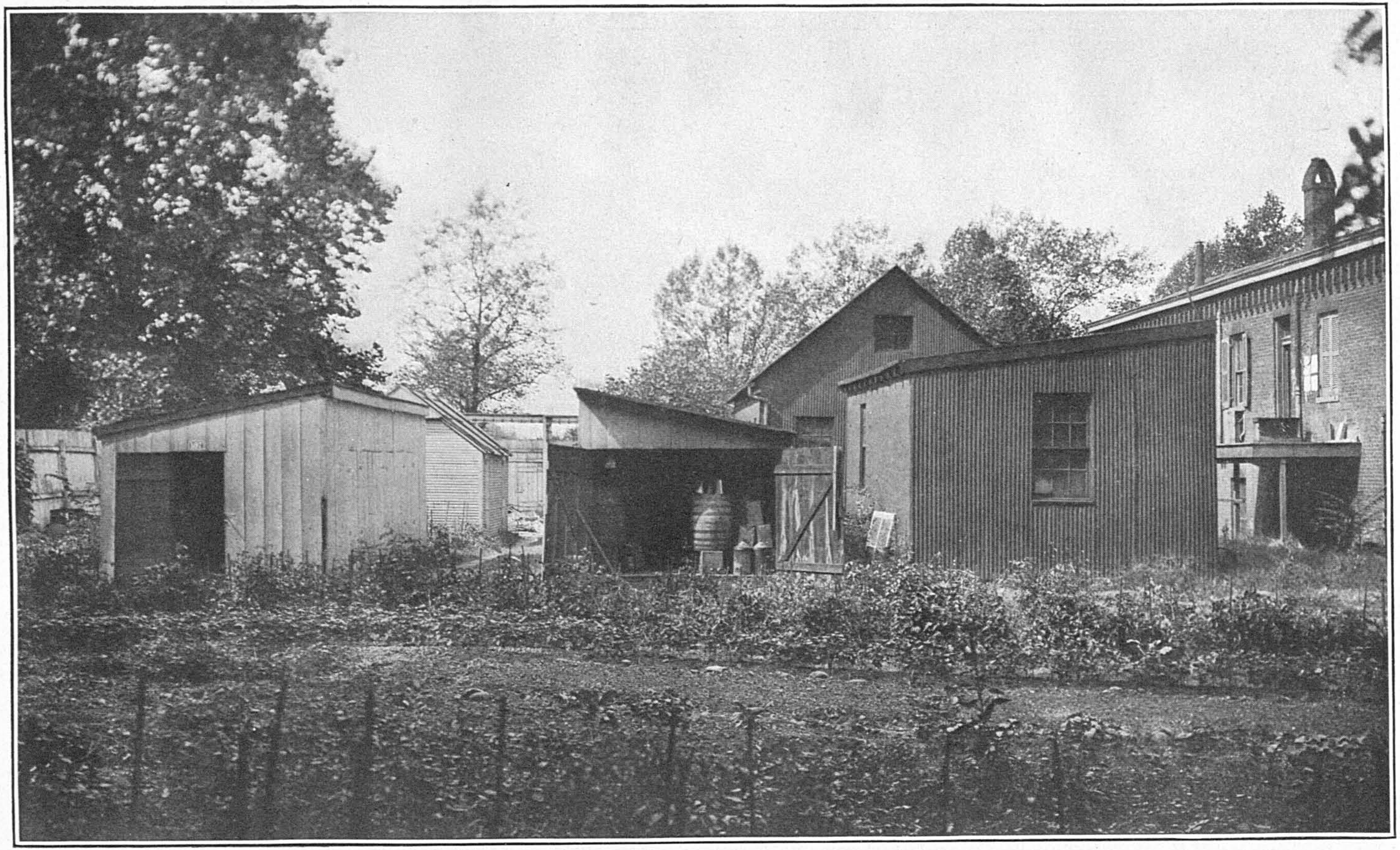
COAST AND GEODETIC SURVEY DRAFTING ROOM.



MODERN DRAFTING ROOM.



INTERIOR VIEW OF BUILDING OCCUPIED BY DRAFTSMEN.



COAST AND GEODETIC SURVEY OUTBUILDINGS.

INTERIOR VIEW OF STOREROOM IN OUTBUILDINGS.

It is absolutely necessary to increase the force in all departments alike, otherwise congestion is bound to result in those which are not provided for, thereby tying up all work.

IMPROPER QUARTERS IN WHICH THE BUREAU IS HOUSED.

In my last year's report I called attention to the fact that the progress of the work in the Washington office of this Bureau is greatly retarded owing to the unsuitable quarters in which the Bureau is housed. The buildings, one constructed for a residence and the other for a hotel, are wholly unsuited as a place in which to carry on the work of the Bureau, and they are becoming more and more so as records accumulate, and the personnel increases to overflow the already cramped quarters.

Under these conditions, there is constant danger of loss by fire on account of the combustible materials of which these buildings are constructed. These buildings require that a great deal of labor be expended daily to keep them in a sanitary condition, and then the results are not all that are desirable. Because of the lack of room, it is necessary to utilize every available room for the personnel of the Bureau, consequently there is no available space for the installation of facilities and equipment for keeping the buildings in a sanitary condition.

The rooms are small, and in order to secure necessary natural light for engravers and draftsmen, those rooms most favorably located to afford this light must be selected for these employees. As such rooms are widely separated, the drafting and engraving force is scattered throughout the buildings which makes it impossible for the chief draftsman and the chief engraver properly to supervise the work of these employees; and the output is greatly lessened because of the inconvenience of consulting various records and data that are necessary to be used in common by all of the draftsmen or all of the engravers. And even with the force so divided to place each draftsman where the best natural light is available all that is desirable is far from being accomplished. See figure 41, which is a fair representation of conditions in these small rooms in which lack of space prohibits the installation of the proper filing facilities for records that must be constantly consulted in addition to poor light. From the lack of room for expansion, two or three drafting tables and a pantograph must be crowded into a room which affords but light sufficient for one drafting table. See figure 42, which shows what is desirable in the way of natural light for draftsmen and facilities for filing records which are constantly consulted in the work. This is impossible of attainment in the buildings in which the Bureau is housed. The rooms are too small as they are, and the building too weak to permit structural alterations. (See fig. 43.)

In the course of time, as the Bureau has outgrown its quarters, as temporary expedients, small buildings have been put up adjoining the main buildings, largely for the storage of field equipment, lumber, etc. While these answered the purpose for the time being, the work of the Bureau has increased to such an extent that these small buildings are no longer adequate for the purpose, and they are so crowded with equipment that it is impossible to store things in an orderly manner and make them accessible when needed. See figures 44 and 45 which throw some light on existing conditions.

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

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY.

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

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

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

FIELD WORK, ATLANTIC COAST.

The steamer *Bache* was employed from July 1 to January 9 on a hydrographic and topographic resurvey of the approaches to Hampton Roads, Va., from Cape Henry to Sewalls Point. During a large part of this time the vessel was at Norfolk undergoing extensive repairs, including a new spar deck, while the field work was being done by detached parties living on shore. From December 11 to 14, the *Bache* was one of the fleet of Department of Commerce vessels at the Southern Commercial Congress at Norfolk, Va.

From January 17 to May 26, the *Bache* was employed on offshore hydrography extending out to the 100-fathom curve on the coast of Georgia in the approaches to the Savannah River. This season's work of the vessel completes the offshore hydrography from Winyah Bay, S. C., to Matanzas Inlet, Fla.

From May 26 to June 30, the *Bache* was laid up at Norfolk owing to a shortage of funds, and the officers were employed in the completion of the field records of the offshore work or assigned to other duty.

The steamer *Hydrographer* was employed from July to October on a topographic and hydrographic resurvey of the coast of the Delta of the Mississippi River between Pass au Loutre and South Pass where it was found that owing to a deposit by the river dry land existed where depths of 10 fathoms were shown on the chart.

From November to May 7, a comprehensive resurvey was in progress of the inland waters from Lake Pontchartrain to Mississippi Sound as far east as Pascagoula by the party on the *Hydrographer* and by detached parties living on shore.

During March and a part of April, the vessel was at Mobile, Ala., undergoing repairs, which included the installation of an electric-light plant.

From May 7 to June 22, the vessel continued work in the approaches to the Mississippi River. The detached parties continued work in Mississippi Sound until May 23, when they were disbanded for lack of funds.

The steamer *Isis* was at Norfolk undergoing alterations and repairs from July to December 20, when she came to Washington to have the radio apparatus installed. While repairing at Norfolk, a number of the officers were transferred to the *Bache* to assist in the hydrographic and topographic survey of the approaches to Hampton Roads.

From December 11 to 14, the *Isis* was one of the fleet of Department of Commerce vessels at the Southern Commercial Congress at Norfolk, Va.

From January 6 to April 30, the vessel was employed on offshore hydrography extending out to the 100-fathom curve on the coast of Florida for a distance of 40 miles south from a point 5 miles south of the St. Johns River.

The vessel was laid up at Norfolk from May 2 to June 30, because of a shortage of funds, during which time some minor repairs were made and the office work of the past season's records was completed.

The schooner *Matchless* completed the resurvey of the easterly side of Pamlico Sound from Ocracoke Inlet to the vicinity of Cape Hatteras, and Little River, Perquimans River, Yeopim River, Bull Bay, and Scuppernong River, tributaries to Albemarle Sound, N. C.

Repairs were made at Elizabeth City, N. C., during a part of the winter.

From May 4 to June 8, the vessel was laid up at Elizabeth City due to a shortage of funds, during which time minor repairs were made to the vessel.

Wire-drag party No. 1 completed the survey of the northerly approach to Boston Harbor, between Nahant and Cape Ann. Current observations and chart revision work were done in conjunction with the wire-drag work.

A striking feature of this wire-drag work is the large area covered in spite of the unusually numerous changes from the charted depths that were found. The party was able to accomplish this result by taking advantage of the best weather to drag the exposed, deep-water areas while the inshore work was done during less favorable weather. The deep-water work was expedited by the use of a drag 15,000 feet long, towed by two launches, and several records were made with this exceptionally long drag.

An area of about 200 square miles was examined with the drag and in this area nearly 300 changes were discovered. The importance of a large number of these shoals, because of their danger to navigation, can not be fully appreciated without an examination of the chart, especially in the entrance to Salem Harbor and in the vicinity of Thatcher Island.

In a letter reporting that the field work of his party had been completed, the chief of this party stated:

> In spite of the many years spent by me on wire-drag work, I consider the work done since October 1 in Salem Harbor and approaches to be the most striking example of the need for and the possibilities of wire-drag work on a coast that has been navigated for 300 years.

The work was resumed during May and June, 1917, in the approaches to Portsmouth Harbor, N. H.

Wire-drag party No. 2 continued the survey of Cape Cod Bay between Plymouth and Cape Cod Canal. It was found that the bowlder formation which resulted in the discovery of numerous uncharted rocks between Plymouth and Cape Ann does not extend south of Plymouth Harbor, and the work progressed rapidly, being completed on August 16.

This party then took up the survey of Block Island Sound in the vicinity of Montauk Point and including Gardiners Bay. During the season a subparty made a hydrographic and topographic resurvey of Plymouth Harbor, Mass., and the hydrographic and topographic survey of Fort Pond Bay was revised. The work was resumed during May and June, 1917, in Block Island Sound in the approaches to Narragansett and Buzzards Bays.

Wire-drag party No. 3 was organized at Key West in the latter part of April, 1917, and has been employed during May and June on a comprehensive survey of the Florida Reefs.

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

A shore party was engaged from August 18 to December 5, 1916, revising the topography and triangulation of Long Island from Matinicock Point to Eatons Neck including Oyster and Huntington Bays.

A party using chartered launches completed a comprehensive tide and current survey of the westerly part of Long Island Sound from Execution Rocks to New Haven, during the period from August 5 to November 10, 1916. Currents were observed for 51 hours each at important stations in the sound and the principal tributaries.

Automatic tide gauges were maintained at selected stations during the work, staff gauges were operated for short periods at numerous other stations, and approved bench marks were established for all stations and connected up with all previous work of this character which embraced a number of years' observations. On May 24, 1917, this work was resumed in Long Island Sound.

A revision party using a chartered launch was employed in supplementing the hydrography along the shores of Long Island Sound from July 26 to November 23, 1916. The party completed the inshore hydrography from Norwalk Island to Black Rock Harbor on the north side of the sound and from Eatons Neck to Oak Neck Point on the south side of the sound, including Huntington and Oyster Bays and tributaries. Numerous uncharted rocks were found and the safety of navigation was greatly promoted for the great fleet of small craft navigating these waters.

Revision surveys for the location of prominent natural objects and building and locating tall hydrographic signals were made on the coast of Georgia and Florida from October 23, 1916, to March 22, 1917. This work was done by shore parties for the use of the *Isis* and *Bache* in the offshore hydrographic work.

The field revision of the Inside Route Pilot from New York to Key West, which had been made as far as St. Augustine on July 1, 1916, was completed on July 13, 1916.

At the request of the Navy Department, an officer of the Survey revised the speed trial course at Provincetown, Mass., by shifting the ranges, erecting new beacons and verifying the length. This work was done between July 26 and September 20, 1916.

Suboffices of the Survey, each in charge of a field officer of this Bureau, were maintained at New York and Galveston. A stock of charts and other publications of the Survey was kept on hand for consultation by the public and for sale. During the year, a clerk has been assigned to the suboffice at New York, which enabled the field officer in charge to execute some field work within his district. In addition to collecting and giving information, the officer at Galveston has cooperated with the Steamboat-Inspection Service by examining many seamen for certification in compliance with the seamen's act.

FIELD WORK, PACIFIC COAST.

A shore party using a chartered launch made a hydrographic and topographic resurvey of San Diego Bay from November, 1916, to February, 1917. The previous surveys of parts of this area were made 60 years ago, and local interests in requesting the survey stated that because of enormous floods during 1916 the depths in parts of the bay had entirely changed.

Wire-drag party No. 4 surveyed San Francisco Bay and the Golden Gate from November 16, 1916, to March 17, 1917. In addition, a topographic revision of the bay was begun. A pinnacle rock with a least depth of 29 feet at mean low water was found about one-third of a mile westward from the former position of Shag Rock, where a least depth of 46 feet was shown on the chart.

At the request of local interests, an officer of the Survey made a hydrographic resurvey of the west side of San Francisco Bay in the vicinity of Point San Bruno from May 21 to June 17, 1917.

A shore party using a chartered launch was employed from February 5 to April 16 on a comprehensive tide and current survey of Puget Sound southward of Seattle.

Currents were observed from the launch anchored at important stations in the sound and by the tide observers from wharves.

Automatic tide gauges were maintained at selected stations during the work, staff gauges were operated for observing during periods from 60 to 96 hours at 18 subsidiary stations, and approved bench marks were established for all stations and connected up with all previous work of this character, which embraced a number of years' observations.

At the request of the Navy Department, currents were observed in Richs Passage by the parties from the steamer *Explorer* from March 16 to April 13, 1917.

Wire-drag party No. 3 was employed from November 18 to March 8 on surveys in the vicinity of the Puget Sound Naval Station. A wire-drag survey was made of the principal channels, a lead-line development was made to complete the hydrography of the principal tributaries, and the triangulation and topography in the vicinity of Port Orchard were revised to bring them up to date.

A shore party was employed from April to June, 1917, on a revision of the triangulation, topography, and hydrography in the vicinity of Seattle. To the close of the fiscal year, the work in the vicinity of the new waterway joining Shilshole Bay with Lake Washington was completed. At the request of the Navy Department, the submarine trial course at Port Townsend was verified and re-marked.

A field revision of the Pacific Coast Pilot, California, Oregon, and Washington, was made from June to October, 1916. In the course of this revision, the entire coast was covered and a special study was made of the unusual conditions affecting navigation on that coast.

FIELD WORK, ALASKA.

The steamer *Patterson*, during the summer of 1916, was employed in southeast Alaska on the survey of the passages leading southward from Sumner Strait. The charts of this locality were based on a reconnoissance made by the same vessel in 1886. The *Patterson*, in cooperation with the wire-drag parties, was intended to furnish continuous and complete surveys for all passages between Clarence Strait and Eastern Passage. The vessel was on the working ground until October 24, 1916.

The triangulation included a secondary scheme through Snow Passage, connecting previous work in Clarence Strait with that in Sumner Strait; tertiary triangulation through Kashevarof Passage from Coffman Island to Tide Island; location by tertiary triangulation of many intersection points for control of the topography in Clarence Strait between Point Harrington and Ernest Sound and which was carried into Rocky Bay and McHenry Inlet; and tertiary triangulation in Ernest Sound and Zimovia Strait from Clarence Strait to Blake Channel and Chichagof Pass.

The topography was completed for Kashevarof Passage, Kashevarof Islands, and Whale Passage from Lake Bay to Point Colpoys. The west shore of Etolin Island from Point Harrington to Onslow Point and Stone Islands has been completed, except Mosman Inlet and the lower end of Burnett Inlet. Some topography was also done in Zimovia Strait and from Wrangell to Point Highfield.

The hydrography includes Kashevarof Passage, Whale Passage, the west shore of Etolin Island from Point Harrington to Mosman Point, McHenry Inlet, and some work in Zimovia Strait and around Point Highfield.

The *Patterson* arrived at Seattle on October 31, was laid up and her crew reduced. Repairs were made during the winter. On April 25 the vessel left Seattle for the field of work in southeastern Alaska, which embraces the entrance to Cross Sound and the unsurveyed outer coast of Chichagof Island. On May 24 the rudder of the *Patterson* was disabled by striking an uncharted rock in the entrance to Lisianski Strait. Repairs were effected at Juneau and the vessel resumed work about the middle of June.

The steamer *Explorer*, during the summer of 1916, was employed in southeast Alaska on a comprehensive survey of the unsurveyed outer coast from Cape Muzon to Meares Passage. The bottom in this locality was found to be exceedingly broken, and the dangers rose abruptly from depths of about 50 fathoms.

The weather was very unfavorable for the work of the ship, there being a great deal of fog and it being necessary to observe on the mountain peaks for signals. Three detached parties were generally kept in the field, and these were located so as to take advantage of parts of days when work could be done.

The topography accomplished includes the completion of the entire coast from Cape Muzon to a junction with previous work in Meares Passage. By means of triangulation stations on Wolf Rock, Lowrie Island, and Forrester Island, points were determined at frequent intervals along the coast to control the topography, and mountain peaks were located in the same way for the control of the offshore hydrography. The triangulation was also connected with that of the inside passage through Meares Passage.

The hydrography accomplished includes the indentations of the coast and the offshore work westward to a north and south line extending through Forrester Island and Wolf Rock from the parallel 4 miles southward of Cape Muzon to a junction with the work previously done at the entrance of Meares Passage. The part of the work northward of Cape Augustine, however, will require additional development.

The vessel was laid up at Seattle with a reduced crew and repairs were made at Seattle during the winter.

At the request of the Navy Department, currents were observed and some hydrographic work was done in Richs Passage in the approach to Puget Sound Naval Station.

After outfitting at Seattle, the vessel sailed for southeast Alaska on May 1, and during the balance of the fiscal year resumed the surveys of the outer coast of southeast Alaska northward of Cape Muzon.

The steamer *Taku* surveyed Orca Inlet and the delta approaches from southeastward for the use of fishing vessels and small craft employed in that vicinity. The triangulation was carried along the flats for a distance of about 15 miles eastward from Point Whitshed, and included the location of the radio towers on the point and the new radio station about 10 miles eastward of Cordova.

The hydrography included Orca Inlet from Cordova to Hawkins Island Cut-Off, Roswell Bay, and the flats inside of the outer islands for a distance of about 15 miles eastward from Point Whitshed. The inlets at Point Bentinck and Egg Island were developed and the 10-fathom curve on the outside of the flats was located for most of this stretch.

The topography included the shore from Cordova southward to and around Point Whitshed, Boswell Bay, Point Bentinck, and the outlying sandy islands for a distance of about 15 miles eastward of the point. A subparty surveyed the Orca Military Reservation, which included the tributaries and north shore of Orca Bay from its head down to and including Sheep Bay, and the greater part of Hawkins Island northward of Canoe Pass. For this survey contours of 50-foot intervals were determined with more than usual care, and numerous stations were established and marked for future use.

The *Taku* was laid up at Cordova, Alaska, during the winter and the party returned to Seattle.

The party returned to the vessel and on May 2, 1917, repairs were begun, preparatory to resuming work in Prince William Sound. After the completion of repairs, the party took up triangulation, topography, and hydrography in the northwest end of Prince William Sound.

The steamer *Yukon* has been laid up at King Cove, Alaska Peninsula, during the entire year. In June, 1917, a party was organized to repair the vessel for field work in the vicinity of King Cove.

Two wire-drag parties were employed on the Pacific coast during the fiscal year, the working season in Alaska embracing the periods from July 1 to about the middle of October, 1916, and from about the middle of April to June 30, 1917. Both parties had a very satisfactory season, and the importance of the results accomplished can hardly be overestimated. The extent to which navigation in this region has been safeguarded by the discovery of uncharted shoals can hardly be realized without a glance at the charts affected.

In addition to the wire-drag work, the parties have carried out an extensive scheme of triangulation and topography and have obtained valuable current and tidal observations. Another feature of the work has been the close and successful cooperation between the wire-drag parties and the party of the steamer *Patterson*.

Wire-drag party No. 3 began work in Clarence Strait and carried the work systematically up this important waterway until all the open water between the limit of the previous season's work and Zarembo Island had been dragged, after which work was begun in the exposed parts of Ernest Sound. This work was carried to Eaton Point on Cleveland Peninsula during the season, and the survey of Kashevarof Passage was completed. Chichagof Pass and a part of Stikine Strait were also dragged.

Wire-drag party No. 4 began work near the eastern end of Sumner Strait, connecting with the work of the 1915 season. This work was later joined by the work of party No. 3 at the north end of Clarence Strait. Considerable work was also done at the southern end of Sumner Strait during the first part of the season. From the eastern end of the strait the work was carried along the channel between Mitkof Island and Zarembo Island to the entrance of Eastern Passage. A junction was effected with the work of party No. 3 in Stikine Strait and at the eastern end of Chichagof Pass. Eastern Passage and Blake Channel were dragged and, during the last month of the season, the work was extended through Bradford Canal and the main channel of Ernest Sound to Point Peters on the south end of Deer Island.

FIELD WORK, PHILIPPINE ISLANDS.

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

The five vessels of the Survey have been kept at work in the field as continuously as possible, being absent from the field only for the purpose of renewing coal and other supplies and having the necessary repairs made. In the item of party expenses, the continued advance in the price of coal has further increased the cost of the work, as mentioned in the last report.

The steamer *Pathfinder* closed operations in the vicinity of Balabac on July 10, 1916. From August 4 to October 17, combined operations were carried on in the vicinity of Polillo Island. Repairs were made at Olongapo from October 22 to November 29. On December 7, the vessel proceeded to Balabac and continued general surveys until January 10, when she returned to Manila. From January 17 until April 30, she was undergoing extensive repairs at Olongapo Naval Station. The balance of the year the *Pathfinder* was engaged in general surveys at Polillo Island to facilitate the mining of coal recently discovered in that locality.

The steamer *Fathomer* was at Manila undergoing repairs until September 11, 1916. From September 13 until January 29, she was surveying the Busuanga Islands, the vessel engaged in hydrography and a detached party executing the topography. From February 1 to March 17, the vessel was at Manila for general overhauling and repairs, and then returned to Busuanga Islands on March 21, when the survey of those islands was resumed and was in progress until about the close of the fiscal year; the principal work this season has been launch and ship hydrography.

The steamer *Romblon* was employed from July until December among the Cuyo Islands, except from August 3 to September 18, when the vessel was at Manila for repairs. This work, which was principally hydrography, was closed on December 19; after a brief visit to Manila the vessel left for the south end of Palawan Island where combined operations have since been carried on.

The steamer *Marinduque* continued work on the east coast of Palawan Island until December 15. This work was greatly handicapped by the great distance, 250 miles, from her coaling station. Leaving Palawan December 15, while en route to Manila, the inshore hydrography and topography of Cambari Island and some topography in Dumaran Channel were finished and several uncharted reefs and shoals were found and reported. The vessel remained at Manila undergoing repairs until February 10. Combined operations were then taken up in Green Island Bay and vicinity, and on the east coast of Palawan. They were in progress to the close of the fiscal year.

The steamer *Research* was engaged on a hydrographic survey of the approaches to Iloilo until October 11, after which she was employed in making a general survey of Manila Bay. The latter work is still in progress.

SECTION OF FIELD WORK.

This section, as a part of the division of hydrography and topography, has had supervision over the field work with special reference to the methods used and the completeness and extent of the work.

The general locality of work contemplated having been designated by the chief of division, investigations with respect to differences of existing surveys, the character of the locality, the nature of the bottom, and the required closeness of the work to be done are taken up by this section, and data prepared for the final instructions to the chief of party.

This section, which was created in 1915, has had opportunity to realize the benefits derived from supplying the chiefs of parties with carefully prepared data and memoranda for the work to be done. By a careful study of the conditions surrounding the area to be surveyed, a review of former survey records and of data on file in the archives, this section has had opportunity to place before each chief of party data and results which assist him to efficiently direct his operations. The resulting benefit to the work has been considerable. Parties in following the detailed instructions have obtained results that are satisfactory in every detail.

Diagrams showing the progress of the work of each party have been kept and the record of each month's output has been carefully drawn. This enables the section to ascertain at a glance the advisability of continuing the work in any one direction beyond the prescribed limits and to correlate it with surrounding work of similar character.

Investigations and comparisons of surveys with respect to differences and changes occurring from time to time have been carried on with a view to ascertaining the necessity of resurveys.

Inspection of field sheets has been carried on when the opportunity presented. Many miscellaneous duties have of necessity been performed by the chief of the section and the time for critically inspecting all of the field sheets has been limited.

SECTION OF FIELD RECORDS.

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

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

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

This section has handled many miscellaneous requisitions and assignments; in fact, such items have constituted the major portion of its work.

Department and Bureau publicity, through publications, lectures, and exhibits, received considerable attention and entailed much work in the preparation of text and illustrations.

Inquiries in regard to various technical subjects from public and private institutions and individuals were answered as fully as possible and in such manner always as to encourage appeals to this Bureau for information in any way bearing upon its work.

SECTION OF VESSELS AND EQUIPMENT.

The section of vessels and equipment is charged with the construction, maintenance, and improvement of the vessels and their equipment. It also has supervision over the expenditures for the operations of the vessels and other hydrographic parties and general supervision over the ships' officers and crews.

One new vessel, the *Surveyor*, was completed during the past year, all plans and specifications for which were reviewed and passed upon in this office. The boats, launches, and equipment for the vessel were selected and constructed or purchased under the immediate supervision of this section.

Extensive alterations and repairs were made to the steamer *Isis* during this year. This vessel, constructed as a yacht, was purchased in 1915 and put to work as a surveying vessel with very few changes. Because of lack of funds at the time of the purchase and for other reasons the contemplated changes in the arrangement of the vessel were deferred until last summer.

At least one thorough inspection of each vessel of the Service, except the vessels in the Philippine Islands and the two small vessels in Alaska, was made by the chief of section during the past fiscal year. The inspection of the Alaska and Philippine vessels was delegated to officers of the Bureau in those localities and the reports of inspection submitted to this office for consideration. There were frequent inspections made of the Atlantic coast vessels and of the vessel and launches under construction. When repairs were considered necessary, they were made under the direction of this section.

An important part of the work of the section has been the standardization of field equipment and considerable progress has been made along that line, particularly in the matter of launches and boats. The Bureau has worked out and decided upon the types of boats and vessels best suited to its needs for each kind of hydrographic work and is prepared to call for bids immediately upon the appropriation of the necessary funds.

Careful analysis and study have been made of all estimates for field expenses of hydrographic parties with the result that all unnecessary expenditures have been eliminated. Contracts for repairs, purchases, or hire of launches have received careful examination, and methods and procedure in such matters have been standardized.

COAST PILOT SECTION.

During the year this section carried on field work on both the Atlantic and Pacific coasts and in Alaska and, as a result of the field work, two coast pilots, "Alaska, Part I, from Dixon Entrance to Yakutat," and "Pacific Coast, California, Oregon, and Washington," and one inside route pilot, "New York to Key West," were compiled. The last-named volume was distributed in December, 1916; the other two are at present in the hands of the printer.

During the year such supplements or correction sheets were issued as were necessary to keep the information in all volumes up to date.

A large amount of routine correspondence was handled by this section, consisting principally of answers to inquiries on a wide variety of nautical matters. The section also made special reports to the Bureau of Lighthouses, at their request, concerning the most advantageous location of a number of very important aids to navigation.

The record of the issue of coast pilots in recent years is interesting as indicating the usefulness of these publications. As these volumes are sold at a price sufficient to defray the cost of printing (50 cents for coast pilots and 20 cents for inside route pilots), it is obvious that the number sold furnishes an accurate measure of the public demand. The following is the record of sales for the fiscal years from 1911 to date:

	Volumes.
1911	2,720
1912	8,792
1913	5,545
1914	5,228
1915	6,292
1916	7,422
1917	9,739

SECTION OF TIDES AND CURRENTS.

Tidal observations were made throughout the year at seven permanent tidal stations on the Atlantic coast, three in the Gulf of Mexico, three on the Pacific coast, and one in Alaska, in addition to tidal observations made in connection with all hydrographic surveys in the United States, Alaska, and the Philippines.

During the year all permanent tidal stations have been inspected at least once, the inspection in all cases including the connection of the tide staff of the station with the permanent bench marks.

In the summer of 1916 work of a new class was commenced, the making of a complete tidal and current survey of the coasts of the United States. For three months in the summer and fall of 1916 and for one month in the summer of 1917, this work was carried on in Long Island Sound, N. Y., and similar work was done in Puget Sound, Wash., for three months in the early part of 1917.

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

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

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

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

A special current survey was made of Richs Passage and the approaches to the Bremerton Navy Yard, Puget Sound, Wash.

For the benefit of navigation, two tide staffs were erected in Wrangell Strait, Alaska, one at the northern and one at the southern end of the strait. These staffs were set with their zeros at the plane of reference used on the charts, so that navigators could see directly from the staff what correction should be applied to the soundings on the chart to give the depth of water at that time.

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

The Tide Tables for 1917 were received from the printer in October, 1916. In these tables considerable additional information along tidal and current lines has been added, the tables have been greatly enlarged and simplified, and all information has been put in a form specially adapted for the use of mariners and others using the tables. The increase in the value of these tables is shown by the increased sale, especially of the Atlantic and Pacific Coast Tide Tables, as shown in the following table for the fiscal year:

Tide Tables for—	General Tide Tables.	Atlantic Coast Tide Tables.	Pacific Coast Tide Tables.
1909	1,008	1,405	9,430
1910	999	1,354	9,376
1911	1,042	1,575	9,702
1912	1,001	1,447	10,405
1913	1,008	1,507	9,655
1914	1,126	1,684	10,882
1915	1,665	1,994	10,481
1916	1,166	2,367	10,034
1917	1,548	3,526	12,704

The Tide Tables for 1918 were prepared and sent to the printer; considerable additional information along tidal and current lines has been added, and several changes have been made with the view of facilitating the use of the tables and adapting them to the needs of mariners and others making use of the tables.

Considerable new current information was prepared for coast pilots of Alaska, south of Yakutat Bay; Pacific coast, Washington, Oregon and California; and for the Gulf of Mexico.

A new form for evaluating the wind effect upon observed currents has been made and is now in use. This will make it possible to obtain accurate figures for the effect of the wind upon the currents along the coasts which is of the greatest value to navigation.

ASSISTANCE RENDERED IN SAVING LIFE OR PROPERTY.

On August 17, 1916, the officers and crew of the steamer *Patterson*, C. G. Quillian commanding, were called upon to assist in reviving five men of the crew of the cannery tender *Mary Maloney*, who had been asphyxiated, presumably by gasoline fumes. Earlier in the season Capt. Quillian had the officers and men of his command drilled by Dr. Marchand in methods of inducing respiration and the resuscitation of apparently drowned persons and, due to this training, all of the asphyxiated persons were treated at once. Two of the men revived under the treatment, but the others were either dead on arrival of the *Patterson* or too far gone for successful treatment. It is believed that more, if not all of the men, would have responded to treatment if taken in hand earlier. This incident indicates the importance of a working knowledge of the methods of resuscitation by all members of the service.

On October 21, 1916, the steamer *Marinduque*, A. M. Sobieralski commanding, took the small schooner *Florence* in tow at Araceli, Palawan. She was in distress with sails blown away and part of the rigging gone and food and water low. Although the *Marinduque* was short of coal she towed the *Florence* to Coron and took the captain to Manila.

The rescue from drowning by a boat from the steamer *Bache*, Paul C. Whitney commanding, of a seaman who had fallen overboard from the British steamship *Kelvinbrae* is commended by the Department in a letter dated March 30, 1917. The rescue was accomplished at a time when it was very dark and in the face of a high wind and strong flood tide.

On April 28 the steamer *Isis*, G. T. Rude commanding, bound up the St. Johns River, Fla., assisted in putting out a fire on the steam schooner *Rosalie Mahoney*, beached on the east side of the river. The *Isis* went alongside the *Rosalie Mahoney* and for three hours used her fire hose and crew to assist in getting the fire under control.

On February 18, 1917, a fire occurred on the water front in South Jacksonville at a lumberyard and shipbuilding plant. Before the fire was under control a launch from the *Isis* was sent over and towed the yacht *Soncy* to a safe berth.

DIVISION OF GEODESY.

FIELD WORK.

A primary triangulation party operated on the Utah-Oregon arc during the summer and fall of 1916. The arc was completed early in September. The work on this arc was begun during the previous fiscal year and the object was to furnish control for topographic and other surveys in a region that previously had no control whatever. The results will be immediately useful to the topographic engineers of the United States Geological Survey and to the officials of the Forest Service.

Upon the completion of the Utah-Oregon arc the primary triangulation party which had been operating on it was transferred to Utah and work was begun on the arc which will extend from the transcontinental triangulation in that State to the Texas-California arc of primary triangulation in the vicinity of Needles, Cal. Shortly after the observing party and the light keepers took their stations on mountain peaks, which were used as triangulation stations, heavy weather set in. The snow was so deep on some of the peaks that some of the equipment of the parties had to be abandoned as it was impracticable to pack it out. The triangulation therefore had to be abandoned for the season. It was the intention of the Survey to begin observations on that arc early in the summer of 1917, but the war made it necessary to alter the plan. The observing on this arc will be done as soon after the end of the war as is practicable.

Upon abandoning the primary triangulation in Utah, the chief of that party organized a smaller party and made a reconnoissance from the vicinity of Las Vegas, Nev., to a point on the oblique boundary between Nevada and California to the westward of that place. This reconnoissance was for the purpose of extending a spur to the State boundary from the Utah-California arc of primary triangulation. This connection will strengthen the triangulation which was done some years ago along the boundary in question, and will help to coordinate the former work.

Primary triangulation was started in the vicinity of Little Rock, Ark., and carried westward into Oklahoma. This work is a continuation of the arc which previously had been extended from Huntsville, Ala., westward through Memphis to Little Rock. A portion of the arc between Memphis and Little Rock was primary traverse instead of primary triangulation. The change to the traverse was found desirable on account of the country passed over and the high trees. Primary triangulation would have required an excessive amount of signal building which would have been very expensive.

The arc in question will be continued westward to a connection with the ninety-eighth meridian triangulation in the vicinity of El Reno. The work was abandoned in January when the winter weather made transportation very difficult. The progress was retarded by this condition and it was thought best to postpone further work on the arc until the late spring of 1917. As in the case of the Utah-California arc, it was found impracticable to continue on the Little Rock-Oklahoma work on account of the necessity for changing plans as a result of the war.

A building party was organized to erect signals ahead of the observing party on this arc. It operated at first under the general direction of the chief of the reconnoissance party which was operating to the westward of El Reno, Okla. Later it was transferred to the general direction of the party in charge of the primary triangulation to the westward of Little Rock.

A party operated during the early part of the fiscal year between Oklahoma and California, making a reconnoissance for primary triangulation which will follow the general direction of the Atchison, Topeka & Santa Fé Railway from the vicinity of El Reno, Okla., to Needles, Cal. This work was completed and is available for the use of the primary triangulation party which, it is planned, will make the observations as soon as practicable.

During the last month of the fiscal year a party was organized in the vicinity of Harlingen, Tex., which began making a reconnoissance for primary triangulation which will extend from the vicinity of that place northwestward to the Texas-California arc in the vicinity of Van Horn, Tex.

Preliminary plans were made to have subparties work under this reconnoissance party and erect signals over the stations selected. The observing on this arc will begin early in the fiscal year 1918. The work on this arc was called for by the office of the Chief of Engineers, United States Army, for the control of surveys and maps, for military purposes.

On all of the primary triangulation and reconnoissance for primary triangulation done during the fiscal year 1917, motor trucks were used as the means for transportation. On account of the fact that the money spent for labor is one of the heavy items of expense in this class of work, the use of the trucks is very economical in enabling the observers to utilize much of the time for observing which formerly was employed in moving by teams from station to station.

It will probably be only occasionally that horses and wagons can be used in the future on primary triangulation and reconnoissance to better advantage than trucks. With the increase of good roads throughout the country the trucks will become more and more economical on geodetic work.

During the fiscal year primary triangulation was done in southeast Alaska, on an arc which will eventually extend from the vicinity of Tacoma, Wash., to the intersection of the Yukon River and the one hundred and forty-first meridian. The Coast and Geodetic Survey will do that portion of the arc which extends from Tacoma to Point Roberts, Wash., and from Dixon Entrance to White Pass, at the head of Lynn Canal, in southeast Alaska. It is expected that the Geodetic Survey of Canada will make the triangulation along the remaining parts of the arc. These portions of the arc are from Point Roberts to Dixon Entrance and from White Pass, down the Yukon River, to the one hundred and forty-first meridian. The completion of this arc will be a matter of considerable importance to northwest Canada and to Alaska, for it will make it possible to extend the North American Datum into those regions. This datum, as is well known, is now used almost exclusively in the United States wherever the connected scheme of triangulation extends. When a survey and map have been placed on that datum they will never have to be changed, so far as geographic positions are concerned.

The primary triangulation in southeast Alaska is used at the present time to control wire-drag surveys that are in progress. The primary triangulation done in the summer and fall of 1916 was done by a subparty of one of the wire-drag parties. During the spring and summer of 1917 the primary triangulation was done by two separate parties, organized especially for this work.

In the spring of 1917 the Office of the Chief of Engineers, United States Army, requested the Survey to run certain lines of primary traverse in Georgia and Florida for the control of surveys made by the United States Geological Survey for the purpose of furnishing military maps for the War Department.

Two primary traverse parties were organized early in April and they continued in operation throughout the remainder of the fiscal year. One of the lines of traverse extends from Jacksonville, Fla., to Columbus, Ga., by way of Waycross, Ga. The other line extends from Brunswick to Columbus, Ga., by way of Macon. These two traverses will be connected at Columbus. They start from the coast triangulation in the vicinity of Jacksonville and Brunswick. During the progress of the primary traverse, azimuths were observed on Polaris at such intervals as were necessary for the control of the directions of the lines of the traverse. It is planned to have the astronomic longitude of each of the azimuth stations determined in order that the observations for astronomic azimuth may be corrected for the local deflection of the vertical.

The observations on the traverse for the determination of the lengths of the various sections were made with invar base tapes, with the tapes stretched along the top of the rail of the railroad. In order that the measurements might be reduced to the horizontal, precise leveling was run along the line of the traverse and the resulting elevations were furnished to the traverse parties, in order that they might compute the grade corrections. The leveling was done by separate parties.

At the end of the fiscal year 1916 a precise leveling party was operating in Florida. This party continued work until the spring of 1917. The work accomplished during this fiscal year consisted of a line of levels extending from the vicinity of River Junction, Fla., to Mobile, Ala., by way of Atlanta and Birmingham.

When the party mentioned above reached Mobile, it was ordered to discontinue work in Alabama and to proceed to Jacksonville, Fla., and run a line of levels from that place toward Columbus, Ga., by way of Waycross and Albany, Ga. The route followed by this line of levels is the same as that followed by the line of primary traverse mentioned above. The work had not been extended to Columbus by the end of the fiscal year. This leveling party made such extra observations along the railroads as were necessary to supplement the regular observations of a precise leveling party, in order that sufficient data might be furnished the primary traverse party to enable the latter to reduce the traverse measurements for the inclination of the rails on which the measuring tape was supported.

A second precise leveling party operated in Georgia during the last three months of the fiscal year on the line which extends from Brunswick toward Columbus, by way of Macon. This line of levels will be connected with the one mentioned above which extends from Jacksonville to Columbus. The leveling from Brunswick follows the route taken by the primary traverse party in running its line between those two places. As in the case of the other precise leveling party working in Georgia, data were furnished by it to the primary traverse party to be used in making grade corrections to the measurements of distances.

Early in the fiscal year a line of precise levels was run between Little Rock, Ark., and a point on the Mississippi River, just to the westward of Memphis, Tenn. The object of this line of precise leveling was to furnish data with which to compute the grade corrections for the primary traverse which had previously been run over the same route. The traverse work had been completed just before the end of the fiscal year 1916.

The precise leveling party which had been operating in Indiana during the fiscal year 1916 continued operations in that State and also worked in Illinois and Michigan during the first half of the fiscal year 1917. During the fiscal year 1917 a line of levels was completed which extends between Chicago and a point near Detroit, by way of Jackson, Mich. This line had been begun during the previous fiscal year. The line of levels which extends from Jackson to Mackinaw City, Mich., was also completed during the fiscal year 1917.

All of this work in Indiana, Illinois, and Michigan was done by a single party. It is worthy of note that, during the season, a new record was made for rapidity for carrying on this class of work. During the month of September a progress along the line of levels of 159.6 miles was made. Each mile of the line was run over at least twice. The actual amount of running done by the leveling party was 341 miles. There is no record of leveling ever having been done more rapidly than this in any country of the world.

The last few days of the fiscal year 1916 were occupied by a precise leveling party in setting bench marks along a line of levels which was to extend from Boundary to Vanceboro, Me. The observations were begun early in the fiscal year 1917 and were completed before the winter of that year. This line of levels was run for the purpose of strengthening the combined network of precise levels of the United States and Canada. In addition to its usefulness for this purpose, it furnishes fundamental elevations of a number of bench marks in the State of Maine which can be used to control surveys, maps, and engineering work.

When the party which had been working in Maine completed the line in that State it was transferred to Rouses Point, N. Y., where it began running a line toward Troy. Before the winter weather set in this line had been extended as far south as Whitehall, N. Y. It had been planned that this line should be completed during the spring of 1917 but the work had to be postponed on account of calls upon the Survey by the War Department.

Upon the request of the United States Geological Survey a line of precise levels was run during the fall and early winter of the fiscal year, from Clovis, N. Mex., to Pecos, Tex. Leveling along this line was needed to furnish the fundamental elevations for the control of topographic maps which will be made by the United States Geological Survey. The line began at a precise leveling bench mark which had previously been established on the Santa Fe Railway and ended at a bench mark which had previously been established on the Texas & Pacific Railway.

During the early spring of 1917 a line of precise levels was run from Washington, D. C., to Indian Head, Md., by way of Upper Marlboro and La Plata. A spur line was run from La Plata to Popes Creek, which is a railroad station on the Potomac River at the end of the Popes Creek branch of the Pennsylvania Railroad. This line of levels was run in compliance with a request from the Navy Department.

In May, 1917, a precise leveling party of the Survey began running a line of precise leveling between Escanaba and Marquette, Mich. Upon the completion of this line the party moved to the vicinity of Detroit, where a line was run from that place to Algonac. The work on this line was nearly completed at the end of the fiscal year. The work done in Michigan by this party was called for by the United States Lake Survey.

There was more leveling done by the Coast and Geodetic Survey in the fiscal year 1917 in the extension of the precise level net of the United States than in any other year in the history of the Survey. The total amount of precise leveling done was 2,930 miles.

On nearly all of the work done during the fiscal year the chief of party had his instrument mounted on the motor car and the observations were recorded on a listing adding machine. These two ways of working in precise leveling were innovations in the year 1915 and their continued use has proved that they add to the efficiency of the precise leveling work.

The new level rods mentioned in the report for the fiscal year 1916 were used exclusively, or almost so, on the leveling done during the fiscal year 1917. They proved to be a great improvement over the old wooden rods and it is expected that they will be continued in use on all future leveling. During the latter part of the fiscal year 1917 it was necessary to make some metal rods with steel strips instead of the strips of nickel steel. This was made necessary because of the inability of the office to procure invar, or nickel steel metal, as the factories which ordinarily furnish it were engaged entirely on work connected with war munitions.

Astronomic work was done during the year by the triangulation parties and also by the traverse parties. The work consisted in the determination of the azimuths of certain lines of their schemes.

Separately organized parties were engaged upon the determination of the astronomic longitude at a number of places in Oregon, Washington, Idaho, Utah, Nevada, and California. In this work the Survey was greatly assisted by officials of the Western Union Telegraph Co., who permitted our observers to use their wires when exchanging time signals between their observatories.

All of the astronomic work mentioned above was done for the purpose of controlling the azimuths in the triangulation and primary traverse at the stations at which the astronomic observations were made. These astromomic observations will also be of value in any future determination of the figure of the earth and in investigations made to determine the probable distribution of material in the outer portions of the earth.

Two parties of the Survey operated on the western coast of the United States during the first part of the fiscal year 1917 in the determination of the intensity of gravity at a number of places in the States of California, Oregon, and Washington. The purpose of this work was to collect data for an investigation of the distribution of materials in the earth's crust along the Pacific coast and, if possible, to throw some light on the conditions existing along the fault line which formed at the time of the San Francisco earthquake.

A party was engaged during the latter part of the fiscal year in the determination of the intensity of gravity at certain places in West Virginia, New Jersey, and Connecticut. This work was done in response to a request from the chief geologist of the United States Geological Survey. It had been planned to extend greatly the work of this party, but shortly after the beginning of the work it was found necessary to curtail the season's work in order that the chief of that party might be engaged on work of a different nature called for by the Corps of Engineers, United States Army.

Tertiary triangulation was done at a number of places during the fiscal year. In Alaska such work was done by subparties working under the chief of a combined party. In practically all cases where work was done in tertiary triangulation on the coast of the United States it was by parties organized especially for the purpose.

A party which had been operating on the coast of California during the latter part of the previous fiscal year in determining the geographic positions of objects on shore, which were to be used by officials of the Bureau of Lighthouses when placing buoys, completed its work early in the fiscal year 1917.

A party operated, for a short time, in the States of Washington and Oregon, in the determination of the geographic positions of certain wireless towers in compliance with the request from the Navy Department.

A determination of the geographic position of a wireless tower was made by one of the gravity parties which was operating during the early part of the fiscal year on the Pacific coast. This station was located at Marshfield, Oreg.

The inspector of the Coast and Geodetic Survey, located at Galveston, Tex., determined the geographic positions of the wireless towers at certain stations along the coast of Texas during the fiscal year.

A party was organized early in the spring of 1917 which determined the geographic positions of a number of wireless towers at places on the Atlantic coast to the northward of Annapolis, Md.

A second party was organized early in the spring of 1917 and determined the geographic positions of a number of wireless towers on the Atlantic coast to the southward of Norfolk, Va., and along the Gulf coast in Louisiana and to the eastward.

A party was engaged during a part of the winter of the fiscal year 1917 in making a tertiary triangulation in the District of Columbia and that part of Maryland just to the northward of it in compliance with a request from the Washington Suburban Sanitary Commission. The results of this triangulation were used by that commission for controlling certain surveys that it was making in the State of Maryland.

During the winter of the fiscal year 1917 a party of the Survey made a tertiary triangulation of San Francisco Bay and its tributaries for the primary purpose of furnishing control for the wire-drag surveys which were carried on simultaneously with the triangulation. The results of this triangulation will be of value, also, in furnishing the geographic positions of a number of the objects which may be used as aids to navigation and to control hydrographic and topographic surveys which may be made in the future. The party engaged on this work reported that a number of the old stations had been found to be destroyed by the erosion of the shores or the development of the land for commercial and industrial purposes.

During the spring of 1917 a triangulation party worked in the vicinity of Charleston, S. C., recovering and re-marking old triangulation stations and locating prominent objects which might be used as aids to navigation and for control points for maps and surveys.

DIVISION OF TERRESTRIAL MAGNETISM.

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

MAGNETIC SURVEY.

The magnetic survey of the United States has now reached the point where most of the field work is confined to the occupation of repeat stations and the investigation of areas of local disturbance. During the past year observations were made at 319 stations in 29 States, of which 148 were new primary stations, 120 auxiliary stations, 40 repeat stations for the determination of secular change, and 11 new stations in old localities. Meridian lines were established when they were requested by the local authorities. The number of county seats at which magnetic observations have not been made was reduced from 240 to 163.

Observations were also made (declination only in most cases) at a number of places in Alaska and the Philippine Islands in connection with other branches of the work of the Survey. The observations at sea were confined to those needed for the determination of the deviations of the ship's compasses.

DISTRIBUTION OF STATIONS.

State.	New stations.		Repeat stations.	New station in old locality.	Total.
	Primary.	Auxiliary.			
Alabama			1		1
Arkansas	5	6	2		13
California	9		1		10
Colorado	6	4	3		13
Florida	2		1		3
Georgia			2		2
Idaho	21	9	1		31
Illinois	2		1		3
Indiana			1		1
Kansas	4	14	3	1	22
Maine	5		2		7
Mississippi			1		1
Missouri	27	23	4		54
Montana	15	22	3		40
New Hampshire	2	1	2	1	6
New Mexico	8	8	1	1	18
New York	6	14	2	1	23
North Dakota	7				7
Oklahoma	2			1	3
Oregon	8		1		9
Porto Rico				3	3
South Carolina	1	8		2	11
South Dakota	5		1		6
Tennessee			3	1	4
Texas			1		1
Utah			2		2
Vermont	3	7			10
Washington	9	4	1		14
Wyoming	1				1
Total	148	120	40	11	319

MAGNETIC OBSERVATORIES.

The observatories at Cheltenham, Md., Vieques, P. R., Tucson, Ariz., Sitka, Alaska, and near Honolulu, Hawaii, were in operation throughout the year. Continuous photographic records were secured of the variations of declination, horizontal intensity, and vertical intensity. Absolute observations were made at least once a week and scale-value determinations once a month. A seismograph was kept in continuous operation at each observatory, the number of earthquakes recorded being below the average.

All of the magnetic instruments used in the field work were standardized at Cheltenham. In addition comparisons were made between the earth inductor at that observatory and the one from the Porto Rico observatory and also one belonging to the department of terrestrial magnetism of the Carnegie Institution of Washington, the results agreeing closely with previous comparisons of the same instruments.

At Cheltenham much time was devoted to study of the instruments in use with a view to eliminating outstanding differences between the absolute instruments and the two magnetographs. A new method of placing the earth inductor accurately in the magnetic meridian and a modification of the rotating mechanism produced a decided improvement in the vertical intensity results, but the horizontal intensity differences appear to be due to the variometers rather than to the magnetometer. A change in the adjustment of No. 5 variometer was made just at the end of the year, the full effect of which has not yet been determined.

The new building for office and quarters at Sitka was completed near the end of November and the observer moved in on December 6. With the consent of the owner of the Swanson property the absolute building has remained in its original location through the winter. This summer the old blockhouse on the reservation on which the variation building stands will be torn down and the absolute building will be moved to that site.

The repairs to the Cheltenham variation building in progress at the end of the last fiscal year were completed and necessary repairs were also made to the shop and windmill. At the end of the year the necessary materials were purchased for re-covering the roof on the variation building and painting all of the buildings. Work is in progress on plans for a new building for office and quarters, the need for which was pointed out in last year's report. At the Porto Rico observatory extensive repairs had to be made because of the damage done by the hurricane of August 22, 1916. The living and sanitary conditions have been much improved by the installation of plumbing and a sewage disposal system.

APPROPRIATIONS AND DISBURSEMENTS.

The appropriation made by Congress for the United States Coast and Geodetic Survey in the sundry civil act for the fiscal year ended June 30, 1917, was $1,227,140, divided as follows:

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

For the fiscal year ending June 30, 1918, the total amount appropriated is $1,379,970, and the items of appropriation are as follows:

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

DETAILS OF FIELD OPERATIONS.

HYDROGRAPHIC AND TOPOGRAPHIC WORK, ATLANTIC COAST.

MAINE AND NEW HAMPSHIRE.

[JOHN H. PETERS.]

SUMMARY OF RESULTS.—Hydrography: 107 square statute miles dragged; 120.5 miles run while dragging, 4,955 angles taken while dragging, 56 soundings retained, 1 tidal station established, 4 tidal bench marks established, 1 current station established, 26 aids to navigation determined.

Under instructions of March 6, 1917, a party was organized for wire-drag work in the approaches to the harbor of Portsmouth, N. H.

Work was begun at Portsmouth, N. H., on April 17. This consisted in overhauling the machines and other drag equipment and in the organization of the party. The chartered launches reported between April 25 and May 1. Drag work began May 11 in the approaches to Portsmouth Harbor.

From May 11 to June 30, general drag work was done, subject to the general inclemency of the weather, in Portsmouth Harbor and in the area between the entrance to Portsmouth Harbor and the Isles of Shoals, Me.

MAINE, PENNSYLVANIA, AND MARYLAND.

[R. F. LUCE.]

In November an inspection was made of the tide stations at Portland, Me., Philadelphia, Pa., and Baltimore, Md.

Necessary repairs were made to the apparatus, and connection made by leveling between the gauges and permanent bench marks.

All of the gauges were left in satisfactory working order.

The field work of the party engaged in tidal and current work in Long Island Sound was inspected and a visit was made to the party engaged in wire-drag work in the vicinity of Beverley. The suboffice at New York was visited.

Officers of the United States Engineers and Lighthouse Service at Portland, Me., Boston, Mass., New Haven, Conn., New London, Conn., and Philadelphia, Pa., were consulted in regard to tidal and current observations and much information was received from them.

In Boston the chairman of the marine committee of the Boston Chamber of Commerce was consulted in reference to the proposed establishment of tidal indicators in Boston Harbor. On November 13 an exhibit illustrative of the work of the Survey was made at the meeting of the National Academy of Sciences at Boston, Mass.

MASSACHUSETTS.

[N. H. HECK.]

SUMMARY OF RESULTS.—Triangulation: 175 square miles of area covered, 7 signal poles erected, 8 stations in main scheme occupied for horizontal measures, 7 stations in supplemental schemes occupied for horizontal measures, 13 stations occupied for vertical measures, 136 geographic positions determined. 50 elevations determined trigonometrically. Leveling: 4 miles of levels run, 12 permanent bench marks established. Topography: 50 miles of general coast line revised (chart revision work). Hydrography (wire-drag work): 200 square miles of area dragged, 12,921 positions determined (double angles), 659 soundings made, 13 current stations occupied, 4 hydrographic sheets finished and 1 partly finished, scales 1:10,000 and 1:25,000.

Wire-drag work in the region between Boston and Cape Ann, Mass., was in progress on July 1. Progress up to that date is reported in the annual report for 1916.

The plan of the season's work included the completion of all area between the 25-fathom curve and certain inshore limits, from the work of the previous season in Boston Bay to the vicinity of Cape Ann. This area presented the widest possible range of conditions with the exception that the area of excessive currents was very limited. A very large percentage of the area was suitable for the use of the longest drag possible for the launches to operate. On the other hand, the greater part of the area inside of the 10-fathom curve was of the most broken character possible, where the continuity of the dragging was interrupted by the constant discovery of uncharted shoals and by the presence of lobster pots, and the length of the drag was limited by known ledges, islands, or buoys.

In order to make the rate of progress reasonably uniform for all classes of work, a definite method of procedure was adopted with satisfactory results. The comparatively deep offshore area was not marked out in any way though an effort was made to inform trawl fishermen of the general locality in which work was being done. This area was dragged with a 15,000-foot drag whenever the conditions of sea and atmosphere permitted. The inshore areas were marked off in sections as usual and notices were issued for attachment to posted charts. Such areas were dragged on days when conditions were not suitable for work offshore. The extensive shoal areas in Salem Harbor did not permit this treatment, and consequently were deferred till the latter part of the season and then dragged continuously.

Two changes of base were made during the season, though only two harbors, Beverly and Gloucester, were used. Beverly was selected in preference to Salem or Marblehead as it was the only one with wharves at which there was sufficient water and which had suitable buildings for housing the gear and for repair work.

Work was nearly completed within the limits outlined for the season and would have been entirely completed had it not been for the extension of the dragging of Jeffreys Ledge and the investigation of Sandy Bay and approaches for use of naval vessels. The unfinished areas outlined in the original instructions are of small extent and of little importance to navigation. They include two sections near Nahant, Marblehead Harbor, several small areas in Salem Harbor approaches, and part of the area between Thatcher Island and Straitmouth Island. Otherwise all area assigned was completed to Halibut Point, the northern extremity of Cape Ann. Four sweeps were made on Jeffreys Ledge.

In the deep-water work, where the general depth ranged from 12 to 30 fathoms, only two obstructions were found and both of these were wrecks at a depth of about 20 fathoms, the wire catching on the masts or rigging.

In the inshore areas the uncharted rocks and shoals found were so numerous that only the results can be mentioned.

Salem Harbor is one of the oldest in New England and the city was at one time the fourth in size in the United States and had at one time a very large foreign trade. It has also been an important harbor of refuge from the earliest times, being considered preferable to Gloucester for vessels bound around Cape Cod for points to the westward in certain conditions of wind, especially before the construction of the breakwater at Gloucester. It is learned this year that even the moderate-draft vessels of the earlier times were often in danger of striking. It does not appear probable that square-rigged sailing vessels could have always held closely to their chosen courses in entering through narrow channels in the days before towboats, and they were therefore passing close to many unknown dangers.

A few years ago the North Atlantic fleets held maneuvers outside of Salem and used the harbor as an anchorage. This year it was found that they daily had a choice similar to the famed Scylla and

Charybdis in the form of a 20-foot rock close to the deep channel on either side. Both Salem and Beverly have important industries, of which probably the largest is the United Shoe Machinery Co., at Beverly. The numerous large factories in this vicinity use an immense amount of coal which is brought in by vessels, either deep-draft barges or by 5,000-ton steamers drawing 24 feet. In addition to this the Gulf Refining Co. has a large plant at Beverly and their vessels of similar tonnage and draft must be brought to their dock. The fact that these vessels, arriving weekly or oftener, reach their docks in safety under the conditions discovered this season, which proved that they passed dangerously close to rocks beneath them and on both sides while making a sharp turn in a very narrow channel, shows very skillful pilotage and an inexplainable immunity which can only be called luck.

From Bakers Island to Cape Ann it was found that deep-draft vessels must keep outside of a fixed line parallel to the shore. Gloucester Harbor was found to contain not only a number of uncharted rocks but a considerable number of anchors, some of large size. The region surrounding Londoner shoal was found to be rocky with shoal depths over a larger extent than the chart showed, with much reduced depth in numerous places. The channel between this shoal and Thatchers Island was found to have a maximum depth of 20 feet instead of the 40 feet formerly indicated. In the south approach to Sandy Bay several shoals were found which restricted deep-draft vessels to the north approach, as the latter was proved free from obstruction.

In Salem Harbor 49 new soundings all less than charted were found in a single square mile.

In the offshore area the depth to be verified was 50 feet. Inside of certain well-defined limits 33 feet was adopted. This was afterwards modified to 35 feet for Salem Main Ship Channel and the part of the harbor likely to be used by battleships.

Some experimental work was done to test the accuracy of the drag under varied conditions.

The amount of topographic work required was not great, as the charts were found to be in good condition in this respect. A launch cruised along the coast making observations as to changes, and information was obtained in Boston to bring the charts up to date. In Gloucester the United States Engineers furnished some information to bring the charts up to date.

Tides were observed at Beverley and Gloucester on days when drag work was not done, and readings were obtained from the gauge at Nut Island.

Current observations were made from a small launch hired for the purpose. Observations were made almost daily from August 1 to September 1. Thirteen stations at intervals between Nahant and the Dry Savages were occupied. A simple apparatus was devised and used for observing tides in the immediate vicinity of the current stations.

Additional soundings were found necessary in some areas and these were obtained with a sounding machine constructed for the purpose which proved efficient up to 50 fathoms.

The triangulation revision included primarily the determination of objects for use in connection with the wire-drag operations. The chief purpose of the revision was to determine objects from the limits of the previous season's work to the end of Cape Ann. It was found that with very little additional expense this work could be extended to the field of the previous season's work and to the westward and northward of Cape Ann and include a complete revision and recovery of stations.

At the close of the season two quadrilaterals had been completed for the determination of 3 new stations, and 32 stations had been occupied for the determination by intersections of 136 objects. Of the marked stations 21 were recovered and re-marked when necessary.

In addition to this work the positions of radio towers at Boston and Portsmouth were determined.

Improvements in wire-drag apparatus made during the season include a new type of small buoy; a dog with spring clamp that holds the ratchet which prevents the buoy from turning; an improved arrangement of the towline on the guiding launch; an improvement in the air signaling system; the installation of a stationary engine in place of a marine type of engine and the installation of the discarded engine on the end launch, which proved advantageous in taking up the drag; an improvement in the small sinker; the discontinuance of the use of the fathom as a unit of measure in wire-drag work, and the standardization of the apparatus used in measurements.

Information was obtained from fishermen and others on the coasts of Maine and Massachusetts as to possible shoal depths on the banks of the Gulf of Maine.

A device for shoal-water diving was purchased and investigated.

Much local interest was shown in the work of the party. The Chamber of Commerce of Salem was represented by a committee who visited the party while at work, and representatives of various newspapers inspected the work and prepared articles on the subject.

The passage through the drag of a submarine while submerged was an occurrence of interest. In general traffic passed through the drag without inconvenience except on one occasion when a schooner carried away the large buoy and the launch attached to it. After some difficulty, due to inability to stop the schooner, the buoy was recovered.

MASSACHUSETTS AND NEW YORK.

[J. H. Hawley.]

Summary of results.—Triangulation: 15 square miles of area covered, 4 signal poles erected, 7 stations in supplemental schemes occupied for horizontal measures, 10 geographic positions determined. Topography: 23 miles of general coast line surveyed, 7 miles of shore line of creeks surveyed, 2 miles of roads surveyed, 1 topographic sheet finished, scale 1:20,000. Hydrography: 37 square miles of area covered, 534 miles run while sounding, 4,489 positions determined (double angles), 21,648 soundings made, 4 tide stations established, 4 current stations occupied, 2 hydrographic sheets finished, scale 1:10,000. Wire-drag hydrography: 175 square miles of area dragged, 1 current station occupied, 323.1 miles run while dragging, 58 retained soundings, 2,135 positions determined, 3 tide stations established; scales of wire-drag sheets, 1:30,000 and 1:40,000.

On July 1, 1916, wire-drag party No. 2 was located at Plymouth, Mass., and operations were carried on from that base. It was found that the bowlder formation, which resulted in the discovery of numerous important shoals during the 1915 season, does not extend south of Plymouth Bay and few obstructions were found except in areas close to shore.

The work was carried to the southward as far as it could be prosecuted economically from Plymouth and on July 12 the party changed headquarters to the eastern end of the Cape Cod Canal. A workshop and office were obtained at the Cape Cod Canal Co.'s coal yard at Sandwich and the members of the party secured living accommodations at Sandwich and Sagamore. No regular mooring place could be obtained for the launches and it was necessary to keep men aboard them at all times so that they could be shifted about and kept clear of the traffic through the canal.

The difficulty of navigating at close quarters in the canal because of the strong currents, and the unreliability of the mooring dolphins which are constructed of wooden piles and are frequently carried away by vessels or by the current, made the position of the launches unsafe at all times, and the canal could not be considered as a suitable or satisfactory working base except for its nearness to the working grounds.

The work progressed rapidly and was completed on August 16. In addition to the work originally assigned a wire-drag survey of Fishing Ledge was made.

Tidal bench marks were recovered and reestablished at Cohasset, Scituate, Plymouth, and Sagamore Beach.

The weather conditions during July were rather unfavorable and work was prevented by strong winds or fog on 10 days. The most rapid progress was made during August when the weather became more favorable and about 50 square miles were dragged in 9 days.

Very little trouble was caused by lobster fishing operations compared with that of previous seasons.

The outfit was loaded on the launches on August 17 and on the 18th the party left the canal en route to Fort Pond Bay, N. Y., to take up the survey of the western part of Block Island Sound and vicinity.

The party and launches arrived at Fort Pond Bay on August 19 and established headquarters at Montauk, N. Y. Fort Pond Bay was found to be a satisfactory harbor for the launches, except in north to northwest winds to which it is entirely exposed.

Tide staffs were established at Fort Pond Bay and at Montauk Point. Several triangulation stations were recovered and four large tripod signals were erected. Some triangulation was done to provide additional objects for the control of the work.

Dragging operations were started on August 23 and continued until October 6, after which date it was not considered economical to work in exposed waters.

A considerable area was examined with the drag and several shoals were found and reported. The requirements of submarine vessels were considered and in the deeper parts of the Sound the drag was set at a considerably greater depth than is customary.

On one day an area of 20 square miles was covered with a 12,000-foot drag towed by two launches.

On October 9 and 10 the party changed headquarters to Greenport, N. Y., and began the survey of Gardiners Bay.

The work in Gardiners Bay was continued until November 10 when it became necessary to discontinue operations on account of bad weather. Practically all of the unobstructed part of Gardiners Bay was dragged and some work was done in Plum Gut. The inshore limits for the western part of the bay were defined by the limits of the oyster beds which are marked out by numerous stakes. Tidal observations for the reduction of this work were made on a staff at Long Beach Bar Lighthouse.

In addition to the wire-drag work, tidal bench marks were recovered and established at Montauk Point, Fort Pond Bay, Long Beach Bar Lighthouse, and Deering Harbor. The topography of Fort Pond Bay was revised and a dredged channel from Gardiners Bay into Three Mile Harbor was investigated and located. Current observations were made on one day at Shagwong Reef Buoy. A search was made for a reported rock in the channel west of Shelter Island and two bowlders were found and located.

The efficiency and usefulness of the wire drag is well shown by the discovery of these rocks. The letter directing the search for these rocks was received at 8 a. m., and the person who reported their existence was found about two hours later on a fishing boat in Gardiners Bay. From Gardiners Bay the party proceeded to the reported location of the rocks and set out the drag. The rocks were found and located, the party returned to Greenport, the work was plotted, and a full report was mailed at 3 p. m. These rocks were of small extent and surrounded by level, sandy bottom. Even their approximate position could not be given by the person who reported them and it would probably have required close development with the lead and line for one or two days before they could have been found without the drag.

The weather conditions for the work in this region were generally satisfactory. The principal causes of delay and interference with the work were the very strong currents, heavy swell, and extensive fishing operations. Lobster traps were very troublesome.

The inshore areas in this region are obstructed by numerous fishweirs, and in Gardiners Bay some trouble was experienced with oyster stakes and with the torpedo tests conducted by the Navy and by private firms.

The effects of the strong currents, swell, exposed nature of the work, and obstruction by fishing gear are well shown by contrasting the area of 84 square miles covered in this region with the 168 miles dragged in Cape Cod Bay during practically the same length of time.

The three launches used by the party gave satisfactory service.

The change in design of the reel, by attaching the brake to the reel drum, proved to be very satisfactory.

The Roebling method of attaching the sockets to the bottom wire proved to be the solution of a problem which had given considerable trouble in the past.

A semaphore apparatus was devised, constructed, and successfully used to replace the wigwag signal system.

The topographic work of the subparty under I. M. Dailey in Plymouth Harbor, Mass., and vicinity, in progress at the beginning of the fiscal year, was completed on July 22.

The hydrographic work was begun with a chartered launch on July 24 and continued to completion on September 30. In accordance with instructions issued September 6 the hydrographic work was extended from Gurnet Point up the coast to Green Harbor.

Tidal observations were made in Green Harbor, Duxbury Bay, and Black River to supplement the observations on the main staff at Plymouth, and bench marks were established at these points.

Current observations were made in the vicinity of Gurnet Point, Plymouth Harbor, and Green Harbor.

RHODE ISLAND.

[R. P. STROUGH.]

SUMMARY OF RESULTS.—Triangulation: 36 square miles of area covered, 14 signal poles erected, 10 stations in main scheme occupied for horizontal measures, 1 station in supplemental scheme occupied for horizontal measures, 38 geographic positions determined. Leveling: 4 permanent bench marks established, 1 mile of levels run. Topography: 12.1 miles of shore line of rivers surveyed, 1 topographic sheet partly finished, scale 1:10,000. Hydrography: 65.3 square miles of area dragged, 78.1 miles run while dragging, 17 soundings retained (depths less than charted), 18.5 square miles of area sounded, 145.6 miles run while sounding, 831 positions determined (double angles), 4,494 soundings made, 1 tide station established, 1 hydrographic sheet finished, scale 1:10,000.

On April 16, 1917, arrangements were made for organizing and equipping a party for wire-drag work in Block Island Sound. The party was organized at Greenport, N. Y., between April 20 and 25 and on April 28 the party moved from Greenport to Sakonnet, R. I. Actual drag work was begun on May 2, and carried on until May 27 in the vicinity of the eastern approach to Narragansett Bay, except for the period from May 3 to 26, inclusive, when the entire party was engaged in experimenal work in regard to certain phases of wire-drag work under the direction of three officers of the Survey.

On May 27 offshore work was discontinued and the party took up a revision survey of Sakonnet River, including triangulation and topography. This work was carried on during the period from May 27 to June 14, and was then discontinued.

On June 15 the party resumed wire-drag work in the eastern approach to Narragansett Bay, and on days when the weather would not permit dragging operations in that vicinity the revision survey of the Sakonnet River was continued.

As the depths to be verified in the offshore dragging have been increased to a maximum of 85 feet certain minor changes in the wire-drag gear have become necessary. The old wooden floats have been found to be unsuited to this deep work because they water-log very rapidly under the high pressure and they are being superseded by metal floats of a design which was recently submitted to the office. The new style small buoys designed by N. H. Heck are now used in place of the smaller can buoys of the old style and have been found satisfactory in every respect.

RHODE ISLAND, CONNECTICUT, AND NEW YORK.

[PAUL M. TRUEBLOOD.]

SUMMARY OF RESULTS.—Leveling: 32 permanent bench marks established. Hydrography: 11 tidal stations established, 2 current stations occupied.

On May 24, 1917, arrangements were made to begin work on a current and tidal survey of Long Island Sound.

New London was selected as the headquarters of the party.

Two launches were hired for the use of the party, both being equipped with heavy anchors and wire cable for anchoring in deep water and swift currents.

An automatic tide gauge was installed on the lighthouse wharf at New London June 5 and operated continuously till the end of the month. A satisfactory record was obtained.

An automatic gauge was installed at the city dock, foot of Hamilton Street, New Haven, and operated continuously till the end of the month.

Auxiliary tide staffs were put in place and determined by comparative readings at Allyns Point and Norwich on the Thames River, at Mystic, Stonington, Westerly, and Niantic; and at Hartford, Higganum, and Hadlyme on the Connecticut River.

The tidal variation in the Thames River is very distinct as far as Norwich and it is believed that the comparative readings give a good determination of the Norwich staff.

The main channel of the Connecticut River is tortuous and constricted. The tidal variation is so affected by the flow of fresh water downward as to disappear entirely at a certain stage of the river which varies with the distance from the Sound. It is known locally that the tidal variation is from 0.7 to 0.9 foot at Hartford when the river is not more than 2 or 3 feet above the Hartford city datum. The river at times rises to a height of 25 feet or more above datum and may stand for weeks above the 7-foot stage.

Current observations were made from the New York, New Haven & Hartford Railroad bridge at New London for a period of 30 hours. Observations were made at depths of 3 feet, 18 feet, and 42 feet.

At Norwich a 25-hour series was made from an open boat.

Permanent bench marks were established or recovered in connection with every tide gauge. Three marks, one of which was a standard disk mark, were left at every station.

The tidal records were obtained with a special form of pressure gauge.

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

[ISAAC WINSTON.]

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

The demands upon the suboffice for information cover a wide range of subjects including work by many departments of the Government besides that of the Coast and Geodetic Survey. All available publications bearing upon navigation and useful to mariners are kept as reference books, and those issued without charge are kept on hand for distribution. The publications of the Bureau of Lighthouses are in constant demand, and a supply is kept on hand.

Requests for other publications are referred to the proper departments or institutions.

Information in regard to the time of moonrise and moonset was furnished to the branch hydrographic office at New York.

Important information and assistance was rendered to the corporation counsel of New York City in the preparation of a case involving the title to certain land on the north shore of the Harlem River.

The inspector appeared as a witness in court in this case. The hearings extended over a month.

Information has been furnished in reply to numerous requests in regard to the times and heights of the tides and times of slack water. Tables have been prepared to show the times of high and low water at Sandy Hook, Governors Island, and Hell Gate Ferry (Astoria) for 1917, also tables showing sunrise and sunset and moonrise and moonset for 1917 in the form required for printing, and this information is printed daily in 11 of the principal newspapers published in New York City. Similar information has been furnished to other newspapers and to the New York Maritime Exchange.

Repairs were made to the electric tide indicators at the Seaman's Friend Institute and at the New York Maritime Exchange and also to the tide station at Fort Hamilton, N. Y.

Information was obtained for chart correction and for a revised edition of the Table of Depths.

A stock of charts, coast pilots, and tide tables is kept on hand at the suboffice for sale to persons applying for them. Charts were supplied without charge to Government officials requiring them, and to sales agencies upon request, to meet emergencies.

A clerk was assigned to the suboffice on September 19 and has rendered useful assistance.

Assistance was given to officers of the Survey engaged on field work in the vicinity of New York and to the officer in charge of the Coast and Geodetic Survey exhibit at the National Motor Boat Show.

The inspector attended the United States courts as an expert witness on three occasions to explain the charts and furnish information as to tidal conditions in cases involving claims for damages.

In May a determination was made of the geographic position of the Woolworth tower, New York City, and of the Staten Island Lighthouse by triangulation.

Charts were furnished for official use to meet the immediate demands of the military and naval authorities and other Government officials.

CONNECTICUT AND NEW YORK.

[F. S. BORDEN.]

SUMMARY OF RESULTS.—Hydrography: 3 tide stations established, 13 subsidiary tidal records obtained, 15 current stations occupied.

On July 31, 1916, instructions were issued for a complete tidal and current survey of Long Island Sound from the vicinity of Execution Rocks to the eastward.

In accordance with these instructions a party was organized at Oyster Bay, N. Y., and field work was begun on August 5.

Current observations were made as far as possible at stations indicated in the instructions although several of these stations were omitted when, after a few hours' observations, it was found that the maximum current was so small that it could not be measured with any degree of accuracy.

Whenever possible observations were made at each station for 51 consecutive hours. The first four stations occupied were completed without a break in the observations. As the season advanced, however, and the weather became more unsettled, it was often necessary to occupy stations two or three times before the necessary observations could be obtained.

Practically all of the stations occupied were referable to definite objects on the shore, and their positions were determined by sextant angles. At night and during thick weather the direction of the current was obtained by pelorus and compass.

All observations were made with the current pole and line. The velocity as obtained with the sand glass and current line was often checked by measuring with a stop watch the time it took for a carefully measured length of line to run out and computing the velocity. The current pole used at most of the stations was 15 feet in length.

In general, in making current observations for 51 consecutive hours, two persons made the observation from 12 noon until 12 midnight, when they were relieved by two others who made the observations from 12 midnight to 12 noon.

At the entrance to Port Jefferson Harbor the maximum current was found to be 3.4 knots on the flood tide and 2.8 knots on the ebb tide. The exact time of slack water was readily observed.

From September 1 until the close of the season a subparty was engaged in observing the tides. Information as to tidal work done in this locality by the United States Army Engineers was first obtained in order to prevent duplication of tidal work and in order to connect the work of the two services.

An automatic tide gauge was installed at Oyster Bay and was in operation throughout the season, about three lunar months of observations being thus obtained. A second automatic gauge was installed at New Rochelle, N. Y., and was in operation for one lunar month, after which it was removed to Port Jefferson, N. Y., where it was installed and a lunar month of record obtained.

Tidal information was also obtained at all other important harbors in this locality. At places where no previous work had been done, tide staffs were erected and observations made every 15 minutes for a period of an hour before and an hour after the time of high and low water, covering four consecutive high and four consecutive low waters. These observations together with a comparison of the records taken from the automatic gauges were used in working out the tidal data for the subsidiary stations. At all tidal stations at least three permanent bench marks were established.

At 10 tidal stations the bench marks established were connected with those of the United States Army Engineers, and at seven stations they were connected with the line of precise levels run by the Army Engineers between Greenwich and New London, Conn. By request of the city engineer of Bridgeport, Conn., the bench marks established at that place were connected with the city bench marks. At Port Jefferson they were connected with bench marks of the United States Geological Survey. Great care was taken in the leveling.

All of the old Coast and Geodetic Survey bench marks between Execution Rocks and Bridgeport were inspected, and wherever necessary new ones were established.

A sufficient number of current stations was occupied to determine fairly well the tidal current in the important bays, passages, etc., between Execution Rocks and Bridgeport, Conn.

The tidal survey from Execution Rocks to Bridgeport was completed.

[R. P. STROUGH.]

SUMMARY OF RESULTS.—Hydrography: 44.5 square miles of area covered, 838.2 miles run while sounding, 5,454 positions determined (double angles), 32,431 soundings made, 2 tide stations established, 4 hydrographic sheets finished, scale 1:10,000.

On July 25 a party was organized at Southport, Conn., for a hydrographic resurvey of Long Island Sound.

A power launch was hired for the use of the party and arrangements were made for tidal observations in the vicinity of Bridgeport Harbor. Four plain tide staffs were erected for this purpose and connected by leveling with the United States Engineers' datum plane bench mark at Bridgeport, Conn.

The party having been organized and tidal observations arranged for, the actual hydrography was begun on August 3, and work on the Connecticut side of Long Island Sound proceeded without interruption until completed. Between August 6 and 15 the work of the party was temporarily in charge of F. B. T. Siems. The hydrography joined that of P. C. Whitney on the west side near the Norwalk Islands and continued eastward around Penfield Reef to Black Rock Harbor. Split lines were run between the lines on the old sheet, 100 meters or less apart, from the shore line to the 7-fathom curve, and all rocky or broken areas were developed very closely.

On September 23 the headquarters of the party was removed to Northport, Long Island, to take up the hydrography in the vicinity of Huntington and Oyster Bays.

The tide station at Lloyd Harbor New Lighthouse was recovered, a staff gauge set up, and observations were taken from October 25 to November 22.

The work on the Long Island side does not differ materially from that in Connecticut. Split lines at intervals of 100 meters were run and the uncertain areas developed closely.

The work extends from Lloyd Point eastward to the point on the chart marked Arthurs House and offshore to the 7-fathom curve, including the development of Huntington and Northport Bays and Huntington, Lloyd, Northport, and Centerport Harbors. One day was spent in developing an area off the spar buoy at the entrance to Oyster Bay. Triangulation data and revised shore line of Huntington and Lloyd Harbors were obtained from W. C. Hodgkins, who was engaged in revising the triangulation and topography in that vicinity.

The soundings taken between September 23 and October 24 are all referred to the automatic gauge maintained by F. S. Borden at Oyster Bay. All of the soundings taken after October 24 are referred to the tide staff at Lloyd Harbor New Lighthouse.

Special care was taken throughout this work to use all possible means of obtaining information regarding menaces to navigation.

Oystermen, fishermen, and yachtsmen were interrogated in regard to the areas with which they were familiar, and the entire stretch of shore line covered by the season's work was gone over closely with the launch or small boat at low tide for the purpose of finding and locating any outlying dangers which were visible at that time. Where found these dangers were carefully located by sextant angles and the positions plotted on the boat sheet.

The areas of rocky formation that were developed during the season were examined as closely as possible without a large expenditure of time and money. Surveys with lead and line in greater detail might disclose the existence of other dangers, but until the whole area has been examined with a wire drag it is impossible to say with absolute assurance that this much-traveled waterway is free from unknown and uncharted menaces to the safe navigation of ships.

NEW YORK.

[W. C. HODGKINS.]

SUMMARY OF RESULTS.—Triangulation: 20 square miles of area covered, 11 signal poles erected, 17 stations in main scheme occupied for horizontal measures, 61 geographic positions determined. Topography: 32 square miles of area surveyed, 5½ miles of creeks surveyed, 12¾ miles of roads surveyed, 3 topographic sheets finished, scale 1 : 10,000.

The revision of the triangulation and topography of the north shore of Long Island eastward from Matinicock Point was taken up August 18 and continued until December 5, 1916.

Preliminary work began with a reconnoissance of part of the territory to be examined, the organization of a party, and arrangements for securing living accommodations and a suitable launch for the transportation of the party.

The first part of the season was devoted to the revision of the topographic features, while during the latter part the principal work was the new triangulation intended for the control of the surveys in Huntington and Northport Bays, although topographic revision was also continued at every suitable opportunity and often in direct connection with the field work of the triangulation.

Topographic work was begun in the vicinity of the village of Oyster Bay and then carried on for a few days on the shore of the Sound between Oak Neck Point and Frost Creek. Revision work was afterwards taken up at Matinicock Point, the western limit of the district assigned for immediate examination, and was extended eastward from that point.

In the revision of the shore line it was generally found more economical to make an entirely new outline survey rather than to select places where changes were thought probable and to work each way from such spots to junctions with unchanged portions of the coast. This was the case especially in reference to stretches of coast that had to be covered by planetable traverse on account of the lack of intermediate triangulation points.

Such changes as have taken place are due either to the forces of nature, acting through a period of some 30 years, or to human agency.

The natural changes found to have occurred are generally quite small. Exposed shores show a gradual wasting, ordinarily of no great extent. The greatest change noted was at Lloyd Point where a new inlet had broken through the barrier beach eastward of the point and where there seems to have been a well-marked drift of the shore sands from eastward to westward. The extensive marsh lying between the barrier beach and the solid land of Lloyd Neck proper has also undergone considerable change. In 1885 that area was chiefly an open lagoon with numerous small and scattered marshy islets or bunches of marsh grass, while at the present time its character is that of a marsh intersected by numerous passages, though the marshes are still soft and are overflowed by every tide.

At the southeastern extremity of Lloyd Neck, on the sand point called East Beach, some natural changes have taken place. The end of that point south of the old Lloyd Harbor Lighthouse has cut away almost up to the building, while the beach farther north has increased considerably in height so that it is no longer covered by ordinary high waters and is practically a continuous part of the main body of Lloyd Neck.

Other changes on the coast examined consist chiefly of moderate wasting, sometimes amounting to about 20 meters, the most noticeable effect of which has been to destroy most of the old triangulation stations that were situated near the water or on the crests of bluffs.

The artificial changes that have occurred are largely in the way of improvements. Many portions of the coast have thus been completely transformed. In order to counteract the natural tendency to wasting of these improved shores from the effect of storms, most of the waterside estates have been protected by long stretches of masonry or concrete sea wall.

Great changes have also been caused by extensive sand-dredging operations which, beginning on the west beach of Eatons Neck some years before the date of the former survey, have been greatly extended not only in the original locality but also on the northwest shores of both Eatons and Lloyd Necks. These excavations have produced artificial harbors of considerable extent, though of varying depth, that may sometimes serve as refuges for small craft.

Between Matinicock Point and Lloyd Point the loss of most of the triangulation stations determined in 1833 (34) and in 1883 (84) had been supplied to a great extent by new triangulation executed in 1914 and 1915, but eastward of Lloyd Point there was no recent work and only a few of the old points had escaped destruction. Those which were left were not so situated as to afford proper control for the topography of Huntington and Northport Bays and it was therefore found necessary to provide additional triangulation in that section.

The only base for new work in that vicinity which was both practicable and convenient was the line Eaton 2 (1883)-Titus (1885). Both of those stations were recovered, as were also Eatons Neck Lighthouse, Lloyd Harbor (old) Lighthouse and Baldwin Tower, all of which had been determined in 1883 and which were connected with the work of 1916.

In this work 11 new stations of the main scheme and 58 new intersection stations were determined, so that there are now sufficient points available for fixing positions at almost any point within the area covered, except perhaps in some of the deep and narrow coves and on some parts of the outer coast of Eatons Neck.

At the close of the season the revision of the topography had been carried eastward from Matinicock Point as far as the western side of Centerport Harbor, and on Eatons Neck the shore of West Beach and of the western side of the neck as far north as the inlet near the lighthouse had been resurveyed.

The greater part of the shore line of Oyster Bay and part of Cold Spring Harbor had been resurveyed in 1915 by another party, and the work in that section here described consisted in filling the gaps left by that party.

VIRGINIA.

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

SUMMARY OF RESULTS.—Triangulation: 60 square miles of area covered, 4 signal poles erected, 3 stations in main scheme occupied for horizontal measures, 4 stations in supplemental schemes occupied for horizontal measures. Leveling: 3 permanent bench marks established and short lines of leveling run to connect with tide gauge. Magnetic work: 1 sea station occupied for magnetic declination. Topography: 7.9 square miles of area surveyed, 31.5 miles of general coast line surveyed, 5 miles of creeks and inlets surveyed, 23.5 miles of railroads surveyed, 2 miles of roads surveyed, 2 topographic sheets finished, scale 1:30,000. Hydrography: 105 square miles of area covered, 1,002.8 miles run while sounding, 4,899 positions determined (double angles), 27,387 soundings made, two tide stations established, 1 hydrographic sheet finished, scale 1:30,000.

At the beginning of the fiscal year the party on the steamer *Bache* was engaged in surveys in the vicinity of Cape Henry. This work consisted of a detailed hydrographic survey of the entrance to Chesapeake Bay westward from a line joining Cape Henry and Fisherman Island to Thimble Shoal Lighthouse, and thence westward along the south shore to Sewall Point, including Willoughby Bay. Triangulation was executed to locate Thimble Shoal Lighthouse and a few doubtful topographic signals.

The launch hydrography and topography were executed by shore parties located during the first part of the season at Lynnhaven Inlet and the latter part at Willoughby Spit.

Ship hydrography was begun July 11 but was discontinued July 14 in order to receive a party of official photographers detailed from the office for the purpose of obtaining a series of still pictures of the several instruments used in the Survey and a series of moving pictures illustrative of the various activities of the Bureau. The photographers completed their work on August 9.

After a few days' signal building the vessel was tied up at the F. O. Smith Shipbuilding & Dry Dock Co. wharf for general repairs, while the surveying work was continued by shore parties in the vicinity of Lynnhaven Bay.

Instructions being received to cooperate with the Southern Commercial Congress to be held at Norfolk December 11 to 14, 1916, preparations were made to present as creditable a showing as possible. Exhibits of the various instruments were set up in the cabin, and field sheets and records were shown in an attractive manner where visitors could examine them. On December 11 the *Bache*, in company with other vessels of the Department of Commerce fleet, anchored off Hospital Point and was opened for inspection by members of the Southern Commercial Congress and other visitors. Everything possible was done to inform visitors of the scope and activities of the Survey. On December 13 the *Bache* took part in a water parade, consisting of a review of part of the Atlantic naval fleet anchored off Old Point Comfort.

After the congress was over, the *Bache* made preparations to carry on additional hydrographic work at the entrance to Chesapeake Bay. The weather conditions were unfavorable and the work was discontinued under instructions from the Superintendent on January 9, 1917.

The field work of topography was finished November 24 and the launch hydrography completed October 20, with the exception of two days in December when an examination was made near Sewall Point.

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

SUMMARY OF RESULTS.—Triangulation: 10 square miles of area covered, 3 stations occupied for vertical measures. Magnetic work: ship swung for compass deviation at one station.

During the period from July 1 to December 31, 1916, the headquarters of the steamer *Isis* was at Norfolk, Va. From August 1 to December 19 the *Isis* was at the shipyard of the Old Dominion Marine Railway Corporation undergoing extensive repairs and alterations.

Field work was in progress from July 1 to July 12. This work consisted of triangulation for the location of leading marks for the Navy Department along the dredged channels into the port of Norfolk and of prominent artificial objects in the vicinity of the port of Norfolk for charting purposes for the use of navigators.

Such additional stations were established as were deemed necessary to locate all the desirable objects. The objects were then located by cuts from at least three triangulation stations.

During the time that the *Isis* was at Norfolk for repairs the computations and plottings of the work of the previous season were completed.

The *Isis* was swung for compass deviation in Hampton Roads on December 10.

On December 11 the *Isis*, together with five other vessels of the Department's fleet, the *Bache*, *Roosevelt*, *Fish Hawk*, *Orchid*, and *Dixie*, dressed ship for the Southern Commercial Congress and was open for visitors to the congress, and a special launch schedule was arranged for the convenience of the guests who visited the ships to view appropriate exhibits displayed on each.

On December 13 the *Isis*, with the Secretary of Commerce and the Superintendent of the Coast and Geodetic Survey on board, participated in a naval review of the Atlantic Fleet in Hampton Roads. The reviewing fleet was led by the *Mayflower*, with the Secretary of the Navy on board, followed, in the order named, by the *Isis*, *Yankton*, *Dolphin*, *Bache*, *Fish Hawk*, *Orchid*, and *Roosevelt*.

The vessels of the Department carried several hundred specially invited guests of the congress, and were followed by a large number of steamers and small motor craft.

On December 14 the congress adjourned and the *Isis* returned to the dock of the Old Dominion Marine Railway Corporation on the 15th.

NORTH CAROLINA.

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

SUMMARY OF RESULTS.—Triangulation: 16.3 square miles of area covered, 4 signal poles erected, 2 stations in main scheme occupied for horizontal measures, 4 geographic positions determined. Leveling: 1 mile of levels run, 2 permanent bench marks established. Topography: 8 square miles of area surveyed, 4 miles of general coast line surveyed, 19.3 miles of shore line of rivers surveyed, 2 topographic sheets finished, scales 1:20,000 and 1:10,000. Hydrography: 10 square miles of area covered, 284.6 miles run while sounding, 1,774 positions determined (double angles), 12,612 soundings made, 2 tide stations established and 2 hydrographic sheets finished, scale 1:20,000.

At the time of the transfer of the command of the schooner *Matchless* on April 13, combined surveys were in progress in Albemarle Sound.

During the period from April 13 to May 4 the survey of Bull Bay and Scuppernong River was completed, and part of Albemarle Sound west of Laurel Point Lighthouse, Yeopim River and Creek, with approaches, was finished to connect with previous work. The limits of the topography and hydrography were somewhat different on this account.

On May 3 after completing comparative tide observations, the *Matchless* proceeded to Elizabeth City, arriving on May 4. Shortly afterward the chief of party was temporarily ordered to Washington.

The *Matchless* remained at Elizabeth City preparing for work in Pamlico Sound and was held there on account of lack of funds. Office work on records and painting and repairing the vessel were in progress during May. From June 2 to June 26 the command of the vessel was temporarily assigned to another officer.

At the close of the fiscal year the survey of Pamlico Sound was in progress. The principal signals had been built, the necessary triangulation executed, and a small amount of hydrography and topography had been done.

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

SUMMARY OF RESULTS.—Topography: 6 square miles of area surveyed, 18 miles of shore line surveyed. Hydrography: 91 square miles of area covered, 503.5 miles run while sounding, 3,964 positions determined (double angles), 24,986 soundings made, 4 tide stations established, 2 current stations occupied, 1 hydrographic sheet finished, scale 1:20,000.

The hydrographic resurvey of Pamlico Sound in progress at the beginning of the fiscal year was continued during July and August, 1916, and the sheet from Harbor Island Bar Lighthouse to Ocracoke was completed.

The general development consisted of systems of parallel lines spaced according to the depth. Special development was made of isolated shoals or where there seemed to be changes from the charted depths. All channels were carefully developed and particular attention was given to the channels in Ocracoke Inlet. These were developed out to the 6-fathom curve. Work had been begun on the sheet from Ocracoke to Hatteras when the transfer of the command was made.

The topography was continued along the outer island to a point about 3 miles south of Hatteras Inlet. All small islands adjacent to the outer coast were included on the sheet.

The triangulation was executed from time to time as the work progressed. Some difficulty was experienced owing to the unstable support for the instrument afforded by some of the lighthouse structures.

An automatic tide gauge was kept in operation at Portsmouth until the middle of July. Three permanent bench marks were established. Three tide staffs were determined by comparative readings and used in the hydrography. One old bench mark was recovered.

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

SUMMARY OF RESULTS.—Triangulation: 19 square miles of area covered, 4 observing tripods and scaffolds built, heights, one 72 feet, two 55 feet, one 20 feet, 3 stations in main scheme occupied for horizontal measures, 1 station in supplemental scheme occupied for horizontal measures, 5 geographic positions determined. Leveling: 1.5 miles of levels run, 5 permanent bench marks established. Hydrography: 15 square miles of area covered, 91 miles run while sounding, 442 positions determined (double angles), 3,881 soundings made, 3 tide stations established, scale of hydrographic sheets 1:20,000.

After the transfer of the command of the schooner *Matchless* on June 3, the survey of Pamlico Sound was continued and this work was in progress at the close of the fiscal year.

The chief work of the party during June was the erection of tall signals for use in the hydrography. The instructions called for a considerable amount of hydrography to be done in the center of Pamlico Sound where shore objects were not visible, and it was necessary to build specially tall signals on the outer edge of the shoal water which extended out several miles from the shore.

The triangulation of this section had already been completed and two triangulation stations had been determined on the edge of shoal water, one at Bird Island and one at Gull Island. Bird Island could not be recovered, but a signal 55 feet high was erected near the former site of the station. Gull Island was recovered, and a signal 72 feet high was erected over it. A similar signal was erected on the outer edge of shoal water about 2½ miles west of the town of Kinnakeet. A tripod signal was erected over the former triangulation station on Kings Point and another in about 3 feet of water about 2 miles south of signal Water 2.

As stations Bird Island and Red Beacon could not be recovered, some additional triangulation was necessary to locate signals and other prominent objects for hydrographic purposes.

Hydrography was begun June 23 and continued to June 27. The work done was in the vicinity of Muddy Slough and in the channels and passages between Muddy Slough and the coast to the southward, the soundings being spaced closely enough to develop all channels and irregularities of bottom.

A tide staff was established on a wharf at the town of Hatteras and another on Fuersten's fish house, at the eastern end of Muddy Slough, and readings were taken while the hydrography was in progress. A subsidiary tide staff was established at the town of Buxton.

[F. B. T. SIEMS, Commanding Schooner *Matchless*.]

SUMMARY OF RESULTS.—Triangulation: 60 square miles of area covered, 46 signal poles erected, 2 observing tripods and scaffolds built, heights 30 and 35 feet, 11 stations in main scheme occupied for horizontal measures, 30 stations in supplemental schemes occupied for horizontal measures, 55 geographic positions determined. Leveling: 2.75 miles of levels run, 11 permanent bench marks established. Topography: 15.2 square miles of area surveyed, 130.8 miles of general coast line surveyed, 13 miles of roads surveyed, 3 topographic sheets finished, scales 1:10,000 and 1:40,000. Hydrography: 229.3 square miles of area sounded, 1,973.1 miles run while sounding, 9,349 positions determined (double angles), 84,211 soundings made, 5 tide stations established and recovered, 4 current stations occupied, 4 hydrographic sheets finished, scales 1:20,000 and 1:40,000.

The survey of Ocrakoke Inlet was completed just prior to the transfer of the command of the schooner *Matchless* on August 24, 1916, and is referred to in another abstract.

The hydrography, supplemental triangulation, and the topography were afterwards taken up in the area by "the Banks" from Ocrakoke Inlet to and including the town of Hatteras and for a distance of about 9½ miles offshore in Pamlico Sound, also including Hatteras Inlet. All of this work was completed by November 13, 1916. As the weather became unfavorable for the economic operation of the party, field work was closed and the *Matchless* proceeded to Elizabeth City, N. C., for annual repairs.

It was found that the light whaleboat launches are unsuitable for hydrography in the exposed parts of Pamlico Sound during moderately rough weather. On many days field work was prevented by moderate to strong northeasterly winds. It became at times impossible to get up high enough to observe on distant signals while the launch was violently tossed about.

Small boats were anchored and used for signals where shore signals were no longer visible.

The flat-bottomed skiff launch is well suited for most of the shallow inshore area. Where the depth was less than 1½ feet the area was sounded out by wading over the flats or by using small boats. No large areas were left unsounded.

Except for the areas inshore within about 2½ miles of the beach and those affected by the tidal currents of the ocean inlets, the bottom is mostly flat, uniform, and featureless as indicated in the old survey; in fact, practically the same depths and slightly undulated areas appear in both surveys. There are marked changes, however, inshore, and at Hatteras Inlet the bottom is much cut up and very complicated with numerous short deep sloughs many of which do not appear on the present chart. The main channel from seaward at Hatteras Inlet is now obstructed by a 7-foot bar at its entrance, where the old survey shows a clear straight passage of 14 feet from the sea to the sound side of the inlet. A narrow, crooked, and impracticable channel of probably 10 feet least depth was discovered to the eastward of the main channel. Three very complicated channels with 5 feet least depth were discovered leading over the bulkhead from the inlet to the sound. A very careful survey of this inlet was made which will be of value in studying the changes likely to occur in the future by comparing it with the old survey. It appears that the ocean bar will in course of time close up the inlet.

Two scaffold hydrographic signals were built for offshore hydrography, one 70 feet high on Legged Lump and the other 40 feet high on Egg Shoal. The topography of "the banks" was a simple matter except that much time had to be spent in rodding the intricate marsh shore line on the sound side. Difficulties in getting ashore over the vast area of shallow water also hindered rapid progress of the plane-table party. There was good triangulation control for the topography. The only changes of importance in the shore line were found at the inlet, where several islets were found to have shifted considerably.

The triangulation included the determination of the positions of prominent objects, aids to navigation not previously determined, and several intersection points that will prove useful in future surveys. Enough old stations were recovered to obtain good determinations of the new positions.

Tides were observed at Nine Foot Shoal Beacon, at Hatteras, at Hatteras Inlet, and at Shoal Point Beacon.

Currents were observed at a point about halfway between Ocracoke and Hatteras Inlet, 5½ miles offshore, during 17 hours of good weather with very little wind.

The *Matchless* was anchored on the working grounds about 3 miles off Ocracoke from July to September and about 4 miles off Hatteras from the latter part of September to the middle of November.

On January 10, 1917, repairs to the schooner *Matchless* were completed, and on January 15 the ship sailed for the working ground in Albemarle Sound and tributaries.

Combined surveys were made of Perquimans River from January 16 to February 10, Little River from February 14 to March 16, and of Bull Bay and Scuppernong River from March 19 to April 13. On the latter date the command of the vessel was transferred to another officer who then took up the survey of the Yeopim River.

The surveys of the areas mentioned and those executed by the steamer *Hydrographer* in 1915 form a complete resurvey of these tributaries and the adjacent section of Albemarle Sound.

The topography included the location of the shore line and adjacent topographic features, the detail surveys of the towns of Hertford and Columbia, and the location of prominent objects. The shores are washing away in many places leaving the water full of cypress stumps.

Sounding lines were run normal to the shore 200 meters apart or less as required. These lines were crossed by lines parallel to the shore to determine the extent of spits and shoals. A careful survey of the entrance to Little River was made. The channel was found to be narrow but straight and the buoys marking the same sufficiently numerous and properly placed.

Some difficulty was experienced in carrying the triangulation from the main scheme in Albemarle Sound to Little River on account of the washing away of some stations and the poor seeing across the sound. Two tripod and tree signals were built for this work.

Numerous stations were required to extend the triangulation schemes up the tributaries. The stations were carefully marked and referenced, having in view the rapid washing away of these shores.

GEORGIA.

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

SUMMARY OF RESULTS.—Triangulation: 3 hydrographic signals rebuilt, height 100 feet. Magnetic work: Ship completely swung at 2 sea stations. Hydrography: 2,050 square miles of area covered, 1,401 miles run while sounding, 2,315 positions determined (double angles), 18,330 soundings made, 1 tide station established, 448 specimens of bottom taken, 2 hydrographic sheets finished, scales 1:80,000 and 1:180,000. Physical hydrography: 108 current stations occupied, 409 observations of temperature of water taken.

After being repaired at Norfolk, Va., the steamer *Bache* left there January 17, 1917, for Savannah, Ga., arriving January 20. The latter part of January was spent in hydrographic work. On January 29 the *Bache* left Savannah for Charleston, S. C., where the buoys to be used for offshore signals had been delivered.

The necessary superstructures were constructed on the buoys and the buoys were placed in position about 10 miles from shore and 4 miles apart by lighthouse tenders.

On returning to the working grounds it was discovered that three of the tall signals on shore had been damaged by storms, and arrangements were made to rebuild them.

The hydrography completed covers the area between Ossabaw Sound and Port Royal Sound. Its southern limit overlaps the work done by the *Bache* during the spring of 1916. Its northern limit overlaps the work done by the steamer *Isis* during 1916.

On the inshore work, to obtain the necessary development near the entrance to Savannah River and the sounds close by, lines were run at a distance of about one-third of a mile apart. Near the bar at the entrance to Savannah River, on shoals and in places where the soundings were uneven, lines were run considerably closer together. In the offshore work from the line of buoys east to the 100-fathom curve, lines were run 1 mile apart well beyond the 12-fathom curve, 2 miles apart to the edge of the inshore sheet, and approximately 4 miles apart to the 100-fathom curve. Every precaution was taken to determine accurately the positions of these lines.

Current observations were made every two hours on the dead-reckoning lines. Surface temperatures were observed every hour while sounding to 30 fathoms and at every sounding from 30 to 100 fathoms. Bottom temperatures were taken at every anchorage and at every sounding outside the 30-fathom curve. Psychrometer readings were taken every hour while sounding. Tides were obtained from the automatic gauge of the United States Army Engineers located on Tybee Knoll.

On the night of March 22 assistance was rendered the steamer *Kelvinbrae* by rescuing from drowning one of the crew of that vessel who had fallen overboard.

GEORGIA AND FLORIDA.

[T. J. MAHER.]

SUMMARY OF RESULTS.—Triangulation: 4 hydrographic signals built, heights, 94, 94, 92, and 104 feet, 3 triangulation stations recovered, marked, and described, 4 triangulation stations (other than the foregoing), recovered and supplementary descriptions made, 1 new triangulation station established, 4 triangulation stations, other than the foregoing, selected and signals built, 3 triangulation stations occupied for horizontal measures, 3 old signals examined, 2 hydrographic signals occupied for round of angles.

On October 17 orders were issued for the organization of a party to build tall hydrographic signals along the coasts of Georgia and Florida for the use of the parties on the steamers *Bache* and *Isis* respectively.

After consultation with the commanding officers of the two vessels as to the work required, a party was organized at Savannah, Ga., and on November 4 left Savannah for Hilton Head Island, S. C. Station Hilton near the north end of the island was recovered, but the signal which had been erected there during a former season had blown down. The beach in that locality had washed away to such an extent that anchors for the wire guys on the shore side could not be placed. A new signal was erected eccentric to the old in a more suitable locality and located by angles and a measured distance. The height of the signal is 96 feet, and it has a target 50 by 16 feet in dimension, the upper half painted black and the lower half white. The party then proceeded to the south end of the island where a similar signal was erected. This station was located from three triangulation stations along the Savannah River. The shifting of the sand dunes had obliterated all traces of station Braddock which had been established in that vicinity in 1900. The signal near the lighthouse was visited and examined. The signals along the shore north of Port Royal Sound were seen to be standing, but owing to the shallow water could not be reached by the launch or by small boat.

During December the party was engaged in building a signal on the south end of Little Tybee Island and one on the south end of Wassaw Island. The former is 96 and the latter 104 feet in height, not including the elevation of the ground above high water. Two triangulation stations on Little Tybee Island were recovered. One was re-marked with surface and subsurface marks, and additional reference marks were made for the other. Descriptions were prepared for both stations.

A tree marked with a triangular blaze on the side with a nail in the center and branches cut near the top was found near the signal on Wassaw Island. It was close to the edge of a bluff which was rapidly washing away. A surface and a subsurface mark were placed eccentric to the tree and a connection made by measurement and angles. A signal was erected over the stump of the tree and located by triangulation. The dune on which the signal Drop (1913) was located has been washed away. Triangulation station Morrell, Ossabaw Island, was recovered, connected with reference marks, and a description prepared. The signal was rebuilt. Station Land was recovered and a triangulation signal built. Station Coon was established on Raccoon Key. These were occupied for horizontal angles. Hydrographic signal camp was examined and some guys tightened. Signal Meadows was similarly examined. A search was made for station North, but it was not found, as the dune on which it was situated had been washed away. This was verified by a stadia traverse from signal Meadows.

On December 23 work in Georgia waters was nearly completed. Information was received that the signal on Little Tybee Island had fallen during a storm. The remainder of the month was spent in rebuilding this signal, and the work was completed on January 2. The signal at Wassaw Island was examined and additional guys were attached. The signal at Hilton Head which had blown down was rebuilt.

The triangulation in the vicinity of the mouth of the Savannah River was completed. The old Coast and Geodetic Survey station on Fort Pulaski was recovered and the marks renewed.

A signal was built 5 miles south of Pablo Beach and its position determined by a traverse and tape measurement from the old station.

Work was closed on February 4.

FLORIDA.

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

SUMMARY OF RESULTS.—Hydrography: 2,650 square miles of area covered, 2,368 miles run while sounding, 4,794 positions determined (double angles), 23,227 soundings made, 35 stations occupied by ship to locate shore and offshore signals, 210 angles observed (sextant cuts) by ship to locate shore and offshore signals, 8 shore objects located by angles from ship, 11 offshore buoys (signals) located by angles from ship, 2 hydrographic sheets finished, scales 1:60,000 and 1:180,000. Physical hydrography: 1,072 surface temperatures taken, 571 bottom specimens taken, 4 log tests made, 111 current stations occupied, 803 current observations taken.

The steamer *Isis* was undergoing alterations and repairs at Norfolk, Va., from July 1 to December 20, 1916, when she came to Washington to have a radio apparatus installed.

From January 6 to April 30 the vessel was employed on offshore hydrography on the east coast of Florida from the St. Johns River entrance to a point 5¾ miles south of St. Augustine and extending offshore to the Gulf Stream. This work covers an area of 2,650 square miles and consists of 2,368 miles of sounding lines.

The vessel was laid up at Norfolk from May 2 to June 30 because of shortage of funds, during which time some minor repairs were made and the records of the past season's work were completed. The vessel made its headquarters at Jacksonville, Fla., during the entire season.

Very satisfactory signals were erected and located by J. S. Bilby along the entire coast line from the St. Johns River to a point 8½ miles south of St. Augustine. They were of two kinds, the tall type, about 100 feet high, and intermediate signals, about 20 feet high, for the close inshore work. It has been found that the tall signals should not be spaced along the coast more than 3½ to 4 miles apart for the most economical prosecution of the work. Those built by Mr. Bilby were about that distance apart.

The following are tall signals: Pablo, Mier 2, Palm, Jenks 2, Hernan, Dry, Cato, Louis, Crescent, and Corbett. Mt. Cornelia and March are high-type signals built during the previous seasons and used by the *Isis* the past season. They were in excellent condition. The following are small signals built by Mr. Bilby for close inshore hydrography: Z(Lit), Y(Bil), Axe, Way, Vat, Usina and Uno. In addition to these signals artificial objects, previously located by triangulation were used. Other signals were located by sextant cuts from the *Isis* anchored offshore.

Four tall-type can buoys and two whistle buoys, with angle-iron and pipe superstructures, carrying wire-screen target above and three black flags 6 feet long below, were used for offshore signals.

These types of offshore signals are without question the most efficient and durable and have the longest range of visibility of any signals yet devised for this class of work. The body of the buoy is painted white and is the only part which shows when the vessel is between the sun and buoy; the superstructure showing when buoy is between vessel and sun. Any buoy without this reflecting surface is practically worthless for offshore hydrography, for at least one of the buoys of the set of three is on the opposite side of the vessel from the sun on every fix.

These buoys were loaned from the sixth lighthouse district, planted and shifted by the lighthouse tender *Cypress*. Thanks are due to the lighthouse inspector for the promptness with which these buoys were planted and moved and the courtesy shown the party in every possible manner.

These buoys were located as heretofore by means of sextant cuts to shore stations from the *Isis*, located inshore of the line of buoys.

It has been found that these buoys should be planted from 10 to 11 miles offshore and from 3½ to 4 miles apart for the most economical prosecution of the work.

The hydrography off the east coast of Florida consisted of two classes, the ordinary inshore or fixed position work and offshore or precise dead reckoning work.

An anemometer was installed on the *Isis* for use during the past season in obtaining the wind velocity for estimating leeway.

It was found that the amount of leeway estimated for the vessel during the season off the South Carolina coast, 0.1 knot per hour leeway for 10-mile wind, 0.15 for 15-mile wind, etc., was insufficient. During the past season it was found that each course should be corrected for leeway by an amount equal to 0.15 knot per hour for a 10-mile wind, etc.; in other words, 0.015 knot per hour times the velocity of the wind in miles per hour, reduced to the sine of the angle between the wind's direction and the course. This was generally obtained graphically by plotting the course at any place, and then plotting the correct leeway at right angles to the course at the end of the leg. The mean velocity and direction of the wind at the two anchorages were used unless the wind made a decided and noticeable change in direction and force during the time between anchorages. In that case they were employed separately in deducing the amount of leeway.

A diagram was devised from which may be obtained graphically the amount of drift of the vessel while weighing the current anchor at a station in the Gulf Stream.

The *Isis* anchored a barrel buoy at the 40-fathom curve with a 300-pound concrete block and 120 fathoms of ⅛-inch Seimens-Martin strand wire; at the 100-fathom curve with a 400-pound block and 300 fathoms of wire. When the current observation had been made from a small boat, the barrel was taken on board and the wire run through the snatch block on the anchor davit to the fleeting barrel of the anchor windlass and wound in as fast as the windlass would take it.

From current observations made on the vessel while anchor was being weighed, in a current of known velocity, it has been found that the drift of the vessel was considerably retarded within the full drift of the current by the anchor which held her somewhat while she had the full lead of 300 fathoms, the retardation decreasing gradually as the scope of the wire decreased.

At anchorages in the Gulf Stream the drift of the vessel was accurately determined by means of a diagram by the following plan: A base (101.3 feet), equal to 2 knots on a 30-second current line, was measured along the rail of the *Isis* (if the vessel, on account of wind, does not lie with the current, the better plan is to use a current pole and current line, allow the line to run out for 2 knots, and note the time, instead of using the base on the rail). As soon as a strain was put on the anchor wire, a chip was thrown over the side forward and the time required for it to pass along this base recorded. In three minutes' time this was repeated, and the mean of the times was taken for that three minutes. This was done every three minutes till anchor was off bottom.

It will be noted that, if the vessel be in a 3-knot current and the anchor holds her so that the current past the vessel is at the rate of 2 knots per hour, she drifts only at the rate of 1 knot. From this the actual drift was computed for a 1, 2, 3, 4, and 5 knot current, decreased by the amount the anchor held the ship as shown by the mean length of time required for the line to run out 2 knots, and a current curve and diagram were made, from which the actual drift may be scaled for these and intermediate currents.

Another diagram was devised from which may be read directly the correction to be applied to an observed current for the swing of the vessel during the time the observation is being made. Two sheets are necessary, one in which the stern of the vessel swings toward the current pole after the observation is begun and the other away from the current pole.

In order to lessen the chances of losing the survey buoys if sunk from being run down by passing steamers, reference barrel buoys were anchored, with Seimens-Martin, one-eighth inch, strand wire and 300-pound concrete block, an estimated distance away from and on an observed bearing from the survey buoy in order that the buoy might be recovered by grappling hooks.

Later during the season it was found that a 5-gallon tin kerosene can anchored with about a 30-pound concrete block and cotton cod line answered the purpose much better, in addition to being a much cheaper method.

A marked improvement was made to a navigating sextant for use on offshore hydrography by the substitution of a large telescope for the one supplied with the instrument. This change was made by the instrument section, using one-half of a pair of binoculars. It is conservatively estimated that one-third more time was actually spent on sounding work than would have been possible without this instrument. In the afternoon when shore signals became indistinct on account of haze this sextant was used for the least distinct signal and the line continued, whereas with the ordinary sextants the line would have ended and the vessel anchored. This was the case nearly every afternoon during the months of February, March, and a part of April.

C. K. Green, deck officer, devised an electric attachment for a sounding clock, which was used with excellent results during the past season.

Four tests were made during the season over a 2-mile course for standardizing the logs. It is thought that these tests should be made at least once a month in order to have an accurate rate. The rate changes considerably and probably from several different causes, the striking of the rotator against the side of vessel when hauling in, lag due to oil hardening in the working parts, etc.

More elaborate log tests were made for the different speeds. It was found that each log had different rates for slow speed, full speed, running full speed for 1½ minutes and drifting for 1½ minutes for sounding in depths over 15 fathoms with trolley rig, and yet another rate for running full speed for 2 to 2½ minutes and backing to full stop for upright cast with wire and registering sheave. The vessel was run over the measured base several times and the rate obtained for each speed, the different round trips checking very closely.

A large number of bottom specimens were obtained and recorded and a quantity of the best specimens saved. It was impossible to obtain bottom samples in the hard sand and shell bottom along the east Florida coast with the Stellwagen specimen cup. This cup is too blunt and also too large. The greater part of the specimens obtained this past season was by the use of soap in the end of the lead.

A cup, similar to the Stellwagen cup except that it is sharper and has a shorter cone, was devised on the *Isis*. This cup was not completed in time for use during the past season, but it is thought that with it bottom specimens may be obtained in hard sand or shell bottom.

The electric sounding machine installed on the *Isis* at the beginning of this season is entirely satisfactory. It has been used during the whole of the past season with lead line and trolley rig on all inshore dead-reckoning work and on the inner ends of lines to the Gulf Stream, and with wire and registering sheave on the outer ends of these lines.

Before using it for the lead line and trolley it was necessary to install several new kinds of springs to keep the lead line from jumping the drum. The single one on the machine intended for wire would not answer for the lead line.

The controller and brake are excellent, allowing perfect control of the drum at all speeds, in fact much better control than over the hand machine at slow speed.

Considerable information for the accurate running and plotting of the offshore dead-reckoning lines was obtained as to the velocity of the current in the edge of the Gulf Stream by a series of anchorages in the stream instead of only the one at the 100-fathom curve as previously made on this work. On all but the last line it was found that the strength of the current was from 0.6 to 0.8 knot at the 25-fathom anchorage, about 2 knots at the 40-fathom anchorage, and about 3½ knots at the 100-fathom anchorage, the direction in each case coinciding with the trend of the 100-fathom curve.

At all anchorages at and inside the 25-fathom curve the steamer was anchored with her regular ground tackle; at the 100-fathom curve by the same apparatus, devised and used on this vessel last season off the coast of South Carolina, except that Seimens-Martin, one-eighth inch, strand wire was used instead of ordinary strand wire. The drift was obtained by means of an ordinary current pole and the set with pelorus referred to the quarter-deck compass. At each station two observations through two minutes each were made and the resulting current divided by four. Much better results were obtained by this method than by observing three sets for 30 seconds each.

The drift of the current varied from 0.2 to 0.3 knot during small tides and light winds to as high as a knot during large tides and strong winds.

The set, as the tide ebbed and flowed, formed an ellipse, the axis of which was about west-northwest and east-southeast. Wind produces a marked effect upon this ellipse, lengthening from the origin in a direction with the wind and shortening toward the wind. During a heavy wind the whole ellipse is forced to the leeward of the origin and the direction of the currents apparently moves counter clockwise while as a matter of fact they are working clockwise but outside the origin.

During the season while at anchor when conditions were unfavorable for sounding, current observations were taken from the *Isis* every hour day and night.

Tidal observations for the reduction of soundings were obtained through the office from the automatic tide gauge at St. Augustine.

In order to obtain a relation between the tides outside and those at the St. Augustine gauge, the results from the Army Engineer staff erected at Atlantic Beach may be utilized.

Upon arrival at Jacksonville the tall hydrographic signals along the coast had not been erected, so the time necessary for the signal-building party to get ahead by a few signals was spent on log test, ship swings, and compass compensations.

Owing to the *Isis* having been moored, heading in one direction for six months, and also on account of new construction, the deviation had increased from 3° to 11°. The compasses were compensated and this deviation again reduced to 3°.

While engaged on lines to the 100-fathom curve, observations were made at fixed intervals with whirling psychrometer and also surface and bottom temperatures were obtained. In addition to these, barometer, air, and surface temperatures were recorded in the ship's log by the quartermaster on watch every hour during the season.

The ship was swung for deviation four times during the period January 30 to April 27. The deviation changed very little between swings.

Observations were made at intervals with the dip measure when the sea was smooth, rendering these observations possible. When the sea was rough and the vessel rolling, reliable observations with this instrument were impossible. The three axes, fore and aft, horizontal, and vertical, can not be held in position a sufficient length of time for a good contact when the vessel rolls. It is thought, though, that with a rough sea refraction is very near normal and tabulated sufficiently close for a sight at sea.

On February 18 a fire occurred on the water front in south Jacksonville at a lumberyard and shipbuilding plant. Before the fire was under control the launch of the *Isis* was sent over and towed the yacht *Soncy* to a safe berth.

On April 28, when bound up the St. Johns River for Jacksonville, the *Isis* passed the steam schooner *Rosalie Mahoney* afire and beached on the east side of the river half way between beacon 19C and Chaseville. The *Isis* went alongside, made fast to her on the windward side and for three hours used the fire hose and crew to assist the tugs *Smith* and *Volunteer* in getting the fire under control. The *Mahoney* was loading creosoted piles for Cuba. The cargo was ruined and the vessel gutted by fire, only the hull being saved.

[J. H. HAWLEY.]

SUMMARY OF RESULTS.—Hydrography: (wire drag) 92 square miles of area dragged, 130.4 miles run while dragging, 558 positions determined (double angles), 10 soundings made (on shoals), 1 tide station established, 212 soundings made (to supplement charts), 1 hydrographic sheet partly finished, scale 1 : 40,000.

In accordance with instructions issued March 6, 1917, a party was organized for wire-drag work in the western part of the Florida Reefs.

The officers of the party arrived at Key West on the morning of April 23.

Three launches were hired for the use of the party. Although seaworthy these launches were not well adapted to the use of the wire-drag party owing to shallow draft, low power, and lack of accommodations for the party.

From April 23 to May 9 the party was at Key West preparing the outfit, installing equipment on the launches, obtaining supplies, etc. Two whistle buoys and two first class standard cans were furnished by the lighthouse inspector, and superstructures similar to those used by the steamer *Isis* were fitted to these buoys.

After a delay of one day caused by bad weather the party left Key West on May 10 with the three launches and supplies for one month, arriving at Dry Tortugas on the afternoon of the same day. The lighthouse tender *Ivy* preceded the party on May 9, carrying most of the heavy supplies, and placed the four signal buoys in position on the working grounds on May 10.

At Dry Tortugas the party found a good harbor and an abundant water supply. It was necessary for the officers and hands to provide all camp furnishing and cooking equipment.

From May 11 to May 13 the party was engaged in building and locating signals and establishing quarters at Dry Tortugas.

Dragging was started on May 14 but fresh north to east winds with thick haze prevailed until May 21 so that little could be accomplished before that date. From May 21 until May 30 the weather was generally favorable but from May 31 to June 10 fresh winds shifting from northeast at night to southeast during the day created heavy cross seas which, complicated by strong currents, made drag work impossible in open waters.

Work was resumed on June 11 and continued under fairly favorable weather conditions until the end of the month, although fresh east winds and heavy squalls interfered with its progress toward the end of the month.

At the end of June, work was being done in Rebecca Shoal Channel whenever the weather permitted, and at other times to the southward and eastward to Dry Tortugas with the idea of gradually extending this work to join with that in the channel.

The four signal buoys were placed on a line extending southwest by south from Rebecca Shoal Lighthouse and spaced about 2.5 nautical miles apart, being located by theodolite angles from Loggerhead and Rebecca Shoal Lighthouses. These signals are found to be very satisfactory and are readily observed from distances up to 6 miles.

Numerous supplemental soundings were obtained by the large tender along the dragged lines in order to fill in the open spaces on the present charts.

No shoals especially dangerous to navigation were discovered.

In order to drag all areas within the field of work, additional floating signals are needed, and it is believed that a satisfactory type has been devised and constructed, although it has not yet been tried out in actual work.

This signal consists of a heavy center pole 25 feet long with a target at one end and a counterweight at the other. It is supported at a point about 15 feet from the top by three barrels, securely lashed and braced, and the mooring line is attached at the water line. A signal constructed in this manner stands vertical in quite heavy weather, shows up well at a distance of 5 nautical miles, and can be easily handled by our launches.

A tide staff was erected at Dry Tortugas and connected with one bench mark established in 1901. Two additional bench marks were established.

The party is indebted to the lighthouse inspector at Key West for his hearty cooperation in transporting supplies and for assistance in fitting out the floating signals; also to the officer in charge of the marine laboratory of the Carnegie Institute at Loggerhead Key for the numerous courtesies extended by him.

[L. A. POTTER.]

On July 1 the revision of the Inside Route Pilot from New York to Key West had been completed from Norfolk, Va., southward to St. Augustine, Fla.

The section of the waterway from St. Augustine to Key West was covered between July 1 and 13, in a chartered launch, stops being made at all of the towns en route.

On July 14 the return trip to Washington was begun, stops being made at the principal cities to interview United States Engineer Officers, Lighthouse Service officials, and others concerning doubtful points brought out by the field work.

The officer in charge of this work arrived at the Washington office July 24 and began the office compilation of the Inside Route Pilot.

LOUISIANA AND MISSISSIPPI.

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

SUMMARY OF RESULTS.—Triangulation: 120 miles of area surveyed, 3 signal poles erected, 5 observing scaffolds and tripods built, heights 80 to 90 feet, 3 stations in main scheme occupied for horizontal measures, 1 station in supplemental scheme occupied for horizontal measures, 8 geographic positions determined. Leveling: 10 miles of levels run, 11 permanent bench marks established. Magnetic work: ship swung at 4 sea stations. Topography: 274.5 miles of general coast line surveyed, 30 miles of shore line of rivers surveyed, 4 topographic sheets finished, scale 1:40,000. Hydrography: 721 miles of area covered, 2,498 miles run while sounding, 9,889 positions determined (double angles), 77,098 soundings made, 7 tide stations established, 5 current stations occupied, 3 hydrographic sheets finished, scale 1:40,000.

The survey of the eastern approaches to the Delta of the Mississippi River was begun by the party on the steamer *Hydrographer* in July, 1916.

The instructions for this work called for a resurvey of the eastern approaches to the Delta with the principal object of obtaining the present edge of the Delta and the outside shore line.

Actual survey work was begun on July 28 and closed on account of bad weather October 21.

The hydrography between the edge of the Delta and the 20-fathom curve was done with the hand lead. Beyond the 20-fathom curve pressure tubes were used. It was found by experiment that the Tanner-Blish tubes were more accurate than the Bassnet sounders, especially in depths over 50 fathoms. Sufficient soundings were made with the lead to keep a close check on the depths recorded by the Tanner-Blish tubes.

For the offshore hydrography tall hydrographic signals were necessary. Four of these signals from 80 to 90 feet in height and several smaller scaffolds were built.

The currents in this region are so variable that any discussion of them will have to follow an extended series of observations. Without any disturbing westerly wind, the natural trend of the currents is to the westward.

Weather conditions became very unfavorable in October and culminated in a tropical hurricane on October 17 and 18. This hurricane absolutely destroyed the tall hydrographic signals and rendered necessary their rebuilding before any additional work could be done. Work in the Delta was accordingly closed for the season.

The topography of the Delta was extended from the western limits of the sheet to a point about 5 miles west of Pass a Loutre Lighthouse.

The triangulation consisted of the necessary observations to locate the signals for control of the hydrography and topography. The tidal information was obtained from the gauge maintained in East Bay by the Mississippi River Commission.

This survey, even in its incomplete state, shows that this region needs to be frequently resurveyed. The edge of the Delta as marked by the 3-fathom curve has been extended seaward about 1 mile off Garden Island Bay and about 2 miles or more off the mouth of Pass a Loutre. Other changes noted include the closing of various small passes between South Pass and Pass a Loutre, the washing away of the mud lumps in places, and their appearance in others.

Investigations carried on by the United States Army Engineers and the Mississippi River Commission show that the whole area is subsiding. Permanent precise bench marks are impossible within miles of the mouth of the river. The results of the tidal observations at the East Bay gauge, which was used for the present survey, show that during the past few years the subsidence has been relatively the same between the gauge and the bench marks. The lines of levels, which are frequently run along the passes of the river, show that the whole country is sinking at a more or less uniform rate.

On October 30, after the weather had made further work at the mouth of the river unprofitable, instructions were issued directing that a "comprehensive resurvey of Mississippi Sound and tributaries, the islands on the south side, and the entrances from the Gulf between Mobile Bay and Lake Pontchartrain" be made. These instructions provided that in addition to working from the vessels, shore parties were to be established with additional officers and men at such places as were necessary for the successful prosecution of the work. Work under these instructions was begun on November 9 and continued until May 24, when the shore party had to be disbanded on account of a shortage of funds. From the period May 7 until May 24 the vessel was absent from the Mississippi Sound working grounds doing some work at the mouth of the river, in accordance with instructions as mentioned in the following paragraph.

On April 19 instructions were issued directing that certain check soundings be made at points indicated to further check the tube sounding that had been done at the mouth of the river and that certain check lines of soundings be run between the 15 and 20 fathom curves. Supplemental to these instructions, others were received that directed the inshore work to be done out to the 30-fathom curve from the entrance to South Pass westward to meridian 89° 15′. Work under these instructions was done from May 7 to June 21. On the latter date the work had been completed, and the vessel proceeded to New Orleans and was laid up until the end of the fiscal year.

At the mouth of the Mississippi River the hydrography was extended from a few miles north of Pass a Loutre westward to meridian 89° 15′. The inshore limit of this work is in general the 3-fathom curve and the outer limit varies from 20 fathoms at the northern end of the work to 30 fathoms west of South Pass. In the area immediately southeast of the mouth of South Pass, the hydrography was carried out to the 100-fathom curve. Prior to October 21, a large part of the work between the 50 and the 100 fathom curve was done with pressure tubes, the Tanner-Blish tubes being used. The soundings in this area taken in May and June, 1917, are all up-and-down casts made while the ship was stopped and working the engines if necessary to secure them. In general the agreement between the soundings as recorded previously by the pressure tubes and the vertical casts made for checking purposes was excellent. Where any marked difference was found additional soundings were made.

The sounding done between the 15 and the 20 fathom curve was done with the double sounding-chair arrangement mentioned previously. Off the mouth of Pass a Loutre, the depths had changed so that additional lines were run until a satisfactory junction had been made. The Mississippi River had passed through a high-water period since the survey of last year, and an immense amount of sediment had been deposited at the various mouths of the river.

Reports of a shoal off the mouth of South Pass have been made at various times in the past and instructions were given to run several lines of soundings over the area that had been reported foul. These lines were run, and in the area covered the soundings were regular and increased to the southward as might be expected.

It was found that the tall hydrographic signal near the mouth of Southeast Pass could not be carried as far seaward by day as was desired and the work was done at night. Two acetylene signal lights were mounted on the top of the signal. The angle between the two pointings was about 24°, the limits of visibility of the two lights about embracing the limits of the area to be covered. One of the observers was swung in a boatswain's chair at the yard arm. and by this means it was possible to secure one angle and a bearing giving a better location than the dead reckoning to such a distance.

In Lake Pontchartrain and Mississippi Sound the hydrography was extended from meridian 89° 52′ to the western entrance of the Rigolets, and from Shell Point and the eastern entrance to the Rigolets to about half way between Gulfport and Biloxi. In Lake Borgne, a line from Shell Point to Grand Island marks the southern limit of the closely developed work. South of this line several reconnoissance lines were run with the ship. The soundings obtained on these lines showed little change from the soundings shown on the present chart, and the work was extended no farther south. In Mississippi Sound, a line from Grand Island to Isle au Pitre and from Isle au Pitre to the western end of Ship Island marks the southern limit of the closely developed work. Between Grand Island and Isle au Pitre a few reconnoissance lines were run with the ship with the same result as found in the reconnoissance lines in Lake Borgne. A few miles of soundings were run at the western end of Horn Island.

The hydrography in Lake Pontchartrain was done with the launch from the ship. The results of this work showed that the so-called middle ground between the New Orleans & Northeastern Railroad drawbridge and the Rigolets was much smaller than is shown on the present charts and also that the shoal water at the Lake Pontchatrain entrance to Chef Menteur is much more limited than is shown on the present charts.

The launch hydrography of Lake Borgne and of Mississippi Sound from Lake Borgne Lighthouse to Cat Island and the small amount of hydrography at the western end of Horn Island were done by a shore party.

The launch hydrography of Mississippi Sound from Cat Island to the eastern limits of the work was done by a shore party while the vessel was at Mobile for repairs.

The topography in Lake Pontchartrain was extended from a few miles west of West End on the south shore of Lake Pontchartrain eastward to the western entrance to the Rigolets and from the Rigolets to Big Point along the north shore of the lake. In Lake Borgne, the topography was extended from Shell Point to Lake Borgne Lighthouse including Grand Island. In Mississippi Sound the topography was extended from Lake Borgne Lighthouse to Bellefontaine Point, about 10 miles east of Biloxi, Miss. Isle au Pitre, Cat Island,

and the shore line of St. Louis Bay were also surveyed. A couple of days' work at the west end of Horn Island was also done.

All the topography was a revision. Especial attention was paid to features that would be of value in navigation and to securing the names of all points, bayous, creeks, etc. Few great changes in the shore line were found. This is rather remarkable when the destructive effect of the storms to which this section is subject are considered.

The instructions of October 30 called for a connection of the triangulation of Lake Borgne with the triangulation of Lake Pontchartrain. This connection was made at the eastern end of Lake Pontchartrain. The old stations Biloxi Bayou, Malheureaux Point 2, and Old Tower, of the Lake Borgne scheme, were connected with the stations Point aux Herbes Lighthouse, North Draw, and West Rigolets Lighthouse, of the Lake Pontchartrain triangulation.

In addition to this connection it was necessary to do some supplemental work for stations for control of the topography and hydrography. The storm of September, 1915, had destroyed all the beacons, etc., previously located in Lake Borgne and Mississippi Sound, and new locations had to be made of them. Some stations were also located along the north shore of Mississippi Sound to be used as hydrographic signals. The Gulfport Channel beacons were relocated.

All the triangulation was tertiary in character. The new stations were marked and described.

For the hydrography of the Mississippi River Delta approaches, the tidal data were obtained from the Mississippi River Commission, which has maintained an automatic tide gauge in East Bay across the river from Port Eads for a number of years. This gauge is connected with the gauge also maintained by them at Biloxi from which the mean gulf level has been determined by precise levels.

The tidal data for the hydrography of Lake Pontchartrain were obtained from tide staffs placed at West Rigolets Lighthouse and at the north draw on the New Orleans & Northeastern Railroad bridge across Lake Pontchartrain. Each of these staffs was connected with the staff at St. Louis Bay by simultaneous observations. The customary bench marks were established in the vicinity of West Rigolets Lighthouse and the tide staff connected with them. The original instructions called for a tide staff at West End to be connected with the staff at Bay St. Louis by simultaneous observations. This staff was placed, the observations made, and the staff connected with the bench mark, Halfway House, which is connected with the precise level net between Mobile and New Orleans. Three new bench marks were also established at West End and this staff connected with them.

The tidal data for the hydrography of Lake Borgne and Mississippi Sound were obtained from the automatic tide gauge installed at the draw on the bridge crossing St. Louis Bay. This gauge was established the early part of December, 1916, and is still in operation. The staff at this station is connected with one of the bench marks in the net between Mobile and New Orleans and with three new bench marks which were established at the Bay St. Louis end of the bridge.

When the shore party moved from Bay St. Louis to Pascagoula, Miss., a tide staff was erected at the latter place and connected with the staff at Bay St. Louis by simultaneous observations. The Pascagoula staff was also connected with one of the bench marks in the net between Mobile and New Orleans. Three additional bench marks were established at Pascagoula and the staff was connected with them.

A staff was erected at Cat Island Lighthouse and connected with the one at St. Louis Bay by simultaneous observations. Tide observations were made by the lighthouse keeper when the party was working in the immediate vicinty of the lighthouse.

Currents, using the regulation current pole and line, were observed at four stations. The series at the western entrance of the Rigolets extended over a period of about 30 days. At the other three stations currents were observed whenever the ship was anchored in the vicinity.

The ship was swung for deviation at four stations, once off the mouth of Southeast Pass, Mississippi River Delta, in August, 1916, and again in the same vicinity in June, 1917, once about halfway between Shell Point and Malheureux Point in Lake Borgne and once just west of the dredged channel into Gulfport Harbor.

A shore party, living in camp, was established at the mouth of the Pearl River on December 7. The hydrography and topography of Lake Borgne were done from this camp. This party was moved in February to Bay St. Louis, which was used as headquarters for the survey of the western end of Mississippi Sound east to Cat Island. It was then moved to Pascagoula, Miss., April 23, and remained there. A fire destroyed the camp on May 2, and the party was disbanded on May 24.

A shore party was stationed in New Orleans from March 26 to April 11. During this time the topography of the south shore of Lake Pontchartrain from Point aux Herbes Lighthouse to a few miles west of West End was run, the tide staff at West End was erected, and the tidal observations made.

As the *Hydrographer* was to be laid up for repairs for a period of six weeks or two months, practically the entire crew was put in a shore party at Gulfport, Miss., to work in the vicinity of Gulfport while the vessel was being repaired. They were engaged on this work from February 16 until April 11.

An officer was sent to Port Eads in advance of the vessel on April 27 to rebuild the tall hydrographic signal for use in the offshore hydrography of the Mississippi River Delta. Signal Mud was rebuilt, and a small water signal built about halfway between signal Mud and South Pass Lighthouse. This party was working from April 30 until May 12.

TEXAS.

[J. B. BOUTELLE.]

The inspector at Galveston was principally occupied from July 1 to 22 in installing and attending to the Coast and Geodetic Survey exhibit at the Galveston Cotton Carnival.

On September 16 the location of the Coast and Geodetic Survey suboffice was changed from No. 19, Cotton Exchange, to No. 413, Security Building, Galveston, where it is now.

Information was collected for use in the correction of the charts, coast pilots, and tide tables, and a stock of the nautical publications of the Survey was kept on hand for consultation and sale.

Information in regard to publications, surveys, dangers to navigation, tides, etc., was furnished to persons applying for the same.

Sixty-four certificates of efficiency were issued to lifeboat men during the year.

The duties of the inspector include the collection of information for the correction of the charts, coast pilots, and tide tables; furnishing information in regard to surveys, tides, and dangers to navigation in reply to official and private requests; and the distribution and sale of charts and nautical publications of the Survey. The inspector was absent on field duty from April 3 to 17.

Hydrographic and Topographic Work, Pacific Coast.

CALIFORNIA.

[E. B. Latham.]

Summary of results.—Triangulation: 10 square miles of area covered, 1 signal pole erected, 3 stations in main scheme occupied for horizontal measures, 23 geographic positions determined. Leveling: 12 permanent bench marks (tidal) established. Topography: 18 square miles of area surveyed, 38 miles of general coast line surveyed, 12 miles of shore line rivers surveyed, 70 miles of roads surveyed, 3 topographic sheets finished, scales 1:2,500 and 1:10,000. Hydrography: 234.25 miles run while sounding, 1,928 positions determined (double angles), 10,633 soundings made, 4 tide stations established, 3 hydrographic sheets finished, scales 1:2,500 and 1:10,000.

In the early part of July the computations of the triangulation in the vicinity of San Diego and elsewhere on the coast of California undertaken at the request of the Bureau of Lighthouses, were completed.

On July 9 the observer left San Diego for Cayucas and Morro, Cal., to supplement the hydrography off the port of Cayucas and make certain investigations at Morro. The results of this work were included on one topographic sheet, one hydrographic sheet, and one combined topographic and hydrographic sheet.

On the completion of this work the observer proceeded to Lompoc, Cal., and located the naval communication station at Point Arguello from points on the topographic sheet of the locality.

On September 12 the observer proceeded to Los Angeles, Cal., where information was obtained in regard to recent surveys by the United States Engineers at Newport Bay, Cal.

Work in the vicinity of San Diego was begun September 18.

The triangulation to check the positions of the aids to navigation and to determine additional points on the shores of San Diego Bay was completed in this month.

Topographic sheets were prepared and the topography of the bay on two sheets on a scale of 1:10,000 was completed in October and November.

The hydrography was begun in December. Advance information of the results of this work was furnished to the Naval Commission on Navy Yards and Naval Stations.

[L. O. COLBERT.]

SUMMARY OF RESULTS.—Leveling: 3 miles of levels run, 34 permanent bench marks established. Topography: 45.6 miles of general coast line surveyed, 45.6 miles of roads surveyed, 4.3 miles of railroads surveyed, 6 topographic sheets finished, scales, five 1:10,000, one 1:5,000. Hydrography: 64.2 square miles of area sounded, 52 square miles of area dragged, 140 miles run while sounding, 246 miles run while dragging, 599 positions determined (double angles) while sounding, 2,121 positions determined (double angles) while dragging, 2,210 soundings made, 12 tide stations established, 2 hydrographic sheets finished, scale 1:20,000, 2 wire-drag sheets finished.

In November, 1916, a party was organized for wire-drag work in San Francisco Bay.

Drag work was begun November 28 but was discontinued from December 8 to January 8 in order to complete a special hydrographic survey desired.

The limits of the dragged area extend from the Sisters to the 5-fathom curve south of Point Avisadero through the Golden Gate and Bonita Channel.

The effective depth dragged varied with the charted depths. In deep water the standard depth dragged was from 45 to 50 feet. Through the Golden Gate outside of Fort Point the depth averaged about 50 feet; inside the Golden Gate about 35 to 40 feet; in Bonita Channel about 45 feet; in the upper part of the bay from 28 to 47 feet, and in the lower part of the bay from 25 to 35 feet.

One important shoal with 29 feet of water over it was found about 1 mile northwest of Alcatraz Island.

A system of sounding lines was run across the bay from shore to shore about 1 mile apart. Additional lines were run inshore so spaced as to make the distance between about one-third of a mile.

Nine tide staffs were erected and observations made covering various periods during the hydrographic work in vicinity of each.

A topographic revision was made of the entire shore line of San Francisco Bay from Point Bonita to Point San Pedro, from Point San Pablo to San Leandro Bay, and from Hunters Point to the southern limits of Golden Gate Park. Triangulation points for the control of this work and for use by the hydrographic party were determined by E. W. Eickelberg.

The area covered by the instructions was completed on March 12, and the party left San Francisco for Seattle, Wash., March 17.

[E. F. DICKINS.]

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

The inspector has obtained information for correcting the coast pilots and charts and has furnished tidal information and advance notices to mariners for publication in the newspapers. He has attended to the sale and issue of charts and other publications; has furnished information in regard to surveys to Government officials and others applying for the same; attended to the forwarding of instruments and supplies to the suboffice of the Survey at Manila; furnished transportation to officers of the Survey upon request;

supervised the repair and operation of the Presidio tide station; furnished data, instruments, etc., to field parties of the Survey; and attended to other miscellaneous duties.

CALIFORNIA, OREGON, AND WASHINGTON.

[R. S. PATTON.]

The work of revising the Coast Pilot of California, Oregon, and Washington was in progress at the beginning of the fiscal year. A chartered launch was used in examining Puget Sound and adjacent waters, but owing to the small amount of funds available for this work, with a few minor exceptions never exceeding one day, no launches were hired during the remainder of this work.

The general plan adopted in the revision was to travel southward from one locality to the next until the entire coast had been covered, thus obtaining detailed information regarding the various localities, and then to return northward by steamer, changing boats as often as possible, in order to consult with the more experienced navigators on the coast regarding the particular application and usefulness of the volume to their profession.

The descriptive matter of the present volume was found to be excellent. As a rule the only alteration which it will require is in areas where artificial changes have been made.

The principal changes which are contemplated in the new edition are in the sailing directions, which require treatment from a broader point of view so as to emphasize those vital facts that affect navigation and that frequently can not be shown on the charts. Navigation on the Pacific coast is affected by a combination of two factors, fogs and currents, which present to the navigator problems not met elsewhere.

With a view to obtaining the benefit of what navigators had obtained by years of experience, a circular was addressed to most of the able navigators asking for statements on the following points: (1) The track commonly followed by them; (2) the forces which tend to cause deviation from the track, together with the conditions under which they become operative; (3) the methods and precautions used in thick weather to hold the track or guard against being set into danger; (4) any peculiar features which anywhere indicated the proximity to danger or served as a guide in rounding the various turning points; and (5) critical defects in the present charts.

A number of excellent letters were received in reply to this request that will be of material assistance in the preparation of the contemplated statement.

A careful study was also made of the records of investigations by the Steamboat-Inspection Service into the strandings on the coast in recent years, from which much valuable material was obtained.

During the progress of the coast pilot work, a special study was made of the problem of beginning a resurvey of the coast, working from a chartered vessel. Weather conditions, the availability of harbors, the best season for work, and the possibility of obtaining the necessary vessel were carefully considered.

All field work was completed on October 16.

WASHINGTON.

[JOHN A. DANIELS.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 13½ miles, 14 square miles of area covered, 95 lines of intervisibility determined, 38 points selected for scheme. Triangulation: 11 square miles of area covered, 40 signal poles erected, 37 stations in supplemental schemes occupied for horizontal measures, 51 geographic positions determined. Leveling: ½ mile of levels run, 3 permanent bench marks established. Topography: 27 miles of general coast line surveyed, 2½ miles of roads surveyed, 1 topographic sheet finished. Hydrography (wire drag): 21.9 square miles of area dragged, 134.8 miles run while dragging, 3,596 positions determined (double angles), 115 soundings made, 3 hydrographic sheets finished, scales 1:5,000, 1:10,000, and 1:20,000. Soundings: 2.3 square miles of area covered, 70.3 miles run while sounding, 745 positions determined (double angles), 2,367 soundings made, 1 tide station established, 2 hydrographic sheets finished, scales 1:5,000 and 1:10,000.

Between November 18, 1916, and March, 1917, wire-drag party No. 3 was engaged in surveys in Puget Sound and Port Orchard.

A scheme of triangulation was executed connecting the work by C. G. Quillian in 1915 with that by F. H. Hardy in the same year. It also connects with the work by Eugene Ellicott in 1880 and by George Davidson in 1856, although the latter connection is by a single point only.

The scheme was computed from the base Boulin-Bowlder recovered from 1880 work of Eugene Ellicott. The distance and azimuth between these stations were obtained by an inverse computation, the values thus secured being carried through the scheme and checking closely upon the recovered stations.

The total scheme comprises 40 stations, 9 of which are former stations recovered, and 3 of which were unoccupied. There is a total of 58 closed triangles with an average closing error of 4.3 seconds.

The topographic revision indicated in the instructions—that is, the verification of the shore line and addition of changes in Port Orchard Bay, Agate Passage, and Port Madison—was completed as far as President Point and Point Monroe. The revision connects with the 1915 work of C. G. Quillian to the southward and with the work of F. H. Hardy during the same year in Liberty (Dogfish) Bay.

The sounding work consists of a thorough development of Liberty Bay northward from latitude 47° 42′ by lines 100 meters apart and perpendicular to the axis of the channel. This work was plotted on a sheet of scale of 1:10,000. Agate Passage was also sounded with similar lines across the channel upon the same scale. The work in Agate Passage was done because of local reports that the depths in the passage had undergone extensive changes. The reported changes were not found and the soundings closely verify the general charted depths.

The small inlet upon the southern side of Port Madison was carefully sounded out upon a scale of 1:5,000, 50-meter lines being used. Very little change from charted depths was found except at the narrow part of the entrance to the inlet where a 4-foot shoaling was found, due probably to the accumulation of sawdust from the sawmill which has been operated until recently just inside the entrance.

The waters of Richs Passage, Sinclair Inlet, Port Orchard, Agate Passage, and Port Madison were swept by the drag. The depths verified were approximately those charted up to 10 fathoms. The drag was swept so as to verify the 3-fathom curve, and great care was taken to thoroughly cover the area and develop all shoals. Several dangerous bowlders and shoals were located in Agate Passage and in Richs Passage, and a depth of 23 feet was found upon a charted 4½-fathom shoal south of Point Bolin.

The narrow passage into the inlet at Port Madison village has filled in since the last survey was made. It carries a depth of 9 feet now while the charted depth is 13 feet.

The sheet-metal floats used during the last part of the previous season in Alaska were used exclusively upon the work and proved satisfactory.

A device to keep the metal floats from flying back and injuring themselves and the deck of the launch was constructed. It was made of wood padded with old line and attached so as to yield when struck by the float. The device proved very useful in protecting boat and float and increased the safe speed possible in taking up the drag.

A reinforced wooden buoy holder that was attached by means of an ordinary oar socket proved useful for making changes in length of upright from the tender.

A new make of hoisting apparatus for large and small buoys was designed but was not tried out during the season.

[JOHN A. DANIELS.]

SUMMARY OF RESULTS.—Reconnoissance: length of scheme 8 miles, 16 square miles of area covered, 12 points selected for scheme. Base lines: 1 site for base line selected. Triangulation: 16 square miles of area covered, 7 signal poles erected, 12 stations in supplemental schemes occupied for horizontal measures. Topography: 15 square miles of area surveyed, 29½ miles of general coast line surveyed, 21 miles of roads surveyed, 3 topographic sheets finished, scale 1:5,000.

Between April 6 and June 30, 1917, topographic revision work was done along the Lake Washington Canal from Shilshole Bay to Lake Washington, including the changed shore line of Salmon Bay and Lake Union and also the changed topography between Salmon Bay and Smith's Cove. Revision in the vicinity of Alki Point was under way at the end of the fiscal year. During the same time the triangulation was extended from the vicinity of Salmon Bay to Smith's Cove, across Elliott Bay and southward along the Duwamish Valley to South Park, the scheme being approximately 10 miles long.

A base site was selected along the Duwamish River and the necessary observing done to connect with the triangulation. Preparations for measuring the base were nearly complete at the end of the fiscal year.

[PAUL M. TRUEBLOOD.]

SUMMARY OF RESULTS.—Hydrography: 18 tide staffs erected for comparative readings, 2 tide stations established, 62 permanent bench marks established, 6 current stations occupied.

In February a tidal and current survey of the southern part of Puget Sound was begun, the launch *Wanick* having been chartered for the use of the party.

The first work done was the establishment of automatic tide gauges at McNeil Island and Allyn. Bench marks were placed at the same time. The tidal work was taken up at South Colby, Burton, and Gig Harbor. The general plan adopted was to work to the south toward the more remote and less important places. An effort was made to make the current observations simultaneously with the tidal observations, but stormy weather conditions and other causes made this impracticable. The period from March 18 to April 3 was practically one continuous storm. Operations were delayed considerably by the strong southerly winds and rough weather. During this time the bulkhead in the new King County Ferry Dock at Des Moines was carried away and with it the tide staff for that place. No levels had been run on account of the persistent bad weather since the observations were made. No permanent mark was therefore left at this station.

An automatic tide gauge was established on the Federal penitentiary wharf at McNeil Island, where two bench marks were placed and observations continued for two months.

McNeil Island was chosen as a location because it is central to the tidal basin from The Narrows to Johnson Point, including Carrs Inlet. The tide staffs at Steilacoom, Dupont, Arletta, Wanna, Home, Longbranch, and Libbeys Ranch (Henderson Inlet) were referred to this gauge.

Another automatic gauge was established at Allyn and operated for a month. This served to determine the type of tide at the head of Case Inlet.

Observations at South Colby, Des Moines, and Burton were referred to the automatic gauge maintained by the Survey at the foot of Madison Street, Seattle.

An automatic gauge belonging to the Survey was maintained by the field engineer of the State of Washington at Olympia. This gauge had been in operation for about eight months.

Eighteen tide staffs were erected and determined by comparative readings with the automatic gauges. Readings were taken every 10 minutes for an hour before and after high and low water and every hour between high and low water. Sixty hours was the shortest series and a number of them were from 84 to 96 hours.

Three permanent bench marks were put in at each station and were connected with the tide staffs by accurate lines of levels.

Current measurements were made both from the launch and from wharves by the tidal observers.

Observations were made from the launch in the north end of Colvos Passage on three days. The maximum velocity observed was 1.2 knots.

At Point Robinson observations were made for 49 hours from an anchorage 200 meters off the light. The maximum velocity observed was 0.94 knot.

A series of 20 hours was obtained in the southern part of The Narrows. A velocity of 2.65 knots was observed. This series is incomplete.

Additional observations were made by the tide observers at Dupont, Arletta, and Boston Harbor, which give some idea of the relation of the eddy currents at those points to the tides. Observations of the time of slack water and approximate direction of the current were made at Steilacoom, Grant, Arcadia, South Colby, Vaughn, and Totten Inlet.

Field work was closed on April 16.

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

During the winter of 1916–17 some work was done on the survey of the Lake Washington Ship Canal.

The scheme of triangulation laid out by G. T. Rude several years ago was followed, the connection of the canal with Smith Cove practically finished, and a few additional stations established. Topographic projections were laid out and good progress was made on one sheet.

In the latter part of March this work was turned over to J. A. Daniels.

Magnetic observations were made at Restoration Point and a new magnetic station established while the vessel was at Winslow for docking.

After returning to Seattle, observations were made at the established station located in Seward Park.

[T. J. MAHER, Commanding Steamer *Explorer.*]

SUMMARY OF RESULTS.—Triangulation: 2 square miles of area covered, 3 signal poles erected. Leveling: 2 miles of levels run, 3 permanent bench marks established. Azimuth: 1 station occupied for azimuth observations. Topography: ½ square mile of area surveyed, 2 miles of general coast line surveyed. Hydrography: ½ square mile of area sounded, 10½ miles run while sounding, 1,264 positions determined (double angles), 632 soundings made, 2 tide stations established, 4 current stations occupied, 1 hydrographic sheet finished, scale 1:2,500.

A survey of two lanes across Richs Passage was made. Work had been done in this vicinity a number of years ago which was sufficient for navigation, but the lines of soundings did not parallel the direction of the lanes along which soundings were now required. A survey was made on a scale of 1:2,500, which was as large as could be conveniently handled in plotting.

Prior to taking up this survey the party was engaged on current work in the same locality. This work was extended somewhat beyond what was called for in the instructions using the same data. Some additional signals were located by planetable.

A tide staff was erected on the Fort Warddock. A tide staff which had apparently been used by some other survey party was found on the Pleasant Beach dock, and simultaneous observations were begun. Certain bench marks in the vicinity of Pleasant Beach were connected by leveling with the tide staffs. Six high and six low waters observed at Ford Ward were used in deriving a plane of reference for this work. These were referred to Seattle as the main station.

Soundings were made with a launch sounding machine and located by sextant angles taken to the launch by observers at triangulation stations on shore. Only one line of soundings in each of the two directions was required. Five lines over each direction were run. Additional soundings were made over areas where soundings appeared irregular.

GEODETIC WORK.

MAINE AND NEW YORK.

[JOHN D. POWELL.]

SUMMARY OF RESULTS.—326 miles of levels run, 237 permanent bench marks established.

Work on the line of precise levels in Maine between Boundary and Vanceboro, preparations for which had been begun in June, 1916, was continued from July 1 until September 19, when field operations on this line were completed.

This line across the State of Maine followed the lines of the Canadian Pacific Railway and the Maine Central Railroad.

On September 19 the work in Maine having been completed, the party and equipment were moved to Rouses Point, N. Y., but on account of delay in securing the permission from the Delaware and Hudson Co. to use motor cars over their tracks, work was not started at that point until October 4. The work in New York was extended to Whitehall, after which the weather was so severe the season's work was closed and the party was disbanded.

The line of levels across the State of Maine afforded a connection between lines of precise levels run by the Geodetic Survey of Canada.

The line drops sharply from Boundary on a 1.6 per cent grade. The country is very rugged, and curves and deep cuts are numerous. The towns passed include Holeb, Jackman, Greenville, Brownville, Mattawamkeag, and Vanceboro. Commencing at Holeb the line runs for 100 miles through the lake region, and here lakes, small ponds, and connecting streams are on every hand. Lumbering is the principal industry and most of the towns are simply small lumbering camps which afforded no accommodations for the leveling party.

East of Mattawamkeag the right of way is the property of the Maine Central Railroad Co. This portion of the line stretches for 56 miles over a rolling country with steep grades and numerous curves.

At Vanceboro connection was made with bench marks of the Canadian survey. The elevations as recorded by the Canadian survey and the Coast and Geodetic Survey differ by only a very small fraction of a meter.

The work in the State of New York lay along the line of the Delaware & Hudson Co. tracks. It passed through the towns of Plattsburg, Westport, Port Henry, Crown Point, and Whitehall. It started from bench marks of the United States Coast and Geodetic Survey and the Geodetic Survey of Canada. South from Rouses Point the line followed closely the rocky shores of Lake Champlain. Almost constant rock cuts, sharp curves, narrow passes, and several tunnels made the road a very dangerous one to level over. Two velocipede motor cars were used in this work. On one of these the instrument tripod was mounted.

Standard bench marks were set on an average of one for every 2 miles. All bench marks were on ledge rock, large bowlders, railroad structures, or public buildings. Besides these a number of temporary bench marks were used to limit the lengths of section to about 1 mile.

MASSACHUSETTS, RHODE ISLAND, AND CONNECTICUT.

[H. P. RITTER.]

Topographic determinations were made of the locations of radio stations at New London, Conn., on October 18, and at Newport, R. I., on November 26. In each case the station was identified and its position plotted by distances measured with a steel tape to near-by located points shown on the chart, and the latitude and longitude scaled. Afterwards the position of each station was verified in the office by plotting it on the latest planetable sheet.

The naval radio station at North Truro, Mass., was visited by the same observer in August (while engaged in other work at Provincetown) and found by inspection to be located as shown on Coast and Geodetic Survey chart No. 341.

CONNECTICUT.

[H. P. RITTER.]

On September 30, 1916, a revision was begun of the triangulation and topography on the south shore of Connecticut between the easterly end of the Norwalk Islands and New Haven, Conn.

The work was begun by an examination and re-marking of the triangulation stations in the vicinity of the coast.

Between September 29, when the work began, and November 3, when the work was discontinued, 88 triangulation stations were visited and examined.

NEW YORK.

[ISAAC WINSTON.]

In May, 1917, a determination was made by triangulation of the geographic position of the tower of the Woolworth Building in New York City, the most conspicuous object on Manhattan Island, reaching to a height of 750 feet, and also the geogrpahic position of the Ambrose Channel Range Rear Light.

Three stations of the triangulation of Greater New York, Standish Arms, Prospect Water Tower, and Schoolhouse 142 in Brooklyn, were recovered and occupied for observations to determine the geographic position of the Woolworth Building tower, and three lighthouses, Coney Island Light, West Bank Light, and Old Orchard Shoal Light, were used to determine the position of Ambrose Channel Range Rear Light.

On account of the necessity of calm weather for landing at Old Orchard Shoal Light, observations were not made at that station.

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

[J. E. McGRATH.]

SUMMARY OF RESULTS.—Triangulation: 8 square miles of area covered, 21 geographic positions determined, 1 elevation determined trigonometrically. Leveling: 3 miles of levels run.

During the period from April 9 to May 22, 1917, determinations were made of the geographical positions and heights above sea level of a number of wireless stations on the Atlantic coast, and a connection was made between the observatory of Columbia University in New York City and the triangulation scheme of New York City.

The geographic positions were determined of the radio stations at Belmar, N. J., New Brunswick, N. J., T. A. Scott & Co. at New London, Conn., and the National Electric Signalling Co., at Newport, R. I.

The elevations of the bases of radio stations with reference to sea level were determined, as follows: Marconi wireless masts at Belmar, N. J.; Marconi wireless masts at New Brunswick, N. J.; Marconi wireless masts at Seagate, N. Y.; American Commercial Co. mast at Sayville, N. Y.; Marconi wireless mast at Sagaponack, N. Y.; T. A. Scott & Co. masts at New London, Conn.; National Electric Signalling Co. mast at Newport, R. I.; Marconi wireless masts at Siasconset, Mass.; Marconi wireless masts at South Wellfleet, Mass.; and Marconi wireless masts in Boston, Mass.

In New York City the observatory of Columbia University was connected with the primary triangulation in New York City by means of a 1,200-foot traverse.

NEW YORK, NEW JERSEY, PENNSYLVANIA, AND MARYLAND.

[O. W. SWAINSON.]

Between March 14 and April 1, determinations were made by triangulation of the geographic positions and elevations of the ground at the bases of radio stations at Annapolis, Md., Baltimore, Md., Philadelphia, Pa., Cape May, N. J., Tuckerton, N. J., and New York, N. Y.

The observer was then instructed to close work and arrange to take charge of a precise leveling party in Texas.

DISTRICT OF COLUMBIA.

PENDULUM INVESTIGATIONS.

[C. L. GARNER AND MAX STEINBERG.]

Certain investigations were made in connection with the pendulum observations to determine the effect on their periods of the various conditions under which they are used. The detailed results are of special interest only and will be reported on in detail in some future special publication on the determination of the intensity of the force of gravity. As one of the results of the investigations it was found that the pendulums have slightly different temperature coefficients from those previously used. With the use of the new coefficients, the periods of the pendulums at the base station at Washington, D. C., were found to be more accordant than when the earlier coefficients were used.

[C. V. HODGSON AND MAX STEINBERG.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 14 statute miles, 115 square miles of area covered. Triangulation: 115 square miles of area covered, 17 stations in main scheme occupied for horizontal measures, 24 geographic positions determined.

In pursuance of instructions issued in January, 1917, a reconnoissance was made for the extension of the triangulation in the vicinity of the District of Columbia to furnish some control points in Maryland for the Washington Suburban Sanitation Commission on or near the line of the proposed new sanitation district. As a result of the reconnoissance it was decided that tertiary triangulation would furnish all the accuracy required in the results. Primary triangulation would require much more time, and therefore it was concluded that the work should be only tertiary in character, extending from such tertiary triangulation as was available in the District.

The necessary reconnoissance was made as rapidly as the weather and poor condition of the roads would permit, and six points were found directly on the proposed boundary which could be easily located, besides others in the interior of the sanitation district. The observation of angles was begun on February 21 and continued at such times as the weather permitted up to the end of March. During that time 16 stations were completed and observations were partly completed at the remaining two stations of the scheme. Signal lamps were used exclusively on account of the thick atmosphere.

The charge of the party was transferred to another officer on April 1.

At the time of transfer the remaining stations were Ken and Chevy. These stations were located on stand pipes 120 and 140 feet in elevation, and observations were difficult on account of continuous winds. On April 4 and again on the 11th the wind subsided, and the field work was then completed.

DISTRICT OF COLUMBIA AND MARYLAND.

[J. D. POWELL.]

SUMMARY OF RESULTS.—Leveling: 72 miles of levels run, 32 permanent bench marks established.

On February 19 field work was begun on a line of levels between a bench mark on the Capitol Building at Washington, D. C., and the Naval Proving Ground, Indian Head, Md. The field work was completed March 31, 1917.

The line runs from the bench mark at the window sill at the south side of the Senate wing of the Capitol Building, northeastward along Maryland Avenue to Ninth Street, thence north to Florida Avenue, thence east to the intersection of Benning Road. From this point it continues along the tracks of the Washington Railway & Electric Co. to Seat Pleasant, thence along the track of the Chesapeake Beach Railroad Co. to Upper Marlboro where it changes to the tracks of the Pennsylvania Railroad Co. and continues thereon to White Plains, Md. At White Plains the county road passing through Pamfret and Pamunkey was followed to Indian Head.

A branch of the above line was later extended from White Plains to Pope Creek for the purpose of supplying bench marks at a point on the Potomac where the mean level of the water would most likely be identical with mean sea level.

The entire work was done on foot, and because of this fact as little equipment as possible was carried.

Good progress was made in spite of the slower method of traveling. A maximum of 12½ miles per day was attained and on several days 10 to 12 miles were accomplished.

Bench marks were set on the average of one for every 2 miles. These were concrete posts with metal discs inserted. They were constructed in the office of the Survey.

MARYLAND AND VIRGINIA.

[L. A. Potter.]

Between September 5 and 23, 1916, an inspection was made of the triangulation stations in the vicinity of Tangier Sound, in cooperation with representatives of the engineering departments of Maryland and Virginia, who were engaged in placing beacons and buoys to permanently mark the boundary line between the two States.

Eighteen stations were inspected and 10 were recovered. Of those not recovered, 3 were restored by the Maryland and Virginia engineers after making the necessary observations and computations.

Many of the stations in the vicinity of Tangier and Pocomoke Sounds had been established on marsh land, close to the high-water line, and the reference marks had been established close to the station marks, and in many cases both had been washed away. This appears to be the principal cause of the loss of stations in this vicinity.

WEST VIRGINIA, MARYLAND, NEW JERSEY, AND CONNECTICUT.

[Max Steinberg.]

Summary of results.—Gravity determinations: 9 pendulum stations occupied.

During the season from April 16 to June 16, 1917, determinations of intensity of the force of gravity were made at nine stations, as follows: Clarksburg, Rowlesburg, Terra Alta, and Corinth, W. Va.; Kitzmiller, Md.; Pennington, Glen Ridge, and Plainsboro, N. J.; and Hartford, Conn.

This work was undertaken at the request of the Director of the United States Geological Survey. From previous gravity determinations it was known that the anomalies at stations Deer Park and Princeton are positive, while at all surrounding stations the anomalies are negative. The additional gravity stations were established in order to define the area of positive anomaly and correlate it with the geological formations of this region. A station was also established at the Jervis Laboratory of Trinity College, Hartford, Conn., in response to a request from the authorities of the college.

At the termination of the previous field season all of the pendulums were riveted and restandardized. Until the office computations are made no conclusion can be drawn as to the effect of riveting the pendulums.

Toward the close of the season, a new temperature-proof case for use in carrying the hack chronometer from the gravity station to the telegraph office was provided. By its use the uncertainty as to the rate of the chronometer is made very small.

Noon-time signals from the Naval Observatory at Washington, D. C., were obtained over the Western Union Telegraph Co. wires for use in this work.

Field work was begun at Clarksburg, W. Va., April 16, 1917, and closed at Hartford, Conn., June 16, 1917. In that time nine stations were completed making the average time per station 5¾ days.

NORTH CAROLINA.

[J. S. Bilby.]

In January a reconnoissance was begun for primary triangulation and a primary traverse between some point on Cape Fear River or the coast in the vicinity of Wilmington, N. C., and two or more stations of the oblique arc in the vicinity of latitude 35° 30′ and longitude 81° 00′. The observer proceeded to Greensboro, N. C., arriving there January 17.

During the period from January 17 to 25, stations Moore, King, and Young were recovered.

On January 24 orders were issued to suspend reconnoissance work in North Carolina in order that the chief of party might take up more urgent duties in Florida.

GEORGIA.

[J. S. Bilby.]

At the beginning of April orders were issued to make a reconnoissance for a line of primary traverse from Brunswick to Columbus, Ga., by way of Macon, and to erect signals and place marks at the angle stations of the line. This work was done in cooperation with the party under charge of C. V. Hodgson, to whom the actual tape and angle measurements were assigned.

A subparty was organized for building the signals and placing the monuments.

By May 22 the signals had been built, stations marked, curves staked, and line prepared from Brunswick to a point 10 miles to the westward of Hazelhurst, Ga., a distance of 100 miles.

On May 22 the work being done by this party was transferred to C. V. Hodgson, who had charge of the measuring of distances and angles in the traverse.

FLORIDA.

[J. S. Bilby.]

Summary of results.—Triangulation: 19 hydrographic signals erected (10 of 100 feet in height and 9 of lesser height), 19 geographic positions determined.

Between January 27 and March 25, 1917, the building of tall hydrographic signals on the coast of Florida, which had been begun under another chief of party, was continued.

Work was begun in the vicinity of Pablo Beach with the building of a signal at station Pablo.

As the building progressed, the positions of the signals were determined either by invar tape traverse or by triangulation. The geographic positions and descriptions of the stations were furnished to the commanding officer of the steamer *Isis*, who was engaged in hydrographic work along the Florida coast.

Ten of the signals, which were each 100 feet in height, carried targets which were 16 feet wide and 50 feet long. The other nine signals, which were less than 100 feet in height, had targets which were 10 feet high and 16 feet wide.

FLORIDA AND GEORGIA.

[E. H. Pagenhart.]

Summary of results.—Primary traverse: 178 miles measured with tapes on traverse line, 42 signal poles erected, 80 observing tripods and scaffolds built, average height of observing tripods and scaffolds 4.8 feet, 91 stations occupied for horizontal measures, 94 geographic positions determined, 10 miles of levels run.

On March 31 instructions were issued for a primary traverse to be run between Jacksonville, Fla., and Columbus, Ga., via Waycross and Albany, following the Atlantic Coast Line Railroad from Jacksonville to Albany and the Seaboard Air Line Railway from Albany to Columbus; measurements of the distance to be made on the rails with invar tapes, and the angles to be measured with a 12-inch theodolite; all work to be of such accuracy as to make the line a part of the primary control for horizontal positions in the United States, supplementing the primary triangulation; the reduction of the line to the horizontal to be made from the elevations and profile supplied by the precise-level line to be run over the same route between Jacksonville and Columbus; preliminary field positions to be furnished to officers of the Geological Survey who might desire the data for their field work.

The entire work is through timbered country. From Jacksonville to Brookfield, a distance of 150 miles, the country is level and sandy; from Albany to Dawson, a distance of 25 miles, although it is rolling, there are long tangents. Traverse is well suited for both sections.

From Brookfield to Albany, a distance of 50 miles, and from Dawson to Columbus, a distance of 60 miles, the country is rough and heavily timbered, the tracks have many cuts and fills, and the curves are numerous, sharp, and long, making the country less favorable for traversing than the remainder of the line.

Actual field work on reconnoissance was begun at Jacksonville, Fla., on April 10, when connection was made with the coast triangulation, and the reconnoissance and signal building extended along the Atlantic Coast Line Railroad for 190 miles to the vicinity of Albany, to which point this work had been completed at the end of the fiscal year; 122 stations were located and marked, and necessary stands, signals, and poles were erected for the observing.

In the flat country it was found that a maximum of 4 miles, with an average of 2½ to 3 miles, gave the most economical length of line for the construction and observing.

All tripods up to 36 feet were built of 2 by 4 lumber, and have proven of sufficient strength; they were all framed and set up at the lumber yard and carried to place on the gas cars. The tripods less than 14 feet high had no scaffold built around them; the observing party carried with them a temporary platform, which was used at these stations.

Whenever the scheme which follows the track had many short lines making it inadvisable to carry the azimuth through them, as was the case from Enigma to Willingham, other stations were established from 3 to 5 miles apart, through which the azimuth was carried; those stations were connected to the traverse by tape, or by observations from at least three of the rail stations. The supplementary stations along the rails were designated by the name of the southern station, and were given the subscript A, B, C, etc. They were marked permanently wherever possible with regular marks having the name stamped on the disk. Many of the supplementary stations were located on the railway track and could not well be permanently marked.

The tape work was begun at Jacksonville, April 10, following close after the reconnoissance. A double line was completed to the vicinity of Willingham at the close of the fiscal year, a distance of 178 miles, 16 miles of which were measured over stakes, and 162 miles along the rails.

Over several sections, one of the measures, either forward or backward, was made in the rain. Previous work in the rain showed that there is apparently a suction between the heavier tape, due to the water remaining on it, and the wet rail that caused a shortening in each tape length of 1 mm. This correction was applied on those sections.

At offset stations along the tangents the instrument was set up over the rail point and the angle between the rail and the station was measured with a 4-inch theodolite. A direct and reverse reading with a direct check reading were taken.

A Wye level, without any protection from the sun, was used in running levels over the stakes. The steel wheel glass cutter was used in marking the rail. All measurements made with the steel tape were checked by a reading in feet on the reverse side.

Sixteen positions with the 12-inch direction instrument were taken at all main scheme stations, and a double set of six repetitions direct and reverse with a 7-inch repeater was observed at all supplementary stations.

All observations with both instruments were made on targets, except where a heliotrope or lamp was necessary to observe a line when targets could not be seen. An azimuth carried through a single line under generally unfavorable conditions as to lateral refraction is the weakest part of a traverse, therefore additional lines were observed wherever practicable. The time required was about the same for the primary as for the supplemental stations. Four primary stations were sometimes occupied in one day.

FLORIDA, GEORGIA, AND ALABAMA.

[GEORGE D. COWIE.]

SUMMARY OF RESULTS.—462 miles of levels run, 168 permanent bench marks established.

After completing the line of levels from Cedar Keys, Fla., to St. Augustine and Fernandina, Fla., and from Baldwin, Fla., to River Junction, Fla., this party began on July 1 the line from Tallahassee, Fla., to Atlanta, Ga., and from Atlanta carried it to a point about 16 miles from Birmingham, Ala., where work was temporarily suspended for the season. The line run follows the Georgia, Florida & Alabama Railroad, from Tallahassee, Fla., to Richland, Ga.; thence via the Seaboard Air Line Railway to Columbus, Ga.; thence via the South Georgia Railway to Harris, Ga.; thence via the Atlanta, Birmingham & Atlantic Railroad to Woodbury, Ga. From Woodbury the line follows the Southern Railway Co. tracks into Atlanta, Ga., via Williamson and McDonough, Ga. From Atlanta the line follows the Seaboard Air Line Railway tracks toward Birmingham, Ala.

Progress in July was delayed by rain during two weeks and in August by the breaking down of the motor cars. From that time until the middle of September the work was done on foot. About this time a motor car and two velocipedes were received from another party, and these were used on the remainder of the line to Atlanta and a few miles beyond. These velocipedes of the bicycle type were used a while but were abandoned as not being of much use on a grade or in a wind. The motor car was in bad condition and after several minor accidents was also abandoned. The work was then continued on foot until about December 10 when the two repaired motor cars were received from the factory. During this work connections were made with a number of bench marks of the United States Geological Survey and with several of those of the United States Engineers. Agreement with the former was very close, that at Atlanta being within 2 or 3 inches. The average progress of the party was only 80 miles per month with about 8 per cent rerunning. The maximum month's progress was 97 miles and was made in July while the party used cars. The second best month was November when 90 miles were run, the party walking during the entire month, and traveling to and from work in passenger trains.

The line started at an elevation of about 50 feet above sea level and reached its highest point near Dallas, Ga., at an elevation of about 1,100 feet, then dropping to 600 feet by the close of the year.

The total progress was 462 miles. Bench marks were set at a distance of about 2¾ miles apart throughout the entire line.

SOUTH CAROLINA.

RECOVERING AND RE-MARKING TRIANGULATION STATIONS.

[E. B. LATHAM.]

Between April 19 and May 26 field work was done for the purpose of recovering and re-marking triangulation stations on the coast in the vicinity of Charleston, S. C.

All stations with one exception were either recovered or found to have been destroyed. In all 33 stations were recovered, some of them re-marked, and then descriptions were brought up to date where this was found to be necessary.

Where practicable, arrangement was made with the owners of land upon which stations are situated or with persons living in the vicinity to inform the Coast and Geodetic Survey office of the condition of the station, when requested by letter.

The recovered stations furnish a continuous chain of triangulation along that portion of the coast which extends from a point 30 miles eastward of Charleston to a point an equal distance to the westward, except from the western end of Bull Bay to a line north of Capen Inlet, a distance of about 8 miles.

Notes relating to triangulation stations in the immediate vicinity of Charleston were obtained from the office of the District Engineer, Corps of Engineers, United States Army, at Charleston.

GEORGIA.

[O. W. FERGUSON.]

SUMMARY OF RESULTS.—Leveling: 140 miles of levels run, 162 permanent bench marks established.

On April 11, 1917, preparations were begun at Brunswick, Ga., for running a line of precise levels from that place to Columbus, Ga., by way of Macon.

The preliminary arrangements of organizing the party, obtaining the necessary instruments and equipment, and preparing bench marks having been completed, actual field work was begun on May 6 and was continued from that time to the end of the fiscal year. In this time 139.8 miles of leveling was done, and 162 permanent bench marks were established. The work was completed to a point 5 miles beyond Eastman, Ga.

The line of levels followed the route of the Southern Railway.

Connections were made whenever practicable with bench marks of the United States Geological Survey and of the Southern Railway.

The routes followed by this precise leveling party and the primary traverse party under Mr. Hodgson, are identical.

The leveling party furnished such data to the traverse party as were necessary to enable the latter to compute the grade corrections to the distances measured along the tangents of the railroad.

[C. V. HODGSON.]

SUMMARY OF RESULTS.—Reconnoissance (for traverse): Length of scheme 175 miles, 127 stations selected. Base lines: 1 secondary, 1,400 meters in length. Primary traverse: Length of traverse, 169.7 statute miles, 127 observing tripods and scaffolds built, 118 stations in main scheme occupied for horizontal measures, 8 supplemental stations occupied for horizontal measures, 135 geographic positions determined. Astronomic work: 5 azimuth stations occupied. Leveling: 29 statute miles.

In the early part of April arrangements were begun to run a line of primary traverse from Brunswick to Columbus, Ga., via Macon. Reconnoissance and signal building were carried on by a separate party under J. S. Bilby from April 16 to May 21. On the latter date this work was taken over by the main traverse party. The traverse was started from stations of the coast triangulation in the vicinity of Brunswick, Ga., and extended toward Macon along the Southern Railway line. The measurements were made along the tops of the rails of the railroad on the tangents, but the tapes were supported by stakes in the same manner as in base measurement at the curves.

The measurements of distance were made with invar base tapes, 50 meters in length. At the points in the traverse where there were changes in direction, angles were measured with a 12-inch theodolite as in primary triangulation. At intervals the astronomic azimuth of lines of the traverse was determined by observations on Polaris.

A precise-leveling party operated along the same route as was followed by the traverse party, in order to furnish the data necessary for the latter to reduce the distances measured to the horizontal plane. The traverse party did the leveling over the stakes supporting the tape when measuring at the curves.

The first hundred miles of the line was well adapted for traverse work. Although curves were not infrequent the topography usually permitted the stations to be spaced a sufficient distance apart to insure strength in carrying the azimuth. The latter part of the line was much more curved and the adjacent topography was such that the traverse could not be strengthened by triangulation except at a prohibitive cost. On the portion run during June, 22 miles were on stakes out of a total of 69 miles, and the angle stations averaged only about a mile apart. The progress of the work was materially reduced on this section by the extra building, clearing of lines, and setting stakes for measurement around curves.

By the close of the fiscal year the traverse had been completed to within about 15 miles of Macon.

GEORGIA AND FLORIDA.

[G. D. COWIE and C. L. GARNER.]

SUMMARY OF RESULTS.—Leveling: 251 miles of levels run, 114 permanent bench marks established.

Precise leveling on the line from Jacksonville, Fla., to Columbus, Ga., along the Atlantic Coast Line Railroad and Seaboard Air Line Railway, was continued from April 9 to the end of June.

This work was begun by Mr. Cowie after he had completed a line of precise leveling to Mobile, Ala., and was transferred to Mr. Garner at Waycross, Ga., on April 19.

The work consisted of a regular line of precise levels, and extra observations were made which made it possible for the traverse party under E. H. Pagenhart to determine grade corrections to the measured distances. The line of the levels and of the traverse is identical. The line of levels to Columbus was nearly completed by the end of the year, there being only two and one-half days' work to finish the line.

At Kimbrough, Ga., a distance of 232 miles from Jacksonville, a connection was made with a bench mark established in the preceding year by G. D. Cowie.

At Richland, Ga., 6 miles from Kimbrough, the line again joined the work of Mr. Cowie. From this place to Columbus, Ga., the line of the previous work was followed, but only a single line was run. This was for the purpose of furnishing a profile of the railroad along which the leveling was done in order that the traverse party might make corrections to the measured distances to obtain the horizontal distances.

The total number of permanent bench marks on the line from Jacksonville to Richland, a distance of 238 miles, is 114, an average of a permanent mark every 2.1 miles. There are also a number of subsidiary bench marks on that section of the line from Jacksonville to Folkston, Ga., which are on the bases of semaphore poles and are really permanent in character. Mention should also be made of the railroad bench marks from Jacksonville, Fla., to Folkston, Ga., to which connection was made. These were also on the bases of semaphore poles and are almost permanent in character.

A list of the elevations and descriptions of permanent and temporary bench marks between Jacksonville, Fla., and Waycross, Ga., was furnished field officers of the United States Geological Survey operating in Georgia.

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

DETERMINATION OF THE GEOGRAPHIC POSITIONS AND THE ELEVATIONS OF RADIO STATIONS—INSPECTION OF TIDAL STATIONS.

[W. B. FAIRFIELD.]

Between April 12 and June 28 determinations were made of the geographic positions of a number of radio stations on the Gulf and Atlantic coasts between Mobile, Ala., and Virginia Beach, Va.

At Fort Morgan, Ala., various tidal bench marks were inspected and found to be in good condition.

At Cedar Keys, Key West, St. Augustine, and Fernandina, Fla., the tide stations and bench marks were inspected and lines of levels run connecting the tide gauges and bench marks.

The positions of the radio stations were determined at Pensacola, Fla.

At Tampa, Fla., the elevation of the ground at the foot of the wireless station was determined.

At Key West, Fla., the positions of two naval radio stations were determined by triangulation. At Miami, Fla., the position of the Marconi radio station and the elevation of the ground at its foot were determined by triangulation.

The position of the radio station at St. Augustine, Fla., and the elevation of the ground at its foot were determined.

At Savannah, Ga., the elevation of the ground at the Marconi wireless station was obtained from data furnished by the city engineer.

At Buxton, N. C., the position of the Marconi radio station and the elevation of the ground at its foot were determined by triangulation.

A determination was made of the elevation of the ground at the foot of the Marconi radio station at Virginia Beach, Va., from bench marks of the Norfolk Southern Railroad Co.

Field work was closed on June 27.

LOUISIANA AND ALABAMA.

[O. W. FERGUSON.]

Between March 15 and April 9 a determination was made by triangulation of the geographic positions of eight radio towers in New Orleans and Algiers, La., and two at Mobile, Ala.

The elevation of the ground at the base of these towers was determined by leveling.

TEXAS.

[J. D. POWELL.]

SUMMARY OF RESULTS.—Precise leveling: 205 miles of levels run; 115 permanent bench marks established.

A line of levels from Sierra Blanca to San Antonio, Tex., was undertaken at the request of the War Department in order to furnish precise elevations to the topographic parties of the United States Geological Survey working on military topographic maps in the Big Bend region of Texas.

Two parties were assigned to the work with instructions to carry the elevations through on single lines and later check back after the immediate needs of the topographers had been supplied. Mr. Powell's party worked from previously established bench marks at Allamore and Sierra Blanca eastward to Marfa. A party under O. W. Swainson took up the work at the latter point and carried it to Del Rio. Mr. Powell moved from Marfa to Del Rio and made about 100 miles of progress to the eastward of that point before the end of the fiscal year.

The route lay along the Galveston, Harrisburg & San Antonio Railway, a portion of the Sunset Route of the Southern Pacific Co. The principal towns along the way were Sierra Blanca, Hot Wells, Valentine, Marfa, Alpine, Sanderson, Langtry, and Del Rio.

The work was greatly retarded by unfavorable weather.

[O. W. SWAINSON.]

SUMMARY OF RESULTS.—Precise leveling: 85 miles of levels run, 44 permanent bench marks established.

On May 1, 1917, a party was organized at Alpine, Tex., for the purpose of running a line of precise levels from that place westward along the line of the Southern Pacific.

This leveling is a portion of that called for by the War Department for the purpose of furnishing exact elevations to be used in controlling elevations used by the United States Geological Survey when making military topographic maps in the Big Bend region.

After establishing bench marks between Marfa and Sanderson and collecting the necessary instruments and equipment, leveling work was begun on May 14 westward from Alpine. When the line had been completed westward to Marfa and eastward to Altuda the party moved to Marathon. From that time until June 30 leveling was continued to the eastward. By that date the line was completed to Tesnus, Tex.

Two new motor velocipedes were used in this work.

Standard concrete post bench marks were set every 2 miles along the railway. Temporary bench marks consisting of railway spikes driven in telegraph poles were established every other mile between the permanent bench marks.

Descriptions and elevations of bench marks were furnished as soon as they were available to field officers of the United States Geological Survey.

[J. B. BOUTELLE.]

SUMMARY OF RESULTS.—Triangulation: 8 square miles of area covered, 5 signal poles erected, 6 stations in main scheme occupied for horizontal measures, 6 geographic positions determined. Leveling: One permanent bench mark established, 3 miles of levels run.

In April a determination was made by triangulation of the position of the radio towers at Point Isabel and Beaumont, Tex.

Stations East Base and South Base about 3 or 4 miles west of the point were recovered, and a new station Ranch was established on the south end of the point. The radio towers and Brazos Santiago Lighthouse were observed from these stations and from the tower of the old Point Isabel Lighthouse. A line of levels was also run from mean low water to the radio towers.

After completing observations at Point Isabel, the observer returned to Galveston on April 12 and left again on the 15th for Beaumont, Tex. Triangulation stations Cut-off and Spindle Top of the United States Engineers were recovered, and the radio towers of the Magnolia Petroleum Co. were observed from those stations. A line of levels was run from the United States Engineers' station Beaumont to determine the height of the towers above mean low water. On completing these observations, the observer proceeded to Port Arthur and determined the height above mean low water of the Marconi radio tower at that place. This work was completed on April 20 and the observer returned to Galveston.

[J. S. BILBY.]

On June 6, 1917, arrangements were begun for making a reconnoissance, building signals, and marking stations, for primary triangulation along the Rio Grande from the vicinity of Donna, Tex., to the Texas-California arc to the northward of Alpine, Tex.

The motor truck previously stored at Albuquerque, N. Mex., was driven overland to Harlingen, Tex. The chief of party traveled in the truck along the route to be followed by the triangulation and thus was able to learn of the character of the country and the sources of supplies. Other trucks and the outfit, which had been stored at

Needles, Cal., and Fort Smith, Ark., were shipped to Harlingen. At the close of the fiscal year the party was fully organized and equipped and ready to begin actual field work on July 1.

MICHIGAN.

[GEO. D. COWIE.]

SUMMARY OF RESULTS.—Precise leveling: 95 miles of levels run, 50 permanent bench marks established.

In May, 1917, work was begun on a line of precise leveling from Marquette to Escanaba, Mich. The line was completed to Escanaba on June 23, and the party proceeded to Algonac, Mich.

On June 27 work was begun on a line of levels from Algonac to the lower light on the St. Clair Flats Breakwater. This work was completed.

The work in Michigan was undertaken at the request of the United States Lake Survey.

The new leveling was connected with several old bench marks recovered at Marquette and Escanaba. No bench marks of the old leveling between those places could be found from field computations.

The line was about 85 miles long, and the elevations from field computations carried from Marquette are about 6 inches higher than the elevations at Escanaba for the old bench marks.

The work in the vicinity of Algonac, Mich., was done along the shore of the St. Clair River from Algonac to Point Aux Chenes; the line then crossed the North Channel on a 470-meter sight, then ran across Harsons Island and down the eastern shore as far as the Catholic Church, 1 mile south of Tasknoo Park.

From this place to Old Club the levels were run over very swampy ground crossed by about 40 small motor-boat canals. In this section of the work rowboats were used to carry the members of the party from place to place.

At Old Club another river crossing was made on a sight of about 300 meters to the St. Clair Flats Canal Breakwater, and the leveling was carried along the breakwater to Lower Lighthouse, checking on the established elevation of the bench mark there to within about 3 inches.

The time occupied in the work in Michigan was about one and a half months, and the total distance leveled over is about 95 miles.

INDIANA AND MICHIGAN.

[J. H. PETERS.]

SUMMARY OF RESULTS.—Precise leveling: 618.4 miles of levels run, 354 permanent bench marks established. (Note: The statistics for the portion of this work done between April 3 and June 30, 1916, were: 364 miles of levels run and 175 permanent bench marks established. The figures given in the summary of results in the abstract of this work in the Annual Report for 1916 are erroneous.)

On July 1, 1916, work was in progress on the line of precise leveling between Chicago, Ill., and Warsaw, Ind. This line, which is 113 miles in length, follows the main line of the Pennsylvania Railroad through the towns of Indiana Harbor, Gary, Valparaiso, and Plymouth.

After the completion of this line, the following links were added to the precise level net in the order given: Warsaw, Ind., to Jackson, Mich.; Mackinaw, Mich., to Jackson, Mich.; and Jackson, Mich., to Detroit, Mich. The combined length of these lines is 618.4 miles.

The season's work was completed on November 24, 1916.

The outfit of the party consisted of three motor velocipedes, two boxes of tools and repair parts, and the necessary instruments and stationery. This was the minimum with which the party could operate, and it was kept so as to facilitate rapid movement.

Many important changes were made in leveling methods during the season, which may be briefly enumerated as follows: Use of three motor velocipedes instead of two; recording observations with adding and listing machine; changes in field abstracts and computations; mounting the level on a motor velocipede; employment of professional trainmen as pilots for the cars; substituting flat-bottom rods with spike supports for the round-bottom rods with top of rail supports; use of rods that carry the graduations on gamma steel instead of those that carry the graduation on wood; use of three rods instead of two.

That the cost of leveling was lowered in this work in spite of increased cost of materials and labor, speaks well for the methods that were used.

The adoption of motor velocipedes for leveling operations has contributed more than any other single item toward the increased rate of progress and consequent lower unit cost now being obtained. The rate of progress of a party thus equipped depends in a large degree on having the car equipment in active condition.

A Barrett nine-bank calculating and listing machine was used for recording the rod readings and taking totals. All original notes except the descriptions of the bench marks were placed on this record.

Soon after the beginning of the 1916 season, a tripod was constructed by means of which the level could be set up on the motor velocipede, the observations being taken with the level thus mounted, the observer standing on the ground while making the readings. The results of the season indicate that the level thus mounted is more stable than it was before, that it holds its adjustment better, and that the work is less tiring on the observer. The round-bottom rods used in previous leveling were replaced by rods with a flat bottom. The heads of the track spikes were adopted as rod supports instead of the rails which had previously been in general use for this purpose.

A set of three gamma steel rods was received and used for about three weeks at the close of the season. The rods, as constructed, are well adapted to the field work.

The use of three rods instead of two was given a thorough trial and was found to possess several advantages as compared with the former method.

A notable feature of this season's work is the record made for rapidity of leveling in September, 1916, when 159.6 miles of double-leveled line were completed. There were run 340 miles of single line of levels. This record so far has never been equaled by any other party engaged on precise leveling in this or any other country. This record was made possible by the thoroughly efficient manner in which the chief of party organized and managed his party.

NEW MEXICO AND TEXAS.

[O. W. FERGUSON.]

SUMMARY OF RESULTS.—Precise leveling: 276.2 miles of levels run, 170 permanent bench marks established.

Between September 16, 1916, and January 10, 1917, a line of precise levels was run between Clovis, N. Mex., and Pecos, Tex., following the lines of the Atchison, Topeka & Santa Fe Railway Co. between Clovis, N. Mex., and the State line and the Panhandle & Santa Fe Railroad between the State line and Pecos, Tex.

In this work certain improvements in methods and instruments recently adopted for work of this character were utilized. The precise leveling instrument was mounted on a motor car; an adding machine was used for recording and summing the back sights and fore sights; and the new form of invar level rod was used. During the first part of the work railroad spikes were used for turning points, and during the latter part of the work the top of the rail was used.

In every town and at other favorable places standard disk bench marks were set in substantial buildings, depots, and concrete walls, also many reinforced concrete posts with the disks in their tops were used as bench marks.

This line of levels was run in response to a request from the Director of the United States Geological Survey, for the purpose of furnishing precise elevations from which to extend lines of levels that were being run at the same time by parties of that survey for controlling topographic maps.

ARKANSAS.

[J. S. BILBY.]

SUMMARY OF RESULTS.—Triangulation: Signal building, 3 signal poles erected, 27 tripod stands built, stations marked, and lines cleared, 3 observing tripods and scaffolds built, heights 50, 60, and 75 feet.

A building party was organized at Little Rock, Ark., July 1, 1916, for the purpose of preparing stations for the observing party along the Arkansas-Oklahoma arc of primary triangulation. The horses, wagons, and other property on storage at Osgood, Ind., and the motor truck and outfit stored at Nampa, Idaho, were shipped to Little Rock, Ark., and such of this property as was needed was used by the building party.

During the month of July signals were built at three stations 50, 60, and 75 feet in height, respectively, and stands were built at seven stations.

On August 1 the building party was turned over to the foreman, who continued the building of signals and marking of stations to the westward of Little Rock, while the chief of party made the necessary preparations for extending the reconnoissance from El Reno, Okla., to Needles, Cal.

From August 1 to October 31 twenty stations were prepared and made ready for the observing of angles. These stations were on hills having small timber on top which required some clearing near the stations.

On October 31 the building party and outfit were transferred to E. H. Pagenhart, who at that time was in charge of the observing party.

[E. H. PAGENHART.]

SUMMARY OF RESULTS.—Primary triangulation: 1,500 square miles of area covered, 18 stations occupied for horizontal measures, 18 stations occupied for vertical measures, 20 geographic positions determined, 19 elevations determined trigonometrically.

Original instructions were issued May 10, and supplemental instructions June 20, 1916, for primary triangulation beginning at the western end of the Memphis-Little Rock traverse, which is near Little Rock, Ark., and extending westward to stations of the ninety-eighth meridian triangulation near Oklahoma City, Okla. It was to follow the reconnoissance executed in the winter of 1913–14. A connection was required with the Arkansas-Oklahoma boundary at monuments located between Hartford and Fort Smith, towns near the boundary.

The country between Little Rock and Fort Smith is hilly and timbered, and all except the few main roads are very poor. The observing party used two motor trucks for their transportation, one a three-quarter ton and the other one-half ton.

Closures of less than one second were obtained with 12 positions, and authority was given to use that number provided the closures remained below one second; this value was maintained. The average closure of the triangles formed by the 18 stations occupied was about 0.7 second.

On November 1 the building party which had previously been under the general charge of Signalman J. S. Bilby and under the immediate charge of Foreman William C. Nohl, was transferred to the chief of the observing party.

Building operations were discontinued on February 17, at which time the construction work had been completed from Little Rock westward to triangulation station Kanawa, Francis, and Sulzer, leaving only eight stations of the remainder of the scheme unprepared for occupancy.

The observing was discontinued on February 15 on account of bad weather and roads which tended to make the work much more expensive than when the weather and roads are good.

ARKANSAS AND TENNESSEE.

[E. H. PAGENHART.]

SUMMARY OF RESULTS.—Precise leveling: 132 miles of levels run, 125 permanent bench marks established, 2 primary azimuths observed.

On May 10, 1916, instructions were issued for a line of precise levels to be run in conjunction with primary traverse between Little Rock, Ark., and Memphis, Tenn. The field work of the traverse was completed June 30.

The line begins at Little Rock, where three old bench marks were connected with, and extends east to Dixie Mill, where it connects with northwest base, the westernmost point of the Memphis-Little Rock traverse. From that point it follows the traverse, which was along the Chicago, Rock Island & Pacific Railway, to Hopefield, which is just across the river from Memphis. The leveling there connects with triangulation station Hopefield, the easternmost point of the traverse. A spur line from bench mark B1 was run into Memphis, across the Mississippi River over the new Harrihan Bridge, and there a connection was made with previously established precise leveling bench marks.

The points on the railroad track where the tape ends fell during the traverse had their elevations determined, either as rod stations or as instrument stations. As the instrument was mounted on the car, and all stations on which no rod readings were taken were used as instrument stations, elevations of these points were accurately determined, as the height of instrument remained constant.

All of the traverse stations and their reference marks were used as bench marks, and had "B. M." stamped on them. Additional marks were set wherever the distance between traverse stations exceeded 4 miles, also in most of the towns. The railroad levels were connected with at various points along the line.

Leveling was begun on July 19 and was finished at Memphis on September 26. After preliminary computations were made and the outfit had been packed and shipped, the party returned to Argenta, Ark., on September 29. The computations of the elevations of the tape ends were finished on October 14.

From Little Rock to Forrest City a wagon road ran parallel to the track, and the dust from the road caused considerable delay in the work as sights had to be shortened to approximately 50 meters after 2 p. m.

Between October 15 and October 23 a party of three was engaged on making azimuth observations at the two stations DeValls and Forrest, of the traverse line.

ARKANSAS AND INDIANA.

[A. L. BALDWIN.]

During the last few days of the previous fiscal year, Mr. Baldwin proceeded from the office at Washington, D. C., to Little Rock, Ark., for the purpose of inspecting a party engaged on measuring a base at that place. The inspection was made during the early part of July of the fiscal year 1917.

The object of the inspection trip was to observe the behavior of the spring balance used for stretching the tape in the base measurement. As a result of Mr. Baldwin's inspection, slight modifications have been made in the spring balance with beneficial results.

Mr. Baldwin also inspected the precise leveling party which was operating in Indiana. He reported that the party was making excellent progress and that the innovations made in the method of mounting the instrument on the motor velocipedes and the recording of the rod readings on an adding machine, also mounted on the velocipedes, were most successful in enabling the work to be done more rapidly and at lower unit costs than formerly.

OKLAHOMA AND NEW MEXICO.

[J. S. BILBY.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 975 miles, 29,000 square miles of area covered, 80 primary and 14 supplemental points selected for scheme. Base lines: 3 primary selected, lengths 14,300, 15,000, and 17,900 meters, respectively.

A party was organized for carrying on a reconnoissance for primary triangulation which would extend from El Reno, Okla., to the vicinity of Needles, Cal. The actual field work began at the eastern end of the arc on August 7.

The outfit used consisted of a motor truck with the usual camp equipment, tools, and instruments. Three stations, Carson, Kechi, and Lanier, of the ninety-eighth meridian triangulation, were recovered, and the line Carson-Kechi was used for the base from which to start the work, with Lanier for the third point. The work was extended westward and connected with primary triangulation stations in the vicinity of Needles, Cal.

In all 80 points for primary stations were selected for the main scheme, including 5 Laplace stations; 14 supplemental points were provided for; connection was made with six precise-level bench marks and 20 stations of the United States Geological Survey.

Connection was also made with the State boundary marks between Oklahoma and Texas and New Mexico. No marks were found on the boundary line between New Mexico and Arizona except a stone monument erected by the Atchison, Topeka & Santa Fe Railway Co. at a point where the railway is supposed to cross the State line. Two points were selected approximately on the State line to the south of the railway.

The actual field work was completed November 6 and the party moved to Albuquerque, N. Mex., where the outfit was stored and the party disbanded.

A one-half ton motor truck was used in this work. It was found that this truck will carry 1,200 pounds safely over any road practicable for travel with a motor truck, and the power was found to be sufficient under all conditions of roads.

The truck was driven to within a reasonable walking distance of all stations selected.

CALIFORNIA.

[MAX STEINBERG.]

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

Before beginning the field work, a standardization of the pendulums used in the field was made in June, 1916, in the pendulum room of the Coast and Geodetic Survey office at Washington, D. C. After the completion of the field work on November 29, the instruments were returned to the office, and a restandardization of the pendulums was made in January, 1917.

The field season began at San Diego, Cal., July 11, 1916, but the actual observations were not begun until the 18th owing to delay in the arrival of the instruments. Work was closed November 29. Twenty stations were completed during the season of 135 days, making the average time per station including Sundays and holidays 6¾ days or 5¾ working days.

The stations occupied were, as follows: San Diego, Oceanside, Highland, Pomona, Long Beach, Redondo Beach, Burbank, Palmdale, Mojave, Maricopa, Ventura, Conception, Vaila, San Lucas, Monterey, Hollister, Palo Alto, San Gregorio, Point Reyes, and Duncans Mills, all in California.

One latitude was determined by sextant observations at Palmdale, Cal.

During this season a slight modification of methods previously employed was made. Two pendulums were swung at each station instead of three, one for two days of 24 hours each and the other for one day. The period of each individual swing was also increased from 8 to 12 hours. Another change was to place the second pendulum inside the receiver in order to attain the temperature of the receiver while the first pendulum was swinging.

Western Union time signals from the Mare Island Naval Observatory were used through the season.

The mean probable error of observed gravity was 0.0008 dyne.

The results of the restandardization of the pendulums in January, 1917, showed a slight increase in the periods of all the pendulums over the values obtained in June, 1916.

[E. B. LATHAM.]

In the latter part of February a determination was made by triangulation of the geographic positions of two radio stations, one near Avalon and the other near Inglewood, Cal.

The radio station at Los Angeles, Cal., was visited for the purpose of identifying and describing it.

The city engineer of Los Angeles was consulted in regard to the triangulation being done by him. Station West Beach 2, city of Los Angeles, was occupied by the Coast and Geodetic Survey observer when determining the geographic position of a radio station.

An arrangement was made by which the Coast and Geodetic Survey may obtain without charge copies of the results and descriptions of stations of the city triangulation.

[E. W. EICKELBERG.]

SUMMARY OF RESULTS.—Triangulation: 144 square miles of area covered, 25 stations recovered and re-marked, 20 signal poles erected, 28 stations in main scheme occupied for horizontal measures, 5 stations occupied for vertical measures, 65 geographic positions determined, 5 elevations determined trigonometrically. Leveling: 1 permanent bench mark established, 2½ miles run.

In November a party was organized to furnish the necessary control for the hydrography and topography of San Francisco Bay for the party engaged in wire-drag work; to locate any objects of value as aids to navigation; to recover the old triangulation stations in the vicinity of San Francisco Bay; wherever necessary to re-mark these stations; to determine the elevation of the ground at four radio stations; to determine the geographic position of two of these stations; and to make a report on lost intersection triangulation stations located in previous years.

A launch was hired for the transportation of the party, and after the necessary preliminary arrangements had been made, signals were erected in the locality in which the first work with the wire drag was to be done, and the stations visited were re-marked. In this work the usual methods for tertiary triangulation were adhered to.

The area over which the party operated is 144 square miles, and the linear length of the region is 32 miles. An effort was made to meet the requirements of the wire-drag work at the Golden Gate. However, on account of difficulties with the ground wire, drag work had to be given up, and instead sounding lines one-half mile apart were run over the entire area from Brothers Lighthouse to Point Avisadero. The triangulation could not keep ahead of this work, which was completed in a short time, but the signals used by the sounding party were afterwards located and positions thus furnished for the finished hydrographic sheets.

Prominent objects and aids to navigation were located as reported in a special report to the Superintendent.

The recovery and re-marking of the old triangulation stations was attended with some difficulty. In many cases the surface mark had been destroyed or grown over with sod. In some cases there were no surface marks in the original marking of the station. Some underground marks of old stations were found after new stations had been located near them.

Out of a total of 63 triangulation stations searched for only 24 were recovered.

The points in the northern end of San Francisco Bay were more readily recovered than those in the southern end of the bay, owing to better marking of the station.

Stations recovered were carefully marked and reference marks were placed.

The elevations at the foot of the wireless towers were obtained directly by leveling.

At the request of the inspector in charge of the San Francisco suboffice, the accuracy of the resetting of the Presidio tide staff was investigated and found to be very slightly in error. Only two bench marks were in existence of the original five, and a new bench mark was therefore set and its elevation determined by leveling.

Field work was closed March 13.

UTAH, OREGON, NEVADA, AND CALIFORNIA.

[C. V. HODGSON.]

SUMMARY OF RESULTS.—Primary triangulation: 7,720 square miles of area covered, 13 observing stands built and stations marked, 20 stations in main scheme occupied for horizontal measures, 8 stations in supplemental schemes occupied for horizontal measures, 30 stations occupied for vertical measures, 42 geographic positions determined, 37 elevations determined trigonometrically, length of scheme 300 miles. Latitude, longitude, and azimuth work: 4 azimuth stations occupied.

Observations of angles in the primary triangulation along the Utah-Oregon arc were resumed at Stanfield, Oreg., May 10, 1916, and were in progress at the beginning of the fiscal year. The work done to July 1, 1916, is detailed in the last annual report.

By the end of June, 1916, 10 stations had been occupied. The last five of these stations were in the Cascade Mountains where the snow from the previous winter, said to have been the heaviest in 30 years, still lay several feet deep on the upper slopes. This condition not only delayed progress in moving but was also the cause of the peaks being cloud-capped to a degree not usually found at that season of the year.

The occupation of the station Larch completed the connection between the Stanfield base and the California-Oregon arc of primary triangulation. The light keepers were then sent to stations east of Stanfield, Oreg., in preparation for the work on that portion of the arc between the base at that place and the work done during the previous season in southwestern Idaho. The observing party stopped long enough on the way to Stanfield to make the reconnoissance and observations for a connection with the triangulation of the United States Engineers along the Columbia River at Celilo, Oreg. Stanfield was reached by the chief of party August 6, and observations were begun on the arc to the eastward.

There were 14 stations on this portion of the arc. Of these 5 were reached by long packs, and 2 were located by the observing party after it was found that the line Fanny-Iron was obstructed. The observations on the Utah-Oregon arc were completed on September 15.

On September 15 the party was assembled at Nampa, Idaho, to prepare for triangulation from the thirty-ninth parallel in Utah to the Texas-California arc in the vicinity of Needles, Cal.

On September 23 the first of the light keepers were started for their stations, and on the 25th the observing party began traveling by automobile trucks toward its first station 225 miles away. It reached the foot of the mountain on which the station was located, on the 27th. The foot of the last steep slope below the station was reached on the afternoon of the second day following after a hard 18-mile pack. Camp was made and the observing outfit back packed the remaining mile to the station.

It was impossible to get observations on the first night owing to the failure of the light keepers to get their signal lamps in working order. The following night the weather became unfavorable with sleet, snow, and high winds. These conditions continued until the night of October 2, when the lack of wood and shelter on the high slope of the mountain compelled the party to move down about 3,000 feet into a canyon, where the ruins of a cabin and abundant fuel provided better means for protection against the severe weather. On the 5th it stopped snowing, and a fresh supply of provisions was back packed to the top of the mountain. Four hours were spent digging out of the snow the observing outfit and camp equipment, but the party was driven down again by a fresh snowfall. The snow was then so deep that it was dangerous to keep light keepers on their exposed stations, and authority was obtained from the office to suspend operations. In removing the observing outfit from Tushar, the snow was found to be so deep that the outfit had to be hauled on hand sleds for 3 miles to where it could be reached by pack animals.

The party was disbanded on October 14, except those who were needed on the reconnoissance that the chief of party was directed to make in Nevada and California. During the season in Oregon and Idaho, the chief of the Coast and Geodetic Survey party cooperated with the local officials of the Forest Service in the determination of the geographic positions of 13 stations located within the forest reserves that were needed for observation towers and lookout stations in the work of that service.

CALIFORNIA, OREGON, AND WASHINGTON.

[C. L. GARNER.]

SUMMARY OF RESULTS.—Gravity observations: 20 stations established. Triangulation: 1.5 square miles of area covered, 10 signal poles erected, 15 geographic positions determined.

During the period between July 18 and November 29, 1916, the determinations of the intensity of the force of gravity were made at a number of stations on the Pacific coast.

The locality of the work was in the States of Washington, Oregon, and California, following the Pacific coast at a distance never more than 100 miles from the ocean.

There were 20 stations established. They were at the following places: In Washington, Bellingham, Everett, Issaquah, Port Angeles, Port Townsend, Port Gamble, Bremerton, Tacoma, and Moclips; in Oregon, Portland, Tillamook, Newport, Eugene, Marshfield, and Glendale; in California, Sacramento, Willits, Eureka, and Santa Rosa.

At all of these stations very satisfactory conditions were found for the work. No piers for the support of the pendulum receiver had to be constructed, and no changes in the buildings or rooms for the control of the temperature were necessary. A convenient telegraph line was found at each station, and it was never necessary to receive time signals by telephone.

During the course of the gravity work, a determination of the position of the towers of the Navy radio station at Marshfield, Oreg., was made. This was done at intervals between gravity observations without impeding the progress of the party.

In January, 1917, after the return to Washington, a restandardization of the pendulums was made with the result that the mean periods of the pendulum were seven less (seventh place of period) than the previous standardization in July, 1916.

The noon signals sent out from the Mare Island Naval Observatory over the telegraph lines were used for rating the chronometers used in determining the times of swinging of the pendulums.

The usual interest in the work was shown by the public, and on several occasions articles concerning the work appeared in the press. These were in accordance with the general policy of the Survey. After the first few weeks of the season, a multigraphed statement briefly outlining the purposes of the work was ready for distribution and was given out to newspapers and people interested.

WASHINGTON, OREGON, CALIFORNIA, NEVADA, IDAHO, AND UTAH.

[W. B. FAIRFIELD AND J. E. MCGRATH.]

SUMMARY OF RESULTS.—Latitude and longitude: 6 primary latitude stations established, 8 longitude differences (telegraphic) determined, signals exchanged on 28 nights.

During the period between July 15 and December 18, 1916, differences of longitude were determined between Walla Walla, Wash., and Echo Oreg.; Echo and La Grande, Oreg.; La Grande, Oreg., and Mountain Home, Idaho; Mountain Home and Blackfoot, Idaho; Blackfoot, Idaho, and Salt Lake City, Utah; Salt Lake City and Lund, Utah; Lund, Utah, and Moapa, Nev.; and Moapa, Nev., and Needles, Cal.

The first complete set of observations was made at Echo, Oreg., and exchange of signals had with Walla Walla, Wash., on July 31; also on August 1 and 2 others completing the line Walla Walla and Echo.

On August 15, 19, 20, and 21, observations were made and exchange of signals had between Echo and La Grande stations, Oreg., completing the line Echo and La Grande. Observations for the determination of the latitude of Echo station were made on August 22 on 15 pairs of stars.

Observations were made and exchange of signals had between Mountain Home, Oreg., and La Grande station on September 1, 5, and 6, completing the line La Grande and Mountain Home. The latitude of La Grande was determined by observations on August 29, 30 and 31. On September 11 observations were made on 19 pairs of stars for the determination of the latitude of Mountain Home station.

On September 20, 21, and 24, observations were made and exchange of signals had between Mountain Home and Blackfoot, Idaho, completing the line Mountain Home and Blackfoot. The latitude of Blackfoot, Idaho, was determined by observations on October 6 and 9.

Observations were made and exchange of signals had between Salt Lake City and Blackfoot, Idaho, on October 16, 18, 19, and 20, completing the line Blackfoot and Salt Lake City.

Observations were made and exchange of signals had between Salt Lake City and Lund, Utah, on November 2, 3, and 9, completing the line Salt Lake City and Lund. The latitude of Lund was determined by observations made on November 21.

On November 27, 28, and 29, observations were made and exchange of signals had between Moapa, Nev., and Lund, Utah, completing the line Lund and Moapa.

On December 6 observations were made on 24 pairs of stars for the determination of the latitude of Moapa station.

On December 12, 13, and 14, observations were made and exchange of signals had between Moapa and Needles, Cal., completing the line Moapa and Needles, Cal., and also completing the program laid out for the season's work.

Bamberg transits Nos. 20 and 21 were used in making all of the observations in connection with chronographs of the type generally used in the Survey.

The Western Union Telegraph Co. cooperated in the work, making all of the connections promptly as required and furnishing operators at night when needed.

Observations for latitude were made at Echo and La Grande, Oreg., Mountain Home and Blackfoot, Idaho, Moapa, Nev., and Lund, Utah.

At Walla Walla, Wash., and Needles, Cal., new astronomical stations were established which were referred to the old stations.

WASHINGTON.

[J. F. PRATT.]

On April 28 the positions of two radio towers at the United States Naval Torpedo Station at Keyport, Wash., were determined by triangulation.

These two steel open lattice towers, on permanent foundations, are very high, the northerly one being on lower ground than the southerly one, their tops being approximately the same height above the sea level.

This determination was made from stations of a triangulation made by the wire-drag party under charge of J. A. Daniels executed late in 1915 and early in 1917.

[J. F. PRATT.]

SUMMARY OF RESULTS.—Triangulation: 1 signal built, 4 stations occupied for horizontal measures, 15 geographic positions determined.

In February, 1917, a determination was made by triangulation of the geographic positions of a number of wireless telegraph stations in Seattle, Wash.

For this work the stations used had been determined by previous triangulation.

MAGNETIC WORK.

MAINE, NEW HAMPSHIRE, NEW YORK, AND VERMONT.

[FRANKLIN L. ADAMS.]

STATIONS OCCUPIED.—Maine: Dover, Fort Kent, Houlton,* Millinocket, Skowhegan, South Paris, and Van Buren. New Hampshire: Chesterfield, Hanover,* Lancaster, and Orford. New York: Dannemora, De Ruyter, Faust, Inman, Ithaca, Ovid, Fort Kent, and Wampsville. Vermont: Chelsea, Newport, and Richford.

Observations of the three magnetic elements were made at the stations above named between July 1 and August 28.

Of these stations, two marked by asterisks (*) were exactly reoccupied. Stations were occupied at Dannemora and Ithaca within a short distance of the sites of the old stations the marks of which had been destroyed.

The conditions at Dannemora were much disturbed, the station being within a short distance of the abandoned workings of an iron mine.

A new station was established at Ithaca about half a mile distant from the site of the old one.

At Chesterfield a new station was established and a meridian line laid out on the village green 5 miles distant from the old station.

The regions about Richford, Inman, and Faust were found to be strongly disturbed locally and were partially explored. Seven auxiliary stations were made about Richford. Two stations less than 5 miles apart were found to differ more than 9° 25′ in declination.

MARYLAND.

CHELTENHAM MAGNETIC OBSERVATORY.

[GEORGE HARTNELL.]

The regular work of the Cheltenham Magnetic Observatory was continued during the year, including the operation of two magnetographs and a seismograph, observations with the standard observatory instruments and also comparison of the field instruments with observatory standards, the computation of all base lines, as well as of the absolute observations, the hourly scalings of the magnetograms and reports of earthquakes, and all other necessary work connected with the foregoing.

All of the observatory instruments have been in satisfactory operation during the year. Some repairs made to the instruments resulted in an improvement in the record. Considerable attention has been given to the subject of earth inductors both theoretically and experimentally.

Necessary repairs to the observatory buildings were made.

During the year 28 earthquakes were recorded.

FLORIDA, GEORGIA, AND SOUTH CAROLINA.

[J. R. BENTON.]

STATIONS OCCUPIED.—Florida: Cross City, Gainesville,* and Newberry. Georgia: Savannah* and Waycross.* South Carolina: Barnwell, Columbia, and Sally.

Between June 6 and June 30, 1917, complete magnetic observations were made at the stations named.

Old stations were reoccupied at the places marked by asterisks (*).

At the other places on the list new stations were occupied. No permanent marks were left at these stations except at Sally.

At Barnwell auxiliary stations were occupied to determine the extent of the magnetic disturbance. Eight such points were occupied at distances of about 5 to 10 miles from Barnwell to the east, south, west, and north.

ALABAMA, ARKANSAS, KANSAS, MISSISSIPPI, MISSOURI, OKLAHOMA, AND TENNESSEE.

[WALLACE M. HILL.]

STATIONS OCCUPIED.—Alabama: Huntsville.* Arkansas: Booneville, Greenwood, Tyronza, and Yellville.* Kansas: Anthony, Cimarron,* Copeland, Johnson, New Ulysses, Salina,* and Santa Fe. Mississippi: Corinth.* Missouri: Alton, Forsyth, Gainesville, and Thayer. Oklahoma: Jay, Vineta, and Stillwell. Tennessee: Athens,* Knoxville,* and Memphis.*

Observations of the three magnetic elements were made at the above-named stations between March 17 and June 30, 1917.

Old stations were reoccupied at the places marked by asterisks (*).

Meridian lines were laid out at Alton, Jay, and Santa Fe.

Observations were made at auxiliary stations in the vicinity of Yellville, Forsyth, Anthony, and Cimarron.

ARKANSAS, INDIANA, AND MISSOURI.

[WALLACE M. HILL.]

STATIONS OCCUPIED.—Arkansas: Des Arc, Little Rock,* and Piggott. Indiana: Indianapolis.* Missouri: Bloomfield,* Boonville, Buffalo, California, Carrollton, Columbia, Fulton, Hermitage,† Huntsville, Jefferson City,† Kansas City,* Kennett,† Linn, Linn Creek, Marshall,†* Mexico,* Montgomery City, Poplar Bluff, Potosi, Stockton, Tuscumbia, Union, University City, Versailles, Vienna, Warrenton,† and Warsaw.

Observations of the three magnetic elements were made at the stations named during the period from July 1 to Nov. 16, 1916. Old stations were reoccupied at places marked by an asterisk (*). Meridian lines were established at stations marked by a dagger (†). Nine auxiliary stations to test local magnetic disturbances were occupied near Bloomfield and eight near Linn Creek.

CALIFORNIA.

[W. W. MERRYMON.]

STATIONS OCCUPIED.—California: Cooperstown, Downie, Galt, Goat Island, Jackson, Mariposa, Martinez, Quincy, San Andreas, and Sonora.

Between August 1 and September 16 determinations of the three magnetic elements were made at the stations named.

The old station on Goat Island was found and reoccupied.

COLORADO, IDAHO, NEW MEXICO, OREGON, TEXAS, UTAH, AND WASHINGTON.

[H. E. MCCOMB.]

STATIONS OCCUPIED.—Colorado: De Beque, Durango,* Fort Garland, Grand Junction,* Paonia, Rifle, San Luis, Tercio, and Trinidad.* Idaho: Preston. New Mexico: Aztec, Endee, Mills, Mora, Mosquero, Shiprock, Springer, Tierra Amarilla, Tucumcari,* and Ute Park. Oregon: Brogan, Enterprise, Homestead, Huntington, Juntura, La Grande, Ontario, Pendleton,* and Vale. Texas: Amarillo.* Utah: Green River * and Ogden.* Washington: Connell, Davenport, Ephrata, Okanogan, Pasco, Republic, Spokane,* Springdale, and Wilbur.

Between March 19 and June 30, 1917, complete magnetic observations were made at the places named.

Four auxiliary stations were established at each of the following stations: Mills, Springers, Trinidad. and Wilbur.

Old stations were reoccupied at the places marked by asterisks (*).

A meridian line was established at Ephrata at the request of local surveyors.

Local surveyors and engineers manifested great interest in the work in Oregon and Washington and requested copies of observations made in their localities and other available information on the subject.

IDAHO, MONTANA, NORTH DAKOTA, SOUTH DAKOTA, WASHINGTON, AND WYOMING.

[H. E. McCOMB.]

STATIONS OCCUPIED.—Idaho: Albion, American Falls, Caldwell, Coeur d'Alene, Driggs, Emmet, Gooding, McCall, Moscow, Nez Perce, Orofino, Pocatello,* Pollock, Rexburg, Rigby, Rupert, St. Maries, Silver City, Smiths Ferry, Twin Falls and Wallace. Montana: Baker, Browning,* Columbus, Ekalaka, Glendive, Libby, Livingston,* Sidney, Sweetgrass,* Virginia City, Whitehall, Wibaux, Yellowstone, and international boundary monuments Nos. 276, 281, 295, 315, and 350. North Dakota: Amidon, Beach, Bowman, Fort Yates, Leith, Mott, Shields. South Dakota: Dupre, Huron,* Laplant, McLaughlin, and Mound City. Washington: Newport. Wyoming: Yellowstone Park.

Old stations were reoccupied at the places marked by asterisks (*).

Observations of the three magnetic elements were made at the stations listed above during the period from July 1 to November 4, 1916.

The stations on the international boundary were first occupied. These were not permanently marked. The remaining stations were usually marked by concrete posts, excepting Smiths Ferry, Idaho; Baker, Whitehall, and Yellowstone, Mont.; Leith and Shields, N. Dak.; McLaughlin, S. Dak.; and Yellowstone Park, Wyo.

ARIZONA.

TUCSON MAGNETIC OBSERVATORY.

[FRANKLIN P. ULRICH.]

At the magnetic observatory near Tucson, Ariz., the magnetograph was in continuous operation recording variations in declination and horizontal and vertical intensities. Absolute observations were made as previously and time corrections were obtained as usual at least once a week from the Mare Island time signals.

The Bosch-Omori seismograph was kept in continuous operation and 37 earthquakes were recorded. The periods of the pendulums remained unchanged.

Daily meteorological observations were obtained and reported to the local office of the Weather Bureau until October 9 when the Weather Bureau removed all of its instruments. After that date the temperature and weather conditions and amount of rainfall were recorded.

ILLINOIS.

[WM. W. MERRYMON.]

STATIONS OCCUPIED.—Illinois: Hoopeston, Saybrook, and Urbana.

Between June 21 and June 30, 1917, the three magnetic elements were determined at the places named, of which Hoopeston and Saybrook were new stations.

ALASKA.

[JOHN A. DANIELS.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 16 miles, 49 square miles of area covered, 27 lines of intervisibility determined, 14 points selected for scheme. Triangulation: 85 square miles of area covered, 17 signal poles erected, 14 observing tripods and scaffolds built, 28 stations in main scheme occupied for horizontal measures, 34 geographic positions determined. Leveling: 4 permanent bench marks established, 3.1 miles of levels run. Topography: 92 miles of general coast line run, 4 topographic sheets finished. Hydrography: 139.4 miles of area dragged, 282.17 miles run while dragging, 1,714 positions determined (double angles), 62 soundings made, 1 tide station established, 8 hydrographic sheets finished, scales 1:40,000 and 1:20,000.

During the season of 1916 the scheme of secondary triangulation executed by this party in 1915 and terminating in the line Stick-East, was extended in a primary scheme to Dry Strait, terminating on the line Ryn-Kad, situated on Rynda and Kadin Islands, respectively. The triangulation covers a distance of 23 statute miles and comprises 22 occupied stations and 40 closed triangles. The average triangle closure obtained was 0.88 second.

From the line Duck-Gray of the above scheme tertiary work was carried into Zimovia Strait, connecting with the work of 1886 and 1893 in the vicinity of Wrangell. In the tertiary scheme the signals were nearly all built by the party on the steamer *Patterson* and the observing done by the wire-drag party. The tertiary scheme connects with the work of the *Patterson* in Zimovia Strait, and the primary scheme connects with the work of wire-drag party No. 4 at Wedge Point and Five Mile Island. The tertiary scheme extends for a distance of 18 statute miles and covers an area of 46 square miles. It includes 15 occupied stations and 25 closed triangles with an average closure of 4.07 seconds.

The character of Round Point, the point of Zarembo Island at the bend in Stikine Strait near Stikine Lighthouse, a sheer round point with no projections visible from either side, made necessary the insertion of an extra quadrilateral with corresponding signal building and observing. South Craig Point presented similar difficulties. In other cases little difficulty was experienced in obtaining lines of fair length and figures of sufficient strength.

In connection with the scheme the base on the east shore of Zarembo Island was measured in the months of August and September, and the observing in connection with the broken base was done with the direction instrument. The base work comprised seven stations, besides the occupation of stations Kof and Tole to tie the base to the main scheme. The topography of the shore line outlined in the plans for the season's work was completed with the exception of that from Caamano Point on Cleveland Peninsula to a point about 4½ miles southward from Lemesurier Point. The completed work extends northward from this point and includes the irregular shore line in the vicinity of Lemesurier Point.

On the western shore of Clarence Strait the shore line of Prince of Wales Island was completed from Tolstoi Island to Coffman

Island including Ratz Harbor and Coffman Cove. No contouring was done along this shore.

The southern half of Zarembo Island was surveyed but no contours were run. Both the shore line and contours of Woronkofski Island were completed.

In the hydrography all areas were dragged to an effective depth of 50 feet where such depths existed, and all soundings of less depth were verified within the area surveyed, provided such soundings were located within the probable path of navigation.

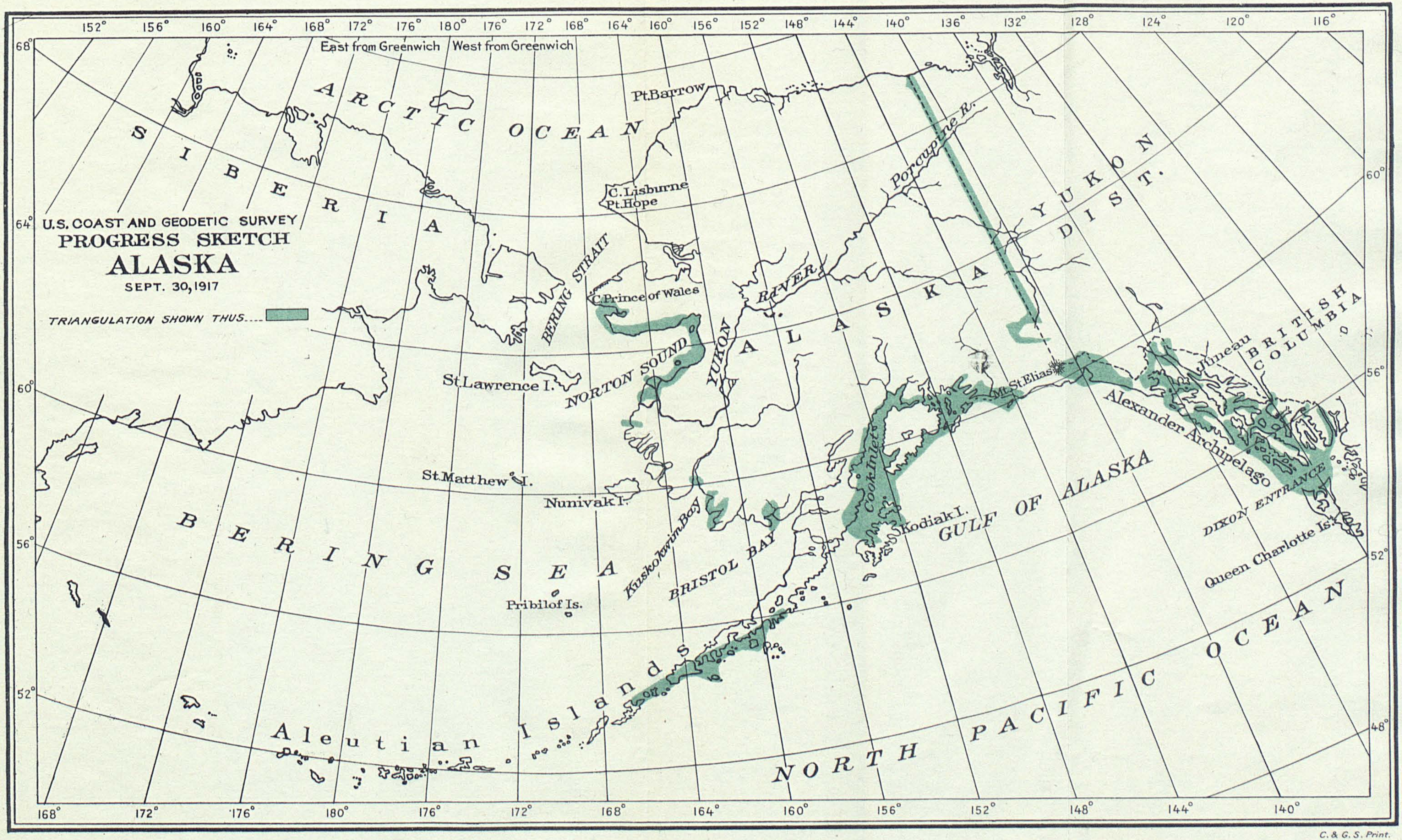
In general the drag was taken within about one-fourth mile of shore, except in bays where the distance from shore was sometimes greater and at headlands where it was less. At headlands or islands that are likely to be used by navigators as turning points in a vessel's course, particular care was exercised to pass the drag as closely as possible to shore. Signals for the control of this work were located by triangulation, except in Chichagof Pass where they were determined by planetable.

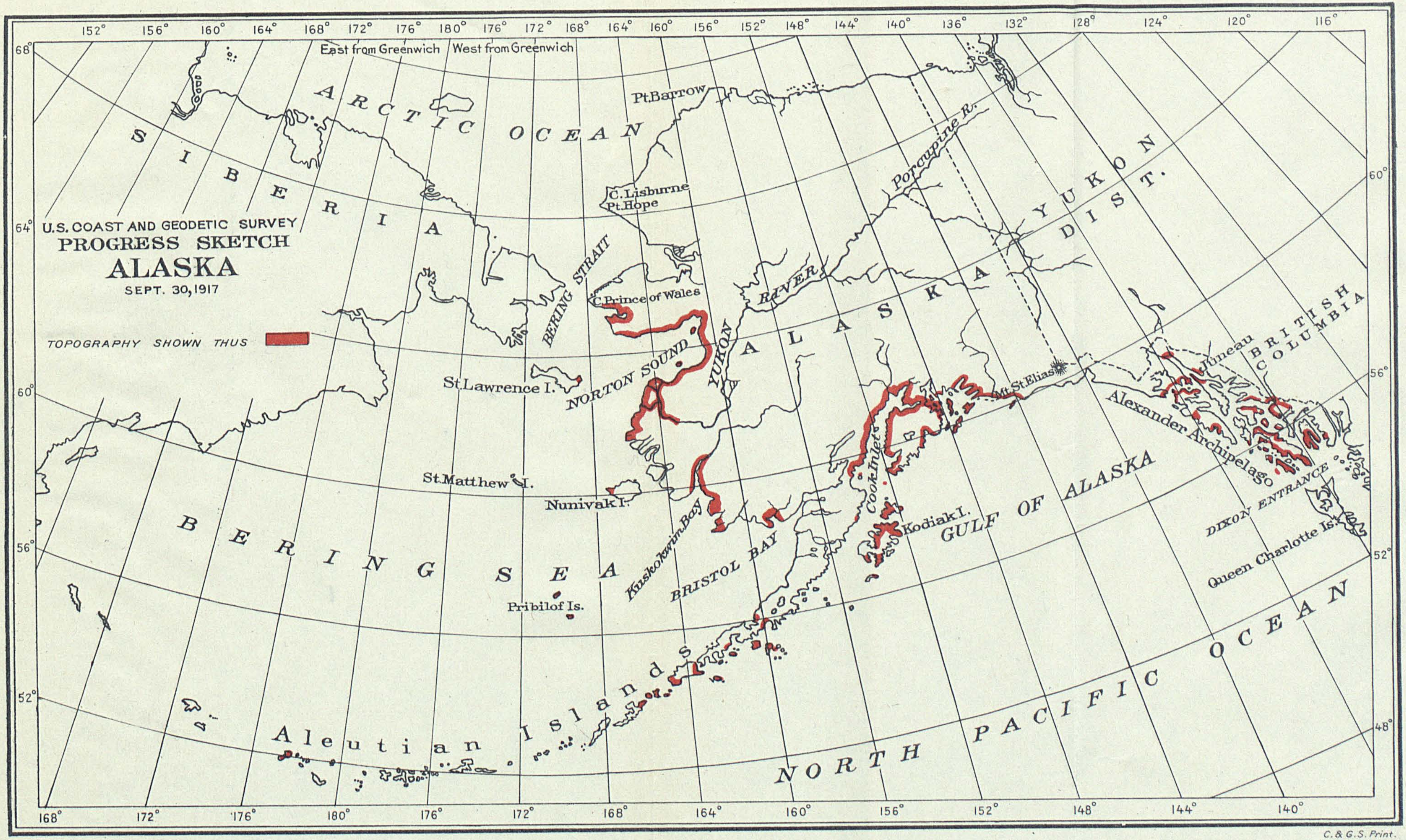
The dragging of Clarence Strait was completed by first covering the small areas left in 1915 to the southward of Lemesurier Point and then working systematically to the northward covering all unswept areas. Good progress was made in the open sections. The work was taken into Rocky Bay where several important dangers were discovered. Ratz Harbor was dragged and sounded and found to be clear as charted. Five important dangers were found in Clarence Strait.

The open area of Ernest Sound was dragged from Lemesurier Point to Point Peters, and six important dangers were found. Upon the southern shore the drag was carried into Union Bay and into Vixen Inlet as far as Sunshine Island. Upon this side of the sound the shore was closely followed throughout, while upon the northern side the numerous outlying rocks and islands prevented a near approach to the shore line without considerable inshore work. As no inshore hydrography was available for control this inshore dragging was not done.

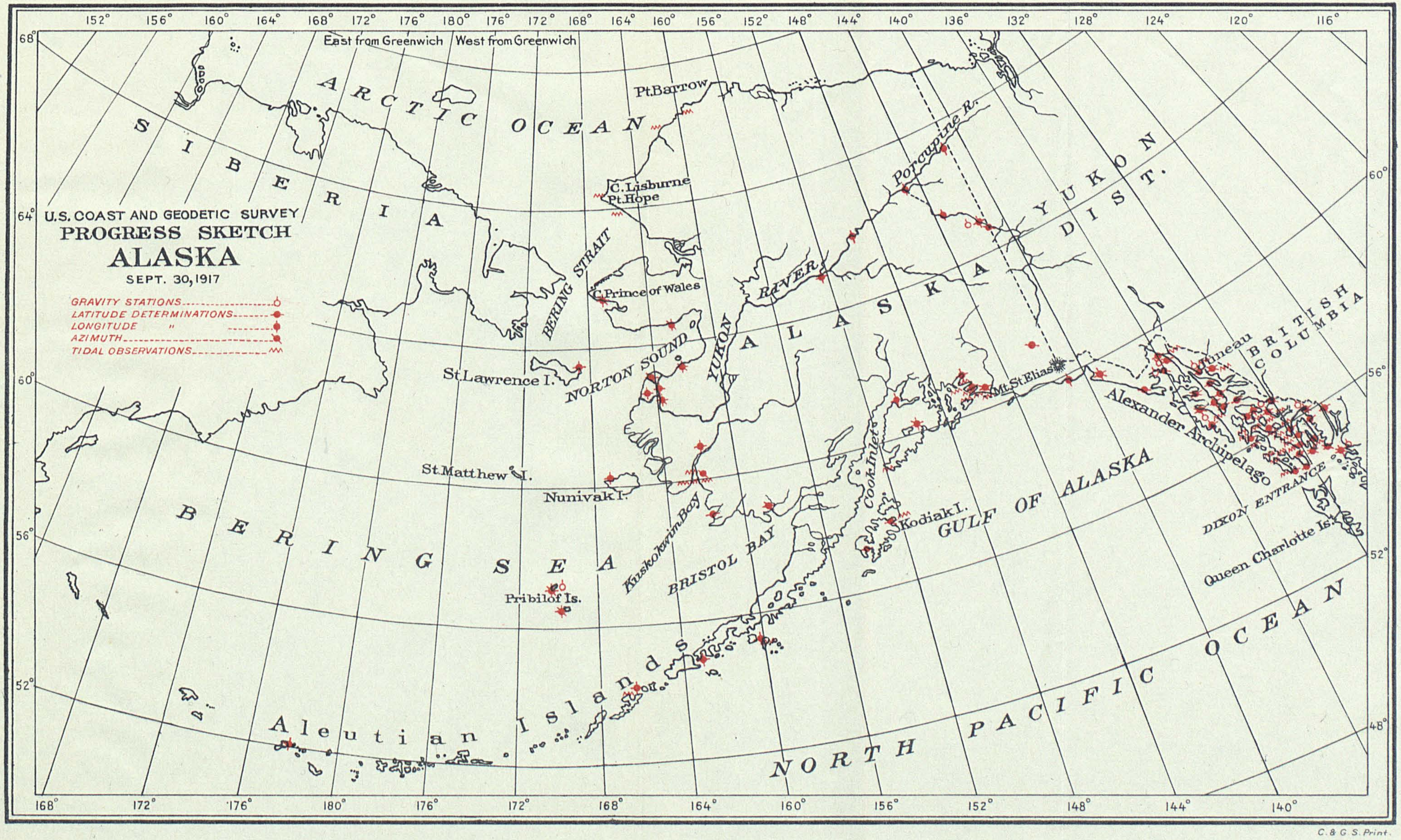
The dragged area of Stikine Strait extends from a junction with that at Steamer Point in Clarence Strait to a line from Wedge Point to South Craig Point, connecting here with the work of wire-drag party No. 4. Although generally clear, this proved to be a difficult area to cover on account of particularly strong and erratic tidal currents. Whirls, eddies, cross currents, and undertows made it almost impossible to use a long drag without parting it, and it was practically impossible to determine from the predicted tides in which direction the flow would be at a particular time in any locality. Stikine Strait was found clear except close to shore where two pinnacles dangerous to small boats were found. The shore line was very closely approached in this locality.

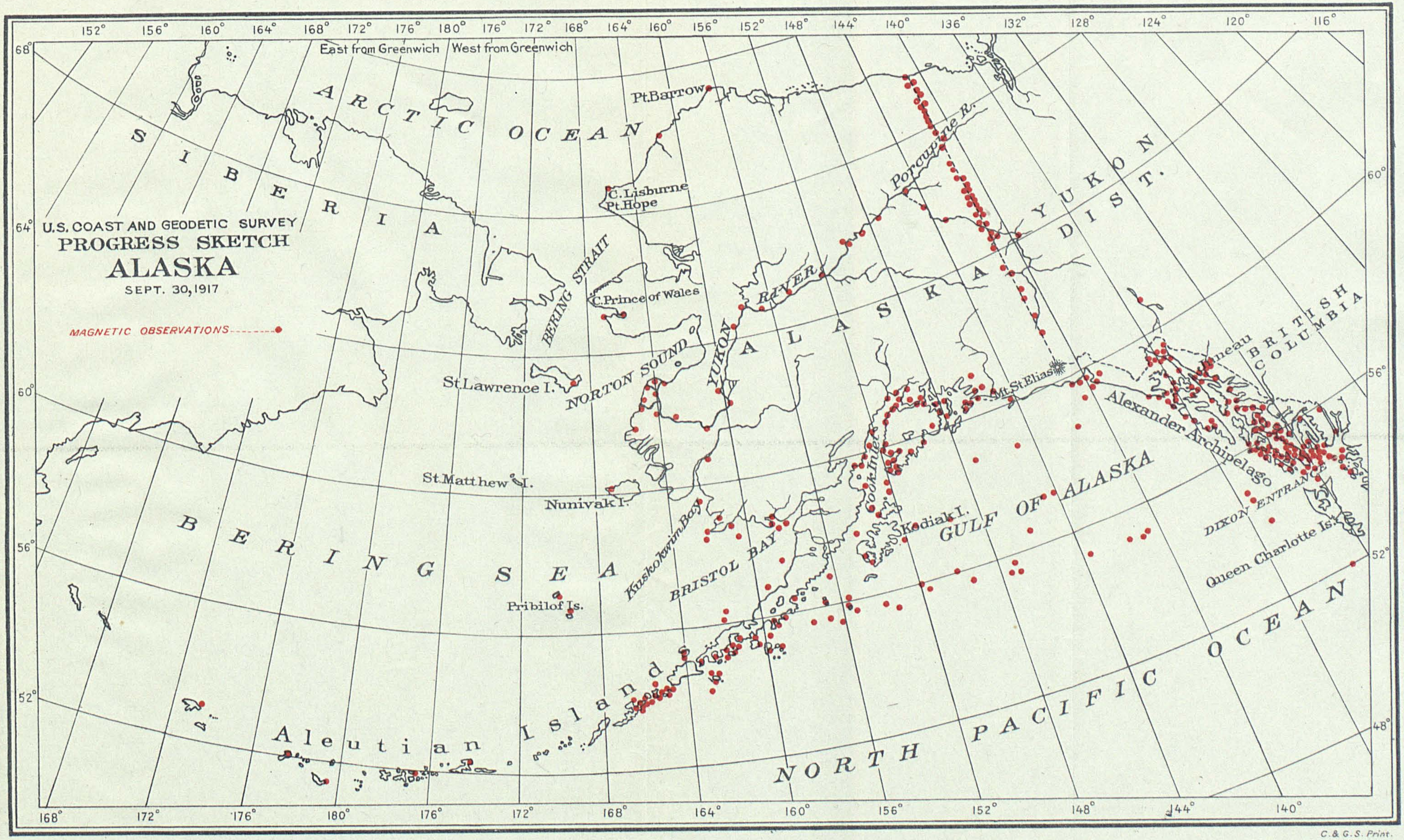
All of the apparently clear area in the southern part of Kashevarof Passage as far north as West Island was dragged, also the two principal approaches to Lake Bay cannery. Numerous shoals, several of which are dangerous, were found, and these in conjunction with the strong tides made this a troublesome area to drag. The work


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
SEPT. 30, 1917
TRIANGULATION SHOWN THUS....
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
St. Lawrence I.
NORTON SOUND
YUKON RIVER
ALASKA
YUKON DIST.
Porcupine R.
BRITISH COLUMBIA
Juneau
Mt. St. Elias
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
GULF OF ALASKA
Cook Inlet
Kodiak I.
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BRISTOL BAY
BERING SEA
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN
C. & G. S. Print.


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
SEPT. 30, 1917
TOPOGRAPHY SHOWN THUS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
Porcupine R.
YUKON DIST.
BERING STRAIT
C. Prince of Wales
YUKON RIVER
ALASKA
St. Lawrence I.
NORTON SOUND
Mt. St. Elias
BRITISH COLUMBIA
Juneau
Alexander Archipelago
St. Matthew I.
Nunivak I.
Cook Inlet
Kodiak I.
GULF OF ALASKA
DIXON ENTRANCE
Queen Charlotte Is.
BERING SEA
Kuskokwim Bay
BRISTOL BAY
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN
152° 156° 160° 164° 168° 172° 176° 180° 176° 172° 168° 164° 160° 156° 152° 148° 144° 140° 136° 132° 128° 124° 120° 116°
68° 64° 60° 56° 52° 48°
168° 172° 176° 180° 176° 172° 168° 164° 160° 156° 152° 148° 144° 140°

C. & G. S. Print.


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
SEPT. 30, 1917
GRAVITY STATIONS
LATITUDE DETERMINATIONS
LONGITUDE "
AZIMUTH
TIDAL OBSERVATIONS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
Porcupine R.
YUKON DIST.
BERING STRAIT
C. Prince of Wales
YUKON RIVER
ALASKA
St. Lawrence I.
NORTON SOUND
Mt. St. Elias
Juneau
BRITISH COLUMBIA
Alexander Archipelago
St. Matthew I.
Nunivak I.
Cook Inlet
Kodiak I.
GULF OF ALASKA
DIXON ENTRANCE
Queen Charlotte Is.
BERING SEA
Kuskokwim Bay
BRISTOL BAY
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN
C. & G. S. Print.


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
SEPT. 30, 1917
MAGNETIC OBSERVATIONS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
BERING SEA
BERING STRAIT
NORTH PACIFIC OCEAN
GULF OF ALASKA
ALASKA
YUKON DIST.
BRITISH COLUMBIA
Pt. Barrow
C. Lisburne
Pt. Hope
C. Prince of Wales
St. Lawrence I.
NORTON SOUND
YUKON
RIVER
Porcupine R.
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BRISTOL BAY
Pribilof Is.
Aleutian Islands
Kodiak I.
Cook Inlet
Mt. St. Elias
Juneau
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
C. & G. S. Print.

in the approach to the cannery, where four dangers were found, was done when the weather did not permit work to be done outside. Short drag work only was done in this locality. The northern part of Kashevarof Passage as far south as Fire Island was dragged, leaving only the narrows between Fire Island and West Island undragged. This northern area was done in conjunction with Snow Passage and the part of Clarence Strait between Snow Passage and Point Colpoys. The locality abounds in islands and shoals, which with the tidal current of from 3 to 6 knots made the drag work extremely difficult. Much time and material were expended with but little apparent result. However, the conditions that interfere with drag work make this a very dangerous locality for navigation, and renders it all the more necessary that the shoals should be correctly charted. Six dangers were located in Kashevarof Passage. The area was well covered and all shoals fully developed.

The area in Chichagof Pass was covered and no dangers were found. Zimovia Strait was dragged from a point 1 mile southward from Young Rock to Olive Cove. Anita Bay was not dragged and only the open water northward from Olive Cove was covered.

NEW WIRE-DRAG EQUIPMENT.

Ground wire of galvanized seven-strand extra strength cable three-sixteenths of an inch in diameter, made into 100-foot sections and joined by means of one-fourth inch drop-forged swivels and special light sockets, was used for the first time and proved a success. It is much more satisfactory than the No. 7 telephone wire formerly used, although it was frequently parted when grounded in the strong tides of Snow and Kashevarof Passages.

The newly designed small buoy, which is nun shaped and larger and heavier than those formerly used, was satisfactory, as it caused the entire elimination of loss due to the collapse on account of water pressure when towed under. This has been a serious hindrance in former seasons in Alaska, and its disappearance is very gratifying. The new buoy is heavier and harder to handle than the others, but upon the whole is more suitable.

During this season metal floats instead of wooden ones were regularly used for the first time in wire-drag work. They are constructed of No. 18 galvanized sheet metal, riveted and soldered so as to be water-tight. The float is cylindrical in shape, with a cone at one end, at the apex of which a ring bolt is inserted and heavily soldered for attaching to the ground wire by means of a short line and snap-hook. In order to provide sufficient buoyancy to support a 100-foot section of the ground wire, this make of float must be of a size to occupy about the same space as the old style wooden float. The great advantage over the wooden float is the constant buoyancy, as one of the most troublesome uncertainties connected with wire-drag work in the past has been the varying buoyancy of the wooden floats due to waterlogging. At a cost of about $1.80 each, these floats are a great improvement.

[L. O. COLBERT.]

SUMMARY OF RESULTS.—Triangulation: 372 square miles of area covered, 105 signal poles erected, 22 stations in main scheme occupied for horizontal measures, 90 stations in supplemental schemes occupied for horizontal measures, 10 stations occupied for vertical measures, 121 geographic positions determined, 10 elevations determined trigonometrically. Leveling: 9 permanent bench marks established. Topography: 381 square miles of area surveyed, 242 miles of general coast line surveyed, 23 miles of shore line of creeks surveyed, 7 topographic sheets finished, scale, 1:20,000. Hydrography: 277 square miles of area dragged, 593 miles run while dragging, 51 miles run while sounding, 21,255 angles observed, 157 retained soundings, 3 tide stations established, 6 current stations occupied, 10 hydrographic sheets finished, scales, one 1:10,000, nine 1:20,000.

Wire-drag party No. 4 began field work in southeastern Alaska April 19 and closed October 14, 1916.

The work done before July 1 is detailed in the annual report for the last fiscal year.

The completed survey consists principally of a wire-drag examination of the areas hereafter described. To control this survey a scheme of triangulation was carried forward. At the same time a topographic revision of the shore line was conducted. The wire-drag survey was supplemented by soundings in certain sections and by tidal and current observations.

The work of the season was in two localities, the first at the entrance to Sumner Strait in the vicinity of Cape Decision and the second at the eastern end of Sumner Strait and the channels adjoining and extending to the eastward from it.

At the entrance to Sumner Strait a complete wire-drag survey was made within the following limits: Beginning in the vicinity of Calder Rocks an area of about 5 miles was covered in mid-channel between the inshore limits of the previous season's work. To the westward of Bluff Island one day's work covered a detached area of about 3 square miles. On the northwestern side of the strait from Cape Decision to the southern limits of the work of the previous season an inshore strip averaging about 1½ miles wide was dragged. The inshore edge of this area is bounded by charted reefs and small islands between which no attempt was made to carry the drag. This latter strip covers an important area to the eastward of numerous reefs and small islands, which lie along the shore of Kuiu Island. It embraces the usual ship track for steamers bound around Cape Decision, which course is taken by many of the larger steamers to avoid Wrangell Strait. It was considered the most important portion of the area to be surveyed, and most of the time allotted was spent in this section instead of in the deeper waters offshore.

The drag was set at an effective depth of 48 feet where the chart did not show less water. In the vicinity of shoals the drag was set at about 2 feet less than the depth over the shoals.

In this section six shoals were found.

An automatic tide gauge was established at Pole Anchorage before commencing drag work. The records of the automatic gauge at Wrangell were used for comparison.

No special current observations were made during the progress of this work, but during the drag work certain facts in regard to the currents were noted.

Information in regard to harbors on this portion of the coast was collected for use in the coast pilot.

A topographic survey was made of the shore line of Kuiu Island from the vicinity of Amelius Islands to Point St. Albans, including also the Diomede Islands and the stretch from Port McArthur to Cape Decision. This survey was made to give an accurate location of the numerous off-lying islets and reefs along this important coast. On account of poor weather conditions during the work and later on account of lack of time, less attention was paid to the contouring than to the delineation of the shore line.

Three recovered stations of the triangulation of 1886 in the vicinity of Shakan Bay were connected by secondary triangulation with three recovered stations located by E. F. Dickins in 1889. This scheme covered the area in which the work of the season was done and was the basis of control for those surveys. The locations and heights of all prominent mountain peaks in this general vicinity were determined.

In the eastern part of Sumner Strait and adjoining channels to the eastward, wire-drag work was taken up from the limits of the work of the previous season in the vicinity of the Eye Opener. A junction was made with the work of wire-drag party No. 3 on a line joining Point Colpoys and McNamara Point. The area south of this line was dragged by party No. 3.

After dipping into the entrance to Duncan Canal and into Wrangell Strait as far as Deception Point the drag was carried through the remaining waters of Sumner Strait. In Stikine Strait a junction was made with the work of wire-drag party No. 3 on a line joining South Craig and High Points. In Zimovia Strait the junction was about 3 miles south of Young Rock. The drag was run close to the southern edge of the flats at the mouth of the Stikine River.

All of Eastern Passage and Blake Channel was dragged with the exception of the small bay north of Point Madan and that part of Bradfield Canal east of Anan Bay. Instead of dragging these waters the time was spent in extending the work to the southward through Ernest Sound to form a junction with the work carried into this body of water from the south by wire-drag party No. 3. In Ernest Sound the main channel only was dragged.

The standard depth to which all deep water was dragged was 48 feet, except close inshore or where the chart showed a less depth. All sunken rocks and shoals located were dragged over with about 2 feet less than the least depth found.

In this section of the season's work there were found 17 uncharted shoals.

Lines of soundings were run across the edge of the flats off the mouth of the Stikine River to determine the present limits of these flats. These lines were run normal to the general trend of the edge of the flats and the system was carried from the Wilson Islands to Gerard Point. Lines of soundings were also run in the vicinity of Rock Point and Point Highfield.

At the head of Blake Channel soundings were also taken to define the limits of the extensive flats off Aaron Creek.

Tides were recorded with an automatic tide gauge at St. John Harbor from April 22 to May 2 and from June 20 to September 26. During this period automatic gauges were in operation in Wrangell Harbor and Lake Bay. A tide staff was erected at Ham Island in

Blake Channel, and tides were observed simultaneously with observations on the gauge at Wrangell.

Observations were made for the direction and velocity of the tidal current at six stations.

The schooner *King and Winge* was used at the principal stations, anchoring in deep water.

The coast pilot information for the localities surveyed was verified, and additional details in regard to these channels were noted in the descriptive reports.

A 10-fathom bank was found in the eastern end of Sumner Strait about mid-channel between Vank and Zarembo Islands and two shoals, one at each end of the passage between Vank and Sokolof Islands. The one in the approach to the western end is the more dangerous, having about 12 feet of water over it. The other has about 27 feet of water over it.

With the exception of these shoals, Eastern Passage and Blake Channel were found free of dangers. The use of these passages by vessels bound for Wrangell should be more general when it is known that no hidden dangers exist. Special mention should be made of the fact that heavy seas in Clarence Strait due to southeasterly gales may be avoided by this route.

No dangers were found in Bradfield Canal or in Ernest Sound where dragged except one off the north end of Deer Island.

Topographic surveys of the shore line of Sumner Strait were begun at McNamara Point on Zarembo Island and at Point Alexander on Mitkof Island and were completed to the eastward including all the islands lying in this end of the strait. The heights and contours of the hills and ridges visible from the strait were determined. These surveys were carried through Eastern Passage and Blake Channel into Bradfield Canal as far as the junction of the latter with Ernest Sound.

A scheme of secondary triangulation was continued from Mitchell Point and Point Colpoys, to which line it had been carried in 1915, to a junction with the primary scheme by John A. Daniels in Stikine Strait. The control of the topographic and wire-drag sheets was based on this work. For the control of surveys in Eastern Passage and Blake Channel triangulation of a tertiary character was observed starting from stations established by O. H. Tittmann at the mouth of Stikine River. In Bradfield Canal the work was joined to bases obtained from C. G. Quillian, who carried the triangulation through Ernest Sound from Clarence Strait.

[L. O. COLBERT.]

SUMMARY OF RESULTS.—Triangulation: 24 square miles of area surveyed, 31 signal poles erected, 6 stations in supplemental schemes occupied for horizontal measures, 8 geographic positions determined. Leveling: 3 permanent bench marks established. Topography: 37 square miles of area surveyed, 72 miles of general coast line surveyed, 1 topographic sheet finished, scale 1:20,000. Hydrography: 48 square miles of area dragged, 127 miles run while dragging, 849 positions determined (double angles), 72 retained soundings, 1 tide station established, scale of hydrographic sheets 1:20,000.

The party organized at Seattle, Wash., in April, 1917, for wire-drag work in Alaska, sailed for Alaska in the chartered steamer *L. Roscoe* on April 26 and arrived at Wrangell April 30 and at Juneau May 3.

The party proceeded to the working grounds May 7, and on the following day signal building and topographic work were begun. Dragging operations were begun May 16.

The hydrography completed by June 30 consists of a wire-drag examination of Favorite Channel and part of Stephens Passage on the west side of Douglas Island. The area covered extends from Sentinel Island to Point Young.

No important shoals dangerous to navigation were located. Several deep soundings not charted were obtained and three shoals with less than 50 feet of water were found. A number of uncharted rocks awash at low water were determined close inshore, and the depth on Spuhn Rock was reduced by 4 feet.

An automatic tide gauge was set up on the cannery dock at Auke Bay on May 15 and a continuous record obtained to the close of the fiscal year.

A topographic survey of the shore line adjacent to the waters dragged was carried on during the period covered by this report. The shore line completed extends from the mouth of Eagle River to Fritz Cove; on the northwest corner of Douglas Island from the edge of the flats to a point 2 miles below Outer Point; on the east side of Mansfield Peninsula, on Admiralty Island, a stretch of beach line about 7 miles long; on the south and east sides of Shelter Island; and including all the small off-lying islands in this section. Contours were determined back of these limits except on the mainland north of Point Lena where check measurements established the completeness and accuracy of the contours on the Geological Survey map of this region.

A short scheme of triangulation was laid out in Favorite Channel ahead of the work of the primary triangulation party under F. S. Borden, and horizontal angles had been observed at 5 stations on June 30.

Mr. Borden's work in recovering and locating certain controlling points in Stephens Passage was of assistance to this party, but as the primary work was not sufficiently advanced to give starting points for the surveys by the wire-drag party, it was necessary to recover additional stations on which to start the topography, and for this purpose three old stations in Fritz Cove were used. Additional signals were also built and located for use in the wire-drag work. Most of these signals were cut in by the triangulation party.

[A. JOACHIMS.]

SUMMARY OF RESULTS.—Triangulation: 85 square miles of area covered, 9 signal poles erected, 7 stations in main scheme occupied for horizontal measures, 4 stations in supplemental schemes occupied for horizontal measures, 15 geographic positions determined. Topography: 75 miles of general coast line surveyed, scale of topographic sheets 1:20,000. Hydrography (wire drag): 201.5 square miles of area dragged, 251.7 miles run while dragging, 9 soundings retained, 1 tide station established. Hydrography (sounding): 8.2 miles run while sounding, 132 positions determined (double angles), 708 soundings made.

In March preparations were made at Seattle for organizing wire-drag party No. 3 for work in southeastern Alaska. The steamer *Equator* and the launches *Roosevelt* and *Freya* were chartered for the use of the party. The *Equator* and *Roosevelt* reported at Ketchikan on April 16 and the *Freya* at Petersburg on May 1.

Headquarters were established at Petersburg where the launches were equipped for dragging, triangulation stations were recovered and signals erected, and on April 27 drag work was begun in Frederick Sound.

During the period from April 27 to June 30 an area was dragged in Frederick Sound, starting on a line approximately east and west across the sound about 3 miles southeast of Frederick Point and ending at a line approximately north and south from Cape Fanshaw. The drag was set at an effective depth of 85 feet at mean lower low water, except over known shoal places near shore where this was not practicable. A small area in the vicinity and northwest of McDonald Island and also a little inshore work west of Farragut and Portage bays were not completed.

A great portion of the area was covered by a long drag using 300-foot to 400-foot sections. The drag was frequently tested and proved to be dragging the full depth set between buoys and with about 1-foot lift at the buoys.

The region dragged proved to be clear in most cases. A 60-foot shoal was located off Cape of the Straits and also a shoal with a least depth of 93 feet at mean lower low water south of the most westerly island of the Sukoi Group.

A determination was made by triangulation of the positions of Mount Elizabeth and Mount Cecil in the vicinity of Patterson Bay.

In the early part of the season it was necessary to run a tertiary scheme of triangulation in advance of the primary work to be done by E. W. Eickelberg. Three old stations Noon, Cape, and Bridge were recovered and used as a base. The work was extended westward from the old station Noon to Portage Island and Bay Point where it was tied onto the primary scheme. A few figures were also extended into Farragut Bay for planetable control.

Hydrography was done in vicinity of buoys 24 and 17 in Wrangell Strait and near the docks at Petersburg. Signals were erected over recovered triangulation stations and a few additional points located. The area was carefully developed by closely run lines and cross lines and soundings were made near the cannery and company docks.

A topographic party was kept steadily at work in the vicinity of drag operations. The shore line of three sheets was nearly completed. A number of mountain peaks were cut in by triangulation.

An automatic tide gauge was established at the old sawmill dock at Petersburg on April 22, and a continuous record of tides obtained from that date.

Tide staffs at stations Mitkof and Petersburg in Wrangell Strait were visited, lines of levels run to see that the zero marks of these staffs were properly set, and the staffs were repaired.

Notes were collected for use in the coast pilot volumes.

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

SUMMARY OF RESULTS.—Triangulation: 56 stations in main scheme occupied for horizontal measures, 63 geographic positions determined. Topography: 130 square miles of area surveyed, 248 miles of general coast line surveyed, 8 topographic sheets finished, scale 1:20,000. Hydrography: 90 square miles of area covered, 835 miles run while sounding, 5,779 positions determined (double angles), 30,726 soundings made, 2 tide stations established, 8 hydrographic sheets finished.

At the beginning of the fiscal year the steamer *Patterson* was engaged in triangulation, topography, and hydrography in the vicinity of the Kashevarof Islands, southeastern Alaska.

A planetable party and a sounding party were operated from the ship anchored in Lake Bay, while two planetable parties and a hydrographic party were camped at Exchange Cove.

Afterwards the topographic and hydrographic parties working from Lake Bay were placed in camp there, while the personal supervision of the chief of party was given to the parties in Exchange Cove, and the secondary triangulation through Snow Passage was taken up.

After the completion of the secondary triangulation in Snow Passage and most of the topography and hydrography in Kashevarof Passage, work was begun on the west side of Etolin Island.

A house-scow was chartered and fitted up to accommodate 3 officers and 10 men. This scow was tended by the launch *Delta* and various small power boats, and from it were operated one sounding party and one to two topographic parties. The work along the west side of Etolin Island and Dewey Anchorage was undertaken by this party.

The general survey was continued along the coast of Etolin Island southward from Point Harrington to McHenry Anchorage, excepting Mosman Inlet and the sounding in Burnett Inlet. McHenry Inlet and Dewey Anchorage and the passages through Onslow and Stone Islands were surveyed.

The triangulation control was extended through Zimovia Strait and a reconnoissance survey made of the narrows in Zimovia Strait.

An automatic tide gauge was maintained at Lake Bay during the entire season.

Staff gauges were established at Exchange Cove, Bushy Island, McHenry Inlet, and Zimovia Strait.

During the latter part of the season two tide staffs were established in Wrangell Strait for the use of passing vessels. These staffs were marked in the following manner so that their purpose was obvious to the mariner: "Tide Staffs, U. S. Coast and Geodetic Survey. Add staff readings to charted soundings."

Work was completed in October. The *Delta* and other boats were stored at Metlakatla and the *Patterson* returned to Seattle October 31.

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

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 38 miles, 30 square miles of area covered, 57 points selected for scheme. Triangulation: 11 square miles of area covered, 56 signal poles erected, 38 stations in main scheme occupied for horizontal measures, 8 stations occupied for vertical measures, 34 geographic positions determined. Magnetic work: 2 land stations occupied for magnetic declination, 7 sea stations occupied for magnetic declination, dip, and intensity, ship completely swung at 7 sea stations. Topography: 40 square miles of area surveyed, 39.8 miles of general coast line surveyed, scale of topographic sheets 1.20,000. Hydrographic: 5.9 square miles of area covered, 52.5 miles run while sounding, 456 positions determined (double angles), 867 soundings made, 1 tide station established, scale of hydrographic sheet 1:20,000.

On April 25, 1917, the *Patterson* sailed from Seattle to resume work in Alaska, stopping at Port Townsend to swing ship for compass deviation.

On arrival at Metlakatla, Alaska, the launch *Delta* was put in commission and the other boats taken from storage.

The *Delta* was towed from Metlakatla to Juneau where the bunkers were filled and the vessel proceeded to the working ground on May 12. Stag Bay was made the headquarters.

After making a reconnoissance the work was started by building triangulation stations and preparing to extend the triangulation from Cross Sound through Lisianski Inlet and Strait.

A camp party was landed on Miners Island at the junction of Lisianski Inlet and Lisianski Strait. The *Delta* and launch *38*, a motor boat, and several skiffs were moored for their use.

On May 24 the *Patterson* struck an uncharted rock in Lisianski Strait and injured the rudder. The vessel made Inian Cove, Cross Sound, under her own power without assistance. Here the rudder was unshipped and brought on deck for temporary repairs. May 27 the wire-drag tug *L. Roscoe* towed the *Patterson* into Juneau and moored her at the Ready Bullion dock of the Alaska Treadwell Gold Mining Co., at Treadwell. The rudder was sent to the machine shop of the Alaska Treadwell Gold Mining Co. and the split stock reinforced with a metal jacket, and a new pintle and a new gudgeon cast.

A diver was obtained and a survey made of the bottom. The diver reported the blows as all keel blows and that excepting the rudder the damage was to the shoe and the false keel. He further reported that, so far as a diver's examination could determine, the hull and keel were uninjured and sound and the vessel seaworthy.

The splintered wood of the false keel was faired off, torn sheathing replaced, missing sheathing renewed with sheathing or lead to protect the keel from toredoes, and a shoe nailed in place. The new gudgeon was shipped and the rudder shipped in place.

From the return of the vessel to the working ground on June 18 until the end of the fiscal year on June 30 the weather was unfavorable for work, there being almost continual rainy spells, and no offshore work was done.

During the time the vessel was being repaired in Juneau, the camp party made good progress and carried the triangulation down Lisianski Inlet and Strait to Stag Bay and extended the topography almost as far. The hydrography of the narrow portions of Lisianski Strait was completed first for use of the ship and in expectation of vessels being sent into the cannery in construction in Stag Bay.

At the end of the fiscal year the progress of the work was as follows: Triangulation completed from Cross Sound to below Stag Bay and signals built to Point Urey; reconnoissance and some of signals built for several figures into Lisianski Inlet below Junction Island; topography completed to Stag Bay. No offshore soundings had been made.

En route to Alaska the ship was completely swung for magnetic observations for declination with standard compass and for dip and total intensity with the Lloyd-Creak Dip Circle at the following seven places: Port Townsend, Wash., and Gulf of Georgia, Queen Charlotte Sound, Lama Passage, Fraser Reach, Milbank Sound, and Chatham Sound, British Columbia.

Valuable assistance was rendered by the Alaska Treadwell Gold Mining Co. of Treadwell, Alaska, in reinforcing rudder; the Chichagof Mining Co. of Chichagof, Alaska, in carrying mail and supplies to the camp party and in bringing mail to the ship on the working ground; the Icy Straits Packing Co. of Juneau, Alaska, in carrying supplies to the camp party from Inian Cove shortly after the injury to the rudder; the Lisianski Packing Co. by bringing supplies to the camp and to the ship, and by Joseph T. Bauer, M. S. E., retired, the owner and manager of the Chichagof radio station, in keeping the *Patterson* in radio communication with Seattle and Washington.

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

SUMMARY OF RESULTS.—Triangulation: 455 square miles of area covered, 19 stations in main scheme occupied for horizontal measures, 3 stations occupied for vertical measures, 38 geographic positions determined. Leveling: 7 permanent bench marks determined, 2 miles of levels run. Topography: 45 square miles of area surveyed, 109.9 miles of general coast line surveyed, 4 topographic sheets finished, scales 1:10,000, 1:20,000, and 1:40,000. Hydrography: 209 square miles of area covered, 745.1 miles run while sounding, 7,332 positions determined (double angles), 6,803 soundings made, 3 tide stations established, 5 hydrographic sheets finished, scales 1:10,000, 1:20,000, and 1:40,000.

At the beginning of the fiscal year the party on the steamer *Explorer* was engaged in general surveys on the outside coast of Dall Island, southeastern Alaska. Progress to June 30 is stated in the last annual report.

The area of hydrography was divided into three parts, the first extending from the longitude of Forrester Island west to the 1,000-fathom curve, the second from the inshore hydrography to the longitude of Forrester Island, and the third to include all the inshore hydrography as well as that of the bays and harbors of the outside coast of Dall Island.

It was found impracticable in the season available to accomplish any of the work in the section first mentioned.

The second division of the work of the hydrography was accomplished by the party on the *Explorer*.

The third division of the hydrography was accomplished by parties working from bases in Security Cove, Port Bazan, and Waterfall Bay.

The extension of the triangulation from the work of 1915 south from triangulation station Luzon was done by subparties on the *Cosmos* and launch *No. 117*.

The topography of Forrester Island and the shore line of Dall Island from Cape Augustine to join the work of R. B. Derickson, was executed by detached parties on the *Cosmos* and working from camps with launches *No. 117* and *No. 46*.

Lines of soundings were run east and west between latitude 54° 36′ and 55° 05′, spaced according to the prevailing depths from 1 to 4 miles apart. The bottom is extremely irregular especially north of the line between Forrester Island and Point Augustine.

This area being exposed to the full sweep of the sea, kelp could not be relied upon as an indication of danger. The best indication of such dangers was a break after a strong westerly blow. The inshore hydrography around Forrester Island and most of that on the outer coast of Dall Island was done by a party on the launch *Cosmos*. Some inshore work north of Port Bazan was done by a party on launch *No. 117*. The hydrography of Port Bazan was done with launches *No. 117* and *No. 42;* the hydrography of Waterfall Bay by a party on launch *No. 117*.

The reconnoissance for triangulation was done by parties working with launch *No. 117* from the ship.

Triangulation stations Augustine, Bazan, and Cornwallis were so chosen that intermediate points along the Dall Island coast could be located from them without observations from station Forrester.

The topography of Forrester Island and the outside coast of Dall Island from Cape Augustine to Port Bazan was done by a party on the *Cosmos*.

The topographic work from the previous topography in the vicinity of Cape Muzon was done from a camp in Security Cove. This party took advantage of clear days to do triangulation, and during weather when it was impossible to land on the outside coast, engaged in inshore hydrography.

The topography of Port Bazan was done on a scale of 1:10,000. The topography of Gooseneck Bay, Gold Harbor, and Waterfall Bay was done by a party in camp working with launch *No. 42*.

[T. J. MAHER, Commanding Steamer *Explorer*.]

SUMMARY OF RESULTS.—Triangulation: 30 square miles of area covered, 5 observing scaffolds and tripods built. Leveling: 3 miles of levels run, 3 permanent bench marks established. Topography: 2 miles of general coast line run (locating signals). Hydrography: 574 square miles of area covered, 931.6 miles run while sounding, 3,716 positions determined (double angles), 3,885 soundings made, 1 hydrographic sheet finished, 1 partly finished, scales 1:20,000 and 1:120,000. Physical hydrography: 3 deep-sea current stations occupied, 26 deep-sea surface current observations made.

The steamer *Explorer* left Seattle for Alaska on May 1, arriving in Port Chester May 7. After starting repairs to launch *No. 117* the steamer proceeded to Ketchikan for coal.

On May 14 ship hydrography was begun off Cape Muzon. Signals in the vicinity of the cape were located for the use of the steamer *Cosmos*. In the offshore hydrography, lines were run by the ship out to the 1,000-fathom curve, while the party on the *Cosmos* ran lines of soundings from Cape Muzon to Port Bazan, confining its work to an area extending 2 miles offshore. Various gaps existing in previous work were filled in, and work in that section is now complete.

The ship work extends north from parallel 54° 38′ and west from the shore of Dall Island for 55 nautical miles, and covers a lane of about 6 nautical miles, widening somewhat at the offshore end. From Cape Muzon to a distance of about 6 miles the soundings were less than 100 fathoms. For about 55 miles beyond that, depths ranged between 100 and 200 fathoms, shoaling somewhat near the outer edge. The bottom slope then became steep, dropping off rapidly to 1,000 fathoms.

Soundings in depths between 100 and 200 fathoms were made one-half mile to 1 mile apart, the greater number being spaced the shorter distance. The lines are approximately 1 mile apart. A line of soundings was run north 40° east from the 1,000-fathom curve to the entrance of Meares Passage. This crosses an area west of Forrester Island concerning the depths in which there was no previous information.

During former seasons widely spaced lines were run in the area east of Forrester Island and Lowrie Rock. Of this area a rectangular section extending 6 nautical miles due east of Forrester Island and 9½ nautical miles north was developed. The ship anchored at night in from 50 to 60 fathoms of water about 5 miles east of Forrester Island. Currents were observed at such times.

Tide staffs were erected at Cape Muzon and at Gooseneck Bay. The automatic gauge at Craig was in operation during the season.

On June 18 the ship was at Klawak coaling. On June 20 she left for the working grounds. Weather conditions were unfavorable and only three days' hydrography could be done by the ship. The *Cosmos* was able to get in only two days' work before the end of June. Some triangulation was done to locate signals for the control of the hydrography at the entrance to Meares Passage.

[E. E. SMITH, Commanding Steamer *Taku*.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 21 miles. Triangulation: 157 square miles of area covered, 12 signal poles erected. Topography; 55 square miles of area surveyed, 103 miles of general coast line surveyed, 5 topographic sheets finished, scale 1:20,000. Hydrography: 111.5 square miles of area covered, 1,264.2 miles run while sounding, 6,120 positions determined (double angles), 40,743 soundings made, 2 tide stations established, 35 current stations established, 6 hydrographic sheets finished, scales 1:10,000, 1:20,000, and 1:80,000.

The survey of Orca Inlet and the Copper River delta begun in April, 1916, was in progress at the beginning of the fiscal year.

The topography of Orca Inlet on a scale of 1:20,000 was done when the weather was unfavorable for work elsewhere. On the east side the short line was run from Point Whitshed to Cordova, on the other side from abreast of Cordova nearly to Canoe Pass. Contouring was done chiefly from photographs made with the photo-topographic camera.

The hydrography of Orca Inlet was closely sounded out with the hand lead by the *Taku* and small boats. In the endeavor to find a channel through from Cordova to the sea all sloughs were developed throughout.

A planetable survey was made of Boswell Bay on a scale of 1:20,000. The outer sandy shore shows some changes.

The hydrography of Boswell Bay was done on a scale of 1:10,000. This bay is small and offers swinging room for about three small vessels. The large rocks at the entrance to the bay make excellent landmarks.

In the region between Point Bentinck and Egg Islands, the islands which show above high water were located by sextant positions, the topographer noting his angles at turns in the shore line or other suitable places, making sketches and plotting on the smooth sheet.

In this vicinity the deeper sloughs were sounded from the *Taku*. Over the flats and smaller sloughs the whaleboat party worked. Outside the bars the soundings were made by the *Taku* running as close in to the breakers as practicable. Work outside was carried to about 15 miles east of Point Bentinck with a gap between but was not completed to the 10-fathom curve when the season closed as the sea would seldom permit the *Taku* to work here. The inner part was sounded on a scale of 1:20,000, but the outer part required the use of distant peaks for signals and was done on 1:80,000 scale.

The topography between Egg Islands and Pete Dahl Slough was located by sextant in the same manner as that of Egg Islands.

The hydrography of Alaganik Channel was done by the *Taku* and the whaleboat. The flats and small sloughs in the vicinity were covered by the whaleboat. A line of sounding was carried through Steamboat Slough and the Race Track by the *Taku*, and further development was made by the small-boat party.

In Kokinhenik Slough a reconnoissance line plotted on the 1:80,000 smooth sheet was sounded to Kokinhenik following the reported lowest part of the flats. In the vicinity of Kokinhenik Island enough work was done with the planetable to locate hydrographic signals. Considerable changes were noticed in the shore line, more than half of Kokinhenik Island having washed away since 1898. The deeper water in the vicinity was located and followed up until it vanished among the sand flats from which it originated.

Triangulation stations Camp, Girl, and Beach were recovered, and stations Mock and Egg were established on the sand bars and station Whitshed 1916 on the rock that sustained a former station of the same name, making a five-pointed figure for which observations were made. It was intended to continue the scheme with quadrilateral Mock-Whitshed-Mike-Egg, but station Mock was washed away before Mike was occupied, and station Coin was established near station Mock and the scheme carried through.

Radio towers in the vicinity of Point Whitshed were located from stations previously established on Orca Inlet. The new naval radio towers 13 miles from Cordova were also located by triangulation.

Observations with compass declinometer were made at triangulation stations Beach, Trade, and Egg.

An automatic tide gauge was established at the edge of the channel near the Point Whitshed wireless station and connected with bench marks previously established.

Comparative readings were made at Alaganik Slough entrance, Kokinhenik Island, and Boswell Bay.

Current observations were made whenever the vessel anchored.

On October 5 the *Taku* was beached in the slough at Cordova, hauled into her winter berth and laid up for the season.

Work was closed October 17 and on the 19th the party sailed for Seattle.

The Coast and Geodetic Survey chart agency at Cordova was inspected in the spring and just before leaving in the fall. The agency at Juneau was inspected as the party returned to Seattle.

[A. J. ELA.]

The field revision of the Alaska Coast Pilot, Part I, begun in May, 1916, was continued in July, August, and September.

The officer engaged in this work traversed the various channels of southeastern Alaska, traveling on chartered launches, regular mail launches, and steamers. He took advantage of opportunities to locate several uncharted rocks and examine reported doubtful areas, in addition to obtaining the usual coast pilot information supplemental to that in the last published volume.

Field work was closed September 22.

[FRANK S. BOBDEN.]

SUMMARY OF RESULTS.—Triangulation: 130 square miles of area covered, 27 signal poles erected, length of scheme 28 statute miles, 25 stations in main scheme occupied for horizontal measures, 1 station in supplemental scheme occupied for horizontal measures, 25 geographic positions determined.

In accordance with instructions issued March 9, 1917, a party was organized at Seattle and left for Juneau, Alaska, on April 13, to carry on the work of primary triangulation in Stephens Passage, southeastern Alaska. Field work was begun on April 25.

The object of this triangulation is to furnish control for the work of the wire-drag party under L. O. Colbert operating in this locality and also to furnish a strong scheme of triangulation through southeastern Alaska on which all triangulation of a lower grade may be based.

The triangulation was carried northwestward up Stephens Passage, through Favorite Channel to the line Little-Sentinel on Little and Sentinel Islands at the entrance to Lynn Canal. From the main scheme stations of the triangulation all hydrographic signals, prominent objects, and peaks were located. From the line Little-Sentinel, which is as far north as the scheme was carried in the season, hydrographic signals were located as far north as Cape Bridget.

The triangulation was connected with the line joining stations Cow-Bib of the old triangulation, and the field computations are based on the old positions of those two stations.

The main scheme of triangulation executed up to the end of the fiscal year is 28 statute miles in length and includes 25 main scheme stations. The average closure of 47 triangles in the scheme is 0.77 second. The longest line is slightly over 7 miles in length and the shortest line is slightly less than 1 mile in length.

[E. W. EICKELBERG.]

SUMMARY OF RESULTS.—Reconnoissance for primary triangulation: Length of scheme 52 miles, 425 square miles of area covered, 35 lines of intervisibility determined, 16 points selected for scheme. Primary triangulation: 425 square miles of area covered, 15 signal poles erected, 1 observing tripod and scaffold built (height 52 feet), 14 stations in main scheme occupied for horizontal measures, 9 stations occupied for vertical measures, 30 geographic positions determined, 10 elevations determined trigonometrically.

The work of primary triangulation of Frederick Sound, southeastern Alaska, was begun April 23, 1917. This work was carried on in the most advantageous location for furnishing geographic positions for the wire-drag party.

On account of the numerous icebergs in the lower end of Frederick Sound the drag operations could not be carried on there, and the triangulation was begun in the vicinity of Cape Fanshaw, instead of in Dry Strait where triangulation work had been done during the previous season. The area available for wire-drag work and controlled by geographic positions at the close of the fiscal year was 425 square miles. This comprises 16 primary stations and furnishes 30 geographic positions.

This triangulation supplements that done by the party under F. S. Borden and forms part of an arc of primary triangulation that will extend from Dixon Entrance northward to White Pass at the head of Lynn Canal. The arc will eventually extend from Puget Sound in Washington to the intersection of the Yukon River and the one hundred and forty-first meridian boundary between Canada and Alaska. The Geodetic Survey of Canada plans to do the triangulation along those portions of the arc which fall within its territory. When this arc is completed all of the triangulation of Alaska can be placed on the North American datum, which will make it possible to compute permanent latitudes and longitudes for the triangulation stations.

SITKA MAGNETIC OBSERVATORY.

[J. W. Green.]

The regular work of the magnetic observatory at Sitka has been continued without material interruption, and practically continuous records have been obtained.

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.

Thirteen magnetic storms were recorded during the fiscal year and in addition 10 disturbances of less intensity.

The seismograph was kept in constant operation. The seismic activity was very slight, only 18 earthquakes of slight intensity having been recorded during the year.

New office quarters for the observatory were erected during the first half of the year.

A set of magnetic instruments from the steamer *Patterson* was standardized at the observatory.

Porto Rico.

[Harold W. Pease.]

In September field magnetic observations were made at three stations, Mayaguez, Ponce, and San Juan South Base.

The old stations could not be found or were no longer suitably located, so new stations were established near by.

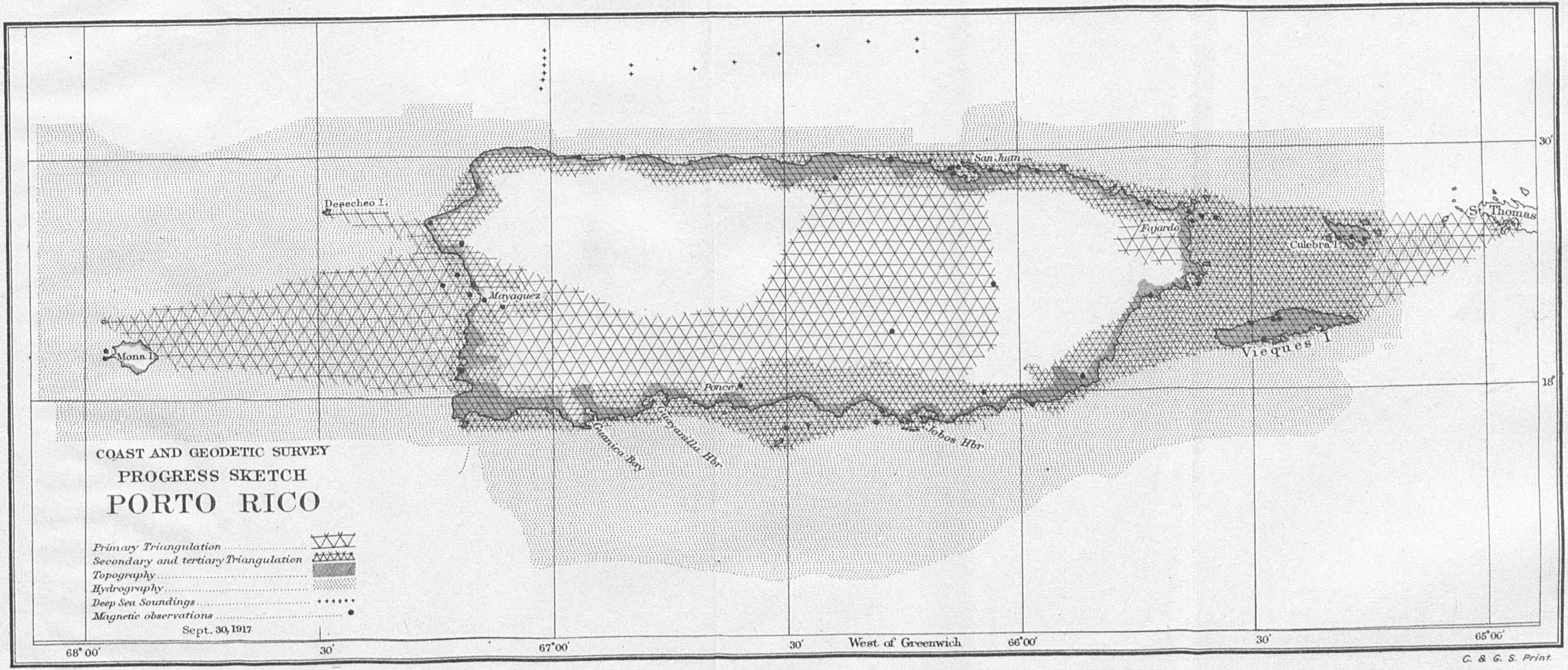
PORTO RICO MAGNETIC OBSERVATORY.

[Harold W. Pease, July 1 to Sept. 13, 1916; F. L. Adams, Sept. 14, 1916, to June 30, 1917.]

At the magnetic observatory at Vieques, P. R., a practically continuous record was obtained from the magnetograph and seismograph, and 24 earthquakes were recorded during the year.

Absolute observations were made twice each week. Time observations were made as often as necessary, and scale-value observations were made at least once each month.

On August 22 part of the roof of the observatory was blown off by a hurricane. The necessary repairs were made as soon thereafter as



COAST AND GEODETIC SURVEY
PROGRESS SKETCH
PORTO RICO
Primary Triangulation
Secondary and tertiary Triangulation
Topography
Hydrography
Deep Sea Soundings
Magnetic observations
Sept. 30, 1917
Mona I.
Desecheo I.
Mayaguez
Guanica Bay
Guayanilla Hbr.
Ponce
Jobos Hbr.
San Juan
Fajardo
Culebra I.
Vieques I.
St. Thomas
68° 00′
30′
67°00′
30′
West of Greenwich
66°00′
30′
65°00′
30′
18°
C. & G. S. Print

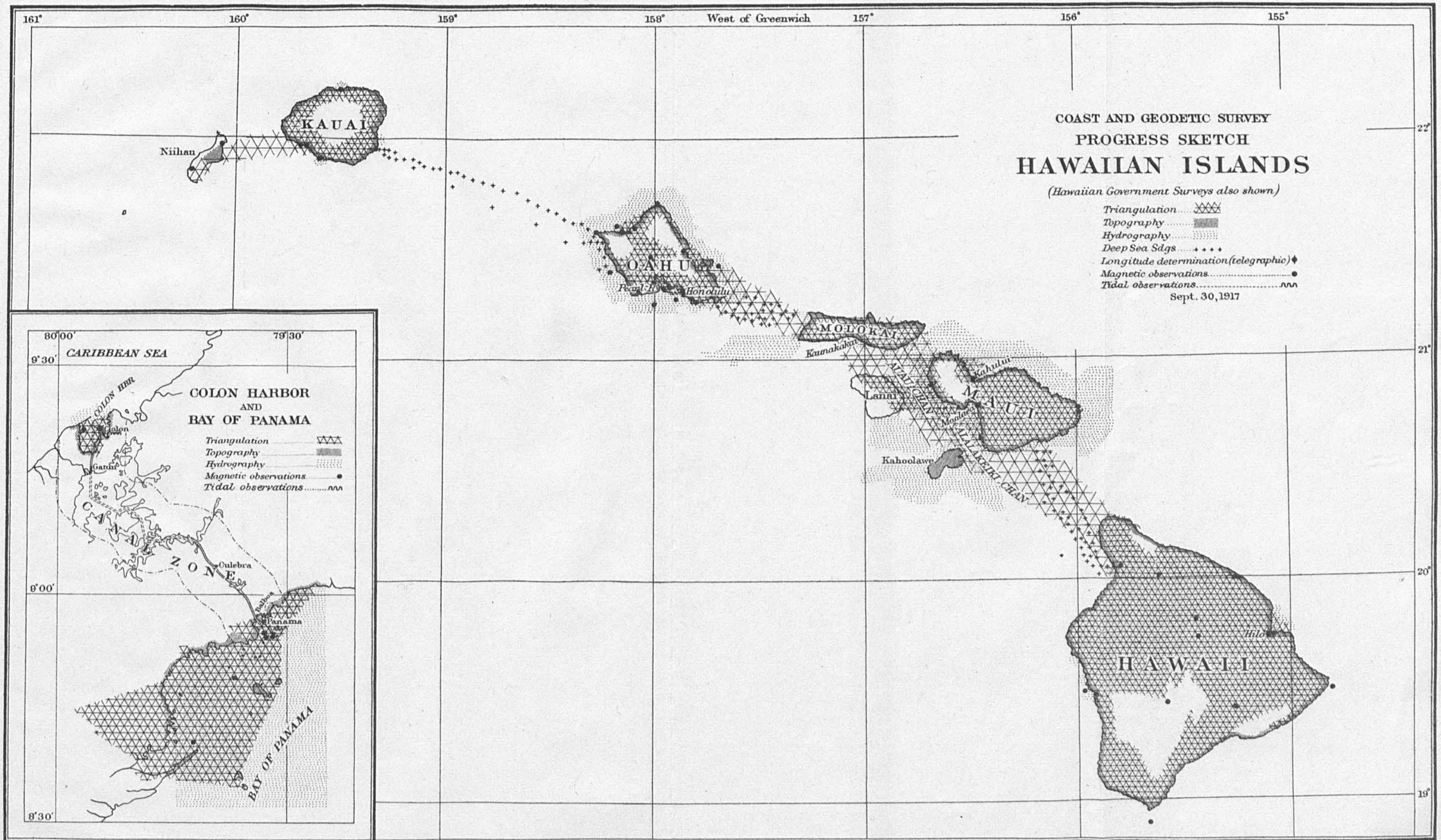
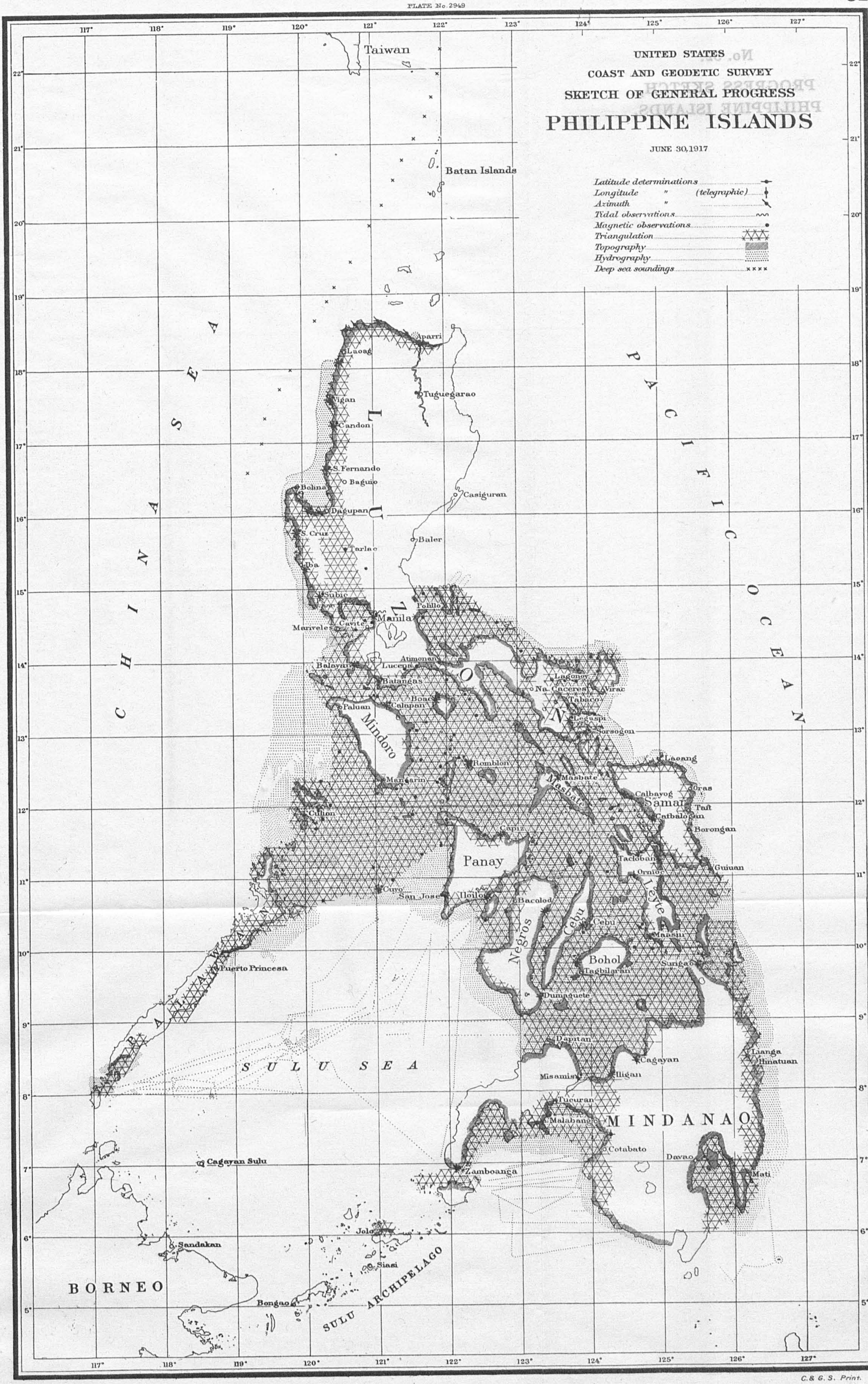

COAST AND GEODETIC SURVEY
PROGRESS SKETCH
HAWAIIAN ISLANDS
(Hawaiian Government Surveys also shown)
Triangulation
Topography
Hydrography
Deep Sea Sdgs
Longitude determination (telegraphic)
Magnetic observations
Tidal observations
Sept. 30, 1917
West of Greenwich
161°
160°
159°
158°
157°
156°
155°
22°
21°
20°
19°
KAUAI
Niihau
OAHU
Pearl H.
Honolulu
MOLOKAI
Kaunakakai
Lanai
AUAU CHAN
MAUI
Kahului
Maalaea
ALALAKEIKI CHAN
Kahoolawe
HAWAII
Hilo
COLON HARBOR
AND
BAY OF PANAMA
Triangulation
Topography
Hydrography
Magnetic observations
Tidal observations
CARIBBEAN SEA
COLON HBR
Colon
Gatun
CANAL ZONE
Culebra
Balboa
Panama
BAY OF PANAMA
80°00′
79°30′
9°30′
9°00′
8°30′
C. & G. S. Print.

PLATE No. 2949



C.& G.S. Print.

possible. Another hurricane on October 9 did further damage to the buildings, which was also repaired. Further necessary repairs were afterward made to the buildings.

At the time of the hurricane of August 22, the absolute instruments were moved to the seismograph house for safety. When remounted on its pier, the earth inductor was found to be out of order and had to be sent to the office for repairs; it was out of use until the following April. Dip observations were made with a dip circle in the interval, and the two instruments were compared in April and May.

HAWAII.

HONOLULU MAGNETIC OBSERVATORY.

[WILLIAM WALTER MERRYMON, July 1 to July 23, 1916; FRANK NEUMANN, July 24, 1916, to June 30, 1917.]

The usual variation observations were recorded continuously during the year near Honolulu.

Absolute observations were made once each week, and scale value determined once a month.

The Milne seismograph was kept in continuous operation, and 149 earthquakes were recorded, most of them, however, being of very small amplitude.

Meteorological observations were continued and the results reported to the United States Weather Bureau office at Honolulu.

PHILIPPINE ISLANDS.

[FREMONT MORSE, Director of Coast Surveys.]

The one fact standing out above all others during the period covered by this report is the great increase in cost of all articles of supply. Coal in particular has been increased more than 100 per cent in price at most of the insular coaling stations.

In the face of this increase and with a fixed allotment, it is obvious that only by rigid economy and careful planning of operations could the various ships be kept in the field. In hydrographic work the great expenditure of coal is made in connection with ship soundings. Hence the endeavor was to keep the vessels at such work as would involve the least amount of this class of work. Thus, on the Palawan coast the main endeavor was to keep the *Marinduque* and *Romblon* as much as possible on inshore hydrography, topography, and the main triangulation of the island.

Had the Survey been obliged to obtain all its coal from the bureau of supplies at the rates quoted there would have been no alternative but to lay up some of the ships before the end of the year. Fortunately, it was possible to obtain coal for the *Pathfinder* and *Marinduque* from the Navy at greatly reduced prices, and the *Romblon* was supplied at Sandakan, Borneo.

The coal account was also reduced during the last six months of the year by the execution of the repairs to the *Pathfinder* by the Navy at the Olongapo station. Owing first to lack of material and later to the rush of naval work incident to the severance of diplomatic relations with Germany and subsequent declaration of war, the *Pathfinder* was detained at Olongapo from January 17 to June 4. During that time she was not burning coal, and the saving on her fuel bills was all that prevented, even with the help of the Navy and the Sandakan coal supply, the laying up of one or more of the ships for a certain period toward the end of the year.

Other supplies have in like manner become more expensive. Prices have increased from 50 per cent to 75 per cent on practically all the articles needed to run the ships.

An unusual amount of repair work on the steamers *Romblon* and *Research*, funds for which purpose were provided by the Philippine Emergency Board, was made necessary by the rapid deterioration caused by the age of the ships and the tropical climatic conditions.

FIELD WORK.

At the beginning of the fiscal year the steamer *Pathfinder* was engaged in combined operations in the vicinity of Balabac Island. Weather conditions early in July rendered it advisable to suspend work in that locality and the ship returned to Manila where certain necessary minor repairs were made. After August 1 the *Pathfinder* was engaged in general surveys about Burdeus Bay and the islands to the eastward of Polillo until October when extensive repairs to the vessel were begun at Olongapo.

As it was not possible to finish all needed repairs at once, the vessel returned to the working ground at Balabac and was actively engaged in surveying work at the end of December.

Shortly after the beginning of the calendar year the vessel returned to Manila for transfer of officers and resumption of repairs at the Olongapo Naval Station. She reached Olongapo on January 17, and remained there until June 4. This long delay was occasioned by the necessity for repairs to the ships of the Navy rendered imperative by the severance of diplomatic relations with Germany and the final declaration of war.

On the completion of the repairs it had been the intention to have the *Pathfinder* resume work about Balabac Strait, in order that she might be handy to the cheapest source of coal supply, Sandakan, Borneo. The plan was changed when the naval authorities, instead of merely letting the vessel have a few tons of coal to take the ship to Sandakan, kindly filled her bunkers, and thus enabled the work to be taken up in the vicinity of Polillo Island, where on account of the interest in that locality caused by the formation of a national coal company by the Philippine Government, it has become necessary to have better charts.

The coal deposits on Polillo are said to be among the most promising prospects in the islands.

The Navy Department also desired more detailed surveys in that vicinity, and the *Pathfinder* will complete these with the help of the *Fathomer* during the prevalence of the southwest monsoon. To this end it has been arranged that the Navy will furnish coal for both ships, thus very materially aiding the work.

At the close of the year the *Pathfinder* was on the working ground.

The steamer *Fathomer* was at Manila undergoing repairs until September 11 when she sailed for Busuanga Island where surveys were in progress at the end of December. By that date the survey of the north coast of the island was approaching completion.

The *Fathomer* continued her regular work in the vicinity of Busuanga Island during the entire period from January 1 to June 30. Among the important results of her surveys was the discovery of a small but well-protected harbor not previously shown on any chart on the northwest coast of Busuanga, suitable for a typhoon refuge.

The topography of Busuanga and outlying islands was completed, and a short field season will finish the hydrography in this region.

Many hitherto uncharted shoals were located and sounded out. The commanding officer mentions about 30, of which 3 are of large extent.

Owing to an urgent request from the Navy for a speedy completion of the surveys in the vicinity of Polillo Island, the *Fathomer* will assist the *Pathfinder* after July 1, and the Busuanga work will be postponed for a time.

The most important work accomplished by the steamer *Marinduque* was the reconnoissance, signal building, and observing for the main scheme of triangulation of Palawan Island, which was carried to the vicinity of Puerto Princesa, completing in connection with work previously executed, a strong scheme available for both coasts for more than half of the entire length of the island. After the determination of the triangulation points, the ship was chiefly engaged in triangulation. Enough topography was executed to keep ahead of the other work.

The *Marinduque* continued her work on the east coast of Palawan after a period of repairing and outfitting in Manila. She sailed for her working grounds on February 10, and has been engaged in topography and hydrography in Green Island and Honda Bays and on the reconnoissance and observing for the main scheme of triangulation of the island of Palawan. This work is extremely arduous, as the scheme involves the occupation of the high mountain peaks far back from the coast. In fact, so far as carried down the island by the party of the *Marinduque*, the triangulation is so planned and executed as to be available for the survey of both the east and west coasts. By the end of the year the scheme had been laid out down as far as a nearly straight line across the island from Albion Head on the west coast to Aloaba, a peak in the interior of the island, and thence to Tagalipog Island, off the east coast, below Separation Point; and the observations were well under way. It required eight days to reach the most difficult station on Victoria Peak, 5,680 feet high.

At the beginning of the fiscal year the steamer *Romblon* was at work in the Cuyo group engaged in filling in gaps in previous work. A small amount of hydrography was done at San Jose, Panay.

Between August 1 and September 19 the vessel was undergoing repairs at Manila, after the completion of which field work was resumed in the same locality as before. On December 19 the work in the Cuyo Islands was finished and the vessel returned to Manila.

The *Romblon* resumed field work, general surveys, at the south end of Palawan Island on February 16. She returned to Manila for repairs and supplies March 19 and resumed her work in the field in the same locality on April 15 and was still there at the end of the year.

During the first part of this period, the prevalence of the northeast monsoon rendered work impracticable except in sheltered localities. Hence the topography and hydrography around the southern part of Palawan and up the west coast were first taken up. The former was completed up to Reposo Point and the latter nearly to Capyas Island.

The reconnoissance for the main scheme of triangulation up the island was later taken up and by the end of June had been extended to Brooks Point, ending on the line from this point to Mount Mantalingajan.

The topography was also completed on the east coast of Bugsuk Island and extended up the east coast of Palawan as far as Iglesia Point. The inshore hydrography was also completed to the same point, and considerable offshore work was done extending still farther north.

The extension of the triangulation scheme to Brooks Point leaves a gap of only about 30 miles between the work of the *Romblon* and that of the *Marinduque*.

At the beginning of the fiscal year the steamer *Research* was undergoing extensive repairs at Engineer Island which were not completed until August 9. On the 15th the vessel proceeded to Iloilo to take up the survey of Oton Bank and vicinity on which work she was engaged until October 12. The *Research* then returned to Manila for transfer of the command, which was effected October 18, and afterwards a general survey was begun of that portion of Manila Bay which had not been surveyed by the Coast and Geodetic Survey. Work was begun at the entrance and continued along the west shore toward the head of the bay. This survey was still in progress at the end of the fiscal year.

A new scheme of triangulation was executed for the control of the work in the northern end of the bay, extending up the two navigable streams that empty into it, the Pasag and Orani.

In the course of this triangulation the positions of the new radio towers on Sangley Point, the Masonic Temple in the city of Manila, and other prominent objects useful for navigation as well as for surveying purposes were determined. Owing to the low and swampy nature of the country about the bay, some scaffold signals from 40 to 50 feet in height were necessary, and water signals constructed of bamboo were used in some instances out in the bay for hydrography. The land stations were permanently marked with concrete posts, set deep in the ground and with their tops projecting about 6 inches above the surface.

The topography was run in about the bay except where previous surveys covered the ground. For use in the hydrography a plane-table survey of the shore line for the location of signals was made along the previously surveyed portion.

OFFICE WORK.

The routine of the Philippine suboffice was continued with only a few important changes. A nautical expert was assigned to take charge of the chart division, and a topographic draftsman sent from the United States was placed on duty in the drafting division.

On the resignation of the former chief of the geographic division, the duties of that division were turned over to the drafting division, which now conducts all the drafting work of the office.

The computing division, besides checking all field computations and making final least square adjustments of the different triangulation schemes, has charge of the records pertaining to triangulation, hydrography, and tides.

The main endeavor has been to complete the adjustment of minor schemes and points in regions where the main scheme had been previously adjusted and to extend the computation of geodetic positions on the Luzon datum.

In the drafting division tracings for two new charts, and one correction piece for a new edition were forwarded to Washington during the first half of the fiscal year. Eight chart drawings in various stages were on hand on December 31.

In the geographic division good progress was made on map No. 100 covering the entire Philippine group on a scale of 1:1,000,000. The completion of this map was delayed by the receipt of new and important data making necessary the reconstruction of part of the map, which will be prepared for publication in four sheets.

Three other maps were in course of construction on December 31, covering Mindanao, Samar, and northern Luzon.

One new map, No. 8, of southern Luzon, central sheet, on a scale of 1:200,000, was received from Washington and placed on sale.

Hand corrections were made to published maps to keep them as nearly as possible up to date.

A large number of miscellaneous maps are kept on hand for reference, which together with the list of municipalities and townships, constitute a very useful collection of geographic data.

The chart division receives and registers all documents that contain information affecting the charts and coast pilots, and publishes local notices to mariners in regard to dangers discovered by the surveying vessels.

It also attends to the correction, sale, and distribution of the published charts.

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

SUMMARY OF RESULTS.—Triangulation: 227 square miles of area covered, 33 signals erected, 4 observing tripods and scaffolds built, heights 81, 91, and 110 feet, 33 stations in supplemental schemes occupied for horizontal measures, 40 geographic positions determined, 2 elevations determined trigonometrically. Topography: 33 square miles of area surveyed, 116 miles of general coast line surveyed, 5 miles of rivers surveyed, 4 miles of creeks and sloughs surveyed, 2 topographic sheets finished, scale 1:20,000. Hydrography: 1,034.4 square miles of area covered, 3,443 miles run while sounding, 10,137 positions determined (double angles), 37,561 soundings made, 3 tide stations established, 7 hydrographic sheets finished, scales, one 1:60,000, six 1:20,000.

From July 1 to July 10 the party on the steamer *Pathfinder* was occupied in combined operations in the vicinity of Balabac Island. On account of weather conditions the work was suspended on July 11 and the ship proceeded to Manila arriving on July 14. The remainder of the month was occupied in making minor repairs and outfitting. This work being completed the vessel sailed from Manila for the working ground in vicinity of Polillo Island on August 1.

Field operations were begun at the north end of Burdeus Bay on August 4, and the survey of the Uala Group and other islands to the eastward of Polillo was engaged in until October 17 when the northeast monsoon had become well established and made it impracticable to continue field operations in this vicinity. The *Pathfinder* then returned to Manila to undergo extensive repairs to her hull, but on account of lack of material, the work on the hull was deferred until the arrival of the necessary material from the United States. The vessel was docked, however, at the Olongapo Naval Station, and such repairs as could be done at the time were completed. The *Pathfinder* then returned to Manila, outfitted, and proceeded to Balabac Island to continue the operations suspended in July. On December 31 this work was in progress.

During the season in vicinity of Polillo Island eight typhoon warnings were received, but the center of only one of these storms passed near. The heavy swell from distant storms made it impracticable, however, to land parties for topographic work or to engage in inshore hydrographic work on the north coast of Polillo Island.

From December 11 to 31, while operating in the vicinity of Balabac Island, on seven days only were the conditions favorable for topographic work, and on three of these the work had to be done between rain squalls.

The purpose of the triangulation in the vicinity of Polillo Island was merely to secure control for the topography and hydrography in the Uala Islands and on the northeast coasts of Polillo and Patnanogan Islands. To accomplish this it was necessary to extend the old scheme through a number of figures in order to establish new triangulation stations with the necessary lines of visibility for locating the topographic signals.

From old stations on the reefs south of Palasan Island a line was determined on the high ridge of Polillo Island, and from this new line the scheme was expanded to the northward and eastward, thus determining a station on an island off the north coast of Polillo and carrying the control through Uala Islands and to the east end of Patnanogan Island.

At Malolo and Hill on the highest point and northeast point, respectively, of Polillo Island, high instrument stands and scaffolds were necessary.

At Malolo an instrument stand 72 feet in height and scaffold (height of signal 91 feet) were built as separate structures and completed in two days.

At Hill a platform and stand combined were built in the upper branches of a single tree, giving an instrument elevation of 90 feet and a signal 110 feet above ground. This tree was cross braced to two other trees, the work requiring a day and a half in all.

The topography of Polillo Island was done from a camp on Anibawan Bay, the only safe anchorage for small boats. As the work progressed it was necessary to transport the parties a considerable distance to and from work. Along the north shore of Patnanogan Island where it is heavily fringed with mangroves, work could be done only at low tide.

The work in this vicinity was done on two sheets, including 51 and 20 miles of shore line, respectively.

The topographic work done in the vicinity of Balabac Island includes the shore line of Canabungan, Secam, the north side of Bancalan Islands, and a part of the west side of Balabac Island. This was done on three days between December 12 and 19.

During the entire time the ship was in this vicinity, December 11 to January 5, a heavy swell from the China Sea prevailed and landings were difficult.

The shore of the islands exposed to the China or Sulu Sea consists of sand beaches. The west coast of Balabac Island is a sand beach. The reefs, which extend far offshore, break up the swell so that at all times, even at high tide, the planetable may be set up at the most advantageous points. Along this coast traverse lines must be run in advancing the work of surveying the shore line.

Thirteen miles of shore line were completed. No contouring was done.

The hydrography in the vicinity of Polillo Island developed two deep-water entrances into Burdeus Bay from the eastward, also a harbor (Anibawan Bay) to the northeastward of Burdeus Bay on Polillo Island, which is well protected and affords good shelter from winds in any direction. The depths range from 5 to 20 fathoms, mud bottom.

In the survey of the area around Uala Islands, many anchorages were developed that are safe during the ordinary monsoons but not during typhoon weather.

The area between Polillo, Jomalig, and Balesin Islands was surveyed with the result that the depths were found uniform, ranging from 30 to 60 fathoms. The inshore work on the west coast of Baleskin Island indicated a very irregular bottom, but the survey had to be closed on account of weather conditions before a thorough development had been made.

The work during December around Balabac Island was confined to North Balabac Strait, which was completed.

An automatic tide gauge was installed at Burdeus Bay and three months' continuous observations were obtained.

During the survey of North Balabac Strait, staff readings were made at Calandorang Bay.

The *Pathfinder* continued work in Balabac Strait until the middle of January when she returned to Manila for transfer of officers and the resumption of repairs at the Olongapo Naval Station. She reached Olongapo on January 17 and remained there until June 4, when work was taken up in the vicinity of Polillo Island. This work was in progress on June 30.

The results of the field operations consist of the completion of the charting of North Balabac Strait, the Uala Islands off the east coast of Polillo, and the development of a safe typhoon anchorage (Anibawan Bay) and its approaches, on the northeast coast of Polillo. The work accomplished is principally hydrographic and covers a comparatively small area on account of close development being necessary.

The triangulation executed was only of a supplemental nature to determine sufficient geographic positions for topographic and hydrographic control.

The topography consists of the survey of the shore line bordering North Balabac Strait, the Uala Islands to the eastward of Polillo, also the northeast coast of Polillo, including Anibawan Bay.

In order to locate signals to control the hydrographic work between Polillo and Patnanongan Islands, a planetable traverse was run on the shores of these islands that had been previously surveyed in 1907 and 1908.

The hydrographic work accomplished during the year completes an area of 1,036 square miles and is plotted on seven sheets, one 1:60,000 and six 1:20,000.

The ship's work consisted of the survey of North Balabac Strait, the area to the southward of Polillo and Patnanongan Islands, also the approaches from the eastward to Burdeus and Anibawan Bays, on Polillo Island.

Two launches were used in the development of the inshore hydrography and the different anchorages; also the area between Polillo and Patnanongan Islands was surveyed by launch parties with the result that three ship channels were developed leading into Burdeus Bay from the southward.

An automatic tide gauge was installed in Burdeus Bay and a continuous record of two and one-half months was obtained.

[J. W. MAUPIN, Commanding Steamer *Fathomer*.]

SUMMARY OF RESULTS.—Triangulation: 177.9 square miles of area covered, 19 signal poles erected, 14 stations in main scheme occupied for horizontal measures, 20 geographic positions determined. Leveling: 9 permanent bench marks established. Magnetic work: ship swung at 1 station at sea. Topography: 61.6 square miles of area surveyed, 143.8 miles of general shore line surveyed, 8 miles of shore line of rivers surveyed, 5 topographic sheets finished, scale 1:20,000. Hydrography: 941.9 square miles of area covered, 7,179.5 miles run while sounding, 30,137 positions determined (double angles), 82,674 soundings made, 4 tide stations established, 2 current stations occupied, 4 hydrographic sheets finished, scale 1:20,000. Physical hydrography: 418.4 miles run in deep-sea sounding, 149 deep-sea soundings made, 2,080 square miles covered in deep-sea sounding.

At the beginning of the fiscal year the steamer *Fathomer* was undergoing general repairs at Manila, which were completed September 10. On September 11 the vessel sailed from Manila to take up general surveys on the north coast of Busuanga Island. The *Fathomer* arrived at Busuanga Island on the following day, and a temporary anchorage was made in Port Caltom. The next day a small but good anchorage, sheltered from all weather and centrally located for the work, was discovered in the mouth of the Pangauran River, and the vessel was shifted to this anchorage. This harbor was made the headquarters for the ship during the entire season. A tide gauge was established in the Pangauran anchorage and used for all the work on the north coast of Busuanga Island.

The weather during the first half of the fiscal year was unfavorable for work on this coast. The season's work was opened during the height of the typhoon season, and a number of typhoons passed while the work was in progress, the severest of which blew from September 23 to 26.

The north coast of Busuanga is open to the China Sea and the effect of every blow was marked by a heavy swell. At the end of the typhoon season the northeast monsoon set in and blew with more or less regularity during the rest of the year. Landing was very difficult, and some of the hydrographic signals had to be made by throwing buckets of whitewash against the cliffs from pulling boats.

Owing to the heavy weather and a lack of outside anchorages, the vessel had to make the Pangauran anchorage every night, and during the latter part of this period a run of about 20 miles to and from the working grounds had to be made.

A camp and launch headquarters were established at the Barrio of Calauit during the latter part of this period, and by using the estuary to cross over to the west coast of Busuanga Island, this proved to be on a very convenient point. Camping parties for topography and hydrography were always left either here or at the Panguaran anchorage when the vessel went for coal.

By the end of December the triangulation, topography, and hydrography on the north coast of Busuanga Island were nearly completed, and it was planned to shift the headquarters of the party around to the west coast.

At the beginning of January the *Fathomer* was engaged upon general surveys on the north coast of Busuanga Island with headquarters at the mouth of Pangauran River in Port Caltom. Throughout the season Manila was used as the coaling station, and this vessel had to make a run of approximately 400 miles for coal every three weeks. Lines of deep-sea soundings were usually carried about halfway to and from Manila while running for coal, and camping parties were nearly always left on the working grounds.

The northeast monsoon, with increasing strength, made work very difficult on the north coast of Busuanga, and after the semiannual repairs were completed on March 19, it was considered advisable to shift headquarters from the north to the west coast of Busuanga Island. A new anchorage was selected and tide gauge established at Malbinchilso Island which is the farthest anchorage to the westward and nearest the working grounds. This anchorage was used to carry the work about halfway up the west coast of Busuanga Island. Another small but well protected anchorage, which is not shown on the old chart, was discovered and surveyed during the early part of the season on the northwest end of Busuanga Island, locally called Illultuk Bay by the natives. The *Fathomer* shifted headquarters to this bay on May 12, and established a camp and tide gauge. This anchorage is the nearest point to the remainder of the work and was used till the end of the period of this report.

The topography of Busuanga and outlying islands was entirely completed by this vessel, and this completes the topography of the entire Calamianes Group. The hydrography is also nearing a state of completion. The 5,011.7 miles of soundings were done in approximately four months. It will be noted that the development is comparatively close from the number of soundings, 54,817, taken in an area of 710 square miles (this does not include deep water soundings 5 miles apart). Approximately 30 off-lying shoals were discovered and developed. One of these shoals is 13 miles long and covers an area of 12 square miles. Another is 4 miles long and covers an area of 7 square miles. A third covers an area of 4 square miles.

[A. M. SOBIERALSKI, Commanding Steamer *Marinduque*.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 16 miles, 157 square miles of area covered, 5 lines of intervisibility determined as per sketch submitted, 3 points selected for scheme. Triangulation: 878.6 square miles of area covered, 53 signal poles erected, 23 stations in main scheme occupied for horizontal measures, 7 stations in supplemental schemes occupied for horizontal measures, 13 stations occupied for vertical measures, 63 geographic positions determined, 35 elevations determined trigonometrically. Magnetic work: 2 land stations occupied for magnetic declination. Topography: 82.8 square miles of area surveyed, 43.5 miles of general coast line surveyed, 15.8 miles of shore line of rivers surveyed, 5 miles of roads surveyed, 2 topographic sheets finished, scale 1:20,000. Hydrography: 726.6 square miles of area covered, 4,171.5 miles run while sounding, 15,100 positions determined (double angles), 72,989 soundings made, 4 tide stations established, 6 current stations occupied, 7 hydrographic sheets finished, scales 1:80,000, 1:40,000, and 1:20,000.

Up to July 1, 1916, the party on the steamer *Marinduque* had been chiefly engaged on the main scheme triangulation of Palawan Island, but although most of the signals had been built, very little observing had been done.

The ship arrived at Buena Vista, 250 miles from a coaling station, with only 37 tons of coal and about two weeks' work to do. However, the conditions proving favorable, the work on the west coast was completed as planned, and the ship returned to Puerto Princesa with a ton of coal to spare.

The remaining stations in the main scheme, with the exception of Mount Peel, were reached from the east coast. Mount Peel was occupied by a party which crossed the Baheli portage. Thumb Peak was afterwards occupied.

On August 5 the ship arrived at Manila for transfer of officers. Two parties had been left in the field engaged on triangulation, one at Cleopatra and one at Mount Peel.

Up to this time all the efforts of the party had been devoted to the triangulation so that very little hydrography had been completed. It was now necessary to prosecute the offshore hydrography in order to complete the development of Pasig Shoal before the good weather should end. One party, however, was continuously engaged on the triangulation, and not until October 21 were the observations finally completed.

As a result of the season's work, a strong main scheme was extended to the line Thumb Peak–Table Head, more than halfway down the island. A well-determined line for the extension of local schemes was established in Puerto Princesa and Honda Bay, while in Ulugan Bay two intersection stations were located. Supplementary stations were located between Bold Point and Fondeado Island, so as to give the topographer some check along this coast where a local scheme is not feasible. The local scheme from Dumaran Island to Bold Point was connected to the main scheme on the line Escarpado–Stripe Peak. Numerous intersection stations were located, practically every island on the west coast within the limits of the work and every peak of any prominence being located by three or more cuts. The reconnoissance was made for an additional figure. As the triangulation became sufficiently advanced the hydrography was taken up. The ship work in Green Island Bay was extended offshore with the object of defining the limits of launch work on Pasig Shoal.

By the end of October the hydrography had been extended out to the 100-fathom curve and Pasig Shoal developed. The triangulation then being completed, three hydrographic parties and a topographic party were kept in operation until December 15, when the season closed and the ship returned to Manila.

With the exception of a few small areas, the hydrography of Green Island Bay out to the 100-fathom curve was then completed.

In Honda Bay numerous reconnoissance lines were run.

On the way to Manila the inshore hydrography and topography of Cambari Island and a small patch of topography in Dumaran Channel were completed.

A number of uncharted reefs and shoals were discovered and reported.

One topographic sheet was completed from Bold Point to Emmit Point. This was straight traverse work with one triangulation station for a check at about the middle of the sheet.

Current observations were taken on the outside reefs.

Two stations were occupied for magnetic declination.

An automatic tide gauge was kept in operation continuously at Puerto Princesa, and a tide staff at Tinitian while hydrography was in progress.

At the beginning of the calendar year the ship was at Manila, repairing and outfitting. An Eckliff automatic boiler circulator was installed. Its action is very satisfactory.

On February 10 the ship left Manila, arriving on the working grounds on the east coast of Palawan two days later. The northeast monsoon was still blowing so strong that work could be prosecuted only in sheltered places. A party was therefore left at Green Island to complete the inshore hydrography, while two parties were left in Honda Bay to extend the tertiary triangulation and the topography in that vicinity.

Owing to the exhaustion of the coal supply at Puerto Princesa, the ship had to run to Coron for coal, a distance of 190 miles.

When the inshore hydrography in Green Island Bay was completed, two hydrographic parties and a topographic party began work in Honda Bay while the ship worked in Green Island Bay. Early in April this work was completed, and the ship returned to Manila for cleaning boilers and for supplies, leaving one party in Honda Bay.

On account of the extremely high price of coal it became necessary to exercise the utmost economy in coal consumption. Most of the time of the party for the rest of the season was therefore devoted to extending the main scheme triangulation.

The results of the season's work are as follows:

The hydrography of Green Island Bay out to the 100-fathom curve is finally completed.

In Honda Bay the inshore hydrography from Pasco Point to Addison Point is completed, including all the area between the islands and the mainland and extending from 2 to 5 miles to the southward of the island.

Some reconnoissance lines of soundings were run as far as Separation Point in connection with the triangulation. No dangerous reefs were discovered.

Some reconnoissance work was done in Puerto Princesa to investigate a report of errors in the existing chart.

Several dangerous uncharted reefs in Honda Bay were located.

The hydrography of Green Island and Honda Bays reveals a very peculiar formation. Jutting out from the shore are long projections with moderate depths (about 30 fathoms) terminating in reefs like the inclosing reefs of an atoll, with stupendous slopes on the outside, often dropping from 3 to 700 fathoms within a mile. This same formation seems to extend down the Palawan coast. From a study of this formation the conclusion was drawn that the most dangerous reefs occur close to the 100-fathom curve, excepting, of course, those that occur close to shore. In navigating the unsurveyed waters to the southward of Puerto Princesa, this theory has been found useful, for one can almost predict where shoal water will be found. Similarly, in executing the hydrography, the work can be better planned when knowing where to expect shoal water. Another conclusion is that it is better to travel inside of the 100-fathom curve than outside, for the reefs are very steep-to on the outside and give no warning, and besides, the currents are stronger on the outside and are very irregular, being influenced by these various projections.

The completion of the survey of Green Island Bay shows a channel which, with a few aids, could be used by vessels bound to Manila, affording good shelter from the northeast monsoon from Green Island to Coron. Most of the traffic to Palawan consists of small steamers and sailing vessels towed by launches. During the strength of the monsoon these vessels often have to seek shelter. Several ship captains were consulted about the possibilities of this route—i. e., north of Johnson Island, north of Green Island, through Dumaran Channel, then in the lee of the islands off the east coast of Palawan—and they all said they would use it if a few lights were installed to make it navigable at night. The *Marinduque* found occasion to use this route on one of the trips to Coron, the weather being so bad that no progress could be made outside.

In connection with the ship hydrography a trolley system with hand lead was used for all depths up to 30 fathoms. A drum was attached to the Lucas sounding machine by means of an additional shaft, driven by a handmade geared pulley. This does away with the arduous labor of hauling in the lead line by hand, reduces the time required to haul it in, and makes it possible to use heavier leads. By using two lead lines, sounding with one while the other is being hove in, soundings up to 30 fathoms can be obtained in one-minute intervals with the ship making 5 knots. Three men can handle the operation. Soundings with the Tanner-Blish tubes can be obtained faster, or just as fast with a greater speed, and require the same number of men, but the increased accuracy and reliability of the soundings certainly offsets this slight advantage. All the appliances—the trolley, drum, geared drive, etc.—were made aboard by hand out of materials on hand.

One station was occupied in Green Island Bay for current observations, and another off Arena Island, the latter being occupied for 6½ days. Nothing of interest was developed, the currents being weak and irregular.

The automatic tide gauge at Puerto Princesa was continued in operation, and tide staffs were maintained at Tinitian and Babuyan while hydrography was in progress. There were evidences at Arena Island that the seiches, which are so marked at Puerto Princesa, occur in this vicinity as well, for a reef was noticed to bare and cover and bare again within a few hours. No observations, however, were taken.

One topographic sheet, Honda Bay from Pasco Point to Addison Point including the offshore islands, was completed. The Babuyan, Tandayak, and Tapul Rivers were traversed to the first rapids, and the Tapul-Baheli portage was traversed to the limits of the sheet.

The reconnoissance and signal building for the main scheme triangulation were extended from the line Thumb Peak–Table Head to the lines Albion Head–Aboaba–Tagalinog Island.

Three of the stations were occupied including the most difficult of all, Victoria, 5,680 feet high. It took eight days to reach this peak. Afterwards Cleopatra (5,200 feet), Stripe Peak (4,800 feet), and Mount Peel (3,600 feet) were occupied. Of the other stations in the scheme, only Anepahan and Central are difficult to reach. Albion Head was reached by the portage from Separation Point.

Tagbanua guides and cargadores obtained at various points along the coast were used on all the trips to the mountains, a party consisting of from 6 to 11 men, depending on the length of the trip.

At Aborlan, the Government maintains a reservation where these natives may attend school and get practical teaching in agriculture, etc. The natives here speak English better and more generally than anywhere along this coast, not excluding Puerto Princesa.

A 42-foot observing scaffold was built at Arena Island. Supplementary stations were built at Inagauan, Malanao Island, Emelina Island, and Crawford Cove.

The reconnoissance was made very difficult by the fact that Victoria Peak is surrounded by flat ranges from 3,000 to 5,000 feet high. All the lines radiating from Victoria pass very close to obstructing peaks, so that a slight variation in the location of any of the stations would make the scheme fail. To add to the difficulties, Victoria shows out of the clouds only at rare intervals, usually very early in the morning.

Besides the main scheme triangulation, the local scheme in Honda Bay was extended to furnish control for the topography, and the signals were built and some observing done on the local scheme in Puerto Princesa.

The northeast monsoon continued very strong until March 20, but after that date it was not as strong as last year, when it continued till April 15. After that date the weather was generally good. Early in May there were 10 days of very unusual haze, which caused fear among the natives. It was impossible to learn the cause of it.

Up to April, Port Uson was used as a coaling station. After May 1, coal was obtained at Manila.

[R. R. LUKENS, Commanding Steamer *Romblon*.]

Triangulation: 360 square miles of area covered, 41 signal poles erected, 1 observing scaffold and tripod built, height 110 feet, 25 stations occupied for horizontal measures, 6 stations occupied for vertical measures, 41 geographic positions determined, 6 bench marks established. Topography: 100 square miles of area surveyed, 101.9 miles of coast line surveyed, 3 topographic sheets finished, scale 1:20,000. Hydrography: 1,251 square miles, 6,963.5 miles run while sounding, 84,356 soundings made, 5 tidal stations established, 2 current stations occupied, 14 hydrographic sheets finished, scales 1:100,000, 1:40,000, 1:20,000, and 1:10,000.

On July 1, 1916, the steamer *Romblon* was at Manila obtaining supplies and outfitting. On July 12 the steamer sailed for the Cuyo Islands arriving off Quinaluban Island the following evening. On the morning of July 14 a launch hydrographic party was put in camp with instructions to complete the inshore hydrography of that group.

The ship then proceeded to the southward and took up work on a sheet covering a large gap in the existing work in the vicinity of Matarabis and Tabubuc Islands. This work was continued under favorable weather conditions until the evening of July 28, when the vessel proceeded to Iloilo for coal, arriving there the following morning.

On August 1 the *Romblon* sailed from Iloilo for Manila via the Cuyo Islands where the camp party was picked up, and arrived at Manila on August 3.

The vessel was undergoing extensive repairs at Manila until September 19 when she again sailed for the Cuyo Islands, arriving on the following evening. A launch hydrographic party was put in camp at Manamoc Island and remained there until October 1. The ship again took up the work where it had been discontinued, but was delayed three days by a typhoon passing to the north.

While coaling ship at Iloilo on October 30 instructions were received calling for some additional hydrographic work off the town of San Jose de Buena Vista, west coast of Panay. The *Romblon* arrived off San Jose at noon on October 31, and work was started at once. The survey was finished the next day, and the *Romblon* left for the Cuyo Islands at 12.30 a. m., November 2.

The hydrographic work included many small gaps to be filled, many split lines and a considerable area of new work. Work on the shoal development, inshore hydrography and filling small gaps was taken up first, in order to take advantage of good weather. The launch was used for the inshore hydrography of all islands and also for the development of small offshore shoals and banks.

Search was made for a rock reported by the British ship *Belted Bill* about 7 miles southeast of Agutaya Island. About 1 square mile was dragged with an 1,800-foot drag set to 36 feet in the reported position of the rock, but nothing was found in the area examined.

A shoal with a least depth of 17 feet was discovered about 5 miles southwest of Lubic Island. This shoal is reported to be near the track taken by some large ships, which come through the Sulu Sea in order to avoid the heavy northeast monsoon in the China Sea, while en route to the China coast.

No systematic current observations were made during the work, but experience in running sounding lines showed that there existed a southwesterly set during the northeast monsoon and a northeasterly set during the southwest monsoon. This set is variable in direction and force, being deflected and at times reversed by the tidal currents. Narrow belts of currents have also been noted, so that the question of currents seems to be a very complicated one for this area.

The only triangulation done was the location of a station on Tabac Rock. The line Patunga-Lean was used as a base and all three angles were observed.

No general topography was done. In a few cases the planetable was used to locate hydrographic signals where the previous points could not be recovered.

During the survey of the Quinaluban and Manamoc groups a tide staff at Quinaluban Island was read. This staff was referred to the datum determined in previous years. The differences in time and range over the area surveyed seem to be very small.

The whole season was unusually free from storms.

On December 19 the work was finished and the vessel proceeded to Manila via Coron, arriving on December 22.

On January 1, 1917, the steamer *Romblon* was in Manila undergoing minor repairs at the insular repair yard on Engineer Island. The party was engaged on annual inventories and in getting supplies for the coming season's work around the southern end of Palawan Island. Formal instructions for this work were received on January 11, but before sailing it was necessary to await the arrival of the steamer *Pathfinder* in order to arrange limits of sheets and other details in regard to taking up the work to the northward of the *Pathfinder's* assignment. By Saturday, January 13, all necessary data had been received, and on Monday morning the *Romblon* sailed for the working grounds via Puerto Princesa.

The vessel arrived at Puerto Princesa on the afternoon of the 17th and the next day was spent in coaling and watering the ship. At noon on the 19th the *Romblon* sailed for southern Palawan, choosing a route well out on the Sulu Sea. Numerous reefs have been reported in that area so the sounding machine was kept going most of the time, letting out 90 fathoms of wire each time. In no case was bottom reached until well in toward Bugsuk Island. The boat sheets of the *Pathfinder* were successfully used in navigating the ship through the intricate channels between the islands, and on the afternoon of the 20th the *Romblon* anchored off Bancalan Island. The crew on going ashore the following day to visit an American lumber camp found three American soldiers who had come ashore in a banca, having been blown away from Corregidor Island two weeks before. These soldiers had landed on Cabra Island, and in a calm started back for Corregidor only to have the wind come up and sweep them out to sea again. Their next landing was apparently on Busuanga Island. There they got some water but were unable to approach the natives, who took to their heels at the first sight of them. These unfortunates then coasted down Palawan Island missing Busuanga Strait, and because of high seas were unable to land until Bancalan Island was reached; and there they managed to get their craft behind the reef, and landed very close to the lumber camp. In a few days they were able to return to Manila in a steamer which tows schooners loaded with logs.

On Monday morning, January 22, the *Romblon* took up anchorage off Dalagican Island, and the work of signal building, triangulation, topography, and hydrography was taken up in the order given. The launch worked on the inshore while the ship took up the offshore work. The bottom here is uneven and invisible so that very close work was required to avoid missing any shoals. The weather was favorable and rapid progress was made until February 13, when it was necessary to go to Puerto Princesa for coal. Owing to the unhealthfulness of the country and the absolute lack of camping sites near the work, none of the parties was left behind when the ship left for coal. The vessel arrived at Puerto Princesa at 8:45 p. m., February 14, and took up anchorage off the wharf.

Coaling operations were begun the following day, but the ship was not filled up until the afternoon of February 17.

At noon on the 19th the *Romblon* sailed for the working grounds, and arrived there the following evening.

Topography, triangulation, and hydrography were continued up the east coast of Palawan, the ship maintaining anchorages near the center of the work. The work was much hampered by the persistent northeast monsoon which was blowing at the time. As the vessel is equipped with only one launch, a good deal of running had to be done with the ship itself in order to keep signals ahead of the hydrographic party, and subsequent surveys show that the vessel passed very close to several dangers that were not visible.

The work of repairing and overhauling by the crew was continued while in Manila, and on April 14 the *Romblon* sailed for Palawan, arriving there on April 17.

By that time the weather had become fine and work on reconoissance for the main scheme triangulation was at once taken up. A launch-hydrographic party was put in camp on Arrecife Island and continued the hydrography of Coral Bay, while the ship took up hydrography and moved parties around for signal building and reconoissance.

On April 30, the *Romblon* started for Sandakan, British North Borneo for coal, and arrived there the next afternoon. Arrangements were made with the Cowie Harbour Coal Co. (Ltd.), and the vessel was coaled with considerable dispatch.

Upon the return to the working grounds work was continued as before, with special effort put on the triangulation. The hazy weather which had obscured the peaks for some time now disappeared and the reconoissance for three figures extending to Brooks Point was soon completed. This included stations on Bulanjao Range, and on Mount Mantalagajan, 3,500 and 6,800 feet, respectively. The first ascent was made on Bulanjao, and much difficulty was encountered both in finding the proper route and in getting cargadores. The coast line is peopled by Moros who are in general a lazy and shiftless lot, and it is only at the command of their headmen that they will go with a party and then they are slow and arbitrary about the work.

Datto Batarasa, at Bonabona, procured cargadores for the first attempt which was routed by way of the Iwahig River, a route recommended by the datto himself, but after traveling for four days, the Moros refused to go farther; and the party was forced to return to Bonabona, where it was picked up by the ship.

It was then decided to make up a party including one officer and five men from the ship and try a route up the Sumbiling River. This trip was successful, four tagbanuas were induced to accompany the party, and with this help they reached the top in three and one-half days. The slopes of this mountain are covered by thick undergrowth and every step of the trail had to be cut through with bolos.

Fortunately, the weather cleared for sufficient time and the required observations were made. Altogether, the party was in the hills 14 days. It must be remembered that this country is very wild and there are no trails or communication whatever, and even the wild natives are only familiar with the immediate vicinity in which they live.

The triangulation scheme included one high signal at Tami Point. About nine days were consumed in clearing and building the scaffold. The signal is about 110 feet high, and a tree is used as instrument support.

The establishing of a station on Mount Mantalagajan and the occupation of the same was assigned to a subparty. This party consisted of the best 2 sailors on the ship and 11 wild tagbanuas, one of whom, their "Capitan" or head man, had charge of them. It took the party nine days to reach the top. Part of the time they were short of water and consequently unable to cook rice. In fact, they had to depend almost entirely on rain water and pitcher plants for their water supply after they reached the 3,000-foot elevation. At the top, where they remained three days, the party suffered much from the intense cold. Three days more were consumed on the return trip, making a total of 15 days for the expedition, which was a success in every way.

At the close of the fiscal year, signals had been built for three figures of the secondary triangulation, and six stations had been occupied, including the base stations.

The launch was kept at inshore hydrography continuously, working from camps on Arrecife Island, Bowen Island, and Bonabona.

The ship took up offshore work when possible. A great deal of time was required for shifting parties for the triangulation and reconnoissance, so that the mileage made by the vessel is small as compared with the previous season.

The area covered is very full of reefs and shoals, making the work both tedious and difficult. With a good light overhead, these shoals can always be seen, but when running toward the sun it is a very different proposition, and the vessel is in constant danger of striking.

Topography was completed from Capyas Island on the west coast to Iglesia Point on the east coast. Most of the shore line is covered with mangroves, and the work was difficult. The parties worked in waist-deep water nearly all of the time, and at times it was necessary to hold the table down by force. All the streams of any size were traversed by launch or pulling boat using estimated speed and compass courses. All topography was closely controlled by triangulation.

Sandakan, British North Borneo, was the headquarters for the party during the last half of the season. It is about 180 miles distant from the working grounds. All kinds of provisions are procurable there, and coal can be purchased at present for 30 shillings per ton. It takes about three and one-half hours to coal the *Romblon.* Water is furnished free by the Government and runs at the rate of about 8 tons per hour, while ice can be purchased at $25 per ton Borneo currency, with a rate of exchange ($1=1.175 pesos). Ships laundry can be done in one and one-half days, at the rate of 5 cents per piece. There are two wharves there, one belonging to the coal company, and the other to the Government, which is the North Borneo Co. This company has a concession from each of the various sultans, and operates the Government as a British protectorate. No one can have absolute title to land, but it can be leased for 999 years. The resources of the country are slowly being developed. The interior of the country is very wild and abounds in big game, including elephants. The elephants scratch their backs on the telegraph poles, which causes the company a great deal of trouble. This country is also the home of the "Orang Utang," the English translation of which is the "Wild man of Borneo," which recalls our youthful circus days.

In ordinary times a steamer from Manila makes monthly trips to the Palawan coast, going as far as Brooks Point, but that steamer has been withdrawn and there is now only a hit-and-miss communication with Manila, and most of this irregular service is furnished by the two Coast Survey vessels which operate along the Palawan coast. All mail for this party was received from Puerto Princesa in native boats and launches.

[O. W. SWAINSON, Commanding Steamer *Research.*]

SUMMARY OF RESULTS.—Triangulation: 3.5 square miles of area covered, 3 signal poles erected, 1 station in supplemental scheme occupied for horizontal measures, 3 stations occupied for vertical measures, 3 geographic positions determined. Topography: 2 topographic sheets finished, scale, 1:20,000. (These topographic sheets were for the purpose of locating hydrographic signals and not shore line.) Hydrography: 196 square miles of area covered, 1,244 miles run while sounding, 4,423 positions determined (double angles), 20,379 soundings made, 1 tide station established, 2 current stations occupied, 2 hydrographic sheets finished, scales, 1:20,000 and 1:40,000.

From July 1 to August 9 the steamer *Research* was undergoing annual repairs at Manila.

On August 15 the vessel sailed for Iloilo, arriving on the 17th. The following day was spent in repairing signals, which had been erected in May, and building and locating others. The hydrography of Iloilo Strait was then begun with launch and ship and continued every day when the weather permitted.

Signals were placed from 100 to 300 meters apart along both the Panay and Guimaras coasts. They were located by planetable traverse and triangulation. The traverse and triangulation were controlled by recovered triangulation stations on Guimaras Island and church spires on Panay Island.

From Iloilo to the southern end of Oton Bank the sounding lines were spaced 100 meters apart and the soundings on these lines were spaced from 20 to 100 meters apart. The hand lead was used up to

8 fathoms in depth; at greater depths soundings were taken with a hand sounding machine.

The positions of all aids to navigation were determined by sextant angles.

Current observations in the south channel were made during 59 hours beginning at 8 a. m., August 28, and ending at 6 p. m., August 30. The maximum velocity of current observed in the south channel was 2.2 knots.

Current observations in the north channel were begun on October 9 at 6 p. m. and continued until 6 a. m., October 12. A maximum of 2 knots was observed there.

The current is about 1 knot stronger off Bondulan Point, and from there past the mouth of the Iloilo River. No observations were made in this part of the straits.

A tide staff was fastened to the inside face of the quartermaster's dock and connected by leveling with permanent bench marks at the beginning and close of the hydrography. Readings were made on this staff every 20 minutes while hydrographic work was being done and every 20 minutes night and day while current observations were being made.

No attempt was made to determine the shore line further than to sketch it in where the old work was considerably in error.

A search was made for a shoal reported in latitude 12° 33′ and longitude 122° 23′, and an area of 2 miles square surrounding this position was carefully sounded over. Uniform depths of 200 to 390 fathoms were found with no indication of a shoal. A new light on Nogas Island, south end of Panay, was located and its arc of visibility determined.

A new triangulation station was established on the northeastern side of Nogas Island in the vicinity of the unrecovered station Ani.

The work in Iloilo Strait was completed on October 12.

[EOLINE R. HAND, Commanding Steamer *Research*.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 14 miles, 177 square miles of area covered, 11 lines of intervisibility determined as per sketch submitted, 6 points selected for scheme. Triangulation: 440 square miles of area covered, 3 signal poles erected, 5 scaffolds and signals built, heights 40 to 55 feet, 6 stations occupied for horizontal measures, 12 stations occupied for vertical measures, 18 geographic positions determined, 18 bench marks established. Topography: 47.5 square miles of area surveyed, 85.3 miles of general coast line surveyed, 81 miles of shore line of creeks surveyed, 4 miles of roads surveyed, 4 topographic sheets finished, scale 1:20,000. Hydrography: 697 square miles of area covered, 5,855 miles run while sounding, 27,387 positions determined (double angles), 99,758 soundings made, 6 hydrographic sheets finished, scale 1:20,000 and 1:40,000.

On October 18, when the charge of the vessel was transferred, the steamer *Research* was at Manila taking on supplies and undergoing slight repairs.

On October 23 the vessel left the harbor with instructions to make a general survey of Manila Bay.

It being deemed advisable to begin operations at the entrance and proceed north along the west, or Batan coast, the survey was begun in the waters surrounding Corregidor and Caballo Islands, effecting a junction with hydrography previously executed by the Coast and Geodetic Survey and thus extending the sounding out of both the North Channel and the South Channel into Manila Bay.

When the unsurveyed portions about the entrance to the bay were completed the hydrography was continued northeastward from the channel islands to a line drawn northwest from San Nicolas Shoals beacon and then north to Pampanga Bay, covering all of the area west of longitude 120° 41′. The topography was begun at a point near station Limay, at the end of a sheet begun the year before, and carried north to Pampanga Bay. There are accurate maps of this shore, so no interior detail was drawn beyond that necessary to properly connect with them. The triangulation consisted of reconnoissance only. A scheme was selected, resting on the base Orion-Malabon, to control the north end of the bay, and the necessary signals were erected.

Existing triangulation furnished sufficient control for the topography and hydrography.

A graphic location with the planetable was made of a large signal (Api) erected on the shore, which will be one of the occupied stations of the triangulation.

A comparison of the soundings made with those on the published charts indicates that the bottom in the entrance has become more uniform. Farther north the soundings are in general 2 fathoms greater than on the charts, except near Pampanga Bay, where there is but a slight difference. Shoal water does not extend as far off the west shore as the old soundings represent.

The charted shore line of the Pasag River was found to be considerably out of position to the northwest.

On January 1, 1917, the steamer *Research* was engaged in a general survey of Manila Bay. The operations in the bay were continuous after that time. New triangulation was thrown over the hitherto uncontrolled north half and extended up to the navigable Pasag and Orani Rivers, the shore line was run around it, and the included waters closely sounded, so that the end of the fiscal year views the practical completion of the work called for by instructions. There remained, on June 30, 55 square miles of undeveloped area in the center of the bay, and a week's work each of topography and hydrography up the above-mentioned streams.

Starting from the base Orion-Malabon C. D. (an east and west line that spans the bay) a quadrilateral was determined whose opposite side rested upon the north shore, and from the stations of this figure such intersection points were selected as would best check the topographic sheets, and in addition serve effectually as signals for ship soundings.

From the line Orion-Api two figures were extended north to control Pampanga Bay and also the Pasag and Orani Rivers which empty into it. Because these streams are used by steamers as far as Guagua, it was intended to carry the topography and hydrography up each river to that town.

The country triangulated being low and swampy, scaffolds from 40 to 55 feet were a necessity, and difficulty was experienced in finding ground in the required positions sufficiently solid for their erection; then, to insure stability, scantlings had to be driven to serve as piling. A type of mark was adopted to suit the marshy nature of this ground.

The topography was continued from a point on the west side of Pampanga Bay and executed in detail eastward around the shore to Malabon C. D., where it joined old work. From here soutnward to Paranaque, and southwest from Sangley Point, the shore line only was run for the purpose of locating hydrographic signals.

This north shore is chiefly a succession of river mouths, with nipa swamps and fishponds between. These rivers are all joined into a most intricate system, so that one may pass by boat in almost any direction; indeed, it is possible, though not practicable, to proceed by launch from Manila to Orani across on the west shore without going into the bay at all. The delineation of the shore, drawn sufficiently wide to provide an ample topographic fringe when reduced to chart scale, usually includes the first of these negotiable passages between mouths. The watercourses among the swamps and fishponds were surveyed, not sketched, and this offers a firm foundation for the building on of interior work from other sources. The fishponds are areas of cleared swamp dyked off from the streams and connected with them at intervals by elaborate concrete gates. Where the ponds come down to the bay shore, the dykes are protected against erosion by strips of mangrove carefully cultivated and guarded.

The topography was finished and the sheets turned in, excepting a short piece of mapping up the Orani and Pasag Rivers, purposely left to the last.

The ship hydrography was continued over the remaining unsounded portion of the bay (east of 120° 41′ and south to San Nicholas Shoals) with 200-meter lines, which are being opened up to 250 meters in the center. No change was found in the remarkably even bottom previously reported, and it was invariably mud, except in the proximity of the shoals. The north part is very shallow, which forced the ship to anchor 2 and 3 miles offshore to the great inconvenience of the parties sent out. The launch carried the sounding in from the ship limits to low water, keeping a consistent relation between the width of line and the importance of the locality. Pampanga Bay (more appropriately Pampanga Flats) was developed, and the channels through it of the Pasig and Orani Rivers. In connection with the development off the north shore, those streams that led to the marsh villages, or appeared to offer a feasible power-boat route to the big towns inside, were sounded to the limit of the topography, stopping preferably at a fork. None of them is used regularly by launches, for the Manila Railway serves effectually all that north bay country above the swamps.

The river at Malabon was sounded to the shipyards of the Yangco Steamship Co., close work was done off the Pasig River mouth and the Manila breakwater, the channel buoys were located, and the survey was extended behind the breakwater up to the limit of dredging operations.

SPECIAL DUTY.

MASSACHUSETTS.

RELOCATION OF TRIAL COURSE FOR SUBMARINES AT PROVINCETOWN, MASS.

[H. P. RITTER.]

In accordance with a request from the Navy Department arrangements were made at the end of July, 1916, for the inspection at Quincy, Mass., of four beacons constructed for end ranges of the submarine torpedo-boat trial course of Provincetown, Mass., and afterwards for the relocation of the ranges and the supervision and inspection of the work of location and construction of the foundations for the beacons.

The officer assigned to this duty arrived in Boston on the afternoon of July 27, and on the 28th proceeded to the works of the Fore River Shipbuilding Corporation at Quincy and inspected the 4 beacons and the 12 forms for the concrete piers, which were found to have been satisfactorily completed.

On the morning of the 29th the observer returned to Boston and on the following morning proceeded to Provincetown.

It being the desire of the Navy Department to have the ranges more to the westward (about one-eighth of a mile) so that the eastern range beacons would be clear of the sand dune and the Long Point Lighthouse buildings, a preliminary inspection and survey were made to ascertain just how much the ranges could be shifted and preserve the best range location for each end of the mile.

It was found that by shifting the ranges 600 feet to the westward, the eastern range would be clear of the above-mentioned obstructions, and the range defining the western end of the measured mile would be clear of the buildings of the Wood End Coast Guard station.

Afterwards, the old ranges Nos. 1 and 5 were checked by means of the triangulation stations and other points used in the verification of 1909 and 1915 and the new ranges laid out parallel to and 600 feet to the westward of the old ranges.

A profile of the surface of the ground of each range was then made and the location of each one of the four range beacons determined.

Stakes were set for the center of each range beacon and its three concrete piers.

The work of placing the concrete piers and the erection of the beacons by the contractors was supervised during construction by the officer assigned to this duty and verified after completion.

New quarter, half, and three-quarter mile ranges were also determined.

Front and rear targets were placed on the half-mile range, and range stakes on the quarter and three-quarter mile ranges.

EXHIBIT OF THE COAST AND GEODETIC SURVEY AT THE MEETING OF THE NATIONAL ACADEMY OF SCIENCES.

[R. F. LUCE.]

On the afternoon and evening of November 13 an exhibit illustrative of the work and methods of the United States Coast and

Geodetic Survey was made at the meeting of the National Academy of Sciences in the buildings of the Massachusetts Institute of Technology at Boston.

The exhibit was most successful in calling attention to the activities of the Survey.

The scientific members of the society and visitors manifested much interest in the material shown and made a number of useful suggestions for improving the charts and nautical publications.

EXPERIMENTAL WORK TO TEST THE ACCURACY OF THE WIRE DRAG.

[N. H. HECK.]

During the season of 1916 some interesting experimental work was done by N. H. Heck to test the accuracy of the wire drag.

These experiments were necessarily made on land as the actual operation of the drag beneath the surface of the water can not be observed by any means available.

The primary object of these experiments was to discover under what conditions it is possible for the drag wire to slide over the top of a smooth bowlder at a depth less than the effective depth of the drag without being noticed.

The liability of the drag to slide over an obstruction is of course dependent largely upon the slope of the obstruction and whether its surface is rough or smooth and also upon the depth to which the drag is set as compared to that of the obstruction.

The actual conditions of wire-drag work were of course not obtained in these experiments, but it was assumed that, no matter how the wire is brought in contact with the rock, it will act in a similar manner.

It is found that there is little danger of the drag failing to hold when the rock has projections and that the wire will hold at a slope of about 25° or more. At a less slope the action of the wire is uncertain.

Marine growth has a tendency to hold the wire.

With a heavy swell the tendency of the drag to a slide over an obstruction is increased.

NEW YORK.

EXHIBIT OF COAST AND GEODETIC SURVEY AT NATIONAL MOTOR BOAT SHOW AND AT PAN AMERICAN AERONAUTIC EXPOSITION.

[L. A. POTTER.]

An exhibit illustrating the activities of the Coast and Geodetic Survey was made at the Thirteenth Annual Motor Boat Show held at the Grand Central Palace, New York City, from January 27 to February 3, inclusive.

The space assigned to the Coast and Geodetic Survey was on the second floor of the building near the Lexington Avenue side and in a very desirable location.

Charts, photographs, and sketches were displayed at the back of the space and on the front of the counters, and miscellaneous publications on the counters. Two movable tables were provided, one for the display of the instruments and one for the spare charts not on the walls.

The exhibit was made up as follows:

Charts.—About 100 charts, including all of the sailing and general charts of the Atlantic coast; the 1:80,000 scale charts from Maine to South Carolina; the harbor charts from the eastern end of Long Island Sound to Delaware Bay entrance; and the general charts covering the Pacific coast, Porto Rico, Hawaii, and the Philippines. About 20 charts were displayed on the space at the back and the remainder on a table for ready reference.

The charts of New York Harbor and vicinity attracted the most attention, but practically every chart on hand was referred to and consulted at some time during the show. The 1:80,000 scale charts, Nos. 1211 to 1215, inclusive, were pasted together to form a complete chart of Long Island Sound, Long Island, and New York Harbor, and attracted the most attention. Next to this was chart No. 369, also pasted together to form a complete chart of New York Harbor. There were many inquiries for the new chart of New York Harbor and that of Jamaica Bay and Shinnecock Bay to Great South Bay from people who had learned from their local papers that such charts had recently been issued, clearly demonstrating the value of this method of advertising. Many people expressed a desire for a chart covering the difficult inland waterways between areas covered by these two charts.

Coast pilots and tide tables.—A complete set of the volumes issued by the Survey was on display. They were freely consulted and brought forth most favorable comment. The inside route pilots, and especially the one from New York to Key West, attracted the most attention.

Special publications.—About 20 of the more recent publications on the wire drag, magnetics, geodesy, topography, the annual reports of the Superintendent and the Secretary of Commerce, etc., were on display. They were of special interest to many people interested in the particular subjects. Each was plainly marked with the information as to how copies could be obtained.

Instruments.—A sextant, three-arm protractor, Courts protractor, parallel rule, and signal lamp were the instruments exhibited. An engraved plate of Woods Hole, Mass., was also on display. There were a large number of requests for an explanation of the operation of the sextant and many inquiries from amateur navigators for an explanation of the use of the parallel rule and the methods of laying off a course. The signal lamp also attracted considerable attention. It was operated by a single, 9-volt, "Hy-Watt" dry battery, made by the Cleveland Battery & Electric Co., 30 Church St., New York, and loaned for the show.

Photographs.—About 40 photographs illustrating different phases of Coast Survey activity were displayed. They attracted much attention from people of all classes. The wire-drag pictures were displayed by themselves in a conspicuous position and attracted a large amount of attention.

Miscellaneous material.—A card showing the flags of the Department of Commerce, chart showing graphically the limits of coast pilots and inside route pilots on the Atlantic coast, diagrams showing the location of wrecks in Alaska and on the Pacific coast and the relative size of Alaska as compared with New England and the United States, and some other miscellaneous material were exhibited.

The Lake Survey Bulletin and the Annual Report of the Chief of Engineers were on hand to answer specific inquiries concerning the inland waterways.

Publications for distribution.—The following publications were on hand for distribution: List of Publications of the Department of Commerce; Elements of Chart Making; The Work of the Coast and Geodetic Survey; The Department of Commerce; Notes Relating to the Use of Charts; Circular No. 236, The Regulation of Motor Boats; Pilot Rules; Laws and Regulations Prescribed by the Steamboat-Inspection Service; Coast and Geodetic Survey Chart Catalogue; printed cards showing the location of the suboffice and the other agencies in New York; a mimeographed list of agencies on the Atlantic coast; and a mimeographed sheet showing in tabular form the distances and maximum drafts that can be carried through the inland waterways from New York to Key West, thence to New Orleans, thence to Chicago, thence to New York by way of the Great Lakes.

The attendance at the show was said to be over 100,000, and a large percentage of this number showed more or less interest in the Coast and Geodetic Survey exhibit. After the first day, the show was open from 10.00 a. m. to 10.30 p. m., and the officer in charge was present at all times, except for two half-hour periods daily, at which times the clerk from the New York suboffice relieved him. The inspector in the New York suboffice rendered every assistance possible, both in the arrangement of the exhibit and in his attendance during some of the busiest periods. The crowds attending the show were so large that the exhibit could not be greatly expanded without requiring the attention of more than one man.

At the end of the motor boat show the exhibit was transferred to another location in the Grand Central Palace and continued throughout the Pan American Aeronautic Exposition, from February 8 to 15, inclusive.

DISTRICT OF COLUMBIA.

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

[R. P. STROUGH.]

In connection with the annual meeting of the Chamber of Commerce of the United States an exhibit was made of a selection of charts showing the progress and needs of the Survey and of some of the instruments used in the actual field work.

Due to the lack of funds and limited time available for the preparation of this exhibit, it was not possible to adequately show many of the most interesting features of the work.

Notwithstanding these drawbacks, many persons manifested an interest in the work accomplished and in the methods used in surveying operations.

VIRGINIA.

[F. B. T. SIEMS.]

In July, 1916, arrangements were made for taking a series of motion pictures and photographs of survey operations.

The photographic party left Washington for Norfolk, Va., on July 24.

Some delay was occasioned by the fact that films for the motion pictures were not received until July 31, but in the meanwhile, photographs were obtained and borrowed film was used in getting motion pictures of the topographic party at Lynnhaven Bay, Va.

In all, 44 motion pictures and 48 photographs were obtained illustrating various phases of the surveying operations.

The work was completed by August 7.

WASHINGTON.

VERIFICATION OF SUBMARINE SPEED TRIAL COURSE, PORT TOWNSEND BAY, WASH.

[JOHN A. DANIELS.]

In the latter part of April, 1917, the work was begun of checking the submarine speed trial course located in Port Townsend Bay, Wash., between Walan Point and Crane Point.

After an examination of the ground it was decided that the most expeditious and satisfactory means of verification would be by means of a traverse. It was also decided to establish permanent marks so that the course would be readily reestablished at any future time without remeasurements in case the range marks were destroyed.

Base measurement methods were used on the traverse. Two measurements were made of each section, and the greatest discrepancy between the two measurements of a section was 3.9 millimeters in a 1,400-meter section. The accepted value for each section was taken as the mean of the two measurements. The correction for grade was obtained by running a check line of spirit levels over the stakes. The angles at the turns in the traverse were measured with a 4-inch Berger instrument.

In order to set permanent marks at the half and quarter points, it was necessary to devise a method of locating these points accurately for this purpose. It was first determined by inspection what number of stake of the traverse fell nearest these desired points, then the horizontal distance to this stake was carefully computed. The remaining distance required to make up the half or quarter mile was then reduced to the traverse and taped off carefully from the chosen stake. The desired point on the traverse having been found, the instrument was placed over it, and a line parallel to the initial line was laid off. Upon this line at a convenient point above high water the mark was set.

The north range marks were recovered as they were originally established. This line was permanently marked as an initial line, and all other lines were referred to it. The range at the half mile and at the mile had been recently rebuilt, but the half-mile front range had been destroyed. In consequence, the ranges at the beginning and end of the mile were the only ones that could be verified.

Permanent marks for restoring the ranges at the beginning and at the end, as well as at the half and quarter mile points, were established. Explicit directions are given upon the drawing, showing the present condition of the course, for reestablishing the course at any time, no matter if all of the range marks are destroyed. The length of the course between the present ranges was found to be exactly a nautical mile.

NEW ELECTRIC LAMPS.

On July 18 the chief of the instrument section visited the Hawthorne Manufacturing Co., at Bridgeport, Conn., to arrange in regard to the manufacture of searchlights for the new electric signal lamps. After some discussion and explanation, satisfactory arrangements were made with this firm for furnishing these lamps.

On July 19 the same officer called on H. W. McCandless Co., in New York, and learned that 100 of the special lamp bulbs made for this Survey had been forwarded the day before. These proved to be equal to the sample on which the contract had been given and were accepted.

MISSISSIPPI RIVER COMMISSION.

[H. P. RITTER.]

In accordance with law and in addition to his other duties an officer of the Survey has continued to serve as a member of the Mississippi River Commission and to perform the duties incident thereto, including attendance at the meetings of the commission and the annual low-water inspection of the river from Rock Island, Ill., to New Orleans, La.

Respectfully,

E. LESTER JONES,
Superintendent.

To Hon. WILLIAM C. REDFIELD,
Secretary of Commerce.

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No. 53.

CONDITION OF FIELD OPERATIONS, UNITED STATES, 1917.


125°
120°
115°
110°
105°
100°
95°
45°
40°
35°
DOMINION OF
WASHINGTON
Olympia
Portland
OREGON
IDAHO
Boise City
MONTANA
Helena
NORTH DAKOTA
Bismarck
SOUTH DAKOTA
Pierre
MINNESOTA
St.Paul
WYOMING
Cheyenne
NEBRASKA
Lincoln
IOW
Des Moines
NEVADA
Carson City
Salt Lake City
UTAH
COLORADO
Denver
KANSAS
Topeka
CALIFORN
Sacramento
MIS

CONDITION OF FIELD OPERATIONS
UNITED STATES
1917
Wire drag surveys completed
Wire drag surveys required
Unchangeable areas, no present work required
Unchangeable areas, additional work required
Changeable areas, recent surveys
Changeable areas, old surveys
Reconnoissance work or unsurveyed
Triangulation completed
Triangulation begun
Precise Leveling completed
Gravity Stations, positions
PACIFIC OCEAN
LOWER CALIFORNIA
ARIZONA
NEW MEXICO
OKLAHOMA
TEXAS
ARK
Prescott
Santa Fe
Guthrie
Austin
GUL
30°
25°
115°
110°
105°
100°
95°

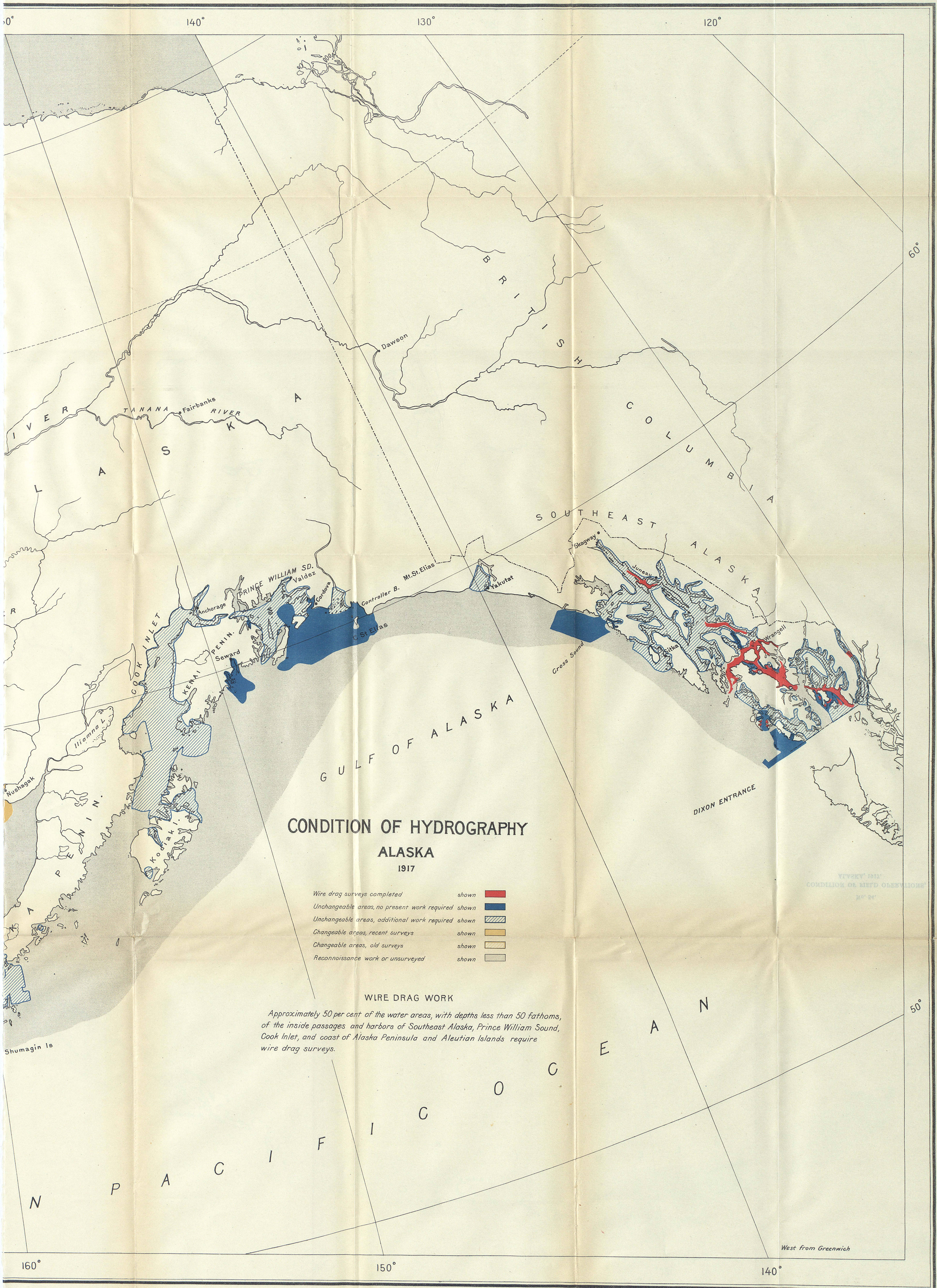

100°
95°
90°
85°
80°
75°
70°
65°
45°
40°
35°
O N O F C A N A D A
TH DAKOTA
marck
TH DAKOTA
Pierre
BRASKA
Lincoln
KANSAS
Topeka
OKLAHOMA
Guthrie
MINNESOTA
St. Paul
IOWA
Des Moines
MISSOURI
Jefferson City
WISCONSIN
Madison
ILLINOIS
Springfield
LAKE SUPERIOR
LAKE MICHIGAN
MICHIGAN
Lansing
LAKE HURON
INDIANA
Indianapolis
KENTUCKY
Frankfort
TENNESSEE
Nashville
OHIO
Columbus
LAKE ERIE
LAKE ONTARIO
NEW YORK
Albany
PENNSYLVANIA
Harrisburg
W. VIRGINIA
Charleston
VIRGINIA
Richmond
Washington
NORTH CAROLINA
Raleigh
Columbia
NEW JERSEY
Trenton
Dover
VERMONT
Montpelier
NEW HAMP.
Concord
MAINE
Augusta
MASS.
Boston
CONN.
Hartford
Providence
ATLANTIC OCEAN


KANSAS
Topeka
Jefferson City
MISSOURI
Springfield
ILLINOIS
INDIANA
Indianapolis
Columbus
Frankfort
KENTUCKY
Charleston
W. VIRGINIA
VIRGINIA
Washington
Richmond
Raleigh
NORTH CAROLINA
Nashville
TENNESSEE
OKLAHOMA
Guthrie
ARKANSAS
Little Rock
S. CAROLINA
Columbia
Atlanta
GEORGIA
MISSISSIPPI
ALABAMA
Montgomery
Jackson
LOUISIANA
Baton Rouge
TEXAS
Austin
FLORIDA
Tallahassee
ATLANTIC OCEAN
BAHAMA ISLANDS
Nassau
GULF OF MEXICO
35°
30°
25°
100°
95°
90°
85°
80°
75°

No. 54.

CONDITION OF FIELD OPERATIONS, ALASKA, 1917.

160°
170°
180°
170°
160°
A R C T I C O C E A N
Pt. Barrow
Icy Cape
S I B E R I A
Pt. Hope
BERING STR
Nome
St. Michael
St. Lawrence I.
Y U K O N
KUSKOKWIM RIVE
60°
St Matthew I
Nunivak I.
BRISTOL BAY
Pribilof Is
B E R I N G S E A
Unimak I.
Unalaska I
Attu I
A L E U T I A N I S
Kiska
Tanaga I
Atka I
Umnak I.
East from Greenwich.
180°
170°


CONDITION OF HYDROGRAPHY
ALASKA
1917
Wire drag surveys completed shown
Unchangeable areas, no present work required shown
Unchangeable areas, additional work required shown
Changeable areas, recent surveys shown
Changeable areas, old surveys shown
Reconnaissance 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.
140°
130°
120°
60°
50°
160°
150°
140°
BRITISH COLUMBIA
SOUTHEAST ALASKA
Dawson
Fairbanks
TANANA
RIVER
Anchorage
PRINCE WILLIAM SD.
Valdez
Cordova
Controller B.
Mt.St.Elias
Yakutat
C.St.Elias
Seward
KENAI PENIN.
COOK INLET
Iliamna L.
Nushagak
Kodiak I.
Skagway
Juneau
Sitka
Wrangell
Cross Sound
GULF OF ALASKA
DIXON ENTRANCE
Shumagin Is
PACIFIC OCEAN
West from Greenwich