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# ANNUAL REPORT

OF THE

# DIRECTOR, UNITED STATES COAST AND GEODETIC SURVEY

TO THE

# SECRETARY OF COMMERCE

FOR THE

## FISCAL YEAR ENDED JUNE 30, 1920

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# National Oceanic and Atmospheric Administration

## Annual Report of the Superintendent of the Coast Survey

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1. Butler Building; contains library and archives, division of terrestrial magnetism, part of division of geodesy, and part of division of charts. 2. Front Richards Building; contains part of division of geodesy, part of division of charts, division of accounts, and part of division of hydrography and topography. 3. Back Richards Building: contains Director's rooms, part of division of charts, part of division of geodesy, and part of division of hydrography and topography. 4. Formerly a stable: now houses the printing office, division of charts. In this building the entire output of charts of the Bureau is printed. 5. Chart, Instrument, and Archives Building; contains part of division of charts, the instrument section, and the carpenter shop.

# REPORT

OF THE

# DIRECTOR, U. S. COAST AND GEODETIC SURVEY.

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DEPARTMENT OF COMMERCE,
COAST AND GEODETIC SURVEY,
*Washington, October 5, 1920.*

SIR: There is submitted herewith my sixth annual report, the five preceding as Superintendent and this as Director of the U. S. Coast and Geodetic Survey for the fiscal year ended June 30, 1920. This is the eighty-ninth annual report of this Bureau.

PART I.

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Chapter II. Salary readjustments needed to produce an efficient and permanent personnel, pages 15 to 19.
Chapter III. Work of the Washington office of the Bureau during the fiscal year, pages 20 to 36.

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## INTRODUCTION.

Congress, during its last session, wisely recognized the commissioned officers of the Coast and Geodetic Survey by giving them a pay status equal to the other five commissioned forces of the Federal

Government. The vital importance of this legislation can not be overestimated, for it not only gave these highly trained engineers, navigators, and surveyors salaries commensurate with their worth, but it literally saved a service so important to the protection of human life and property. It is no exaggeration to state that the action of Congress has already had a national and far-reaching effect for the welfare of the country which is hard to estimate. It is only a few months since the legislation became effective, but the judgment of the Senate and House is clearly obvious. Already this service, which was on the brink of certain demoralization, has taken on a new life; the morale is better than ever before; in fact, the real permanent groundwork of this old and invaluable service, whose very foundation has only begun to be genuinely recognized, and after more than 104 years of existence it is on a just and permanent basis.

But with due and full appreciation of what Congress has recently done, there are other vital necessities required by this service, some of them equally as important as the one relieved by the recent legislation.

There are three other branches of the Coast and Geodetic Survey which, judged from their importance and value to the country, must be immediately recognized by providing just salaries, if they are to be retained, otherwise the necessarily high standard of the Survey must permanently suffer. These three classes of men are the computers (mathematicians), draftsmen (cartographers), and instrument makers.

The computers, when first taken into the service, must be highly qualified as engineers and mathematicians, such as our best technical universities produce, but this is not all. When they have passed the rigid examination it takes some years of application to the highly specialized work before each man is looked upon as thoroughly efficient.

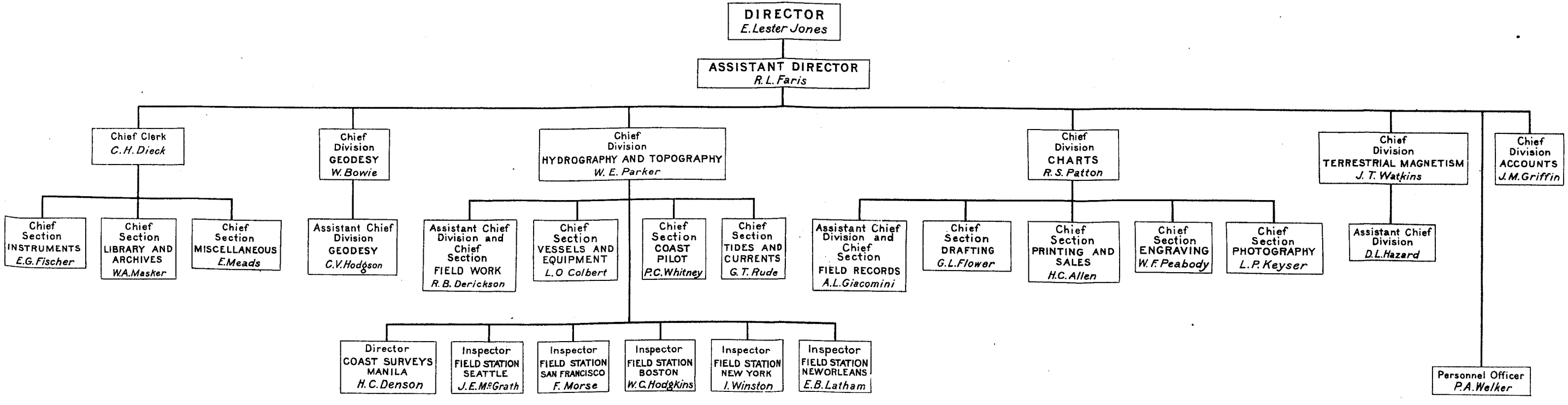
Then the draftsmen, who, like the computers, are trained in the fundamentals of engineering. Their great value in putting the final touches on our charts for navigation lies in the fact that their years of experience, after a difficult basic training, gives the confidence in them only made possible by the years of practical application in the difficult and highly technical work which they encounter each day. The word draftsman is deceptive as applied to the men in this service, for their work is not in outlining or drawing a map or chart, but a draftsman of the Coast and Geodetic Survey must be able to place absolutely accurately on the charts produced by this Bureau symbols representing pinnacle rocks, shoals, and other hidden dangers of our waters, which information means so much to the protection of human life and commerce.

And the third class of men—long neglected—without adequate pay is represented by the instrument makers. Few can interpret the importance of these men to the service. Without this force, our vessels and land parties could hardly function. Years ago the service bought most of its instruments, but now, with changed conditions, it is found to be more economical, not to mention the saving of time, to manufacture most of the delicate and intricate instruments necessary to all the work within the Bureau. Many of the most valuable and complicated instruments have been conceived by men in the Coast and

Effective Oct. 15, 1915
Revised to Oct. 5, 1920.



CHART SHOWING ORGANIZATION OF THE
# U.S. COAST AND GEODETIC SURVEY
1920

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Geodetic Survey. One, the "tide-predicting machine," popularly known as the "brass brains of the Coast Survey," saves in labor the work of 60 highly trained men. This remarkable instrument predicts with precision the tides of the coastal waters of the world.

The Bureau has already faced the loss of a number of these experts, who have been drawn to statutory positions in the other branches of the Government where the pay is not only greater than offered by this service but the duties are far less exacting than those at less salaries now offered by this Survey. Unless this unfortunate situation is corrected soon, there is but one answer. The instruments much needed for parties will not be forthcoming, resulting in untold delay in carrying on the field work. Instruments must be kept in repair at all times, with a reserve in case of emergencies. This is impossible under existing conditions.

The situation in these three branches is just this: The salaries are far too low to retain first-class and experienced technical men; the now apparent outcome is the necessity of filling many vacancies, if filled at all, with men lacking in fundamental training or groundwork, which obviously means delay, inaccuracy, and additional cost of production. It takes years of training to produce a first-class computer, draftsman, or instrument maker. Shall the service lose this class of technical men and continue to accept anyone available? The field force is now on a substantial basis and will be handled with economy and thoroughness, and there is needed the same atmosphere of efficiency among the technical force in this office; otherwise the results will be complicated and delayed. The remedy is clear and economical, besides giving correct and prompt results to the country.

Later in this report fuller detail will be given on the merits involved in this introduction, and also chapters on the imperative need of modern surveying vessels, a new building for the Washington office, and adequate salaries for the engraving and clerical forces.

## Part I.—NEEDS OF THE WASHINGTON OFFICE.

### CHAPTER I.

#### FURTHER EXPANSION IMPOSSIBLE WITHOUT A MODERN BUILDING.

This Bureau occupies quarters that are a disgrace—insanitary and directly responsible for a clear loss of 25 per cent efficiency, not to mention the fact that it has far outgrown such quarters as it now occupies. The absolute necessity for modern and healthful quarters with a chance for expansion is a daily problem.

1. The Bureau is housed in five different buildings, but one of which is designed for its needs.

2. Employees under the direct supervision of chiefs of divisions and chiefs of sections are necessarily hundreds of feet away from the directive head, and communication is only possible through a labyrinth of stairs, halls, and bridges.

3. Original field records made at a cost of thousands of dollars are continuously exposed to destruction by fire.

4. The assessor for the District of Columbia states that the value of the buildings occupied by this Bureau is $317,900. The average yearly expenditure for repair and upkeep of buildings occupied by this Bureau for the past five years has been $7,835. The cost of the repairs and upkeep of the buildings yearly is 2½ per cent of their total value. Substantial repairs can not be made because the basic structure of the buildings is not generally sound enough to permit them to be made economically.

The greater merchant marine, the increased marine commerce of the country, and the Army and Navy have made calls on the Bureau for its navigational charts to the number of 311,699 during the fiscal year ended June 30, 1920, of more than four and one-half times the demand in 1900—20 years ago—when 71,614 were printed.

To meet this demand has meant an expansion of personnel and equipment, so that the buildings that house the Bureau are taxed to their capacity. At best these buildings are not adapted to the purpose for which they are utilized. With the principal two of the five buildings originally designed for a hotel with small rooms and 16 different floor levels in the two buildings, the 5 more or less detached buildings (see frontispiece), constructed as they are, result in an actual handicap to the orderly and efficient administration of the work of the Bureau and the operation of its chart-manufacturing equipment.

The office work of the Bureau lends itself to seven natural divisions of personnel. These are as follows: (1) The Director's office, with directive control of the office and field work; (2) the division of hydrography and topography; (3) the division of geodesy; (4) the division of charts; (5) the division of terrestrial magnetism; (6) the division of accounts; (7) the chief clerk. In but two instances are

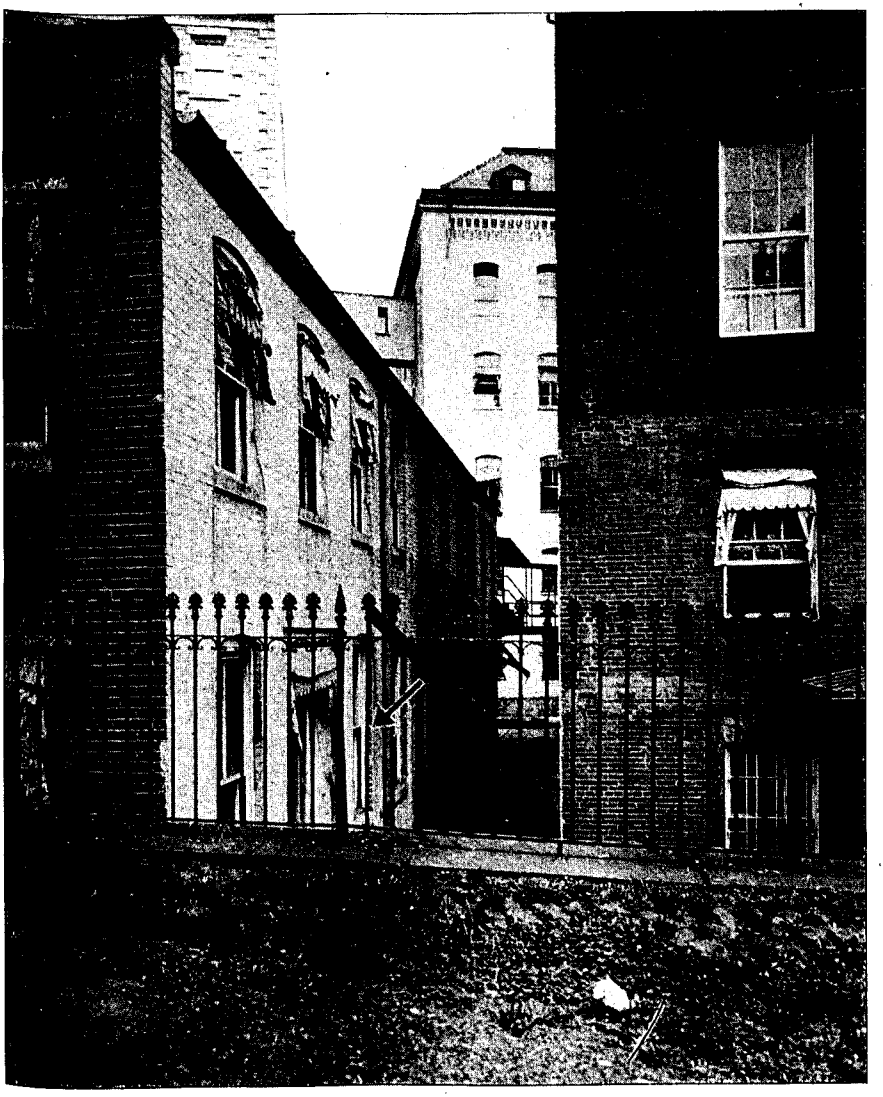
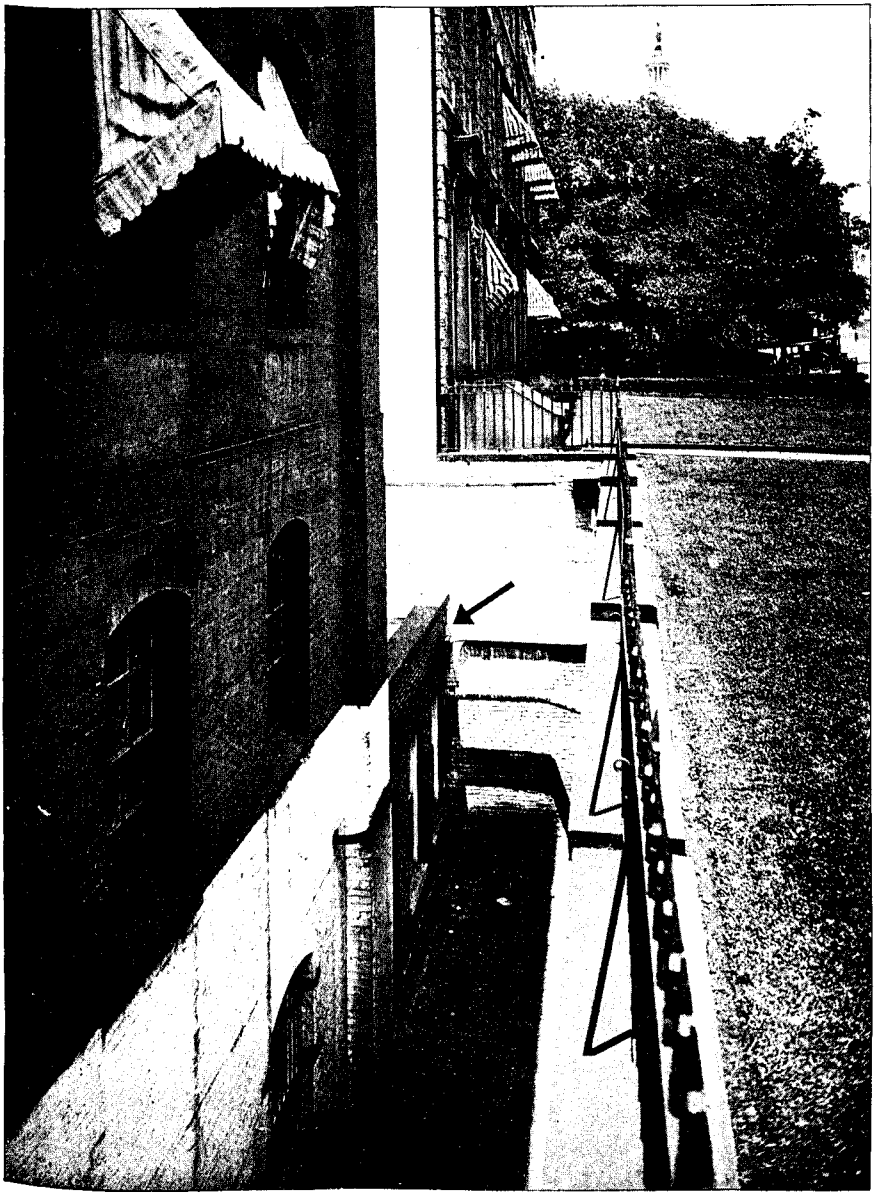


CHART PRINTING ROOM.

In the room indicated by the arrow above, more than 20 feet below the street level, is printed every chart that is issued by the Coast and Geodetic Survey, more than *300,000* during the current fiscal year.



ENVIRONS OF CHART-PRINTING ROOM.

View of buildings occupied by the Coast and Geodetic Survey, from New Jersey Avenue, showing the location of the building in which the charts of the Bureau are printed.

or is it possible to house the members of any one of these divisions in contiguous rooms. Arbitrarily it would be possible to distribute the personnel of each unit of the office organization so that the members of the several units would be in contiguous rooms, but there are other weighty factors that must have consideration in the distribution of the personnel of the various sections and divisions. The engraved characters on the copper plates from which are printed the charts of this Bureau must be placed with a high degree of exactness as to position on the plates in order that the printed charts may represent actual conditions and be relied upon without question by the navigator. To permit the engraver to do this properly requires that he have the best possible light facilities. There are relatively few rooms in the building occupied by the Bureau that afford proper natural light for engraving work.

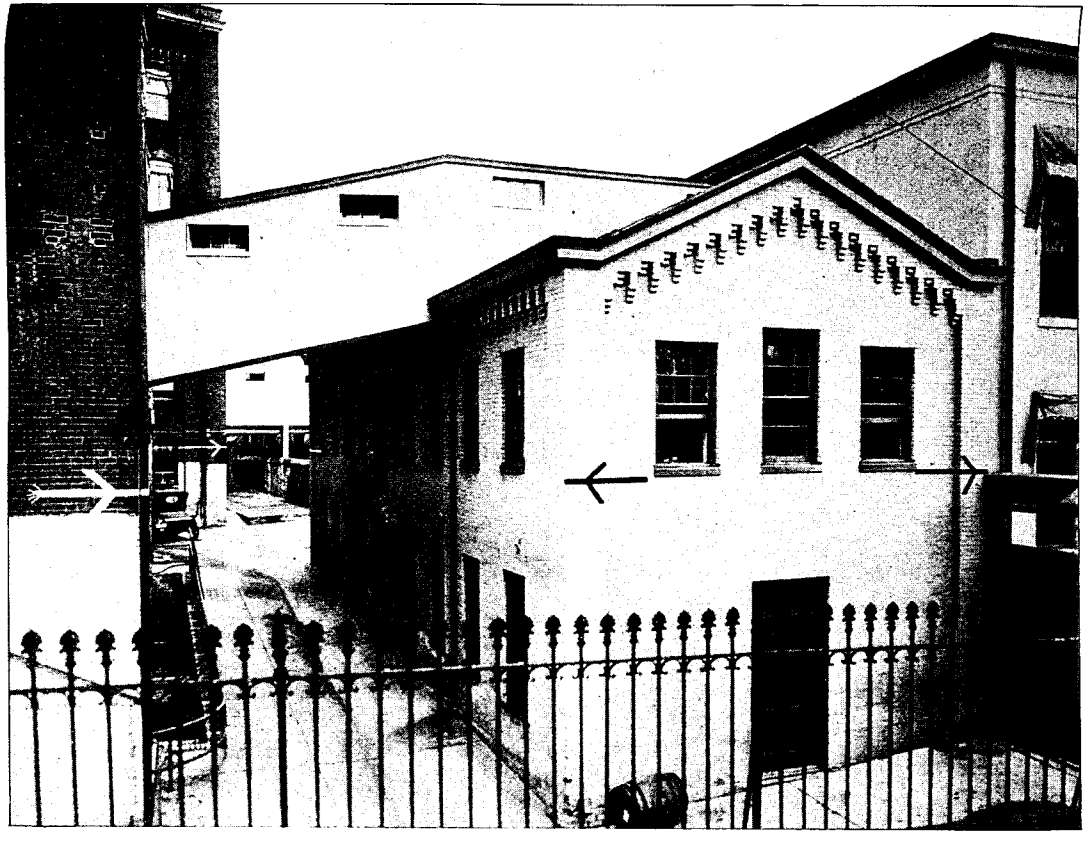
For this reason the engravers must be distributed wherever it is possible to obtain the requisite amount of natural light. The same condition applies to draftsmen, though fortunately we have recently been able to bring the draftsmen together on one floor and in one building as a unit organization. There are other divisions of the office that require the constant consultation of the charts of this Bureau, as well as of the Navy Department and foreign countries. To have these charts constantly available requires numerous chart cases. These chart cases are considerable in size, and therefore those by whom they are consulted should be housed in commodious rooms. In no instance is there a single room sufficiently large for this purpose, nor are there large rooms adjoining each other. Therefore, charts that are constantly consulted by various employees of the Bureau are in cases in widely separated rooms, resulting in an inconvenience and loss of efficiency that is readily appreciated. To make one set of charts available for two different divisions housed in different buildings, the expedient has been adopted of placing the chart cases in two rooms somewhat isolated from both divisions, but at the end of a bridge connecting the buildings in which the divisions are housed, so they are equally available for both divisions, but with considerable inconvenience to each. The heavy chart-printing presses used in producing the charts that are issued by the Bureau must be placed on a solid foundation, in rooms large enough to contain them, and with the best possible light conditions to help the printer in adjusting registration, etc., during the process of printing. The rooms most suited to these conditions are found in a small two-story building, 20 feet and 8 inches below the street level of the main front of the building in which the Bureau is housed, and 7 feet below the street level at the rear of the buildings in which the Bureau is housed, surrounded on three sides by buildings that are five and six stories high. (See figs. 2 and 3.)

Furthermore, the rooms are merely large enough to contain the chart-printing presses, and the only available place to store the paper on which these charts are printed is in a building adjoining the printing building and which was originally built for a stable. The awkward arrangement of the buildings and the different floor levels make it impossible to bring the paper on which the charts are printed to the press by mechanical means; consequently it is carried in the arms of the printers and their helpers. Again, the lack of storage room for the completed charts in the printing building requires that they

be carried by hand to a near-by building to be placed on shelves from whence they are distributed to meet the official and public demand. When it is considered that an average of more than 1,000 charts are issued by the Bureau each working day and that many of these charts require hand corrections due to the fact that information has been received since their print, necessitating the addition or change by draftsmen of the data shown on a chart which requires their assembling in a correction room, it would seem of necessity to follow that these charts should be kept in a properly constructed mailing room. But in order to leave free rooms needed by other branches of the service requiring proper light facilities, these charts are stored on shelves in five rooms, nearly all considerably removed from the assembling and correction room and 11 feet and 5 inches below the main street level. This means that every chart that leaves the Bureau must be carried by hand to a distance of 205 feet and up three flights of stairs to the mailing room and from thence to the mail wagons at the front of the building.

As stated before, the engravers of the Bureau must be housed in rooms that permit the best possible natural light. To leave free as many rooms as possible for this and other work of the same requirements, such as computing, lithographing, chart correcting, etc., the copper plates on which the engraving is done and from which the charts are printed are stored in the basement of one of the buildings. The engravers are in most instances four floors above the basement of the building in which these copper plates are stored, and the majority of them in other buildings. The only elevator in the whole group of buildings is a freight elevator, and that is so removed that it is of little use for hoisting the copper plates. They are therefore carried by hand up and down several flights of stairs and hundreds of feet from the storeroom to the engravers and back to the storeroom. Resulting from the lack of proper housing facilities administrative conditions inherent in directing the work of the divisions and sections of the office are even greater and of more serious consequence than what might be termed "operating difficulties." In but two instances has it been found possible to have the division chief and all of the employees under his direction in connecting rooms. The employees of one division are distributed through five different buildings in 69 rooms and on 15 different floor levels. (See figs. 4 and 5.) The office of the chief of this division is 393 feet from one of his section chiefs, and to reach the office of this section chief he must go down two flights of stairs and up two flights of stairs. (See fig. 6.) The employees of another division are housed in five different buildings in 62 different rooms and on 17 different floor levels. The distance between the office of the chief of division and the office of one of his section chiefs is 312 feet down two flights and up two flights of stairs. Other divisions are almost equally widely scattered. (See fig. 7.)

This distribution is necessary in order to permit an approximation of proper working conditions for those engaged on the technical duties requiring a high degree of accuracy, and therefore the best possible light conditions. Even with this wide distribution of employees, the conditions are far from satisfactory. Within a comparatively few years wonderful progress has been made in the Bu-



FLOOR LEVELS.

The arrow to the left is on the floor level of the back Richards Building. The other arrows show where this level is in the other buildings.

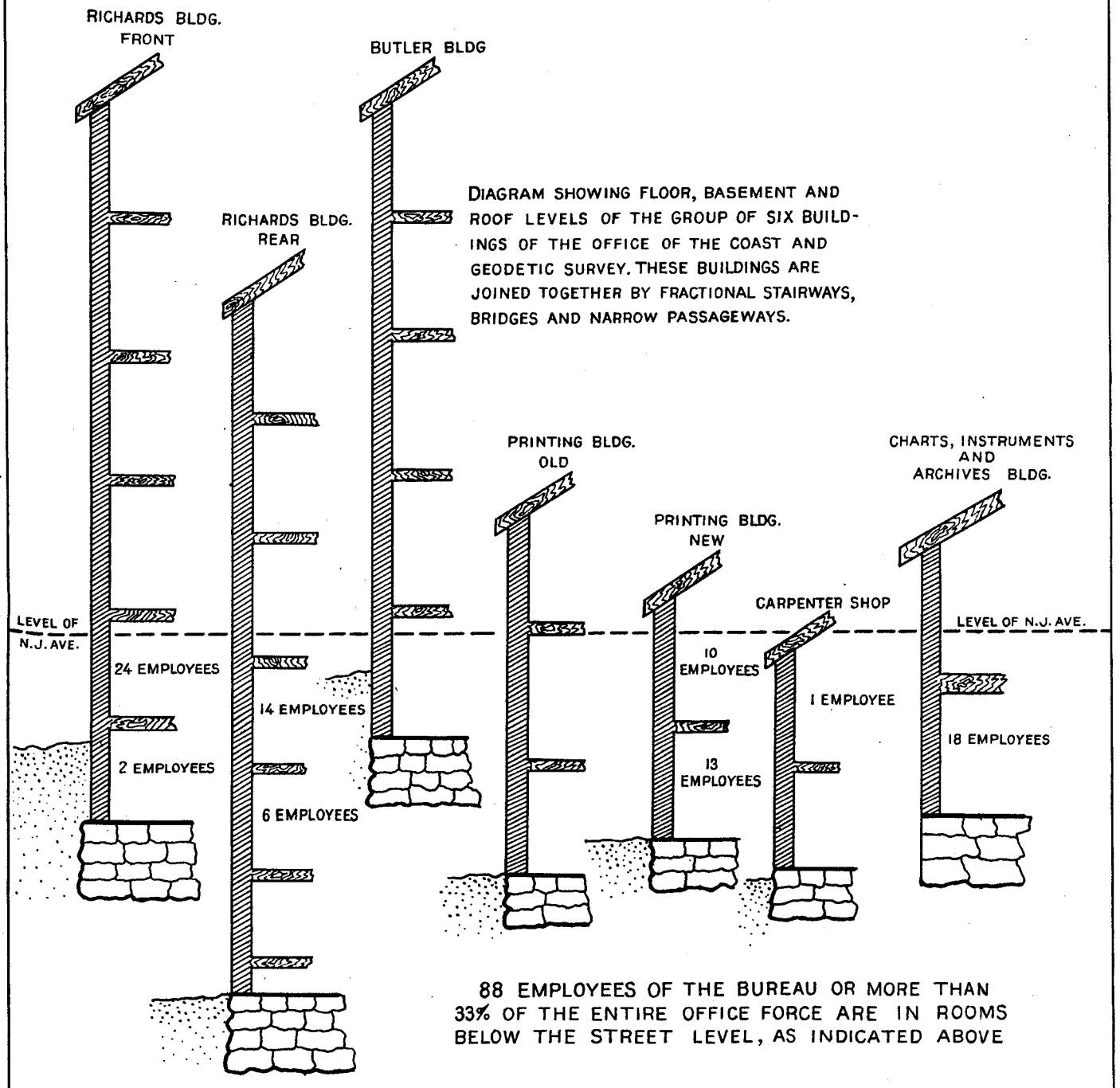
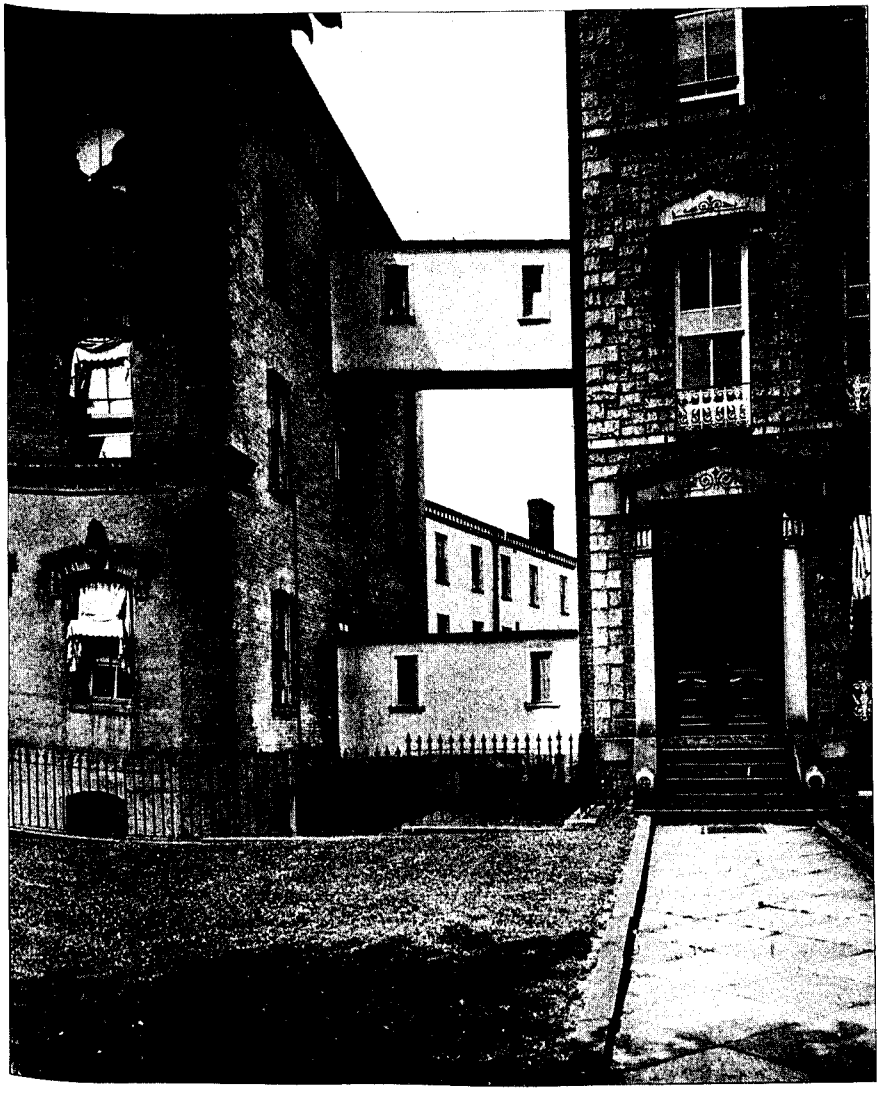



DIAGRAM SHOWING FLOOR, BASEMENT AND ROOF LEVELS OF THE GROUP OF SIX BUILDINGS OF THE OFFICE OF THE COAST AND GEODETIC SURVEY. THESE BUILDINGS ARE JOINED TOGETHER BY FRACTIONAL STAIRWAYS, BRIDGES AND NARROW PASSAGEWAYS.

88 EMPLOYEES OF THE BUREAU OR MORE THAN 33% OF THE ENTIRE OFFICE FORCE ARE IN ROOMS BELOW THE STREET LEVEL, AS INDICATED ABOVE

A MAIN HIGHWAY OF COMMUNICATION BETWEEN BUILDINGS.



BRIDGES CONNECTING DETACHED BUILDINGS.

The *roof* of the printing office where all the charts issued by the Bureau are printed is below the lower bridge and below the street level.

reau in the development of the process of producing charts by lithography through photographic transfer from the original drawings. This has resulted in a material saving and in time and effort to get our charts into print, and to the introduction of this method can be attributed our ability to keep abreast the very greatly increased demand for the charts of this Bureau. One of the steps in the production of charts by this method requires the adjustments of the negatives by lithographic artists. On the accuracy of these adjustments depends the accuracy of the finished chart. Therefore, the lithographic artist should work under conditions where he has proper light and where his work is not disturbed by vibration, yet as this is comparatively a new development there was no place to assign the new personnel of lithographers, lithographic artists, and lithographic transferrers except on the second floor of the chart-printing room, directly over the printing presses and surrounded on three sides by buildings five and six stories high. Under these conditions artificial light must be resorted to to a considerable extent, and other disturbing agencies make it hardly possible to attain the accuracy that is necessary. Twenty years ago photography was largely dependent on natural light, and therefore the photograph gallery of this Bureau was placed on the top floor of one of the six-story buildings of the Bureau. At the present time photography is almost entirely done by artificial light, and, due to the fact that there is no other suitable or vacant place other than where now located, the photograph gallery can not be moved. Yet it is next to impossible to produce accurately registered negatives for printing purposes owing to the fact that the camera is thrown out of adjustment by the vibration of the building from the heavy chart-printing presses being run in the basement of the building adjoining.

Aside from the disturbing elements under which the Bureau is conducting its work in the Washington headquarters, there is a constant menace to the quarters of the Bureau by fire. The Bureau should be housed in a fireproof building, or certainly one more nearly fireproof than the present buildings. Gasoline, benzol, alcohol, ether, and other explosives are necessarily used in photography, lithography, and plate-printing work. Although every precaution possible is taken, there is a constant dread of what might happen should a fire start under favorable conditions, as there is so much inflammable material in these old buildings that they would certainly be absolutely destroyed should a fire get much headway. Incipient blazes have started from various causes, such as overheated steam pipes, spontaneous combustion from oily rags, crossed electric wires, etc. Every precaution is taken, even to the extent of putting oily waste in containers partly filled with water and removing accumulation from the buildings at the close of each day, and keeping explosives such as gasoline, benzol, ether, etc., in automatically closing containers. However, it is in all probability merely a question of time under present conditions when we shall have a disastrous fire. The consequences of such a fire are appalling to contemplate. On the original field records of this Bureau are based the data that are contained on every nautical chart of the navigable waters of the United States and possessions. Likewise, on the original field records in these buildings are based the triangulation and leveling controls of

the interior of the entire country. The Coast and Geodetic Survey is the only institution of its kind in the country, and its work is duplicated nowhere else. Therefore, with the destruction of its original records are destroyed the results of more than 100 years of continuous effort by the scientific men who have contributed toward the development of surveys that are the most precise in the world. When these records are destroyed they can only be reproduced by actual resurveys in the field, and so accurate must they be that progress is necessarily slow. It would take years to again build up basic and original data sufficient to use to produce charts and standard controls for mapping the country.

In brief, the Bureau has necessarily expanded to meet the official and public demands that have been made on it for its product—hydrographic charts, nautical publications, and geodetic publications. This expansion has now reached the point where it is absolutely impossible to go further in its present quarters. Where the restriction on the proper operating and administrative work of the Bureau is so pronounced it is no longer a problem as to how best to do some things but a problem as to how to do them at all. Records that are constantly consulted are not readily accessible. Intercommunication between the chiefs of divisions and chiefs of sections, as well as employees, is possible only at a great inconvenience and at an absolute waste of valuable time. There is a constant menace to the valuable public records stored in the building through fire. It is impracticable to provide elevator service, though the buildings are five and six stories high, because the buildings are so separated that a single elevator would serve but one building. The buildings are so cut up that it is necessary to devote more than the average amount of space in them to halls and bridges between buildings, so that nearly one-fifth of the area of the buildings is used for these purposes. The point has been reached where the cost in the loss of time and efficiency, to say nothing of the dangers through fire to valuable records, is far more than would be the interest on the investment were a proper building constructed for the Bureau.

# CHAPTER II.

## FURTHER SALARY READJUSTMENTS NEEDED TO PRODUCE AN EFFICIENT AND PERMANENT PERSONNEL.

If the Government work is to progress as it should, the Government must provide pay for its employees that will permit at least the ordinary comforts of life and some provision for old age. The average pay of the Government worker under existing economic conditions does not permit this. The entrance pay is generally too low to attract applicants, especially efficient applicants. The result is that in the lower grades there is a continuous turnover and a very large number of temporary employees. This condition puts a direct burden on the whole organization in that the time of the seasoned employees is constantly consumed in instructing the new temporary employees. Further, under present economic conditions, the Government organization is becoming weakened, due to the fact that the entrance pay in the Government service is relatively lower than elsewhere.

Consequently the Government secures only those who are unable to meet the competition where the entrance pay is higher. This brings into the Government service many who will never fit themselves for larger responsibilities. The result is, at least in this Bureau, that we have numbers of low-paid employees. This condition has been brought about by the very low entrance salary and the necessity of filling the positions permanently by the appointment of those best fitted for the work, though it was known that they were not up to the standard that should be maintained. Experience has proven that work is more efficiently and cheaply done by a fewer number of relatively well-qualified employees than by a larger number of lower-paid, inefficient employees. Even the efficient employees who came into the service before the Great War and who have proven their worth are very much dissatisfied with present conditions.

Outside the Government service the salaries and wages have steadily increased to meet the increased cost of living, but within the Government service the statutory salaries have remained about the same, with the exception of the relatively inconsiderable bonus of $240 per annum. The administrative officer in the Government service who is zealous that a high degree of efficiency shall be maintained is constantly face to face with the fact that the employees under his supervision are not adequately paid and that he dare not force the issue by demanding results that the Government should ordinarily expect, because to do so would be to drive those employees from the service, only to be replaced by less-experienced and less-competent employees. The outcome is a compromise in a not too rigid exaction of results, a condition in which the morale of the whole organization suffers, and a laxity of discipline which will be harder to overcome the longer it is allowed to continue. Yet the administrative officer has but one or the other of two courses open

to him: He can exact the services that should be rendered under ordinary conditions and have a continuous turnover of dissatisfied employees, or he can lower the standard of duties required to meet the salary scale provided by the Government and retain fairly continuously the employees who receive intermediate salaries. The entrance grades are never continually filled either by permanent or temporary employees.

During the fiscal year for which this report is presented there were 34 statutory places provided for computers in this Bureau; 23 of these places were filled permanently at the close of the fiscal year and there had been 23 separations from this roll during the year, or a turnover of 67 per cent.

Thirty-six statutory places were provided for draftsmen; 23 of these places were filled permanently at the close of the year and there had been 7 separations from this roll during the year, or a turnover of 19.4 per cent. Forty-two statutory places were provided for clerks; 34 of these places were filled permanently at the close of the year, and there had been 15 separations from this roll during the year, or a turnover of 35.8 per cent. Thirty places were provided for messengers and laborers; 28 of these places were filled permanently at the close of the year and there had been 18 separations from this roll during the year, or a turnover of 60 per cent.

While there has not been any turnover in the class of employees designated as "instrument makers" in this Bureau, this is due to the fact that it has been impossible to fill vacancies caused by resignations. The term "instrument maker" does not convey the full meaning of the qualifications and training requisite for a person to perform the duties assigned those appointed under that designation in this Bureau. There is really no readily understood term that fittingly describes the position. The prime requisite of the work of this Bureau is that the results must be precise. In order to attain exactness, it is absolutely necessary that the instruments used in making these precise surveys shall be graduated perfectly and shall be mechanically perfect. The ordinary toolmaker or lathe operator found in factories is about as proficient in repairing and keeping in order the delicate and exact instruments that are used by this Bureau as is a blacksmith to repair a watch. There are very few firms in this country that devote any time to making surveying instruments of the more precise kind such as are used by this Bureau. Those engaged in making instruments produce the cruder instruments used by surveyors. Surveying instruments used for scientific purposes are admitted to this country duty free. Therefore most of our precise instruments are imported. Resulting from this there is in this country a very limited field from which to draw men qualified to repair these delicate and exact instruments, and when we do secure such men they are invaluable to us. They are drawn largely from those who have had apprenticeship in shops abroad where these instruments are made. An early apprenticeship and training in this work where these delicate instruments are made fits a man better for this work than a long term of actual experience in shops where close attention to exactness and painstaking care in handling delicate instruments is not required. The deplorable feature of this matter in connection with this Bureau is that the salary paid our instru-

ment makers for this precise work is so very low that men can go from our shop, where so much care is required, to a quantity-production shop, where less care is required, and get more pay. Men have left our shop and gone to other shops where the requirements as to care and accuracy are not so great, and therefore the tax on the man is not so great, and secured more than twice the amount of pay they were drawing in our shops.

The inadequacy of the existing salary scale in the engraving section is striking.

Our youngest engraver has had 10 years of experience, and the others have been working at engraving for from 11 to 61 years. Their basic salaries range from $1,000 to $2,500.

One engraver with an experience of over 30 years and two engravers appointed last year have resigned, and we have two unfilled positions.

The engraver with 10 years' experience, who is receiving a basic salary of $1,000, is being urged by his family and friends to leave and is made a subject of ridicule by others for remaining. He has remained, he says, because he likes engraving better than any other work he could get to do and hopes he will not be driven to do less congenial work by a continuance of his inadequate pay. He is a skilled engraver and faithfulness personified in his work. He should easily command a much higher salary in another occupation.

A cause for this discouragement and these resignations is shown by contrasting the pay of our engravers with that in the Bureau of Engraving and Printing.

A comparatively few years ago the average pay of the letter engravers of the Bureau of Engraving and Printing and our engravers was practically the same; now there is a difference of 50 per cent, although it is generally recognized that the skill and study required is the same in both branches of engraving.

The bank-note engraver can get employment outside the Government; the chart engraver can not. The employer of both is the same, yet one branch has been advanced 50 per cent, while the other has received practically no increase for years. As the value of the bank-note engraver has been apparently determined by his ability to receive higher pay outside the Government and the chart engraver can not get employment elsewhere, he is, of course, discouraged by the change of relation between his pay and that of those who received practically the same only a few years since. Now, driven by discouragement the chart engravers are seeking employment at other work. Four engravers have resigned in the past three years and but one of these is at present employed at engraving.

Older engravers have no encouragement to offer their sons or friends who would like to learn chart engraving; the grade of apprentices on the register has become lower and lower, and now the Civil Service Commission has no eligibles at all.

It is apparent that no young man of ability will seek employment at work which takes years to learn and where he is almost absolutely under the control of his employer, when he feels that he will not receive the same relative treatment given others whose profession requires no longer to learn and whose chance of employment is not confined to one employer. But because the Government alone makes

charts a corps of engravers is the most permanent force we can have. The engraver, however, has to be trained and must feel that his pay will be adequate to the time required to learn his profession.

We have reached the point where young men of the required ability are no longer seeking engraver's positions, and engravers of over 30 years of experience are resigning.

The majority of our charts are on copper plates—which have to be kept corrected to date—and more charts should be on copper.

Properly paid, we can maintain a force of engravers who can be depended upon to have our charts ready at all times, but the discouraging conditions under which the engravers have been working is having a serious effect on the Coast and Geodetic Survey, an effect which will take years and added expense to overcome unless the relief we are asking is given us.

In my annual report for the past fiscal year I mentioned the waste of Government funds due to the lack of properly trained clerical help. This arises from the fact that a clerk to be of value to the Bureau must have at least a working knowledge of its scientific methods. In but few instances is the work of any two clerks in the Bureau of like character. Therefore clerks are not readily interchangeable, and when a vacancy is created it falls on the chief of division or chief of section to either do the clerical work of the division or section or spend a very considerable period of time training those unacquainted with the clerical work in that particular branch of the service. Due to the continuous separations from the service, many of our specialists, as computers, draftsmen, etc., have become really quite profficient in the performance of clerical work at a materially lessening of accomplishments in these specialized lines, not because they have any preference for clerical work, but because information is requested by the public, and there is no other means of having it placed in proper shape to transmit to the public. This whole situation is brought about by the low salary scale for clerks in the Bureau and the relatively poor prospects of advancement of those who continue with the Bureau. Salaries should be provided to retain the services of competent clerks. Within the year many competent clerks have left the Bureau and had offers to leave at far better salaries than are there provided. Only recently one of our clerks at $1,800 per annum left the service to take a position outside the public service at a salary of $300 per month.

The result of the continuous turnover mentioned above is not yet fully apparent, nor is it yet reflected in the lack of integrity of the data issued by the Bureau, and my hope is that it will never reach a point where the exactness of the data issued by the Bureau can be questioned; yet, right now, it is only through the zeal, painstaking care, and extra efforts of the seasoned employees of the Bureau who are imbued with the old-time tradition that the Bureau shall set the standard of scientific exactness that prevents the disintegration that would mean the loss of fidelity of our charts, tide tables, magnetic, and triangulation publications. The results shown on our charts and in our publications are now accepted without question as to accuracy, and this the public has the right to expect, but it is my duty to issue the warning that a dissatisfied and underpaid personnel and one that is continuously changing with only the responsibility of the moment,

can not be expected to continue to produce the high standard of the past, and there is a point where the supervisory officials, no matter how diligent, can not check these inaccuracies because it is not humanly possible to go into the details necessarily involved. The only possible way to maintain this accuracy is that the individual employee shall be so zealous that his work shall be above question, and this ideal is only approached by having properly compensated contented employees, and can never be expected where employees who are engaged on work that it has taken years of experience and training to make them proficient at are receiving salaries below those of lesser ability and training in private life. I am continuously confronted by the fact that employees of our intermediate grades are leaving this service and receiving salaries that are higher than those received by our highest grades. Such conditions are not conducive of efficiency in Government service. Right now we are dangerously near the point where these conditions will be reflected in the inaccuracy of the product of this Bureau.

# CHAPTER III.

## WORK OF THE WASHINGTON OFFICE OF THE BUREAU DURING THE FISCAL YEAR.

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

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

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

Division of geodesy.

Division of charts: Section of field records, section of drafting, section of engraving, section of printing and sales, section of photography.

Division of terrestrial magnetism.

Division of accounts.

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

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

The general duties of this division were: The care and upkeep of the buildings occupied by the Bureau; the designing and repairing of surveying instruments and equipment and packing and shipping them to the field parties; the purchase of supplies for the office, for chart-printing work, and to some extent for the field; the care and custody of most of the original records of field surveys, as well as the library of printed publications kept for the use of the Bureau; the keeping of the records of leave of absence taken by the personnel of the Bureau; the custody and accounting for the receipts from the sales of charts and publications sold by the Bureau.

The more important items of accomplishment of the division of the hydrographic and geodetic engineer in charge of the office during the fiscal year for which this report is made are as follows:

In my annual report for the fiscal year ended June 30, 1919, I gave considerable details regarding the new two-story building then in the course of construction to house the chart division and instrument section and the carpenter shop. The needs of the country for the output of this Bureau in the way of charts and special instruments for the Army and Navy were so great during the war and its activities were so hampered through the congestion due to inadequate housing facilities that the President allotted funds out of those placed at his disposal by Congress for the national defense for the construction of a new two-story building for this Bureau. This building had not been completed at the close of the fiscal year ended

June 30, 1919, and was not completed and accepted until August 4, 1919.

The responsibilities of transferring furniture, equipment, and records to the new building fell on the office of the hydrographic and geodetic engineer in charge of the office. Considering the small force available for the purpose of moving, the labor in connection with the moving of the equipment of the various sections of the office involved in the transfer from the old to the new building was enormous. The following parts of the office were involved: The drafting section, instrument section, carpenter shop, electrotype section, section of tides, parts of the division of geodesy, and the library and archives. This work was commenced about the middle of June and was not completed until the close of the calendar year. Even after the latter date minor details were left. The original topographic and hydrographic sheets, indicating records of surveying work in the field, all of which were in metal tubes, drawings, blue prints, and miscellaneous documents, were transferred from the second floor of the Butler Building to the new vault in the Chart, Instrument, and Archives building and placed under the charge of the division of charts. The transfer involved the inspection of every tube and making record of all the contents. The work was commenced August 21 and was finished October 13, 1919, for the tubes then in storage. With the transfer of the chart division, the instrument section, and the carpenter shop in the new building, much needed room was left for expansion of the then exceedingly cramped other divisions of the office. Before occupying these rooms they were thoroughly renovated, painted, and equipped with modern illuminations.

Many other repairs were made to the buildings occupied by the Bureau during the year, such as painting exposed parts of the buildings, equipping rooms for chart-paper storage and drying purposes, making changes in the heating equipment, replacing broken slate in the roofs of the buildings, repairing ceilings, etc. The total cost of these repairs was $14,830.21.

During the fiscal year the expenditure from the appropriation for general expenses for the Bureau, which was under the direct control of the office of the hydrographic and geodetic engineer in charge of the office, was $103,233.66.

In the library and archives 59 hydrographic and 26 topographic sheets, each representing new surveys made by the Bureau, were received. Two thousand six hundred and fifty-one office and observatory records were received in the library and archives during the fiscal year.

In the instrument section 963 instruments, apparatus, and tools, etc., were repaired during the year, and 475 instruments, tools, and apparatus were made.

The official records kept by the hydrographic and geodetic engineer in charge of the office show that the total number of permanent and temporary employees in the office and field, which included all employees appointed through civil-service certification, were as follows:

| | |
|---|---|
| Office force | 230 |
| Field force | 217 |
| Total | 447 |

The above is in reference to classified employees. Persons employed in rodding, as chainmen, recorders, and heliotropers in the field parties and enlisted men on vessels of the survey, are not enumerated, as these are variable, depending upon the extent of activities in the field.

The statistics in regard to leaves of absence during the calendar year are as follows:

| | Days. |
|---|---|
| Annual leave | 7,940 |
| Sick leave | 2,190 |
| Without pay leave | 2,423 |
| Accrued leave | 2,252 |

While the number of employees naturally varied on account of resignations and vacancies, calculated on the number actually in the service on June 30, 1920, as a basis of computation, the average annual leave taken during the year by each employee was approximately 20 days and the sick leave 4.9 days.

Based on the official day of seven hours, the overtime performed by the employees of the office during the fiscal year amounted to 1,050 days.

The receipts from the sale of charts, publications, etc., amounted to $58,847.47.

## DIVISION OF HYDROGRAPHY AND TOPOGRAPHY.

The division of hydrography and topography has supervision of all hydrographic and topographic surveys executed by this Bureau, which supervision includes the determination of where surveys or resurveys are required, how they shall be conducted, the preparation of instructions for surveying parties, the organization of the parties, and the inspection of the field work, and examination of the records. It is also charged with the construction, maintenance, and repairs of the vessels and other field equipment, except instruments, the records of the seamen employed on this work, the compilation of the coast pilot in the field and office, the observation of tides and currents, and compilation of tide tables.

For administrative purposes the division is divided into four sections, known as the section of field work, section of vessels and equipment, section of coast pilot, and section of tides and currents. Each of these sections is under the direction of a hydrographic and geodetic engineer, who is responsible for the efficient and economical administration of his section under the general supervision of the chief of the division of hydrography and topography.

The division also has supervision over the five field stations located at Boston, New York, New Orleans, Seattle, and San Francisco, respectively, and over the office at Manila, P. I. The field stations are for the purpose of maintaining close relations between the Bureau and those who have occasion to use its charts, publications, and data, and to keep the Bureau informed of the needs for further work in these general localities. They are in charge of hydrographic and geodetic engineers, but undertake no surveys unless specifically directed to do so by this office. The Manila office performs all of the functions of a field station, and, in addition, has direct charge of all surveys in the Philippine Islands and much of the office work incident to these surveys. This office is in charge of a hydrographic and geodetic engineer, with the title of director of coast surveys.

SHIP AND LAUNCH HYDROGRAPHY.

| | Statute square miles. |
|---|---|
| Ship hydrography performed during fiscal year: | |
| Delaware Bay approach | 213.00 |
| Chesapeake Bay approach | 480.00 |
| Doboy Sound, Ga., entrance | 42.25 |
| Pamlico Sound, N. C | 76.00 |
| Key West vicinity | 300.10 |
| Gulf of Mexico—Pensacola Bay—Chandeleur Islands and offshore surveys | 3,203.00 |
| Mississippi River approach | 225.00 |
| San Francisco Bay | 109.60 |
| Point Arena to Cape Mendocino, offshore surveys | 705.00 |
| Shelikof Strait, Alaska | 650.00 |
| Philippine Islands | 21,770.00 |
| Wire-drag surveys: | |
| Between Portsmouth N. H., and Cape Porpoise, Me | 146.00 |
| Approach to Narragansett Bay and Block Island Sound | 175.00 |
| Lake Washington | 5.00 |
| Stephens Passage, S. E. Alaska | 127.50 |
| Launch hydrography: | |
| Cape Porpoise Harbor, Me | 1.00 |
| Gravesend Bay, N. Y | 2.00 |
| Hampton Roads, Va | 22.25 |

Topography in connection with hydrographic work was executed, as follows:

| | Shore line, statute miles. | Area, square miles. |
|---|---|---|
| Gravesend Bay, N. Y | 6.0 | |
| Hampton Roads, Va | 13.0 | 3.0 |
| Pamlico Sound, N. C | 115.0 | 76.0 |
| Doboy Sound, Ga | 12.0 | 11.0 |
| Vicinity Key West | 18.7 | 2.8 |
| Humboldt Bay, Calif | 17.0 | |
| San Franscisco Bay, Calif | 76.0 | 11.1 |
| Lake Washington and Lake Union, Wash | 110.0 | 50.0 |
| Shelikof Strait, Alaska | 28.0 | |
| Virgin Islands | 44.0 | 50.0 |
| Philippine Islands | 214.0 | 340.0 |

DIVISION OF GEODESY.

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

Computation and adjustment of the following pieces of triangulation:

1. Primary triangulation, Rio Grande arc.
2. Primary triangulation, ninety-eighth meridian, vicinity of Waco, Tex., eastward to Mansfield, La.
3. Primary triangulation, Sanford to oblique arc.
4. Primary triangulation, Mexican-California boundary.
5. Primary triangulation, vicinity of Phoenix, Ariz.
6. In Maryland and District of Columbia.
7. In Massachusetts.
8. In Rhode Island.
9. In New York.
10. In California.
11. In Virginia.
12. In Oregon.
13. In Maine and New Hampshire.
14. In Florida.
15. In Utah and Arizona forest areas.

Computation of the following lines of precise traverse:

1. Norfolk, Va., to Savannah, Ga.
2. Wilmington to Sanford, N. C.
3. Macon to Griffin, Ga.
4. Little Rock, Ark. to Memphis, Tenn.
5. Mansfield to Naples, La.

Computation and adjustment of the following lines of precise levels:

1. Troy to Whitehall, N. Y.
2. Hillsboro, Tex., to Natchez, Miss.
3. Norfolk, Va., to Savannah, Ga.
4. Rouses Point to Niagara Falls, N. Y.
5. Buffalo to Watertown, N. Y.
6. Kirk, Oreg., to Roseville, Calif.
7. San Jose to Santa Ana, Calif.
8. Southeastern United States.

The computation of azimuths along the following pieces of triangulation and traverse were in progress:

1. Savannah, Ga., to Norfolk, Va.
2. Wilmington to Sanford, N. C.
3. Rio Grande arc, Tex.
4. Texas–Louisiana, from the ninety-eighth meridian eastwardly.
5. Utah–Oregon arc.
6. Sanford, N. C., to oblique arc.
7. Little Rock, Ark., westward.
8. Yuma district, Ariz.
9. Little Rock, Ark., to Memphis, Tenn.
10. Macon to Forsyth, Ga.
11. Salt Lake, Utah, to Needles, Calif.
12. North Vernon to South Bend, Ind.

Computations were made of longitude along the Rio Grande arc and the ninety-eighth meridian eastward. Latitudes were computed along the traverse lines in Georgia, North Carolina, and Virginia.

One of the most important pieces of work completed during the past fiscal year was the primary computation of all the traverse lines in Florida, Georgia, North and South Carolina, and Virginia. These lines were run at the request of the Chief of Engineers, U. S. Army, during the war. In this preliminary computation an adjustment was made only for the azimuths, which were held final as observed. The discrepancies resulting from the computation in latitude and longitude were distributed according to the number of positions involved.

In most of the lines of traverse it is difficult to get an idea of the degree of accuracy, on account of the fact that they start with and end on the tertiary triangulation of the coast. But in the two instances where we have complete loops of traverse the errors of closure are comparatively small. For instance, in the all-traverse loop, Macon–Savannah–Everett City, about 400 miles in length, the closure is 1 part in 110,000. In the all-traverse loop, Albany–Callaham, 330 miles in length, the closure is 1 part in 250,000.

Computations were made of a base-line measure at Santo Domingo, the field work for which was done by the United States Geological Survey.

Computations were also made of the triangulation done in the Utah and Arizona forest areas, which was requested by the Forestry Service.

## DIVISION OF CHARTS.

The accomplishments of the chart division, under proper headings, are as follows:

### CHART PREPARATION.

*Drafting.*

| | |
|---|---|
| Schemes approved for new charts | 1 |
| Approved schemes on hand, charts not started | 3 |
| Compilations of charts finished | 14 |
| Compilations of charts in hand | 8 |
| Compilations of started work discontinued awaiting data | 1 |

| | |
|---|---|
| Compilations of started work discontinued for more pressing work | 2 |
| Smooth drawings of charts finished | 11 |
| Smooth drawings of charts in hand | 7 |
| Extensive corrections finished | 99 |
| Extensive corrections in hand | 6 |
| Extensive corrections started, work discontined awaiting data | 2 |
| Drawings for minor corrections finished | 645 |
| Corrections, aids or dangers | 2,334 |
| New charts or new editions for which complete aids were plotted | 73 |
| Proofs of charts verified | 2,176 |
| New drawings of charts from Manila, finished | 5 |
| Drawings of extensive corrections from Manila, finished | 5 |
| Drawings of extensive corrections from Manila in hand | 1 |

*Engraving.*

| | 1916 | 1917 | 1918 | 1919 | 1920 |
|---|---|---|---|---|---|
| New plates for new charts finished | 2 | 8 | 6 | 6 | 4 |
| New plates for new charts in hand | 11 | 6 | 9 | 6 | 5 |
| New plates for lithograph charts finished | 0 | 3 | 2 | 1 | 0 |
| New plates for lithograph charts in hand | 3 | 2 | 1 | 1 | 0 |
| New bassos for new editions finished | 11 | 16 | 8 | 12 | 11 |
| New bassos for new editions in hand | 16 | 3 | 7 | 8 | 4 |
| New bassos for reissues finished | 3 | 9 | 17 | 9 | 13 |
| New bassos for reissues in hand | 10 | 18 | 10 | 9 | 8 |
| New editions using current plates finished | 24 | 32 | 16 | 12 | 15 |
| New editions using current plates in hand | 2 | 2 | 14 | 4 | 0 |
| Extensive corrections applied to plates | 314 | 269 | 144 | 175 | 158 |
| Extensive corrections applied to plates in hand | 14 | 7 | 17 | 5 | 20 |
| Miscellaneous plates engraved or corrected | 22 | 21 | 1 | 2 | 13 |
| Minor corrections applied to plates | 1,158 | 696 | 719 | 236 | 247 |
| Charts in section, engraving not started | 0 | 0 | 0 | 2 | 1 |
| Various miscellaneous engraving | ..... | ..... | ..... | ..... | ..... |

*Photographing.*

| | | | | | |
|---|---|---|---|---|---|
| Glass negatives made | 1,225 | 1,109 | 1,208 | 1,592 | 1,481 |
| Paper negatives made | 11 | 0 | 6 | 0 | 0 |
| Velox prints made | 4,313 | 3,413 | 1,761 | 2,430 | 1,345 |
| Vandyke prints made | 52 | 36 | 8 | 0 | 0 |
| Bromide prints made | 500 | 391 | 489 | 359 | 322 |
| Blue prints made | 2,411 | 1,921 | 1,513 | 1,824 | 993 |
| Photostat prints made | 18,519 | 19,017 | 11,550 | 22,476 | 16,416 |
| Lantern slides made | 354 | 208 | 109 | 88 | 45 |
| Matrices made | 43 | 96 | 52 | 18 | 108 |
| Redeveloping prints | ..... | 197 | 267 | 0 | 79 |
| Prints mounted | 39 | 63 | 118 | 39 | 214 |
| Negatives developed | 32 | 41 | 22 | 235 | 10 |
| Photolithographic negatives for charts | 30 | 29 | 110 | 354 | 590 |
| Various miscellaneous negatives and prints | ..... | ..... | ..... | ..... | ..... |

Two outstanding and sharply contrasting facts tell the story of the division of charts for the past fiscal year.

1. The issue of charts has been the greatest of any year of the more than 100 that the Bureau has been in existence.

2. The failure of Congress to provide salaries adequate to enable the Bureau to fill existing vacancies in its technical chart-producing force has made the problem of meeting this increased demand one of unusual difficulty.

Navigational charts are as essential to the upbuilding of an American merchant marine as are the compasses or the engines of the vessels themselves. Without the charts of the Coast and Geodetic Survey free and unrestricted intercourse by water is impossible, as this Bureau alone produces the charts of all navigable tidal waters under the jurisdiction of the United States.

The gradual increase in the number of charts issued, culminating in the abruptly increased issue during and subsequent to the war, is shown in the following table, in which the issue for the fiscal year 1900 is taken as 100 per cent and the figures for the subsequent years represent the ratio of the issues for those years to the 1920 issue:

| 1900 | 1905 | 1910 | 1915 | 1917 | 1918 | 1919 | 1920 |
|---|---|---|---|---|---|---|---|
| 100.0 | 145.7 | 168.1 | 181.8 | 353.6 | 339.9 | 441.5 | 455.8 |

It should not be assumed that this increase in the issue of charts necessitates a corresponding increase in the force required to produce them. The time and effort required in chart production is expended in handling the miscellaneous data received from various sources, compiling them into the form in which they are to be published, and carrying them through the various processes by which they are finally put down on the printing plate. Once the plate is ready for printing, with presses printing from 1,000 to 3,000 charts per hour, it is a simple matter to so increase the size of the editions printed as to take care of any reasonable increase in demand.

These large issues of charts in recent years, therefore, are chiefly significant as indicating the increasing extent to which the charts are being used, and in direct consequence the increasing importance of keeping them so adequate and up to date that the mariner can use them with assurance that they portray the actual present conditions of the waters he is traversing.

At present such assurance is not justified by the facts. Some of our charts are all that they should be. They are constructed according to the best modern practice and the information shown on them is adequate and up to date. Others, however, are so antiquated as to be of questionable value. They were constructed many years ago on projections which have long since been discredited for navigational use, and the information shown on them is so obsolete, due to progressive natural and artificial changes in the regions charted, that recent data received as a result of surveys by the Coast and Geodetic Survey, the Army Engineers, and the Geological Survey can not properly be coordinated with the remainder of the chart.

This, then, is the present situation. We at present have charts more or less modern of all navigable waters of the United States and its dependencies. Some of these charts are not what we would have them; they are on the polyconic instead of the Mercator projection; they are not oriented with the meridian; they have an unstaisfactory, or two units of soundings; they are not of adequate scale for most efficient use; the surveys upon which they are based have been superseded by later ones, of which only the most essential parts of the information obtained are charted, or the surveys themselves are inadequate or incomplete, etc.

Our problem is twofold—first, and most important, to keep our present charts corrected for all essential information received since they were originally compiled; and, second, to as rapidly as possible replace our present unsatisfactory charts with new ones conforming

to our present standards. Correction of the present charts must be given precedence. The essential parts of the constant stream of information pouring into this office, showing the river and harbor improvements by the United States engineers, changes in aids to navigation by the Bureau of Lighthouses, natural or artificial changes in channels or shoals revealed as a result of our own surveys, and water-front development by various municipal or private agencies, must be passed on to the navigator. Only such time as remains from this task can be devoted to the production of new charts.

In 1910, and again in 1916, thorough surveys of this situation were made and a definite program of chart reconstruction was adopted. To-day, 10 years after the work on this program was begun, this program is less than 50 per cent completed.

The present situation, therefore, is one of long standing. It is not a result of the war; in fact, the war has tended to improve it rather than make it worse, for the amount of material for chart correction received during the war was much below the normal, due to the transfer to military duties of the men who formerly had been collecting such material in the field.

The reason for this situation is lack of trained personnel to produce the charts.

The number of employees required should be measured by the amount of data received by the Bureau for application to the charts. Between 1900 and 1919 the amount of such material received increased over 150 per cent, while the number of employees authorized to chart it increased only 16 per cent. Obviously, if the methods and practices in use in 1900 were even reasonably efficient according to the then existing standards, the only possible result would be that much of the information received would never be adequately shown on our charts. Such has been the actual result. In spite of every ecoomy in time and effort which the Bureau has been able to effect, we are to-day issuing to the navigator charts which are obsolete in many important respects, while the material from which modern and adequate charts might be constructed is lying in our achives.

The remedy for this situation is twofold:

1. Slight increases in the numbers of employees authorized in the various sections engaged in chart production.

2. Such increases in the salaries of positions at present authorized as will enable the Bureau to fill existing vacancies and to hold the men who demonstrate their capacity for the work.

Consider, for example, the draftsmen. The drafting force completes and verifies records turned in by the field parties, compiles all the material into the form in which it is finally to appear on the charts, and makes finished drawings of such charts. The present authorized number of draftsmen is 36. Forty would be an adequate number to properly handle the work. But of the 36 authorized positions, approximately 40 per cent have been vacant during the past fiscal year, and there is no prospect of filling those vacancies at the salaries which the Bureau is authorized to pay. The draftsman should have had at least three years of a civil-engineering course. For men so trained the Bureau is offering $1,200 and $1,400 per annum, or little more than half what its competitors both inside and outside the Government service have been offering.

The increased demand has been met. The charts have been kept in print, and have been corrected promptly for the essential parts of all information received at the office in condition to use. That of itself, considering all the circumstances, is an achievement in which the Bureau may well take pride. But it has been accomplished, in part at least, at the sacrifice of certain desirable qualities in the charts, and it has left too little time available for work on the program of chart reconstruction.

Another noteworthy feature of the division's work during the year has been its contributions to the science of map projection, with particular reference to those projections whose qualities adapt them to use in maps of the whole United States or the North American Continent. Two base maps of the United States, on the Lambert conformal conic projection and the Lambert zenithal equal-area projection, respectively, and an Aitoff's equal area projection of the sphere have recently been published, along with a number of treatises on these and other projections. The demand for these projections has greatly exceeded our expectations and affords ample evidence of the service which may be rendered the public by studies of this character. It is worthy of note, in passing, that much of the work on these subjects was done outside of office hours. The graphic diagrams opposite this page show the issue of charts from 1896 to 1920, inclusive, and the issue of Coast Pilots from 1901 to 1920.

## DIVISION OF TERRESTRIAL MAGNETISM.

The reduction of the work of the Honolulu magnetic observatory for 1917 and 1918 was completed and the results were submitted for publication. At the end of the year results for the same period for the Sitka and Tucson observatories were ready for publication, except for the preparation of tracings of the principal magnetic storms, and the reduction of the Porto Rico work was nearly completed. The reduction of the Cheltenham results was delayed until the conclusion of the investigation of the difference between the records of the two $H$ variometers.

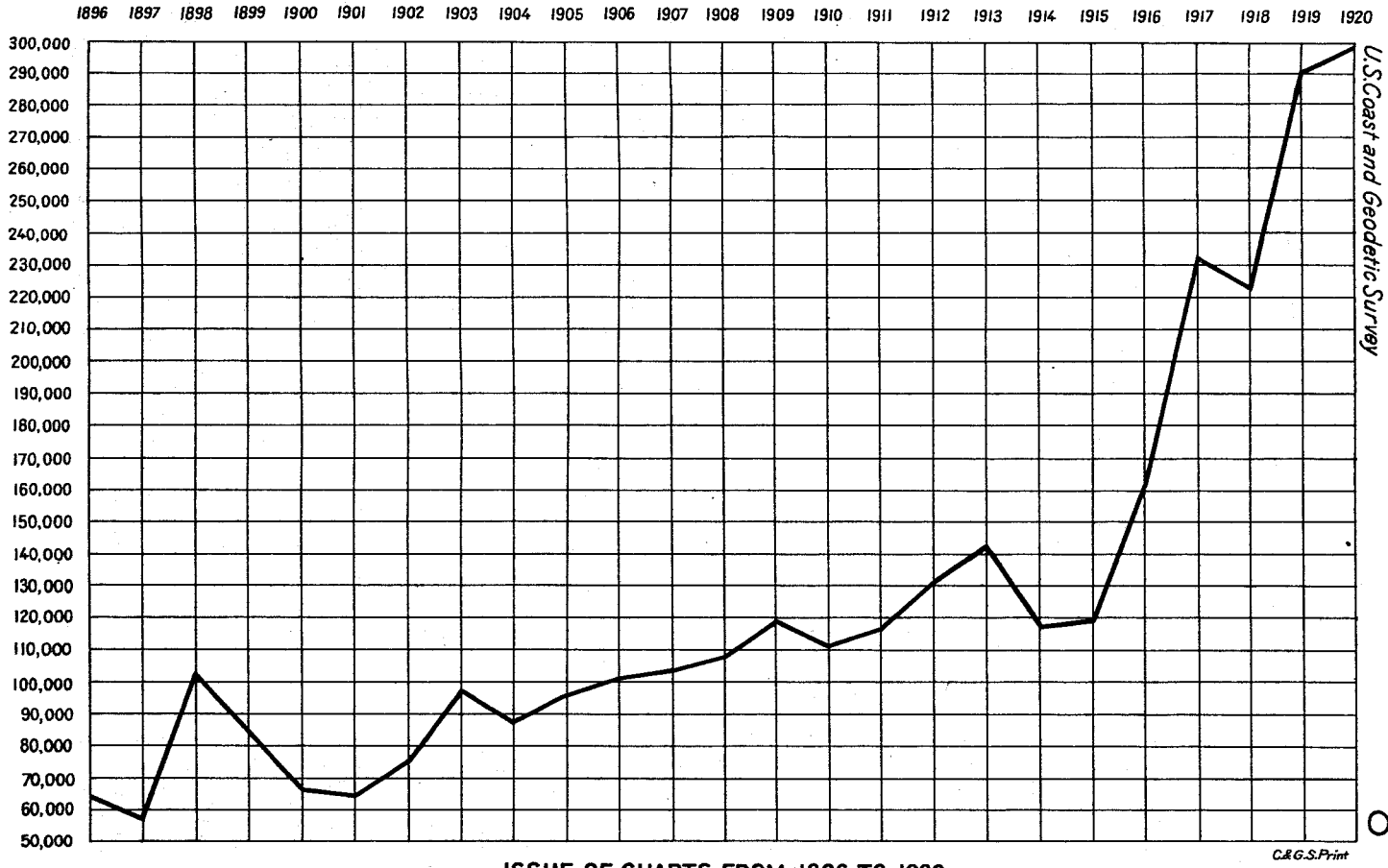
The investigation of the difference between the two $H$ variometers at Cheltenham is still in progress. The Eschenhagen variometer was readjusted in September, 1919, so as to have the magnet more nearly in the magnetic prime vertical, and the subsequent results are in better agreement, but there are outstanding differences still to be explained.

Considerable progress was made in the reduction of the observations for 1919. The tabulation of the hourly ordinates for Honolulu, for July, August, and September, was made. The observer had been unable to do this at the observatory because of eye trouble.

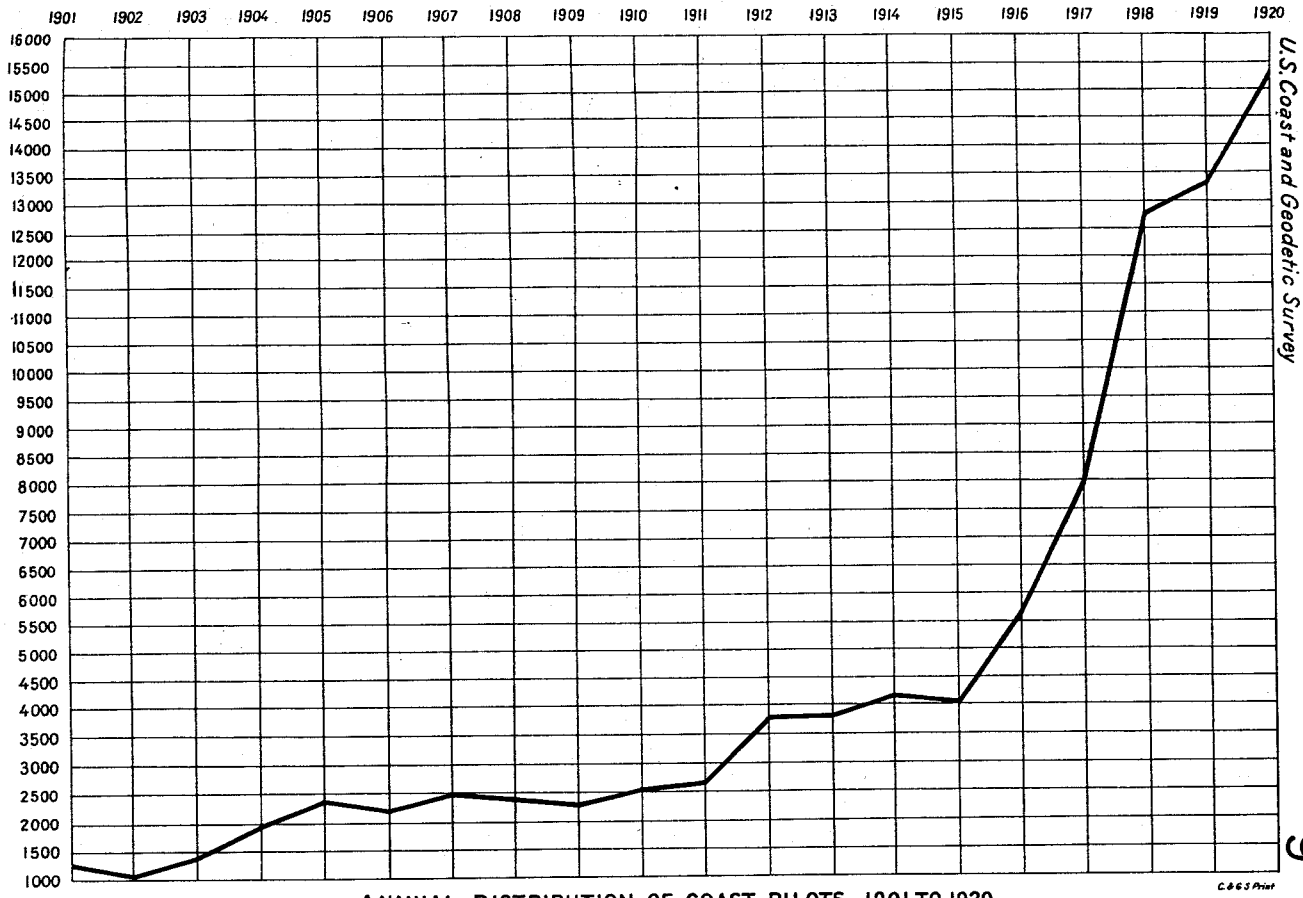
The results of the field work executed during 1919 were computed and prepared for publication as Special Publication No. 64.

The results of magnetic observations made in Alaska up to the end of 1918 were published as "Alaska Magnetic Tables and Magnetic Charts for 1920," Special Publication No. 63. This includes secular change tables and charts showing the lines of equal magnetic declination, dip, and horizontal intensity.

The earthquakes recorded at five magnetic observatories have been tabulated monthly, and the results have been published in the




ISSUE OF CHARTS FROM 1896 TO 1920




ANNUAL DISTRIBUTION OF COAST PILOTS 1901 TO 1920

Monthly Weather Review and transmitted to the International Seismological Association and others engaged in a comparative study of earthquake data.

Special observatory data were prepared for the department of terrestrial magnetism of the Carnegie Institution of Washington, the Dominion Observatory of Canada, and the observatory at Eskdalemuir, Scotland.

A table giving values of the magnetic declination and the annual change for numerous places in the United States was prepared for the 1921 World Almanac.

An isogonic chart of the United States for 1921 was prepared for C. H. Birdseye, of the Geological Survey, for use in a new edition of appendix 1 to Part III of his "Orientation for Coast Artillery."

A report on magnetic variations recorded at the five observatories at the time of the solar eclipse of May 29, 1919, was prepared for the department of terrestrial magnetism of the Carnegie Institution of Washington.

Reports on the magnetic storms of August 11, 1919, and March 22, 1920, were prepared for the Journal of Terrestrial Magnetism; also an article explaining some of the methods adopted in the reduction of work of our magnetic observatories.

Chapters on terrestrial magnetism and seismology were prepared for the new edition of Special Publication No. 23, and the chapter on terrestrial magnetism in "General Instructions for Field Work" was revised.

An extended series of observations was made, in cooperation with the division of geodesy, to determine the magnetic properties of the new invar pendulums and the effect of the earth's magnetism upon their time of oscillation.

A test was made as to the practicability of using a planimeter for reading the hourly ordinates from magnetograms.

An investigation was made of the accuracy of the time scales of our seismographs, which showed that in most cases a better time-marking clock is needed. The experience with a chronometer at Tucson indicates that the needed improvement can be secured in that way.

Compass data were supplied for 165 charts.

### SEGREGATING THE RESULTS OF SURVEYS A BENEFIT.

The geodetic surveys by this Bureau cover large areas of the country. In the past it has been the practice to issue publications containing the results of these surveys with reference to the area covered by the particular arc of triangulation or line of precise leveling and without reference to any geographical portion of the country. (See fig. 50 opposite p. 136.) These surveys established the framework for large mapping and surveying projects throughout the country, as well as to determine State and national boundaries. Before these surveys had been sufficiently extended to establish triangulation stations and elevations sufficiently numerous to be of use for local projects but little attempt had been made to bring them to the attention of those interested in these local projects. Now that these surveys are sufficiently extended to make the points determined sufficiently numerous to be of use locally, there is no reason why the data

resulting from them, when the points are within available distance, should not be used for these local projects.

With this realization came the knowledge that the publications as heretofore issued, covering, as they do, many States in the Union, were not sufficiently known to local engineers. Furthermore, it was realized that to send out announcements regarding these publications without a definite guide as to their contents would result in random requests for them and a wasteful distribution. Therefore an endeavor was made to economically place the geodetic and other data in the possession of this Bureau at the disposal of local civil engineers and surveyors and to call them to the attention of all likely to be interested in local surveying projects. In putting this information into practical form, work is now in progress in making for each State in the Union a separate digest of the geodetic publications issued by this Bureau. Up to the present time digests have been made for Iowa, Minnesota, and Illinois. These digests contain in alphabetical order the counties in the State, and by a tabular arrangement are shown in alphabetical order each place in each county where our observations (triangulation, leveling, and magnetic) have been made, the publication of the Bureau containing the data, and the page in the publication where the data will be found. Each of these digests is accompanied by a small outline diagram of the State upon which, by symbols, are shown where triangulation, leveling, and magnetic observations have been made. (See fig. 9a.)

The response in requests for information resulting from the issue of these digests is exceedingly gratifying and demonstrates the need for some such means of economically bringing to the public the information that this Bureau has accumulated in its more than 100 years of existence and of which the public heretofore has had too little acquaintance.

## PUBLICATIONS ISSUED DURING THE YEAR.

Serial No. 104. U. S. Coast Pilot, Philippine Islands. Part 1. Luzon, Mindoro, and Visayan. First edition, 1919. Octavo.

Contains sailing directions for and descriptions of the coasts of these islands for the use of navigators. Covers the area formerly included in Sections I to IV of the Philippine Islands Sailing Directions.

Serial No. 108. Pacific Coast Tide Tables for Western North America, Eastern Asia, and Many Island Groups for the Year 1920.

(Reprinted from General Tide Tables for the year 1920.)

Serial No. 110. General Theory of Polyconic Projections. By Oscar S. Adams, geodetic computer. Special Publication No. 57. 174 pp. 1 map, 48 figs.

In this volume an attempt has been made to gather together all of the investigations that apply to the systems of polyconic projections for maps.

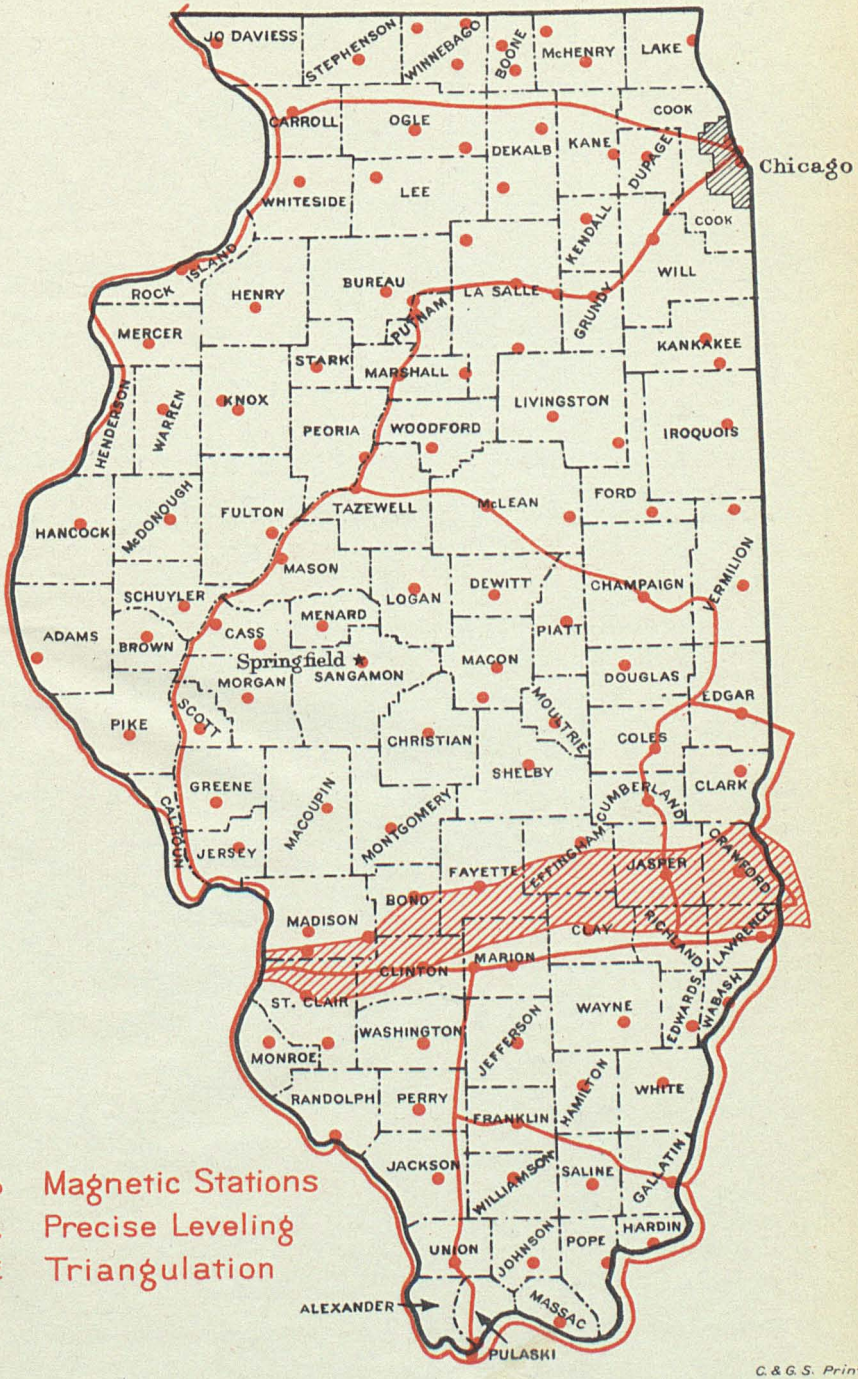
Serial No. 111. Geodesy. General Instructions for Precise and Secondary Traverse. Special Publication No. 58. 49 pp. 5 figs. Octavo.

Designed for highest class of traverse, equal in accuracy to primary triangulation, and for secondary traverse comparable in accuracy with secondary triangulation.

Serial No. 112. Grid System for Progressive Maps in the United States. By William Bowie, chief, division of geodesy; major of engineers, U. S. Army, 1918–1919; and Oscar S. Adams, geodetic computer. Special Publication No. 59. 227 pp. 6 fig. Octavo.

Contains a description of the grid system devised for use in surveys and maps of the United States, and the method of using the same, with a table of grid coordinates for five-minute intersections covering an area 9° wide in longitude and 21° 20′ in length in latitude. These tables can be used for the whole area of the United States proper by changing the designation of the longitude to fit the particular zone needed.

# ILLINOIS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McLEAN
FORD
HANCOCK
MASON
DEWITT
CHAMPAIGN
VERMILION
SCHUYLER
LOGAN
MENARD
CASS
PIATT
ADAMS
BROWN
Springfield
SANGAMON
MACON
DOUGLAS
MORGAN
EDGAR
SCOTT
PIKE
CHRISTIAN
MOULTRIE
COLES
SHELBY
GREENE
CLARK
CALHOUN
MACOUPIN
MONTGOMERY
CUMBERLAND
JERSEY
FAYETTE
EFFINGHAM
JASPER
CRAWFORD
BOND
MADISON
CLAY
RICHLAND
LAWRENCE
CLINTON
MARION
ST. CLAIR
WAYNE
EDWARDS
WABASH
WASHINGTON
JEFFERSON
MONROE
RANDOLPH
PERRY
HAMILTON
WHITE
FRANKLIN
JACKSON
SALINE
GALLATIN
WILLIAMSON
HARDIN
UNION
JOHNSON
POPE
ALEXANDER
MASSAC
PULASKI
Magnetic Stations
Precise Leveling
Triangulation

Serial No. 113. A Study of Map Projections in General. By Oscar S. Adams, geodetic computer. Special Publication No. 60. 24 pp. 15 figs. Octavo.

In this publication an attempt has been made to treat in a simple way some of the fundamental ideas that underlie the subject of map projections in general.

Serial No. 115. General Tide Tables for the Year 1920. 497 pp. 7 figs. Octavo. Price, 50 cents.

Gives tidal data for the principal seaports of the United States and for many foreign ports, and tables by means of which tides may be calculated for other localities. Also current tables and diagrams for many localities and tables of sunrise and sunset and moonrise and moonset.

Serial No. 116. Supplement to U. S. Coast Pilot, Atlantic Coast. Section D, July 18, 1920. 27 pp. Octavo.

Gives the more important corrections and additions affecting the text of the Coast Pilot volume since its publication.

Serial No. 117. Supplement to U. S. Coast and Geodetic Survey Catalogue of Charts, Coast Pilots, and Tide Tables, 1918. 6 pp. Quarto. August 15, 1919.

Gives corrections to the list of published charts, coast pilots, and tide tables.

Serial No. 118. Catalogue of Charts, Coast Pilots, and Tide Tables. January 2, 1920. 218 pp. 85 figs. Quarto.

Corrected to date of issue. Lists 659 charts, besides miscellaneous maps; also topographic maps compiled by the Philippine Government.

Serial No. 119. Catalogue of Charts, Sailing Directions, and Tide Tables of the Philippine Islands, 1920.

(Reprinted from the General Catalogue of Charts, Coast Pilots, and Tide Tables.)

Serial No. 120. Physical Laws Underlying the Scale of Sounding Tubes. By Walter D. Lambert, geodetic computer. Special Publication No. 61. 45 pp. 2 figs. Octavo.

Contains development of general formulas for sounding tubes, and numerical data and tables for the new sounding tube of the Coast and Geodetic Survey.

Contains also a compilation of physical data likely to prove convenient in a further study of the subject.

Serial No. 121. Special Publication No. 62. Triangulation in Rhode Island. By Earl F. Church.

97 pp. 1 pl. 8 text fig. Octavo.

Serial No. 122. Inside Route Pilot, Key West to New Orleans, 1919. Second edition. 82 pp. 6 maps in pocket. Octavo. Price, 10 cents.

Describes the inside routes along the Gulf of Mexico between Key West and New Orleans. The maps show routes practicable for small vessels.

Serial No. 123. Atlantic Coast Tide Tables for Eastern North America for 1920.

(Reprinted from the General Tide Tables for the year 1920.)

Serial No. 124. Pacific Coast Tide Tables for the year 1921.

(Reprinted from General Tide Tables for the year 1921.)

Serial No. 125. Terrestrial Magnetism. Alaska Magnetic Tables and Magnetic Charts for 1920. By Daniel L. Hazard, assistant chief, division of terrestrial magnetism. Special Publication No. 63. 31 pp. 3 maps in pocket. Octavo.

Contains observed and reduced results of the most recent magnetic observations in Alaska and adjacent regions. The maps show, respectively, lines of equal magnetic declination, inclination, and horizontal intensity.

Serial No. 127. Inside Route Pilot, New York to Key West. Fourth edition. 1920. 93 pp. 8 charts in pocket. Octavo. Price, 20 cents.

Serial No. 128. Terrestrial Magnetism. Results of Magnetic Observations Made by the United States Coast and Geodetic Survey in 1919. By Daniel L. Hazard, assistant chief, division of terrestrial magnetism. Special Publication No. 64. 27 pp. Octavo.

Gives results of magnetic observations at the magnetic observatories and in the field in 1919.

Serial No. 129. Leveling. Terrestrial Magnetism. Digest of Geodetic Publications Issued by the United States Coast and Geodetic Survey Resulting from Surveys in the State of Iowa. 6 pp. 1 fig. Octavo.

Summary of results of geodetic surveys in Iowa available for engineers.

Serial No. 130. Geodesy. Instructions to Light Keepers on Primary Triangulation. Special Publication No. 65. 51 pp. Duodecimo.

Gives detailed instructions in regard to signaling, care of electric signal lamps and batteries, accounts, etc.

Serial No. 131. Digest of Geodetic Publications Issued by the United States Coast and Geodetic Survey Resulting from Surveys in the State of Minnesota. Triangulation, leveling, variations of compass. 1920. 12 pp. 1 map.

Summary of results of geodetic surveys in Minnesota available for engineers.

Annual Report of the Superintendent of the United States Coast and Geodetic Survey for the Fiscal Year Ended June 30, 1919. 150 pp. 6 pl. 40 maps. Octavo. Cloth.

Contains report of the work done during fiscal year ending June 30, 1919; of conditions in the service occasioned by the war and the rise in living costs; of need for reestablishment of normal conditions in the service; need of new building; illustrated by diagrams and maps.

Two New Base Maps of the United States. Description by Charles H. Deetz. 44 pp. Octavo.

A brief description of two base maps recently constructed by this Bureau, one on Lambert's zenithal equal area projection and the other on Lambert's conformal conic projection with two standard parallels.

Coast Pilot Notes on the Hawaiian Islands. Second edition. 60 pp. Octavo. August 15, 1919. Price, 20 cents.

Supplement to United States Coast Pilot. Section D. January 2, 1920. 25 pp. Octavo.

This supplement gives the more important corrections and additions affecting the text of the Coast Pilot volume since its publication. The supplement is printed on one side only, so that it may be cut up and the slips inserted on the pages affected.

Notices to Mariners. Issued weekly, jointly with the United States Bureau of Lighthouses. Nos. 1–52.

Philippine Islands Notices to Mariners. Nos. 2, 3, 4 of 1919 and No. 1 of 1920.

Coast and Geodetic Survey Bulletin. Issued monthly. July, 1919, to June, 1920, inclusive.

NEW CHARTS AND NEW EDITIONS OF CHARTS.

New charts:

187a. Western approach to Pensacola Bay, Fla. and Ala.
220. Stratford to Sherwood Point.
221. Sherwood Point to Stamford Harbor, Conn.
224. Oyster and Huntington Bays, south shore of Long Island Sound.
245. Harbors of Plymouth, Kingston, and Duxbury.
801. Calais to West Quoddy Head.
1209. Nantucket Sound and approaches.
1266. Mobile Bay and entrance, Ala.
1267. Mississippi Sound and approaches, Dauphin Island to Cat Island.
1268. Lake Borgne and approaches.
4314. Northern part of Busuanga.
4319. Green Island Bay, Palawan and vicinity, P. I.
4355. Harbors on Dumaran Island, P. I.
8102. Hecate Strait to Etolin Island.
8152. Dixon entrance to Chatham Strait.

New editions of charts:

101. Calais to Little River, including Gobscook Bay, Me.
154. Isle of Palms to Hunting Island.
156. Savannah to Sapelo Island.
157. Sapelo Island to Amelia Island.
158. St. Marys entrance and southward to latitude 30° N.
159. St. Augustine Inlet to Halifax River, Fla.
166. Key Biscayne to Carysfort Reef.
167. Elbow Key to Matecumbe Key.
169. Newfound Harbor Key to Boca Grande Key.
204. Galveston Bay.
243. Ipswich Bay to Gloucester Harbor.
245. Harbors of Plymouth, Kingston, and Duxbury.
248. Boston Inner Harbor.
276. Harbors of Refuge at Point Judith and Block Island.
278. Providence River and Head of Narragansett Bay.
274. Harlem River.

New editions of charts—Continued.

284. Hudson River—Corsackie to Troy.
293. New London Harbor and Naval Station.
317. Winter Harbor, Schoodic Peninsula.
325. Portland Harbor, Me.
329. Portsmouth Harbor.
330. Isles of Shoals.
352. Providence Harbor, R. I.
353. Narragansett Bay, R. I.
366. Hempstead Harbor.
369. New York Harbor, N. Y. and N. J.
381. Philadelphia water front, Schuylkill River.
400. Hampton Roads.
413. Pensacola Bay entrance.
428. Winyah Bay.
431. Charleston Harbor.
434. North Edisto River.
440. Tybee Roads, Savannah River, and Wassaw Sound (2 new editions).
445. Charleston and vicinity.
450. Satilla River, Bailey Cut to Burnt Fort, Ga.
494. York River, entrance to Yorktown.
525. Brazos River entrance.
541. New York Harbor, Upper Bay and Narrows, N. Y. and N. J.
560. Potomac River, Mattawoman Creek to Georgetown.
584. Key West Harbor and approaches.
908. San Juan Harbor.
950. Colon Harbor, Canal Zone.
1111. Charleston Light to Cape Canaveral.
1205. Cape Elizabeth to Portsmouth.
1206. Portsmouth to Cape Ann.
1208. Cape Cod Bay.
1211. Block Island Sound.
1214. Shinnecock Light to Fire Island Light.
1222. Chesapeake Bay entrance.
1229. Currituck Beach to New Inlet.
1232. Cape Hatteras, Wimble Shoals to Ocracoke Inlet.
1269. Lakes Pontchartrain and Maurepas.
4109. Honolulu Harbor.
4219. Passages between Luzon and Masbate, and Sorsogon Bay.
4346. Harbors of Palawan Island, P. I.
4347. Harbors of Balabac Island, P. I.
4416. Iloilo and Guimaras Straits.
4454. Harbors of Burias and Ticao Islands and Ragay Gulf, P. I.
4714. Southwestern Luzon and Mindoro.
4716. Palawan Island.
4720. Balabac Strait and approaches.
5532. San Francisco entrance.
5602. Point Arena to Trinidad Head.
5971. Coquille River entrance.
5984. Coos Bay.
6003. Umpqua River entrance.
6023. Siuslaw River.
6112. Tillamook Bay, Oreg.
6122. Nehalem River.
6153. Columbia River from Grims Island to St. Helens.
6154. Columbia River, St. Helens to Willamette River, including Vancouver and Portland. (2 new editions.)
6380. Washington Sound.
6400. Seacoast and interior waters of Washington, from Grays Harbor to Semiamoo Bay.
6443. Port Orchard, northern part, Puget Sound.
6448. Everett Harbor and approaches.
6451. Commencement Bay and city of Tacoma, Wash.
7002. Cape Flattery to Dixon entrance.
8068. Custom House Cove and Mary Island anchorage.

New editions of charts—Continued.
8077. Harbors in Prince of Wales Island.
8170. Wrangell Harbor.
8300. Lynn Canal and Stephens Passage.
8302. Lynn Canal, entrance to Point Sherman.
8304. Icy Strait and Cross Sound, Port Frederick to Cape Spencer.
8520. Prince William Sound, eastern entrance.
8550. Prince William Sound.
8588. Port Chatham, Alaska.

Of the publications mentioned above issued during the fiscal year there are some that are important enough to justify special mention.

One of these is an outline base map of the United States on the Lambert zenithal equal-area projection, scale 1:7,500,000, dimensions 19¾ by 25¾ inches. This map covers the whole of the United States, including the northern part of Mexico. Only State names and boundaries, principal rivers, capitals, and largest cities are shown, the chief object being to furnish a base map for political, census, or statistical purposes on a projection in which the property of equivalence of area is one of the essential features. It is the first publication of a projection of this type by the Bureau.

The two errors, to one or both of which all map projections are liable, are changes of area and distortion, as applying to portions of the earth's surface. The former error is perhaps best illustrated by the Mercator projection, in which a unit of area at the Equator is represented by one approximating infinity as we approach the pole, the projection being thus responsible for many false impressions of the relative size of countries differing in latitude. Likewise, the polyconic projection, when used for the whole of the United States has the serious defect of exaggerating the areas of its eastern and western limits. Errors of distortion imply deviation from right shape in the graticules or network of meridians and parallels of the map, involving deformation of angles, curvature of meridians, changes of scale, and errors of distance, bearings, or area.

In the Mercator projection, as well as in the Lambert conformal conic projection, the changes in scale and area can not truly be considered as distortion or as errors. A mere alteration of size in the same ratio in all directions is not considered distortion or error. These projections being conformal, both scale and area are correct in any restricted locality when referred to the scale of that locality, but as the scale varies in latitude from point to point large areas are not correctly represented.

Inasmuch as the favorable showing required to meet any particular mapping problem necessitates the sacrifice of other less desirable properties, the choice of a projection should be made the subject of special study, and, as a rule, that system of projection should be adopted which will give the best results for the area under consideration. The use of a projection to which it is not suited is, therefore, generally unnecessary and should be avoided. On the one hand, a projection may be constructed in which there is no change of area, as in the projection under consideration, but with distortion for localities that are distant from the center; on the other hand, a projection may have little distortion but great change of area in distant parts. Between these lie the properties usually adopted by geographers with the tacit purpose of greatly reducing the error of one

kind by the admission of a small error of the other kind, so that the result of their combination shall be most advantageous to the general use of the map.

In the Lambert zenithal projection the zenith of the central point of the surface to be represented appears as pole in the center of the map; the azimuth of any point within the surface, as seen from the central point, is the same as that for the corresponding points of the map; and from the same central point, in all directions, equal great-circle distances to points on the earth are represented by equal linear distances on the map. The amount of scale error as we depart from the center of the map radially increases (scale becoming smaller), while in a direction at right angles thereto the scale is by the same amount too great. For a distance from the assumed center of the map equal to 22° of arc of a great circle, an extent embracing the whole of the United States, the maximum scale error is but $1\frac{7}{8}$ per cent. The amount of this error is less than one-third of the scale error in a polyconic projection of the same area, while the direction errors (errors of angles and azimuths) are likewise considerably less than in the latter projection.

Whereas the Lambert conformal and the polyconic projections are suited to areas of large extent, the former for predominating east and west dimensions and the latter for predominating north and south dimensions, the zenithal projection is specially suited to large areas of circular outline, the reason for its selection in the present base map being governed by the inclusion of a large extent of Mexico within its limits.

The more essential or desirable feature of the projection under consideration, however, and the one that will meet numerous modern demands, is the property of equivalence of area. An equal area or equivalent projection is one in which areas on the projection are proportional to the corresponding areas on the sphere; that is, any portion of the map bears the same ratio to the region represented by it that any other portion does to its corresponding region.

The useful property equivalence of area as a controlling element to be ascertained directly from the map gives the Lambert zenithal projection a place in cartography accordingly as the shapes of extensive areas have approximately equal magnitudes in all directions.

Another base map of the United States was developed during the year on the Lambert conformal projection on a scale of 1:5,000,000. The dimensions of this map are 25 by 39 inches.

This map is similar to the one on the zenithal equal-area projection in general treatment. It is larger in scale, however, but embraces a lesser extent of latitude, being limited to the area of the United States, whereas the zenithal equal-area map includes the greater portion of Mexico. The map is of special interest from the fact that it is based on the same system of projection as that which was employed by the allied forces in the military operations in France. This projection is also used in a map covering the North Atlantic Ocean, including the greater part of North America and Europe.

The term "conformal" has been defined as follows: If at any point the scale along the meridian and the parallel is the same (not correct, but the same in the two directions) and the parallels and

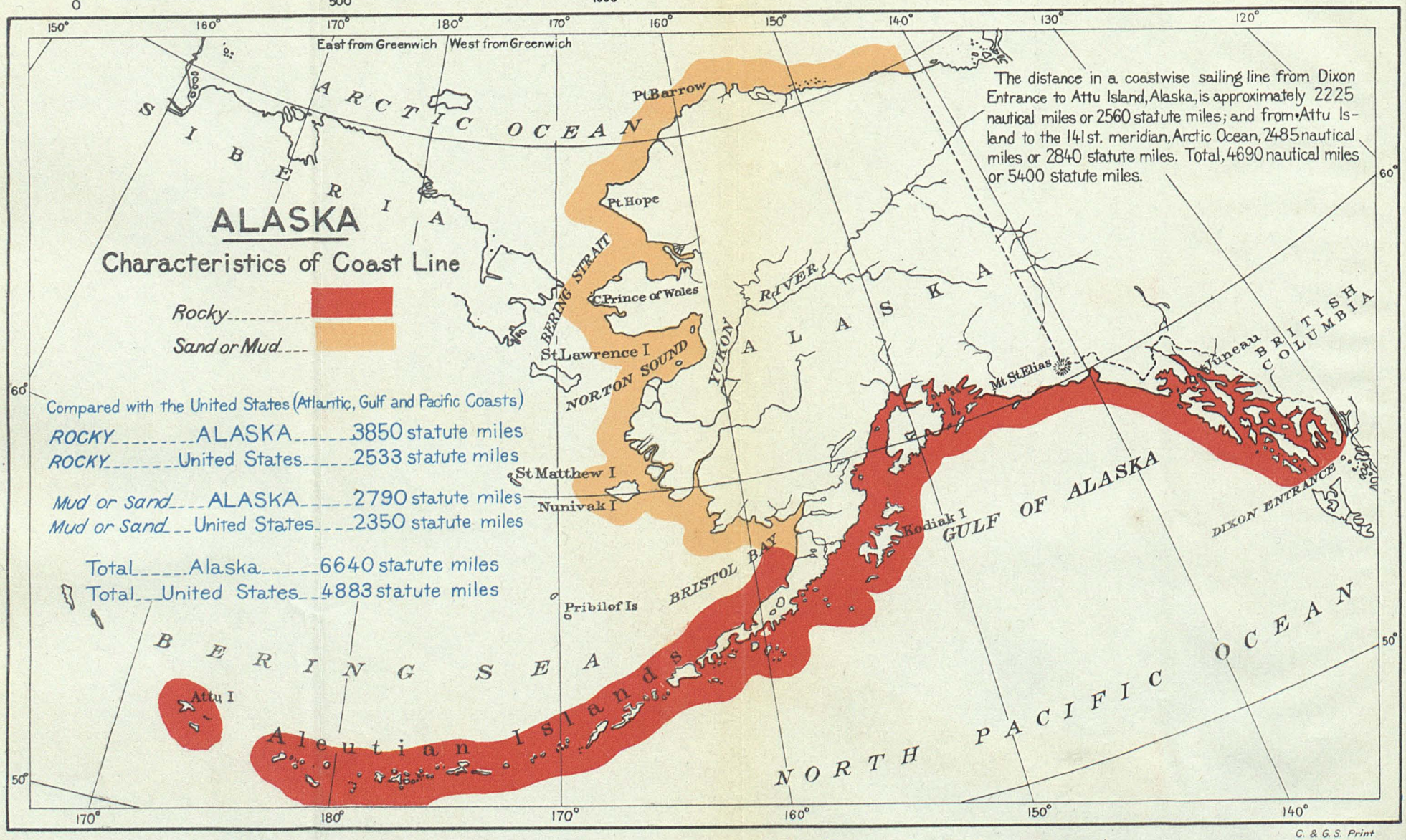
meridians of the map are at right angles to one another, then the shape of any very small area on the map is the same as the shape of the corresponding small area upon the earth. The projection is then called orthomorphic (right shape).

The value of this new outline map can best be realized when it is stated that throughout the larger and most important part of the United States—that is, between latitudes 30½° and 47½°—the maximum scale error is only one-half of 1 per cent. Only in southernmost Florida does this projection attain its maximum scale error of 2½ per cent. This implies, however, an error in the areas at these extreme parts of 5 per cent. Although this error in area may be accounted for by methods already described, the zenithal projection, on the other hand, is free from this inconvenience.

The choice, then, between the Lambert zenithal and the Lambert conformal for a base map of the United States, disregarding scale and direction errors which are conveniently small in both projections, rests largely upon the choice of equal areas as represented by the zenithal and conformality as represented by the conformal conic projection, the former properly appealing directly to the practical use of the map, the latter property being one of mathematical refinement and symmetry with definite scale factors available, the projection having two parallels of latitude of true scale, the advantages of straight meridians as an element of prime importance, and the possibilities of indefinite east-and-west extension without increase of scale error. For the purposes and general requirements of a base map of the United States, either of these recent publications of the United States Coast and Geodetic Survey offers advantages to other systems of map projection heretofore in use.

Comparison of errors of scale and errors of area in a map of the United States on three different projections follows:

| | Per cent. |
|---|---|
| Maximum scale error: | |
| Polyconic projection | 7 |
| Lambert conformal conic projection with standard parallels of latitude at 33° and 45° | 2½ |
| (Between latitudes 30½° and 47½° only one-half of 1 per cent.) | |
| Lambert zenithal equal-area projection | 1⅞ |
| Maximum error of area: | |
| Polyconic | 7 |
| Lambert conformal conic | 5 |
| Lambert zenithal | 0 |

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The length of Coast Line as given above represents the General Coast Line measured in unit steps of 30 minutes of latitude (=35 statute miles).

With unit steps of 3 statute miles, the comparative lengths of tidal shoreline are as follows:

Alaska ..... 15,132 Statute miles

United States (Atlantic, Gulf and Pacific Coasts) ..... 12,877 Statute miles

The use of a smaller measuring unit gives 26,376 statute miles of shoreline for Alaska which, when the survey is completed, may be increased 40 per cent.

# Part II.—FIELD WORK AND NEEDS OF THE FIELD SERVICE.

## CHAPTER I.

### ALASKA NEEDS IMMEDIATE, DEFINITE, AND ADEQUATE RELIEF.

Alaska has had much written about her, our great frontier country with its 26,000 miles of coast line; but there has never been a well-defined and concentrated effort on a big business scale to develop the Territory as it should be done. For 53 years we have gone along giving this vast and rich empire a "dab of paint" here and there, but no definite policy has ever been suggested that has been fully and comprehensively carried out. The result has been much complication and continued neglect.

The Coast and Geodetic Survey is a very interested and vital agency in the safe development of Alaska. It can be said with no fear of being contradicted that on this arm of the Federal Government rests, and properly should rest, the responsibility of erecting the steel structures, so to speak, in building up this great Territory.

It is peculiarly appropriate in the proper development of any frontier territory to look to the safeguarding of its people, and the safety in erecting the foundation paves the way for future success.

Alaska, with its miles of detailed coast line, can not be approached without plying the waters that nearly surround it. On the east are gigantic mountain ranges that may never be surmounted by railroads. Therefore, the only means to get to Alaska's seaport towns is by means of ships. It thus follows that the protection of these vast water areas by the most careful surveys in locating hidden dangers is the essential step in the Territory's proper development. Alaska's waterways are her gateways and her highways of commerce, and certainly the first protection should be given these before the coast or interior can have its proper development. (See fig. 10.) It will be interesting to know, however, that in 53 years they have had to spend in Alaska on this work only $4,067,578, or an average annual expenditure of $78,223. Appropriations in 11 years for the construction and maintenance of military and post roads, bridges, etc., for the interior of Alaska, have been $2,120,000, or an average annual appropriation of $192,778. Congress has appropriated for a Federal Government railroad from Seward to Fairbanks $48,000,000. These figures are not given in a spirit of criticism, but, on the other hand, simply to show what a small proportion the Survey has had, which has resulted in great retardation of work that should invariably precede development of a new country. In comparison with the amounts given for these other two objects it is a mere pittance.

The Survey has had a difficult problem to contend with in this half century's work in Alaska. It has been sorely handicapped with vessels that were in almost every instance not adapted to the work

in Alaska and unable many times to cope with the unusual weather conditions of that region. Many times the officers and crews of these craft have had to cease operations and seek harbors of refuge from storms, which often put not only their lives but the vessels as well in actual jeopardy.

The exports from Alaska for the last 53 years have amounted to about $943,000,000, reaching a high-water mark the past year of about $94,709,359, and this does not include, of course, the great amount of fish, lumber, and other products of the Territory that have been consumed by its population.

The imports to Alaska for the past 53 years have amounted to $547,400,000, reaching the high-water mark in 1918, $146,020,124. These figures are to show briefly the enormous amount of shipping necessary to handle this large amount of trade.

For the first 30 years after the purchase of Alaska by the United States a few small vessels only were required for the commerce between Alaska ports and the ports on the Pacific coast of continental United States. In 1919 there were over 4,000 vessels, with a tonnage of over 2,000,000, entering and clearing Alaska; but instead of having vessels of 10 or 12 feet draft, as were the earlier ones, we now have them up to 28 feet. In other words, when the work of the Coast and Geodetic Survey is at its lowest ebb there, Alaska's prosperity is greater than ever before.

Few people realize or even think of the Territory's enormous area. From Dixon Entrance, on the international boundary line, to the farthest Attu Island it is nearly 3,000 miles. Along this stretch of coast there are about 465 islands in Alaska containing 1 or more square miles and innumerable smaller ones. The longest island is Prince of Wales, 131 miles long and 39 miles wide, while Kodiak Island has the largest area, 101 miles long and 63 miles wide—equal to the combined areas of Connecticut and Rhode Island.

The total area of Alaska is 586,400 square miles, or nearly twice the size of the original 13 States of the Union. To this we can add seven other States east of the Mississippi River, and still we do not have the amount of area in Alaska. Norway, Sweden, Finland, England, Scotland, and Ireland do not contain as much territory as Alaska. Germany, France, and Spain have only a trifle more area than this Territory.

## MANY UNDEVELOPED HARBORS OF ALASKA.

Unlike the waters adjacent to the States bordering on the Pacific coast, Alaska has many fine harbors; and, except a stretch beginning at Cross Sound, in southern Alaska, and extending to Controller Bay, Prince William Sound south, central Alaska, a distance of 275 miles, where there is only one harbor of refuge for vessels (Yakutat Bay), over the many miles of Alaska's coasts nature has provided bountifully for ships and shipping in splendid harbors.

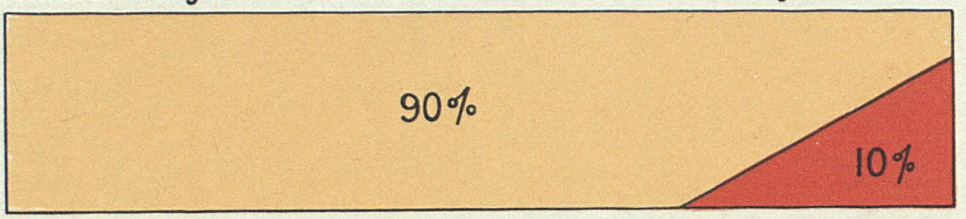
In this respect the south coast of Alaska resembles Norway and Sweden, her harbors being so numerous as to meet every demand for the future development of the entire Territory. In Bering Sea, northward and eastward of Unimak Pass, the harbors are not so plentiful and are characterized by shoals in the approaches. This

*Condition of water surveys, Pacific Coast and Alaska, 1920, as compared to the Philippine Islands*

# United States Coast and Geodetic Survey

## Alaska

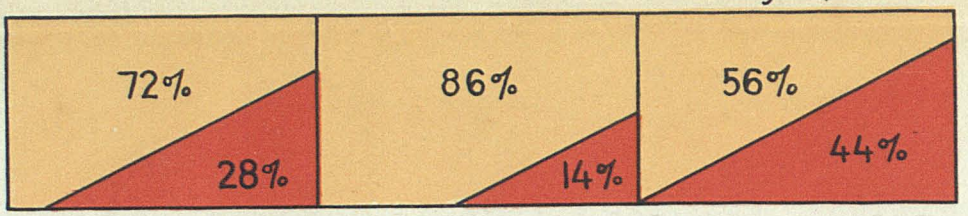
Owned by the United States since 1867 (53 years)




Yellow (90%) - represents unsurveyed water areas.
Red (10%) - represents water areas surveyed in past 34 years.

## California Oregon Washington

Part of continental U. S. since 1848 (72 years)



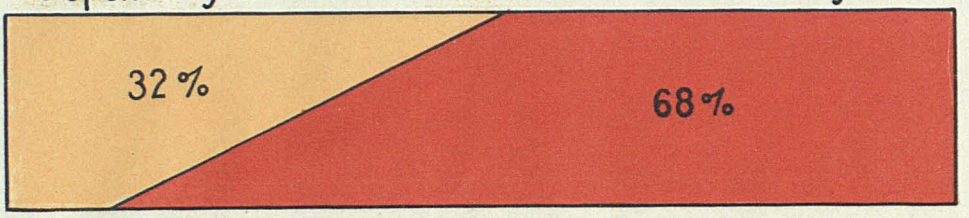

Yellow (72%, 86% and 56%) - represents unsurveyed water areas.
Red (28%, 14%, and 44%) - represents water areas surveyed in past 70 years.

For 23 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 (22 years)




Yellow (32%) - represents unsurveyed water areas.
Red (68%) - represents water areas surveyed in past 20 years.

Philippine surveys have progressed more rapidly in 20 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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makes it specially necessary that accurate surveys be made in order to permit safe navigation. There is little accurate knowledge available in connection with the many bays adjacent to the mainland, and more especially about the many islands of Alaska.

Not until these are properly safeguarded can it be hoped that they will be properly or permanently developed.

With the great demand for paper and substitutes for wooden boxes the country is looking to Alaska for the supply of raw materials. Never in the history of Alaska has there been such a centering of interest on these important products that have been so scarce and in such demand in the past two or three years. One of the first conditions looked for by those who are interested in building paper mills or factories are good harbors and cheap power. Alaska abounds in both. Hundreds of harbors adequate for the carrying of large vessels and conducting manufacturing plants are in southern Alaska, and in close proximity to many of them is wonderful water power that is only waiting to be put to proper use. The anticipated development along these lines is about to be realized, but the principal forerunner for encouraging this development is to safeguard the waterways by completed surveys. In very few instances is this done. Now the demand by the public for surveys of many of these harbors is being made, and to prevent further delay it would require vessels, more men, and sufficient money to bring about the imperative initial step to this very important commercial development.

### HOW LITTLE THE PRESENT CHARTS MEAN TO MARINERS.

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. It is estimated that *90 per cent* of the water areas of Alaska are unsurveyed or insufficiently surveyed. (See fig. 11.) The development of the country has 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.

In order to appreciate the need of rapidly extending 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 only trunk line is the waterway from various ports in Alaska to Puget Sound 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, agricultural grazing, and lumbering, the last two of minor importance but developing, are scattered everywhere, and connection with the principal ports is by boat alone. 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 de-

clines in importance. In practically all cases the canneries and mines along the shores are generally visited directly by steamers.

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.

### WHAT THE TOLL HAS BEEN IN WRECKS.

It is impossible to give an accurate list of hundreds of vessels that have stranded, foundered, and been total wrecks in the waters of Alaska during the past 53 years. The records which have been somewhat neglected, especially in the earlier history of this comparatively new possession of the United States, are anything but complete, but they are sufficiently known to convey to the minds of those who are interested a most harrowing condition that has existed during more than half a century. While it should not be understood that all of these disasters have been caused by lack of proper sailing charts and lack of knowledge of currents, it can be said that the greater portion of the wrecks have been directly due to the lack of accurate nautical information, which can be furnished by proper surveys.

Accidents to vessels in Alaskan waters have caused the loss of hundreds of lives and property to a value not far from twenty-five millions and which would represent to-day with the high cost of shipbuilding at least 50 per cent more. It will appeal to many as a matter of very poor economy that there is so little protection given to human life and vessel property employed in building up this truly great and remarkable empire of the United States.

From 1867 to 1919 there have been approximately 468 vessels wrecked in Alaskan waters with a loss of about 985 lives. Among these vessels were large sailing craft, as well as freight and passenger vessels; also some Government vessels. When we stop to think for a moment of this enormous loss, and consider alone that the National Government has suffered the loss of three splendid vessels worth more than a million and a half dollars or over one-third the total amount appropriated for surveys of Alaska in 53 years the serious side of the question is emphasized, especially when we think how much could have been done with this money if it had been applied in surveying the waters of Alaska.

### WHY UNSURVEYED WATERS RETARD ALASKA'S DEVELOPMENT.

The history of the industrial development of Alaska shows that, almost without exception, the establishment of industries and commerce has preceded, rather than followed, the surveys of the locality and that their establishment and development have been greatly retarded and oftentimes entirely suspended by the lack of such surveys. The following cases are given to illustrate these conditions:

Deposits of excellent marble were discovered in Davidson Inlet, and a company was organized to quarry the rock and ship it to Seattle. However, as the approaches to the quarry were incompletely surveyed, the steamship companies refused to send their vessels there, and, thus denied transportation, the marble company was helpless.

Finally, one of the steamship companies sent one of its pilots to the locality to report on the feasibility of sending in vessels in advance of complete surveys. The examination made by this pilot revealed so many uncharted dangers in the approaches that the company demanded a prohibitive price for permitting its vessels to enter.

The Coast and Geodetic Survey was appealed to, and a Survey steamer made a detailed survey of the harbor and its approaches. The result of this survey, while confirming the dangers previously reported by the pilot, developed a practical channel through them, with the result that large quantities of marble are now being shipped annually to Seattle.

An outcropping vein of gold-bearing quartz was discovered in Khaz Bay, on the west coast of Chichagof Island. Development work, begun immediately, showed the claim to be a rich one; portions of the uncovered vein showed nuggets and wires of free gold, and assays made of certain choice samples showed the gold contents running as high as $2,200 per ton of ore.

Yet, rich as was the vein, the owners were helpless to profit from it. The mine was at the head of a small bay which, with the waters leading to it, was unsurveyed, but known to be foul and dangerous; vessels passing along the coast could see large areas of reefs with jagged rocks showing above the surface. Therefore, the steamship companies refused to send in their vessels, to bring in mining machinery, or to carry out ore, except at a prohibitive cost. And there are many other instances of similar nature where lack of accurate surveys has prevented development.

### COMPLETE SURVEYS NEEDED.

Because of the rapidly increasing commercial importance of Alaska, it is imperative that the present conditions as regards survey work be remedied by means of complete surveys carried on in a systematic manner and extended with all possible rapidity.

In order to appreciate the immediate need for this work, it must be clearly understood that Alaska's only connection with the rest of the world is by water routes. The millions of dollars that are being expended to build the Government-owned railroad to the interior of Alaska; the large amount of private capital that has been, and will be, spent to develop her mines, to build up her fishing industry; the certain early opening of the vast coal fields; the utilizing of the great timber resources for paper and lumber; all this would be wasted and her vast resources would be worthless if vessels could not reach and enter her ports or visit the railroad terminals, canneries, and nearest ports as outlets to the many mines, grazing areas, etc.

And it is a fact, at the present time, there are few passages that can be navigated and few harbors that can be entered by a vessel with the assurance that the near-by shore line and landmarks and the contour of the bottom over which she is traveling are accurately shown on the charts, or that the hidden dangers that may lie in her path have all been discovered and charted.

That, in the past, instead of blazing the trail for water-borne commerce, the Coast and Geodetic Survey, because of lack of funds and essential equipment, has been forced to lag far behind is as deplor-

able as it has been unavoidable. The time has now come, however, when we must face the issue squarely and realize that the interests of passengers, commerce, shipowners, navigators, and those who have invested their capital in Alaska's industries must be safe-guarded by adequate surveys prosecuted vigorously and on a much larger scale than heretofore. Even then it will take time before the surveys can reach a point where they can meet the present needs of commerce; and it must not be overlooked that the time is not far off when our naval vessels will frequent Alaska's waters in numbers.

Scarcely enough work has been done up to the present time to give an accurate idea of the amount of survey work that will be required. The following, however, may be taken as a general statement of conditions along this line.

In southeastern Alaska the first and most obvious need is to complete the surveys and especially wire-drag work. Only the principal channels of these waters have been fairly well sounded, so that detailed surveys and wire dragging necessary to complete the survey. The importance of wire-drag work in this locality and in other parts of Alaska will be discussed under a separate heading.

In many regions only scattered surveys have been made. Complete hydrographic and topographic surveys must be made of all passages, bays, and harbors. In practically every case this work must be supplemented by wire-drag surveys, and many localities in which the ordinary hydrographic surveys have already been completed must be dragged.

On the outer coasts soundings must be extended for a sufficient distance offshore to enable the navigator to determine the distance of his vessel from land in thick weather by use of the lead and to fully develop the great fishing banks, which are among the most extensive in the world. On the outer coasts wire-drag surveys will be required only at critical points and in the approaches and entrances to the numerous bays and passages.

### MODERN VESSELS AND LAUNCHES NEEDED.

In the preceding pages it has been the desire to give a clear idea of the present conditions in Alaska, as far as they relate to its coast surveys. It is the present purpose to consider the means at hand and those that are needed to bring these surveys to such completeness that the loss of vessels can not be ascribed to lack of reliable charts and sailing directions.

In the past the Bureau has been inadequately equipped for this work, but conditions are not much better now when the commerce of Alaska exceeds anything in its history and is increasing by leaps and bounds. Since the Government is spending vast sums to provide a merchant marine, it is "good business" to take normal precautions that these vessels may safely navigate the waters of our great frontier country.

Personal observation of these conditions was made in a number of instances this year. Companies were anxious to get machinery across unsurveyed waters, and shipping of products out of Alaska was retarded, and in some cases nothing was accomplished, as the steamship companies absolutely refused to risk going into waters

not properly charted and will continue to do so until the waters are made safe for navigation.

Take the town of Ketchikan. Where a general survey in the immediate vicinity of the original docks was sufficient a few years ago, now a mile north of the town a closer survey on a larger scale is very much needed. Ten times as many docks have been built, and steamers will not stop to pick up exports or bring in supplies with information inadequate to protect their vessels.

The natural resources of Alaska have so tempted commerce that vessels have ventured into those regions far in advance of adequate surveys. The means of the Coast and Geodetic Survey for charting Alaskan waters have been and are so limited that the best that could then be done and can now be done is to shift from place to place and make examinations where industry has preceded surveys and dangers have been found by vessels striking them or where industry has established itself and demands a local survey.

The equipment for these surveys is so limited that no definite plan can be laid for their ultimate completion or for the issuing of charts that will be guides to all parts of Alaskan waters.

The making of surveys and supplying of reliable charts for the urgent needs of Alaska is a question of the number of modern surveying vessels and wire-drag launches available for the work. Poor equipment is uneconomical from every angle.

### IMPORTANCE OF WIRE DRAG.

Ordinary hydrographic surveys are made with a launch or other vessel, which proceeds back and forth across the area to be surveyed until the entire area is covered by a system of sounding lines, usually parallel. The distance between the sounding lines depends on the depth and nature of the bottom and the importance of the locality. As the boat follows these lines the depth of water is obtained by means of a lead and line, cast at regular intervals from the boat. Such surveys must be made in all regions in order that the contour of the bottom beneath the surface of the water may be known; and along the sandy portions of our coasts surveys by this method may be sufficient.

This is decidedly not the case, however, in regions where there are obstructions of small area, such as pinnacle rocks, bowlders, and sharp, rocky ledges, for it is only by chance that they can be found by an ordinary hydrographic survey. It is difficult to explain just how elusive these dangers are when sought with the hand lead. Let us consider, as an analogy, a balloon drifting slowly over a town. Imagine the difficulty of throwing a weight attached to a line and hitting the tip of a church spire or the gable of a house as the balloon passes over them, and remember that the hydrographer not only can not see the obstruction beneath the surface, but does not even know that it exists.

It has, therefore, been necessary to supplement ordinary hydrographic surveys by some means of finding all of these dangers in regions where they exist, and for this purpose the Coast and Geodetic Survey uses an apparatus known as the wire drag. Starting on the Atlantic coast in 1904 the Survey has gradually developed and perfected equipment and methods of operation until at the present time

the modern wire drag is a wonderfully efficient mechanism capable of covering large areas rapidly and finding therein every danger to navigation that exists.

Stated briefly, the wire drag consists of a horizontal wire maintained at any desired distance below the surface of the water by an arrangement of weights and adjustable upright cables extending up to surface buoys. This apparatus is towed by two launches, one at each end. As the drag passes through the water it will catch and show the location of any obstruction extending above the plane of the horizontal wire. Knowing the location of the obstruction, the least depth on it can be easily found by sounding with lead and line from a small boat.

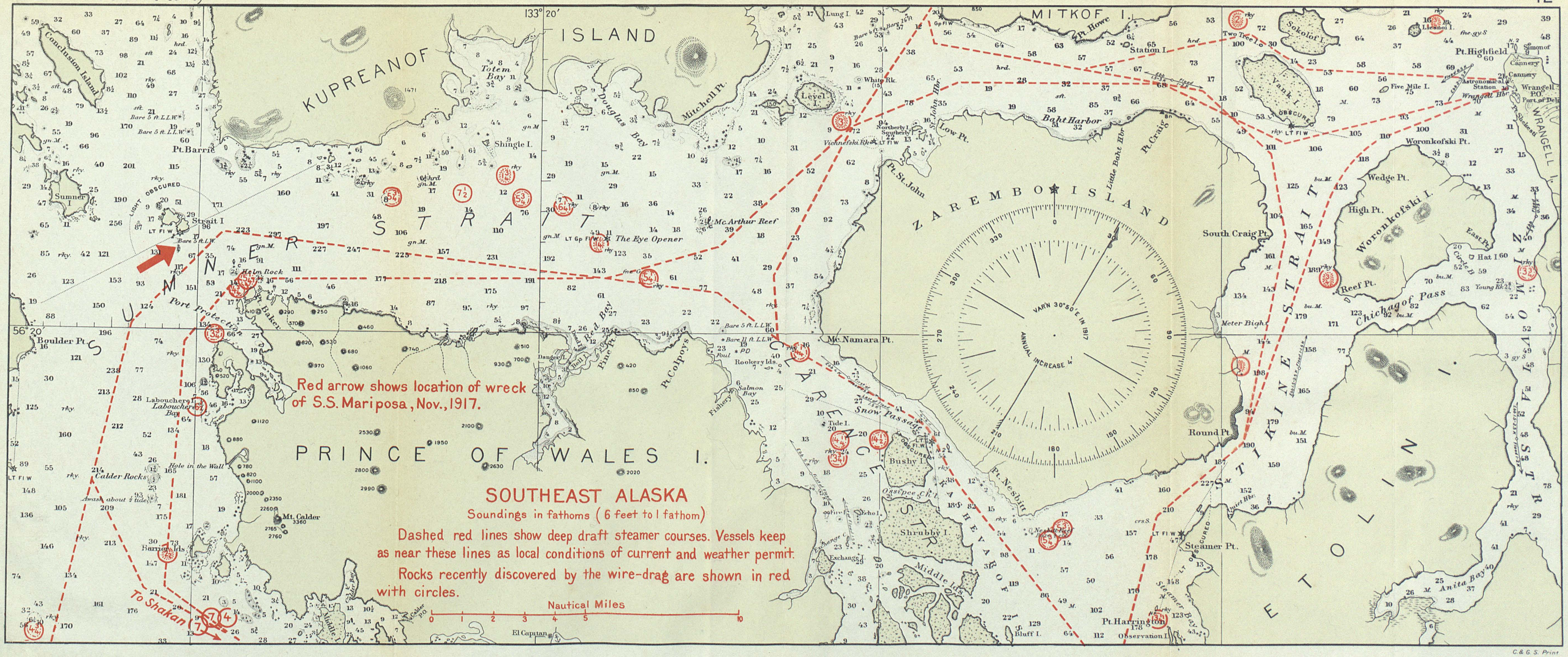
That pinnacle rocks, the most dangerous of all obstructions to navigation, are present in Alaskan waters can be easily predicted from a study of the adjoining land areas; and in a few cases such rocks, their existence indicated by kelp extending up to the surface of the water, were discovered by hydrographic parties. With the increase in the commercial importance of Alaska and the number of ship plying her waters came an increase in the number of accidents to vessels, with loss of life and property; and the fact that many of these accidents were due to striking uncharted rocks caused a realization of the fact that not only do pinnacle rocks exist in large numbers, but that they occur in the most unexpected localities. It was, of course, evident that all these dangers must be found in order to safeguard vessels navigating the waters of Alaska, and wire-drag work was accordingly started in 1914. Since that time it has been prosecuted as rapidly as funds would permit. (See figs. 12 and 13.)

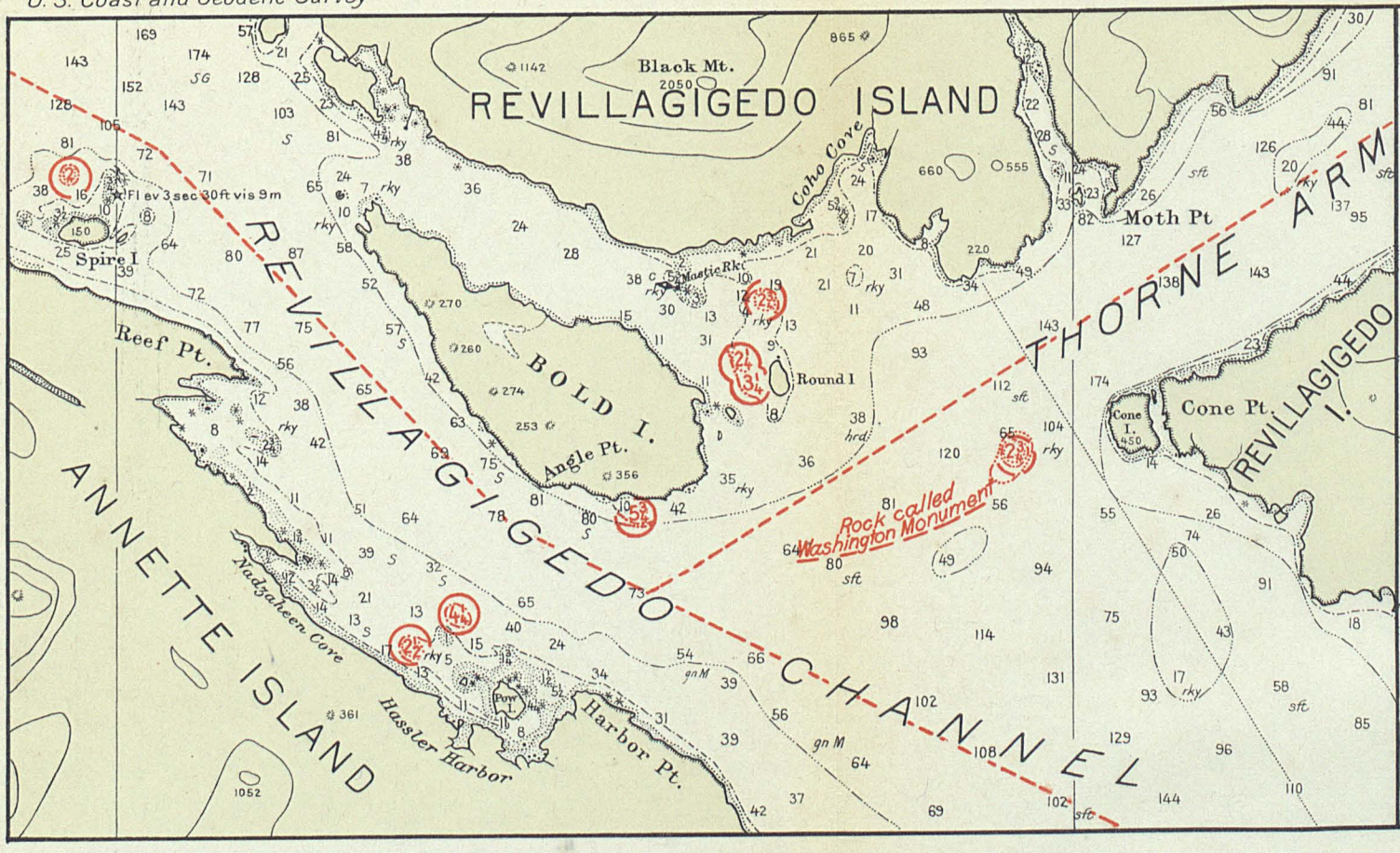
The startling number of dangers to navigation discovered with the wire drag during the short time that it has been used in Alaska waters strongly emphasizes the fact that in regions where the shores are rocky practically all the navigable waters out to the 50-fathom curve must be dragged in order to provide the assurance of safe navigation to which navigators, shipowners, and the general public are so plainly entitled. This is a huge task, but it is imperative that it be prosecuted with vigor and carried to the earliest possible conclusion.

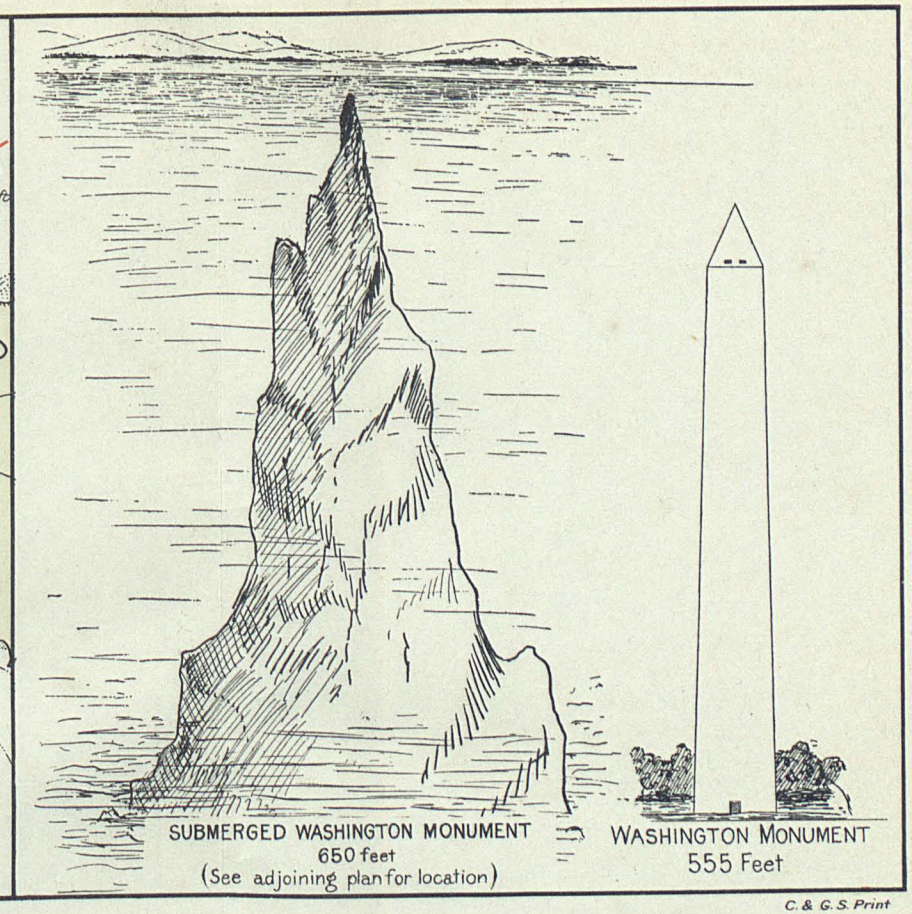
Too much emphasis can not be put on the need of increasing the force for completing the wire-drag survey in Alaska. There is hardly a move made by our vessels that does not indicate that there are pinnacle rocks with great depths of water surrounding them. This can not be permanently or safely done by the usual manner of carrying on hydrographic surveys. To do this economically, quickly, and thoroughly the launches should be built by the Government to meet the needs of this important and peculiar work. The wisdom of having launches built for the wire drag has been evidenced during the past season when they were a contributing factor in reducing the cost per square mile. The old method of hiring launches is a gross waste of time and money. It is hoped that several wire-drag parties can be placed in the waters of southeastern Alaska in 1921.

### FIRST SURVEYS OF INTERIOR ALASKA NEEDED.

*Character of the work needed.*—It would be a mistake to leave the subject of water surveys in Alaska without calling attention to the


SOUTHEAST ALASKA
Soundings in fathoms (6 feet to 1 fathom)
Dashed red lines show deep draft steamer courses. Vessels keep as near these lines as local conditions of current and weather permit.
Rocks recently discovered by the wire-drag are shown in red with circles.
Red arrow shows location of wreck of S.S. Mariposa, Nov., 1917.
Nautical Miles
0 1 2 3 4 5 10
KUPREANOF ISLAND
ZAREMBO ISLAND
MITKOF I.
PRINCE OF WALES I.
SUMNER STRAIT
CLARENCE STRAIT
SNOW PASSAGE
STIKINE STRAIT
ETOLIN I.
WRANGELL I.
Conclusion Island
Pt. Barrie
Summer I.
Strait I.
Port Protection
Boulder Pt.
Labouchere Bay
Calder Rocks
Hole in the Wall
Mt. Calder
Barrier Ids.
To Shakan
Totem Bay
Shingle I.
Douglas Bay
Mitchell Pt.
Level I.
White Rk.
Vicknefski Rk.
Lung I.
Station I.
Two Tree I.
Sokolof I.
Yank I.
Pt. Highfield
Cannery
Wrangell Hbr.
Five Mile I.
Woronkofski Pt.
Wedge Pt.
High Pt.
Woronkofski I.
East Pt.
Hat I.
Chichagof Pass
Reef Pt.
Meter Bigh.
South Craig Pt.
Round Pt.
Steamer Pt.
Pt. Harrington
Observation I.
Anita Bay
Steamer Bay
Bay of Pigs
Little Bay
Pt. Craig
Low Pt.
Pt. St. John
St. John Hbr.
Pt. Howe
Mc Arthur Reef
The Eye Opener
Mc Namara Pt.
Rookery Ids.
Salmon Bay
Fishery
Pt. Colpoys
Tide I.
Bushy I.
Shrubby I.
Middle Ids.
Exchange I.
Bluff I.
Pt. Nesbitt
Pt. Stephens
Sukwan
Kadin
Dangerous Bay
Bay of Pigs
Pt. Baker
Pt. Protection
Bare 5 ft. L.L.W.
LIGHT OBSCURED
VARN 30°50' E IN 1917
ANNUAL INCREASE 4'
133° 20'
56° 20'

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## SOUTHEAST ALASKA

Soundings in fathoms (6 feet to fathom)

Dashed red lines show main steamer routes.

Recent finds of pinnacle rocks are shown in red with circles.

The previously charted depths shown in black demonstrate the need of resurveys in this important thorofare by wire-drag.

Nautical Miles

1 2 0 1 2 3 4

The submerged "WASHINGTON MONUMENT" (pinnacle rock), height 650 feet, found near main steamer route in Alaskan waters in 1915 by the wire drag; only 17 feet of water covers this pinnacle.

The Washington Monument we know so well is 555 feet in height.

great need for establishing monuments (survey control points) throughout the Territory and determining their latitude, longitude, and elevation.

(*a*) Along the coast such control points have been established in many localities where hydrographic surveys have been made, but they are not connected with each other or with the other surveys of the United States or Canada. In the interior control points have been located along the international boundary and in a few small areas inland, but all these various regions must be connected in the immediate future to avoid wasted effort, costly later adjustments, and a delay in the development of the country.

There is no place in the territory of the United States where maps are of more value in industries of various kinds than in the interior of Alaska. These maps, of course, should be good ones, and the only possible way to have a good map is to have a properly coordinated and consistent system of control.

The method of determining the geographic positions of monuments which are used for the control points of the topographic maps and surveys of various kinds is triangulation. In this method a base line or distance between two established points is measured and other distances between contiguous points are determined by computations from this known length and the measured angles of the triangles in the scheme of triangulation. The latitudes of these stations are the distances from the equator and the longitudes are the distances from the meridian passing through the observatory at Greenwich.

(*b*) To join these various detached bits of triangulation and to connect the whole of Alaska to the surveys of the remainder of the continent in its proper geographic relation, observations have been begun with the cooperation of the Canadian Government on a strong chain of triangulation to reach from the vicinity of Seattle, through southeast Alaska to the upper portion of the Yukon River where it crosses the Alaskan boundary. From that point lines of triangulation will extend through Alaska, over routes indicated in a later paragraph.

After being carried by the Canadians through British Columbia, this scheme of triangulation will lead northward across Dixon Entrance, thence up Clarence Strait just eastward of Ketchikan, passing to the eastward of Kupreanof and Admiralty Islands and up Lynn Canal to where the scheme again crosses into Canadian territory.

To that central belt of accurately determined control points will be connected loops of triangulation which have already surrounded or soon will surround many of the large and important islands in southeastern Alaska, such as Revillagegido, on which Ketchikan is located, Prince of Wales Island, and others which are of vital importance to the development of that portion of Alaska.

Accurate elevations are determined in the interior of a country by lines of precise leveling which are extended inland from tidal stations. At these tidal stations the relation between mean sea level and some object on shore is determined by long series of observations. The mean sea level is considered to be zero in the leveling net, and all other elevations are referred to it.

With the longitude and latitude known for each of a number of triangulation stations and the elevations available for bench marks,

we have what may be considered a framework upon which detailed surveys can be made. If the area is local and can never be connected by triangulation with any other (such, for instance, as an oceanic island), then extensive primary triangulation and precise leveling are not necessary; but in an area the size of Alaska each locality that is the scene of present industry and commerce will undoubtedly be connected by surveys and maps with other localities. If we do not have such a framework, as mentioned above, there will be serious discrepancies when two local surveys or maps are joined. There will be offsets, gaps, or overlaps which will be sources of trouble until the whole work has been properly adjusted to the strong control work that must be done to make the local surveys fit into each other.

It is the experience of all civilized nations that for the economical surveying and mapping of their areas primary triangulation and precise leveling have been required. Many of the countries have followed the surveys and maps by primary triangulation and precise leveling, while others have had the control work precede the operations upon which the maps are based. In the United States much of the surveying of the public lands preceded any triangulation whatsoever, with the result that many of the maps have not the proper control.

Surveying is now being done in the interior of Alaska by several organizations of the Government, especially the United States Geological Survey, the General Land Office, and the Forest Service. There are, of course, mineral surveys made also. These organizations are now operating without primary control points, and there is no way of telling just where those local maps and surveys are located, except those that are made near the coast. An approximate position of a survey may be obtained by astronomic observations, but the latitude and longitude of such a survey may be in error by as much as one-fourth or one-half mile, due to the local attractions of the mountain masses on the plumb line, to which all astronomical observations are referred.

A letter from the office of the Commissioner of the General Land Office, under date of September 3, 1920, reads in part as follows:

> A system of triangulation along the Yukon River, especially the upper portion from Tanana to Eagle, will, no doubt, be of value to us in the near future. We have now pending 50, or more, isolated surveys scattered over this district, and others will follow. With triangulation we could adjust these surveys to the rectangular net and lay a foundation for a uniform system with less possibility of confusion than to dot the country with innumerable isolated surveys.

### WHERE CONTROL SURVEYS SHOULD BE MADE.

It would seem to be the most economical method of mapping Alaska to have long arcs of primary triangulation and lines of precise leveling extended throughout the area where maps are being made and where they will be made in the near future. There are some areas which can await the development of the country before the triangulation and precise leveling are done. This control work should be done very soon after opening of a transportation route, but should not in general precede it, as otherwise the work will be excessively expensive.

There is immediate need for a system of primary triangulation down the Yukon River, from its crossing at the one hundred and

forty-first meridian to the mouth, or at least to St. Michael. A line of precise levels should follow along this same route. Another line of precise levels and an arc of triangulation should be carried up the Copper River from its mouth and on to Fairbanks. A spur should be carried from this system to the one hundred and forty-first meridian at a point about 70 miles north of Mount St. Elias. Another route which should be followed by primary triangulation and precise leveling is along the Alaska Railway, from the head of Cook Inlet northward. The other important work should be done along the Kuskokwim River, from its mouth to the Yukon, with a spur line running eastward along the Odgovigamut River. A small piece of work should be done between Cook Inlet and Bristol Bay. Here only triangulation is needed.

The work mentioned above would, it seems, meet all the immediate needs for primary geodetic work in Alaska. It is needed for the interior as well as to strengthen the coast triangulation, which is used to control the sailing charts. The work outlined is, of course, not all that is needed, but additional work can be done and planned as occasion demands.

### ALASKA'S IMMEDIATE NEEDS.

Alaska's greatest need should be given serious thought now and not put off for another year. The provision now of a comparatively small amount of money will save added expense in years to come, not to mention the saving in life and property. It is necessary to have the authorization for two new vessels, of the *Surveyor* type, a modern surveying vessel, and new launches, which is the only way to conduct this work economically from the standpoint of cost, also carrying on the work with greater speed.

So important is the matter of the survey of the waters of Alaska that it is deemed a wise business move to establish at Ketchikan, the entering port of Alaska, as soon as funds are available, a permanent station supervised by a commissioned officer of the Survey, where the launches of the Survey can be stored in the winter, a vessel kept in commission, and where supplies, including coal and fuel, can be obtained. It is unfortunate that at the present station in Alaska our vessels have to depend on foreign coal and are often delayed owing to the fact that Australian coal and Canadian coal are not available for the vessels of the United States. The establishment of this permanent station in Alaska will do much to facilitate matters and help the parties on sea and land to get into the field more promptly in the spring of each year.

### ALASKA'S FUTURE.

It is safe to predict, and with proper emphasis, that Alaska will reach out in the near future looking to development along all lines and through every possible channel. Her next 10 years will most likely place her far in advance of what the past 53 years have produced, and all assistance possible should be forthcoming from the mother country, upon which the responsibility rests. We should be well prepared in every branch of the home Government to facilitate the commercial development and competition that is surely following since the close of the Great War.

Let it be hoped that the day is at hand when it will be no longer necessary to discover uncharted pinnacle rocks by the loss of some vessel, and the custom of commemorating the loss by naming the hidden rock after the unfortunate craft will be impossible in the future.

The question is often asked, "Why don't vessels hit all these hidden rocks?" The answer is, give them time and they will.

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 some years before the surveys can reach a point where they can even meet the needs of the present commerce.

While the United States has already invested many millions and plans to spend many more millions of dollars on a merchant marine to develop foreign trade and study commercial conditions in all corners of the world, we seem to forget Alaska—a part of our own domain—which with thoughtful financial support accompanied by a wise and liberal Federal policy, we would soon build a most profitable trade unrestricted by the innumerable foreign regulations and with conspicuous economy and to the mutual advantage of the people of our own country.

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

In 1914, 1915, 1916, and 1917, I strongly recommended the desirability of the purchase of Dutch Harbor, Aleutian Islands, Alaska, as a Federal Government base. Up to the present time, while the wisdom of securing this property has been shown clearly, nothing definite has been done. Dutch Harbor is the old home and village of the North American Commercial Co., where now the Government wireless station is located. The place is practically abandoned. The buildings are in a fair state of preservation. The harbor is excellent and far better and safer for large vessels desiring to dock there than at Unalaska. There is an abundance of excellent water, which Unalaska lacks. There are also good buildings for living quarters for various Government officials. There was never a greater need for a Government base in western Alaska than at this time. where coal, fuel, and other supplies can be obtained at any time of the year, which under existing conditions is impossible. The idea of making Dutch Harbor an ideal Government supply station is one that should be encouraged, and the opportunity now presents itself, and if further postponed the opportunity for carrying out this wise business venture may be lost.

### FIELD STATION AND BOATHOUSE AT KETCHIKAN, ALASKA.

Since 1898 practically the entire facilities of the Coast and Geodetic Survey on the Pacific coast of the United States have been employed in Alaska in an effort to keep pace with the growing commerce carried on with its coast ports. During the period from 1907 to 1915 three of the Survey's vessels were employed in southeast Alaska in an effort to obtain, by means of adequate surveys, accurate

charts to assist in the commercial development of the country. To assist in this work, launches were employed for the development of shoal areas and ledges and to search out intricate areas where the larger vessels could not be maneuvered. A small boathouse on the naval reservation at Sitka was used to house these launches during the winter seasons, and the naval station at that place was used as the base station for surveying opertions up until 1907, when it became necessary to remove the launch equipment to a place more accessible to the working grounds in southeast Alaska. Ketchikan was selected for this purpose and a boathouse constructed at Metlakatla for housing the launches and storing such of the equipment as it was found advisable to leave in Alaska.

In 1914 wire-drag work was begun in southeast Alaska, and from 1915 to the entering of the United States into the World War two parties were employed. The launches used upon the work were chartered makeshifts remodeled to serve as best they could and were returned to the owners at the end of the season. At the termination of the war relief came in a measure to this very unsatisfactory way of procuring equipment. The Navy supplied the Survey with a number of large launches which were made suitable after alteration for assisting in the wire-drag work.

The additional equipment made it possible to resume survey work with increased activity in southeast Alaska, and the necessity for providing suitable space for housing the equipment at the most advantageous point now presents itself. There are to-day four large steam launches and six large motor launches which will remain in Alaska during the winters, as it is not practicable to tow them or run them south when the approach of winter weather makes it no longer economical to attempt wire-drag and other survey work. To these will be added during the coming year three gas launches which are now stored in Seattle. The repairs incident to the upkeep of this equipment, together with repairs to the wire-drag apparatus, can only be accomplished after the close of the surveying season and must of necessity be completed before the opening of the season in the early spring.

There should be the most serious thought given to the care of this assembled equipment, its upkeep, and its apportionment to parties given the task of sweeping the channels with the wire drag and extending the surveys to meet the need of commerce. With this in mind and the paramount importance of selecting a site suitable for a base, authorization will be sought for the construction of suitable boathouses, ways for hauling out, and a wharf that can be used by the larger vessels for storing coal and supplies needed in the field of operation. If authorization can be secured all plans and specifications will be prepared, bids obtained, and the construction begun at once.

The present plan for construction and estimated cost are as follows:

| | |
|---|---|
| Boathouse with suitable space for overhauling wire-drag equipment, ways, and storing facilities for 13 launches | $15,000 |
| Wharf with 2,000 square feet | 5,000 |
| Watchman's dwelling | 2,500 |
| Total | 22,500 |

The rapid development of Alaska along commercial lines is well illustrated by the request for surveys and for information pertaining to areas where newly selected sites for proposed industries have been chosen. There are, especially in southeast Alaska, some of the finest water-power sites on the Pacific coast, which have attracted the attention of capital with a view to establishing pulp mills and other industries. The water approach to these sites must of necessity be surveyed, dragged, and the dangers charted. The most important of Alaskan water-power projects at this time, and one which has been developed to a considerable extent, is located at Port Snettisham. It is located in the midst of a well-timbered section and surrounded by other valuable material resources easily accessible. An urgent request for a more complete survey of the approaches to this important site has been received through one of the survey parties now operating in its vicinity.

To keep more closely in touch with the needs for such surveys, it is proposed to establish in southeast Alaska a permanent field station of the Coast and Geodetic Survey. This will enable the public to obtain advance information of the navigable waters where surveys are partially completed or totally lacking. With a Survey officer available at such a station small surveys and examinations can be made at once and much valuable information obtained which will enable commercial interests to locate at points accessible to the passenger and freight steamers plying between Alaska and United States ports.

As the proposed operations in Alaska during the next year are to be taken up with increased activity, it emphasizes the necessity of establishing a field station by which the inspector in charge can cooperate with steamship lines to insure prompt reports of dangers discovered and other information affecting the coast charts.

The question of a location for such a station is of course governed by its accessibility to the shipping interests and its relation to the field of surveying operations. Situated as it is on the main artery of commerce, Ketchikan has been selected as the most suitable port for a field station of the Survey in southeast Alaska. By reason of the fact that the shore-surveying season opens earlier and closes later in this section than in others, Ketchikan is better suited for hauling out and storing the floating equipment. It is more accessible to the market from which supplies and repair material will be sent for the upkeep of the launches and wire-drag apparatus, and if arrangements can be made for storing coal for the surveying vessels the freight rate on such coal, supplies, etc., would be at a minimum cost.

By reason of its accessibility other Government bureaus are represented at Ketchikan, notably the Bureau of Lighthouses and the Forest Service. With the Coast and Geodetic Survey permanently represented at that place, close cooperation with the local representatives of these bureaus could be maintained, with resulting benefit to the maritime and commercial interests.

# CHAPTER II.

## WHAT IS NEEDED TO BETTER ACCOMPLISH THE FIELD WORK.

### MODERN SURVEYING VESSELS NEEDED.

For the past five years I have reiterated in my annual reports the urgent need of the Bureau for better vessels to carry on its hydrographic surveys. Each year I have repeatedly pointed out the false economy of trying to accomplish surveys with the fleet of old vessels that is now the property of the Bureau. Some of these that have been in the service for years are now actually unseaworthy and can only be used under the most favorable conditions; yet the cost of operation of each of these old vessels in personnel, fuel, etc., is no less than would be the cost of operation of efficient vessels, yet the limitations on the purposes for which these old vessels may be used on account of their unseaworthiness are such that an enormous amount of time is lost and the cost per unit of accomplishment is excessive, but with no other means at my disposal for making the surveys called for I have no other alternative but to continue the work, excessive as the costs are.

Beginning in 1913 the Bureau has been endeavoring to replace its worn out and unseaworthy surveying vessels by adequate modern vessels and to build up the fleet sufficient to meet insistent demands for hydrographic surveys in the United States, Alaska, the Philippine Islands, and elsewhere in the insular possessions, but the necessary funds have not been provided. The total amount provided to date for the construction or purchase of new vessels during the last 16 years has been only $296,000. Meanwhile the demand for new surveys has become increasingly insistent, particularly in Alaska, although the demand for surveys of the waters of continental United States is urgent.

During the Great War nearly all the vessels of this service were transferred to the Navy and were used for military purposes. For this reason, and because most of the officers also were on military duty, very little surveying was performed by this Bureau during that time, and as a result there is a two years' accumulation of work which, together with the normal annual work, can not be accomplished with the present fleet. With the cessation of hostilities the Navy was in possession of a considerable fleet of auxiliary vessels, which had served its purpose as war craft and was available for transfer whenever required elsewhere in the Government service. It was realized that very few, if any, of these vessels were suitable for surveying, but because no other vessels were available I accepted some of them, regarding them as makeshifts until more suitable vessels could be provided, but hoping that from the lot I could obtain a few that would serve the purpose of this Bureau in a measure for several years.

With this fleet, together with the former Coast Survey vessels which were returned by the Navy, this Bureau endeavored last sum-

mer to resume surveying operations. The first season's work with these ex-Navy vessels showed conclusively that, with one or two exceptions, they were absolutely unsuitable for the work; that the unit cost of work performed with such vessels was abnormally high; and that much of the most urgently needed work could not be done at all with them. Of the seven vessels received from the Navy two were turned back before any surveying work had been done, as the cost of putting them in operating condition would be out of proportion to their original cost or present value. One more vessel will be turned back this winter for the reason that her condition is such that the cost of putting her in seaworthy condition would not be justified by the amount of surveying work that could be accomplished with her annually. The other vessels will do fairly well for a few years, but will always be inefficient.

In the year 1914 the Coast and Geodetic Survey operated 16 surveying vessels, 4 of which were the property of the Philippine government, and the balance were owned by this Bureau. Five of these vessels were over 30 years old at that time, and only 6 of them (3 United States vessels and 3 Philippine vessels) were under 15 years of age. Two of the vessels were built in 1859 and 1862, respectively. Prior to 1914 the Coast and Geodetic Survey had not acquired a new vessel since 1904.

In 1915 one of the oldest vessels was condemned as unseaworthy and an appropriation of $289,000 was made for the purchase or construction of two surveying vessels. As this amount was too small to permit the construction of two new vessels, it was necessary to purchase the best possible vessel at the smallest cost so as to leave sufficient funds for the construction of one vessel. The Bureau was particularly fortunate in securing a fair yacht at a cost of $60,000, and thus was able to enter into contract for the construction of a modern surveying vessel, which ultimately cost $236,000. As the surveying vessel was not completed until 1917, the net gain in the number of ships that year was naught.

In 1916 two more of the oldest vessels were found no longer fit for surveying work and were disposed of, thus reducing the fleet to 14 vessels. In 1917 the new vessel was completed, thus increasing the fleet to 15 vessels.

The vessels were then turned over to the Navy for war purposes, and the surveying fleet was reduced to the few vessels that could not be used for military purposes.

In 1919 seven vessels were obtained from the Navy, but during 1918 and 1919 seven vessels were disposed of, so that there was no change in the number in the fleet over 1917. Of these seven vessels, two were Navy vessels returned because they could not be used in survey work, three old vessels were condemned and sold (one of them the vessel built in 1859), one vessel (the property of the Philippine government) withdrawn from survey operations, and one vessel wrecked.

It will, therefore, be seen that at the present time the number of vessels available for use of this Bureau is one less than the number available in 1914. Furthermore, as stated above, a third naval vessel must be disposed of this year, as she is no longer fit for survey operations, thus reducing the fleet to two less than the fleet of 1914.

This fleet is, of course, superior to the 1914 fleet, as the oldest vessels have been weeded out and replaced by newer craft; but, on the whole, these ships, with the exception of the one new vessel constructed in 1915 and 1916 and one vessel obtained from the Navy, are not very much more efficient than were the old vessels. Furthermore, we have now 14 vessels to do a vastly greater amount of surveying than was required in 1914 from 16 vessels. If we assume that these 14 vessels can do as much work as the 16 vessels of the 1914 fleet, and it is not at all certain that they can do this, it is evident that there will be no advancement in surveying operations. We shall steadily drop behind in this work, each year the charts will become more and more out of date, and I shall have to continue to tell the public that we can not assist in opening up new steamship routes as rapidly as commerce demands.

If this Bureau is to keep its charts up to date, to make revisional surveys where depths have changed, to provide the charts urgently needed for the navigation of our coastal waters, and to chart the at present uncharted portions of Alaska where industries have recently opened up, it will be necessary to provide as soon as possible three new surveying vessels of the most efficient type and exactly suited to this work. Two of these vessels should be of the *Surveyor* type (the vessel that was built for this Bureau in 1916–17) and the third should be a small, light-draft vessel for use in bays, rivers, and sounds.

Hydrographic surveying can be efficiently and economically done only with appliances, including vessels exactly suited to the work. It might be thought that any vessel of the proper size could be used fairly successfully in this work, and this might be true if the function of the surveying vessel is only to provide a means for transporting the hydrographic party. This, however, is not the case. An efficient surveying vessel is really an instrument, or, perhaps, might better be described as a floating stand on which certain surveying instruments can be mounted. In order that these instruments may be operated to their full capacity it is necessary that the stand (surveying vessel) be as steady as possible; that it remain reasonably dry when the sea is rough; that it be provided with power for moving it quickly from place to place and for placing it exactly at any desired spot on the water; that it be rugged enough to withstand severe storms and that it be large enough to carry all necessary surveying instruments, including small surveying launches, and at the same time be not unnecessarily large, thus requiring unnecessarily heavy machinery to operate. These are some of the requirements of a real surveying vessel; and, in addition to the above-mentioned requirements, it should have suitable quarters for accommodating the surveying parties and sufficient fuel capacity to enable it to remain away from the base of supplies for a considerable period. These qualities can not be found in any vessel designed for purposes other than surveying. Consequently it is impracticable to secure suitable surveying vessels except by building them.

A comparison of the cost of work accomplished with an efficient surveying vessel with similar work performed with vessels not designed for this purpose brings out interesting facts. This Bureau is now operating several yachts that were acquired by transfer from the Navy at the termination of hostilities. These are very good

yachts; they compare well with vessels of their type, and probably satisfy the requirements for a survey vessel as well as does any type of vessel not designed for surveying. During the past season two of these yachts and one of our specially designed surveying vessels were employed in the same general locality, on similar work, under similar conditions, and therefore the cost of operating these three vessels at that time is fairly comparable. The larger of the yachts cost $10,840 per month for all expenses, the smaller of the yachts cost $8,414, and the surveying vessel cost $16,372. It would therefore appear that the smaller yacht was the most economical, but the smaller yacht could carry officers, men, and equipment, including boats, for the operation of only two parties. The larger yacht, for the same reason, could accommodate only three parties, whereas the surveying vessel, having been designed to meet the requirements stated above, permitted the operation of five surveying parties. It is therefore evident that the cost of surveying with the surveying vessel was $3,274 per party per month; for the larger yacht, $3,613 per party per month; for the smaller yacht, $4,207 per party per month. In other words, the larger yacht cost 10 per cent more than did the surveying vessel for the same amount of work, and the smaller yacht cost 28 per cent more for the same amount of work.

### ECONOMY IN GOVERNMENT-OWNED WIRE-DRAG LAUNCHES.

Much has been said in the past of wire-drag launches in discussing the needs for equipment of the Survey. In my reports the advisability of having Government-owned launches has been pointed out and appropriations have been asked for to supply this needed equipment.

Not until the summer of 1919 was it possible to draw an actual comparison of the value of these launches with those which heretofore have been obtained from private sources at large rental cost and expense in altering them for the wire-drag work.

During the summer of 1919 for the first time the Survey had in operation four specially constructed wire-drag launches working on the New England coast, which demonstrated their efficiency in carrying on our wire-drag surveys. The launches are specially designed for this class of work, and therefore have the proper amount of space for the appliances required in the search for submerged dangers. They have been found far superior to the clumsy vessels that have been hired heretofore for towing the wire drag, and on which we have been forced to spend time and money in making alterations to fit them in a measure for the work.

With this efficiency and economy evidenced by their use during the summer of 1919, it is apparent that the addition of at least four new launches to the four already provided is warranted.

The new specially-designed launches permit the installation of permanent equipment. The power reels heretofore used on the chartered launches were an outgrowth from a crude hand apparatus unduly cumbersome, complicated, and unsightly. They were designed as temporary expedients to be put on and hauled off the launches every few months, with the natural result that they include features that could be greatly improved in a permanent installation. Such permanent design has been made, the underlying idea being to secure simplicity, compactness, reliability, and permanency.

Auxiliary hoisting engines were improved upon which permits the hoisting of heavy articles on or about the deck. With this kind of apparatus the reel can be set low upon the deck, and neatly covered when not in use. Permanent lockers for stowing buoys and floats can be installed, so that every article of equipment in use has a definite place under cover securely stowed and in order at all times. This plan has greatly simplified the operation as well as improved the appearance of the launches.

At the time of the transfer of vessels from the naval service to this Bureau for survey work, a number of small cruising launches were also transferred. These launches with two exceptions were shipped to the Pacific coast for the purpose of carrying on wire-drag work in southeastern Alaska, the necessity for which has been pointed out in my reports each year.

At present the steamer *Explorer*, acting as a mother ship for these launches, is now engaged in dragging the main channel route in the vicinity of Juneau, Alaska, the vessel itself being used as the guiding launch which tows one end of the drag, determines its progress through the water, and carries the heavy power reels for winding in the drag when it is taken up and the semaphore for signaling to the smaller launches which are in attendance. One of the launches tows the other end of the drag.

The Navy launches, while not designed for wire-drag work, have to some extent been remodeled for this class of work and have been made serviceable for a short period.

It is a source of gratification to have eliminated the large expense of chartering launches for this class of work, although for the first time in several years but one party has been operating on the wire-drag work, not through the lack of equipment, but by reason of the fact that sufficient officers were not available for this class of work.

In my estimates for 1921 I have entered an item for the same number of launches as estimated for in 1920, viz, four 60-foot wire-drag launches and two 30-foot wire-drag tenders. These launches are needed for wire-drag work in Porto Rico and the Virgin Islands and Alaskan waters. The number estimated for is just sufficient to equip two drag parties and, if supplied, will permit in the coming year the operation of two parties on the Atlantic coast, one in Porto Rico and Virgin Islands, and two wire-drag parties in southeastern Alaska. The Navy has urged for several years that the waters of Porto Rico and Virgin Islands be dragged to insure safety to the fleet during the winter maneuvering in those waters and to provide a safe place for a rendezvous. As for Alaska, the need for completing the drag work is urgent. The present launch equipment (the launches supplied by the Navy) provides for but one wire-drag party, while heretofore two parties with chartered launches have been in operation during the working season in southeastern Alaska.

### INCREASED APPROPRIATIONS FOR CONTINUING GEODETIC OPERATIONS.

By Executive order dated December 30, 1919, there was created a Board of Surveys and Maps of the Federal Government. The work of this board bears close relation to the geodetic surveys by the Bureau, and will doubtless have such an influence in shaping the activities of the Bureau in the future, that this subject would be incomplete without some mention of the purposes and aims of the board.

The Executive order directs the board to make recommendations to the several departments of the Government or to the President for the purpose of coordinating the map-making and surveying activities of the Government and to settle all questions at issue between the executive departments relating to surveys and maps, in so far as their decisions do not conflict with existing law. The Executive order further directs that the board shall hold meetings at stated intervals to which shall be invited representatives of the map-using public for the purpose of conference and advice.

It is believed that the creation of this Board of Surveys and Maps is a step that will have very far-reaching consequences in the horizontal and vertical control and the topographic mapping of the country and in planning standard methods to carry on the work connected with surveying and map making of various kinds, done by Government organizations and by private organizations and individuals. Maps have been made in this country ever since the colonists first landed, but there has never been any coordinating agency by which standards of accuracy would be established for the guidance of surveyors and map makers.

The Board of Surveys and Maps since its organization in January, 1920, has had a number of meetings, and it has adopted, as its general opinion, the plan that the control surveys of the country, as far as the fundamental geographic positions and elevations are concerned, should be made by the Coast and Geodetic Survey.

The Coast and Geodetic Survey has, as one of its main functions, the establishment of fundamental horizontal and vertical control along the coast and in the interior of the United States. The stations of the control surveys, both horizontal and vertical, are for the primary purpose of forming the basis for the various classes of surveying and mapping and to fill other engineering needs. They are especially valuable for the standard topographic surveys of the United States Geological Survey, the military surveys of the Army, international, State, and county boundaries, and engineering and surveying work for highways, railroads, and cities.

For about 50 years Congress has been appropriating small amounts of money for the establishment of precise geographic positions and elevations in the interior of the country. On January 1, 1910, there were 10,000 miles of precise triangulation and traverse in the interior of the United States. On January 1, 1920, there were about 16,000 miles, an increase of 60 per cent in 10 years. A small part of this work was done by the United States Lake Survey.

On January 1, 1910, there were 26,000 miles of precise leveling in this country, run by the United States Coast and Geodetic Survey and by other organizations, while now there are 42,000 miles, an increase of 62 per cent.

The rate at which the precise horizontal and vertical control has been done during the last 10 years is far greater than has been the case formerly. This is due to somewhat larger appropriations and also to greater efficiency and skill in the executive and technical work involved. The slowness with which the geodetic work has been extended in the country for the last half century is due almost entirely to the lack of appreciation of the necessity for fundamental control by other organizations of the Government, by States, cities, and by

private organizations and individuals. The officials of the Coast and Geodetic Survey have continually placed the problem before Congress and urged a greater appropriation for this work. The demands are now becoming so urgent on this survey that it is believed far greater appropriations should be made now in order to meet public needs.

Until the organization of the Board of Surveys and Maps the Coast and Geodetic Survey was following the plan which would provide eventually a precise-level bench mark and a precise triangulation or traverse station within about 50 miles of each point in the interior of the country. In order that this might be done, it would need 30,000 miles of precise triangulation and traverse, at a cost of approximately $1,275,000. The total cost of the vertical and horizontal control necessary to supplement existing work on that plan would be approximately $1,725,000.

It is believed that if we should have the amount of vertical and horizontal control mentioned above, supplemental lines of precise or lower grade horizontal and vertical control could be extended into new areas in a very short time, where detailed surveying and mapping operations might be planned. It was thought to be inadvisable to neglect the main scheme by spending the time and money of the Bureau in making detailed control surveys in very local areas.

The result of the meetings and deliberations of the Board of Surveys and Maps has modified very greatly the simple plan outlined above for the control work of the Coast and Geodetic Survey. The board is of the opinion that very much more precise vertical and horizontal work should be done and also that the control be carried on at such a rate that there will be, in the near future, a precise or secondary elevation and geographic position within every 30-minute quadrangle of the country. When the control has been carried on to this extent, we shall have final values for elevations and geographic positions within the area of each quadrangle sheet of the U. S. Geological Survey and near each town and city of the country. Practically all county and State boundaries will have fundamental geographic positions established near them. There will not be the necessity in the future of shifting the geographic positions on a map based on this control or of changing the scale of the map in order to make it consistent with some other maps, or of placing an equation on the map to show the error of the datum on which the elevations and contours are based. The final positions furnished would be on what is called the North American datum and the elevations on mean sea-level datum.

The amount of precise or secondary leveling in the intermediate areas of the main network will be about 87,000 miles, which will cost approximately $1,040,000. The amount of precise or secondary triangulation and traverse necessary to furnish the fundamental control in the intermediate areas of the general scheme is about 59,000 miles, which will cost approximately $2,940,000.

The total cost of the field work to furnish the precise and secondary leveling and also the precise and secondary triangulation and traverse, which will bring control points in each quadrangle sheet—that is, an area 30 minutes square—is approximately $5,700,000.

# CHAPTER III.

## WHAT HAS BEEN DONE IN THE FIELD DURING THE FISCAL YEAR.

As in the past, the field accomplishments for the year are summarized under the following classifications:

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

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

### HYDROGRAPHY.

The following table gives a condensed statement of the vessels at the disposal of the Coast and Geodetic Survey within the fiscal year:

| Name of vessel. | Operated by Survey at beginning of fiscal year. | Received by— | | Disposed of by— | |
|---|---|---|---|---|---|
| | | Transfer from Navy. | Loan from Philippine government. | Return to Navy. | Sale. |
| Arcturus [1] | 1 | | | 1 | |
| Bache | 1 | | | | |
| Cosmos | 1 | | | | |
| Explorer | 1 | | | | |
| Fathomer [2] | 1 | | | | |
| Hydrographer | 1 | | | | |
| Isis | 1 | | | | [3] 1 |
| Lydonia [1] | | 1 | | | |
| Marinduque [2] | | | 1 | | |
| Natoma [1] | 1 | | | | |
| Onward [1] | 1 | | | | |
| Pathfinder | 1 | | | | |
| Patterson | 1 | | | | 1 |
| Ranger [1] | 1 | | | | |
| Romblon [2] | 1 | | | | |
| Surveyor | 1 | | | | |
| Wenonah [1] | 1 | | | | |
| Yukon | 1 | | | | |
| Total | 16 | 1 | 1 | 1 | 2 |

[1] Converted yachts received by transfer from the Navy for surveying.
[2] Owned by Philippine government and loaned to Coast and Geodetic Survey for surveying in Philippine waters.
[3] Damaged by collision with sunken wreck, beached and damaged by storm beyond economical repair.

| | | |
|---|---|---|
| Owned and operated or operated by the Coast and Geodetic Survey at beginning of year | | 16 |
| Received by transfer from Navy | | 1 |
| Received by loan from Philippine government | | 1 |
| Total | | 18 |
| Sold during year | 2 | |
| Returned to Navy during year | 1 | |
| | | 3 |
| Total vessels at disposal of the Survey at end of fiscal year 1920 | | 15 |

The following is a brief statement of the assignments of the vessels at the disposal of the Coast and Geodetic Survey within the fiscal year:

"*Arcturus*."—This vessel was outfitting in New York the first half of July and proceeded to Norfolk, Va., the 16th of that month. Her condition not having proven satisfactory, her personnel and equipment were transferred to the *Lydonia*. She was then laid up, and on January 15 returned to the Navy.

"*Bache*."—This vessel was outfitting at Norfolk at the opening of the fiscal year. During the months of August, September, October, and up to November 21 she was engaged on hydrographic surveys at the entrance of Chesapeake Bay. She was outfitting from November 21 to December 23, when she proceeded to Pensacola Bay and after a brief stop continued to the mouth of the Mississippi River and was engaged in a hydrographic examination of the approach to the entrance. This was completed and she returned to Pensacola January 27. She then cooperated with the *Ranger* in the offshore surveys of the Gulf from Pensacola to the westward. She continued in this work until May 5, when she proceeded to Norfolk and was undergoing repairs from May 14 to June 16.

"*Cosmos*."—This small steamer is used as an auxiliary for one of the larger surveying vessels during the Alaska season. This year she was assigned to the *Lydonia* and was taken out of storage the latter part of May and overhauled for the approaching season's work.

"*Explorer*."—This vessel was laid up in Lake Union, Wash., until the latter part of February, 1920, when she was outfitted as the mother ship to the launches for wire-drag work in Stephens Passage, Alaska. She left Seattle April 15 with the launches, and the necessary preparations and outfitting of the launches were completed at Juneau, and on June 6 the actual field work was started.

"*Natoma*."—This vessel was at the Canal Zone June 30 en route for San Francisco, where she arrived July 27. She was engaged in a hydrographic reexamination of San Francisco Bay until April 15, 1920, when she was overhauled and repaired and was so engaged until June 30.

"*Onward*."—This vessel was engaged in a hydrographic examination at Hampton Roads, Va., from July 1 until September 27. On the latter date she proceeded to Doboy Sound, Ga., and continued on hydrographic work in this locality. This was completed on December 24 and she was undergoing repairs at Savannah, Ga., from December 25 to March 8. She then proceeded to Adams Creek and the Neuse River, N. C., where she was engaged in combined operations to the close of the fiscal year.

"*Pathfinder*."—This vessel operated in Philippine waters throughout the entire year.

"*Patterson*."—As stated in my last annual report, the sale of the *Patterson* was contemplated as soon as the necessary formalities could be complied with. These were completed and the sale effected December 15, and she was removed by the purchaser from where she had been laid up in Lake Union, Wash.

"*Ranger*."—This steamer, having completed repairs and outfitting, proceeded the latter part of July for Mobile, Ala., where she arrived on August 2. She continued on hydrographic surveys of the Gulf coast from that date to the close of the fiscal year.

"*Romblom.*"—This vessel was employed in making surveys of the Philippine waters throughout the fiscal year.

"*Sialia.*"—This vessel was received from the Navy October 6, and then proceeded en route to the Pacific coast, when boiler trouble developed, and it was necessary to tow her into Key West for repairs. After a month's delay on this account she made a new start only to break down a second time. She was laid up at Nuevitas, Cuba, for two months, and then returned to Key West. From Key West this vessel proceeded to Charleston, S. C., and on March 15, 1920, was returned to the Navy Department.

"*Surveyor.*"—This vessel was being repaired and outfitted July 1, 1919. These were completed July 9, when she left Seattle, Wash., for Shelikof Strait, Alaska. She was engaged in combined operations in this part of Alaska until her return to Seattle November 4. She was being overhauled and repaired from November 5 to March 26, when she returned to Shelikof Strait for work in Alaska for the remainder of the fiscal year.

"*Wenonah.*"—On July 1 the *Wenonah* was en route from Norfolk, Va., to her working ground on the California coast. She arrived at San Diego July 17, San Francisco July 31. After some necessary repairs and outfitting at the latter place she proceeded to her working grounds in the vicinity of Cape Mendocino, Calif., where she arrived August 28. From this time onward until December 17 she was engaged in hydrographic work. She was then engaged in being repaired and outfitted both at San Francisco and Seattle until June 20, when she proceeded to her working grounds in southeast Alaska.

"*Lydonia.*"—This vessel was transferred from the Navy August 7, 1919. She completed her outfit and preparations for the voyage to her field of work on the California coast during the remainder of the month. During September she left Norfolk for San Francisco and was outfitting there during the month of October. November, December, and January she was engaged in offshore hydrography between Cape Mendocino and Point Arena, Calif. From February 4 until May 26 she was under repair and outfitting, and on the latter date she left for her field of work in southeast Alaska.

"*Fathomer.*"—This vessel operated in Philippine waters and was in commission the entire year.

"*Hydrographer.*"—This vessel was engaged in hydrographic surveys of the Florida Reefs in the vicinity of Key West during the entire year. On September 7 to 8 occurred a storm notable for its severity. During the height of the storm the *Hydrographer* dragged her anchors and drifted down on another steamer. To avoid sinking or serious damage her cables were slipped and she drifted ashore. Through the energy and resourcefulness of her commanding officer she was floated by the exertions of her crew and without outside assistance. Hydrographic work by the vessel itself was interrupted, due to necessary repairs until January 17.

"*Isis.*"—This vessel was repairing and outfitting from July 1 to August 15. On the latter date she proceeded to her working grounds at the entrance to Delaware Bay and continued on a hydrographic examination of this locality until October 21, when she was ordered to special duty at Washington, D. C. From November 5 to December 12 she was outfitting and repairing for her season's work off the

Florida coast. She arrived at Jacksonville December 31 and up to January 15 was engaged in the actual work of hydrographic surveys. On the latter date she struck a submerged wreck, loosening a number of plates in the bottom. The vessel was beached near St. Augustine, Fla.

*Current observations.*—During the year current observations were made on the following light vessels:

| Light vessel. | State. | Station. | Time employed. |
|---|---|---|---|
| | | | *Y.m.d.* |
| Blunts Reef | California | 1 | 1 0 0 |
| Brunswick | Georgia | 1 | 1 0 0 |
| Columbia River | Oregon | 1 | 1 0 0 |
| Diamond Shoal | North Carolina | 1 | 1 0 0 |
| Frying Pan Shoals | do | 1 | 1 0 0 |
| Overfalls | Delaware | 1 | 1 0 0 |
| Pollock Rip Slue | Massachusetts | 1 | 1 0 0 |
| San Francisco | California | 1 | 1 0 0 |
| Swiftsure | Washington | 1 | 1 0 0 |
| Umatilla Reef | do | 1 | 1 0 0 |
| Winter Quarter Shoal | Virginia | 1 | 1 0 0 |
| Brenton Reef | Rhode Island | 1 | 4 0 |
| Cape Lookout Shoal | North Carolina | 1 | 3 0 |
| Heald Bank | Texas | 1 | 7 0 |
| Portland | Maine | 1 | 4 0 |
| Nantucket Shoal | Massachusetts | 1 | 8 17 |
| Northeast End | New Jersey | 1 | 4 0 |
| Stone Horse Shoal | Massachusetts | 1 | 3 0 |
| Tail of the Horse Shoe | Virgina | 1 | 4 0 |
| Total | | 19 | 14 1 17 |

Short series of current observations were made at the following localities:

| Locality. | Stations. | Time employed. |
|---|---|---|
| | | *M. d.* |
| Block Island Sound, R. I. | 4 | 19 |
| Cape Porpoise Harbor, Me. | 1 | 3 |
| Chesapeake Bay Approaches, Va. | 1 | 1 16 |
| Delaware Bay Approaches, Del. | 6 | 15 |
| Doboy Sound Approaches, Ga. | 3 | 8 |
| Kodiak Island, Alaska | 3 | 19 |
| Mississippi Delta, La. | 1 | 2 |
| Mobile Bay Approaches, Ala. | 22 | 1 11 |
| New York Harbor, N. Y. | 19 | 3 23 |
| Pensacola Approaches, Fla. | 23 | 1 16 |
| Portsmouth Harbor, N. H. | 2 | 18 |
| Total | 85 | 11 0 |

*Tidal observations, principal stations.*—Automatic tide gauges were in operation throughout the year at the following stations:

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

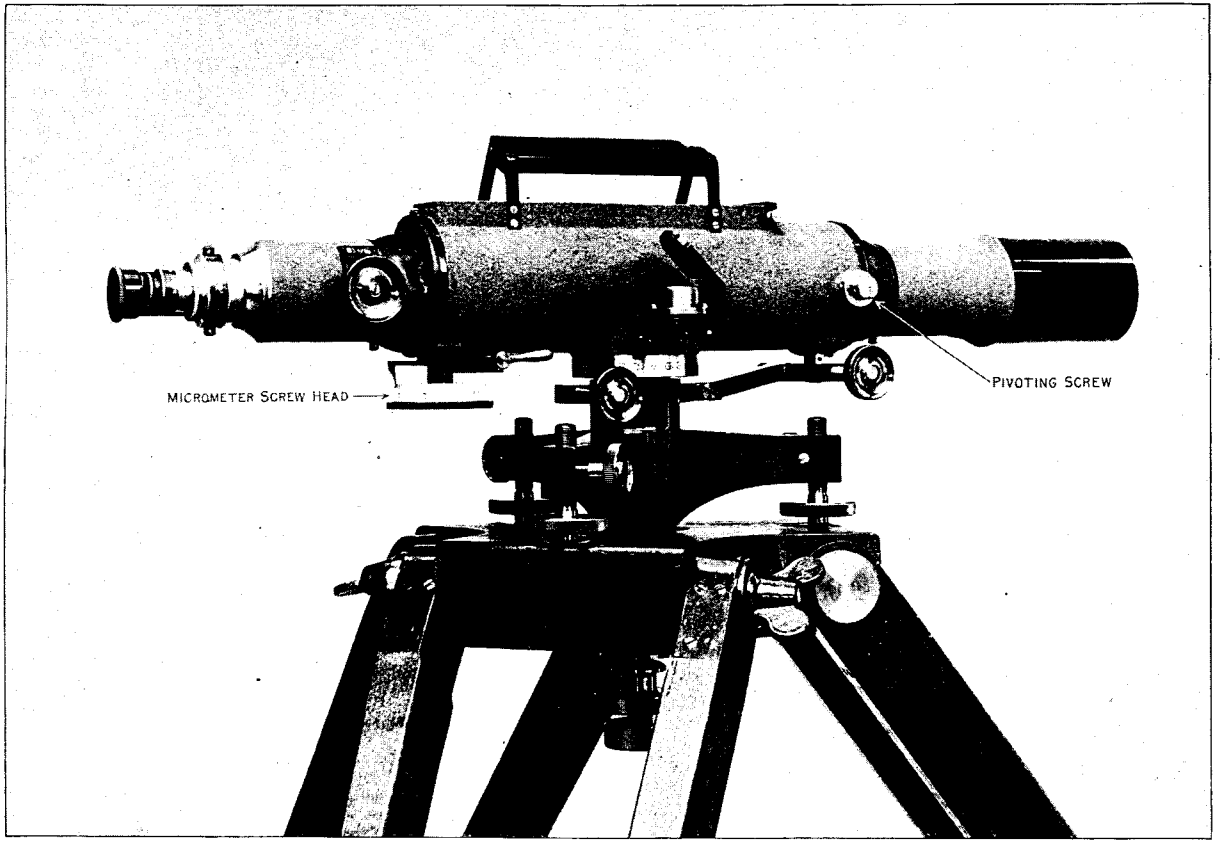
*Tidal observations, secondary stations.*—Tidal observations were made at the following stations during a part of the year:

1. Cape Porpoise, Me.
2. Nahant, Mass.
3. Block Island, R. I.
4. Point Judith, R. I.
5. New York City, Bergen Point.
6. New York City, West Forty-second Street.
7. New York City, New Brighton.
8. New York City, Pier A.
9. New York City, Spuyten Duyvil.
10. Breakwater Harbor, Del.
11. Assateague, Va.
12. Craney Island, Va.
13. Fishermans Island, Va.
14. Mile Watch Harbor, Va.
15. Nansemond River Light, Va.
16. Old Point Comfort, Va.
17. Pine Beach Ferry, Va.
18. Oriental, N. C.
19. Sapelo Lighthouse, Ga.
20. Pensacola, Fla.
21. Saddle Bunch Harbor, Fla.
22. Eureka, Calif.
23. Humboldt Bay, North Jetty, Calif.
24. Morro, Calif.
25. Lake Washington, boathouse wharf.
26. Lake Washington, Leschi Park.
27. Unga, Baroloff Bay, Alaska.
28. Aborlan, P. I.
29. Arrecite Island, P. I.
30. Babuyan, P. I.
31. Balabac, P. I.
32. Binanga Bay, P. I.
33. Brooke Point, P. I.
34. Calandorang, P. I.
35. Cana Island, P. I.
36. Green Island, P. I.
37. Island Bay, P. I.
38. Jamelo Cove, P. I.
39. Makesi Island, P. I.
40. Mantaquin Bay, P. I.
41. Mariveles, P. I.
42. Naranjos Island.
43. Panacon, P. I.
44. Puerto Princessa, P. I.
45. San Bernandina Island, P. I.
46. Village Rocks, P. I.

## GEODESY.

### TRIANGULATION.

| | Length of scheme. | Area covered. |
|---|---|---|
| Primary: | *Miles.* | *Sq. miles.* |
| Oklahoma, vicinity of Hartford to McAlester | 120 | 1,900 |
| Arizona, Nogales-Yuma | 225 | 12,300 |
| Arizona, vicinity of Phoenix | 125 | 7,800 |
| New Mexico, Albuquerque westward | 85 | 4,600 |
| California, Mexican connection | 40 | 600 |
| California, California-Oregon arc | 45 | 375 |
| Utah, forest areas | 105 | 4,600 |
| Total | 745 | 32,175 |
| Tertiary: | | |
| North Carolina, Neuse River | 15 | 65 |
| California, Humboldt and Morro Bays | 50 | 125 |
| California, San Francisco Bay | 12 | 140 |
| Oregon, Umqua River | 6 | 6 |
| New Jersey and Delaware, Cape Henlopen, Bethany Beach, Cape May radio stations | 15 | 20 |
| Georgia, vicinity of Sapelo Lighthouse | 9 | 18 |
| Washington, Lake Washington | 20 | 30 |
| Florida, Key West and Miami | 20 | 110 |
| Alaska, Frederick Sound and Stephens Passage | 45 | 325 |
| Alaska, Shelikof Straits and Cape Iktu northeastward | 98 | 1,520 |
| Virgin islands | 17 | 55 |
| Total | 307 | 2,414 |
| Primary traverse: | | |
| Indiana, North Vernon-Tipton | 100 | ..... |
| Louisiana, Mansfield-Naples | 150 | ..... |
| Total | 250 | ..... |
| Reconnoissance: | | |
| California-Oregon | 400 | 26,000 |
| Washington-Puget Sound | 100 | 500 |
| Indiana (primary traverse), North Vernon-Tipton | 115 | ..... |
| Total | 615 | 26,500 |




GEODETIC LEVEL.

TRIANGULATION—Continued.

| | Length of scheme. | Areas covered. |
|---|---|---|
| SUMMARY. | *Miles.* | *Sq. miles.* |
| Primary triangulation | 745 | 32,175 |
| Tertiary triangulation | 307 | 2,414 |
| Total | 1,052 | 3489,5 |
| Reconnoissance | 615 | ..... |
| Primary traverse | 250 | ..... |

*Precise levels.*—There were 2,246 miles of precise leveling run during the fiscal year 1920. The lines of precise leveling are as follows:

| | Miles. |
|---|---|
| Rouses Point to Williamson, N. Y | 324 |
| Black Rock to Williamson, N. Y | 132 |
| Kirk, Oreg., to Roseville, Calif | 380 |
| San Jose to Santa Ana, Calif | 491 |
| Hillsboro, Tex., to Naples, La | 444 |
| Klamath Falls toward Ontario, Oreg | 55 |
| Weed, Calif., to Portland, Oreg | 420 |
| Total | 2,246 |

An interesting development in long-distance leveling is worthy of note. Although the type of geodetic level now used by this Survey was adopted in 1900, there had been no occasion to use other than ordinary lengths of sights in the extension of the precise-level lines until a connection was required between the bench marks on the opposite banks of the Mississippi River in the vicinity of New Orleans, La. In making this connection a method to which the instrument is peculiarly adapted was substituted for the usual method of waving a target into the horizontal line of sight.

The features of the instrument which lend themselves to this method of observing are that the telescope is irreversible and that it is supported near the object end by a pair of pivoting screws and rests upon the head of a micrometer screw near the eye end. (See fig. 14.) By turning the micrometer screw the eye end of the telescope can be raised or lowered, and thus in sighting through the instrument the stadia wire can be made to pass over a large field. The micrometer head is divided into 100 equal parts, and an index is provided for reading the setting of the head.

The general scheme of this method of observing is that simultaneous reciprocal observations are made at each of the points on opposite sides of the river. Instead of waving a single target into the line of sight, when the bubble is in the middle of the tube, two stationary targets are set on each rod, one above and the other below the line of sight. By reading the micrometer head, with the middle wire on the top target, with the telescope level, and with the middle wire on the bottom target, respectively, the reading on the rod at the point of inersection of the line of sight, when the telescope is level, can be determined, as the distances from this point to the two targets will be proportional to the corresponding differences in the readings on the micrometer head.

At the point selected for the crossing, the Mississippi River is about 1,200 meters wide. Observations were made on November 18 and 19, 1919. Four sets of readings were taken each day, making a total of eight determinations of the difference in elevation for the two days. The probable error of the mean of the eight determinations was ± 0.89 millimeter.

*Magnetic observations.*—In the continuation of the magnetic survey of the United States observations were made during the year at 79 stations in 22 States, of which 24 were new primary stations, 11 auxiliary stations, 42 repeat stations for the determination of secular change, and 2 new stations in old localities. Meridian lines were established when they were requested by the local authorities.

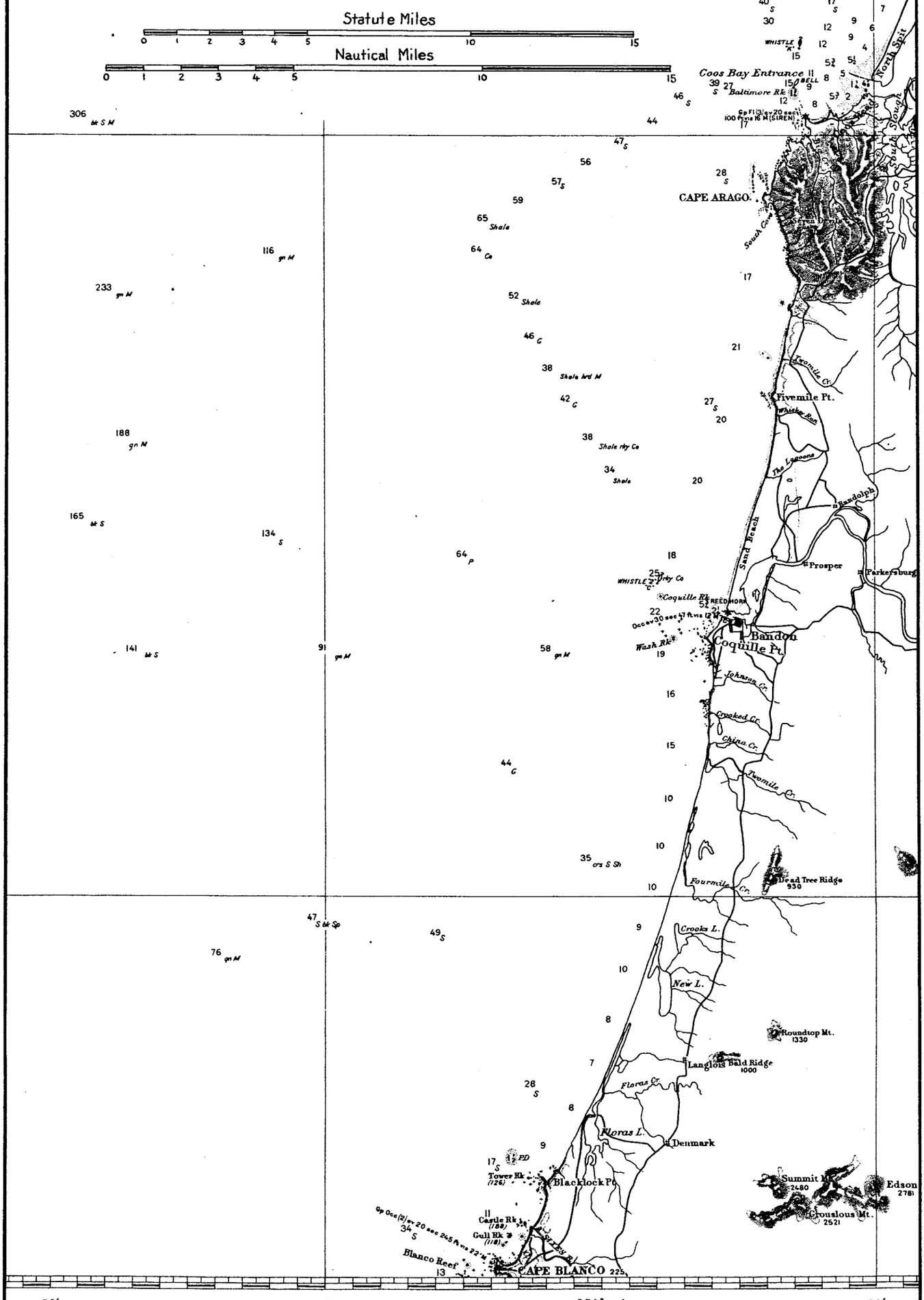
The observatories at Cheltenham, Md., Vieques, P. R.; Tucson, Ariz.; Sitka, Alaska; and near Honolulu, Hawaii, were in operation throughout the year. A continuous photographic record was secured of the variations of declination, horizontal intensity, and vertical intensity. Absolute observations were made at least once a week. A seismograph was in continuous operation at each observatory.

# A TYPICAL SECTION OF A PACIFIC COAST CHART

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

SOUNDINGS IN FATHOMS
1 fathom = 6 feet

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

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# CHAPTER IV.

## SHOWING CONDITIONS AND NEEDS OF HYDROGRAPHIC SURVEYS, WITH ILLUSTRATIONS—UNITED STATES AND POSSESSIONS.

### HYDROGRAPHIC SURVEYS.

In the present and previous annual reports there are printed diagrams of the "Condition of field operations." These diagrams are intended to show in a graphic manner where our surveys are at present adequate, or where surveys are needed and of the type of survey required to make our charts up to date and thoroughly reliable for safe navigation. There have also been printed two special publications, "The Neglected Waters of the Pacific Coast," and "Safeguard the Gateways of Alaska," which were written to call attention to the urgent need for surveys along these coasts.

It is thought it would be helpful to a clearer idea of the Survey's problem in charting the waters of the United States and its possessions if, in addition to these publications, several of the areas where surveys are now in progress should be described and the reasons given for making the surveys.

For purposes of description it is convenient to arrange our hydrographic surveys into five types. One of each type is described below.

1. *Original surveys.*—Areas hitherto unsurveyed or at best covered by surveys of an exploratory character.

It is not necessary to go as far afield as Alaska or the Philippine Islands to find an area requiring an original survey. Such an area is to be found along the coast of Oregon, extending from Cape Blanco northward to near Cape Lookout. The accompanying illustration (see fig. 15 opposite p. 64), which is a reproduction of a section of one of the Oregon coast charts, shows plainly, by the almost entire absence of soundings in the water area, how little is known of the depth along this stretch of coast. It is in the same class with some of the rarely visited portions of Arctic Alaska. But, unlike the latter, these waters of unknown depth which intervene between San Francisco on the south and Portland and Seattle on the north are traversed by a fleet of vessels bearing a large fraction of the commerce of the world.

The Coast Pilot states that their navigation presents to the navigator a problem of unusual difficulty. The courses must be traversed during frequent periods of thick weather, with the vessel subject to the action of currents whose velocity and even direction are uncertain. Under these conditions it is obvious that there is only one method of safe navigation; that is, by means of the lead. But this method can only be efficiently employed when the depths are adequately shown, a condition notably absent on existing charts.

2. *Offshore surveys* are like inshore surveys in that the object of both is to furnish the navigator with information of the depth and configuration of the bottom by which he can lay a safe course and

verify his position from soundings. They differ with respect to the amount of information required. In shoal inshore waters, where the dangers approach the surface, the surveys are more elaborate, and many more soundings are taken than in deeper water offshore beyond such dangers. The surveying methods and apparatus also differ.

For inshore surveys well-determined objects on shore, like spires, lighthouses, or specially built wooden structures are available for fixing the position of the surveying vessel while sounding.

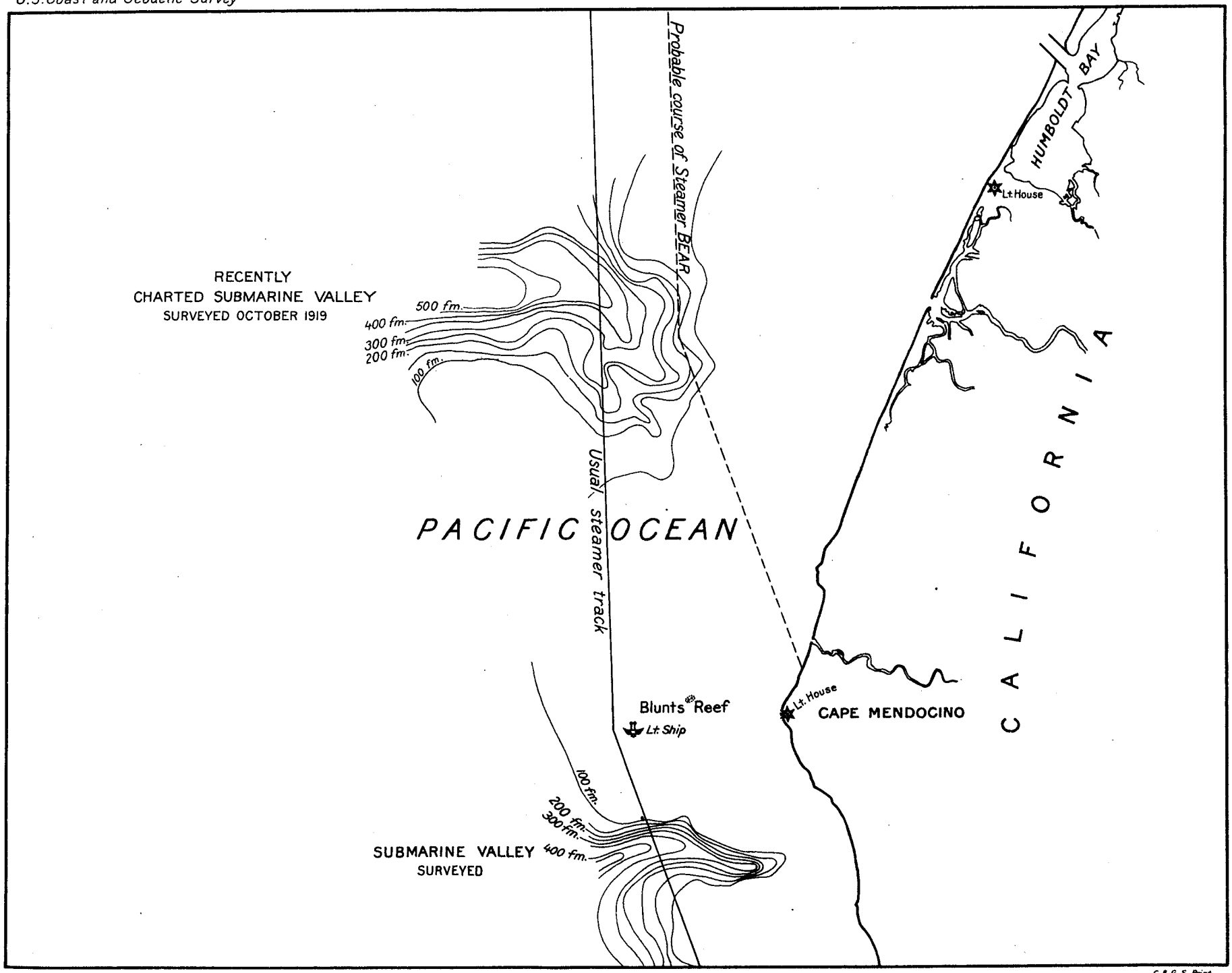
Offshore, beyond the visible range of such objects, well-defined mountain peaks can be used on a mountainous coast like that of the Pacific. But on a low coast, like that of the Atlantic and Gulf, where all land features have sunk below the horizon long before the outer limit of the offshore survey is reached, the location of the vessel and soundings must depend on carefully recorded speed and compass direction, with an allowance for currents and wind pressure. This method is termed by navigators "dead reckoning." In surveying practice the uncertainties which exist in the use of this method in ordinary navigation have been reduced by stopping at intervals to observe currents and wind pressure and by starting from and returning to well-fixed positions.

The work now in progress in the vicinity of Cape Mendocino is an example of an offshore survey on the Pacific coast. Vessels approaching Cape Mendocino from the northward (see fig. 16, opposite) must avoid Blunts Reef, the dangerous area of rocks and shoals off the cape, and at the same time must pass within the sound of the fog signal on Blunts Reef Light Vessel, in order that from it they may shape their course for Point Arena, 97 miles beyond. In order to accomplish this, when about off the entrance of Humboldt Bay they feel their way into a depth of 30 fathoms and then follow the 30-fathom curve, which is almost a straight line, leading clear of all danger, but within easy hearing distance of the fog signal on the light vessel.

The importance of having complete and detailed surveys now becomes obvious. In order that it may be possible for the mariner to utilize the method of verifying his position by sounding, the chart must show in detail the correct depths at every place where it is possible for soundings to be taken. By means of improved devices it is possible for vessels, without stopping, to sound in any depth up to about 100 fathoms (600 feet). Therefore, the chart to be complete should show the depths of all waters out to and beyond the 100-fathom curve. This the charts did not show when the surveys now in progress of this region were undertaken.

The results already obtained are of unusual interest and afford a striking demonstration of the value of this class of surveys. This will appear by referring to pages 13 and 14 of "The Neglected Waters of the Pacific Coast," where there will be found the episode of the wreck of the *Bear*. During the past season the uncharted submarine valley, which was a large factor in causing this wreck, was located, and being charted now becomes an aid to navigation rather than a menace.

Offshore surveys in the Atlantic and Gulf coast will not develop the bold and striking features characteristic of the Pacific. In consequence of its more advanced geologic age the coast of the Atlantic




*Submarine Valleys, Pacific Coast – their relation to Navigation.*

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and the Gulf is bordered by a broad margin of shoal water. In the process of building up this submerged plateau the tendency has been to fill up the depressions and in general smooth out the inequalities of the bottom. A notable exception to this rule is the submerged valley of the Hudson, which can be plainly recognized on the charts extending seaward from near the harbor entrance. The less striking features are equally important, however, and serve as well to identify a particular locality in a water area.

The offshore survey now in progress from Delaware Bay to New York Harbor is depended upon to effect a long-needed improvement of the charts. The depths now shown are from old surveys, when methods and appliances were far below modern standards. In consequence, the contour of the bottom is represented by scattered and unrelated irregularities instead of the systematic arrangement of slopes of a natural formation. The real characteristics of the area can not be recognized, and beyond the fact that they indicate there is sufficient depth for a vessel, the soundings afford no other assistance to the navigator in shaping his course.

The fourth type is an inshore survey where changes have occurred since the last survey and to such an extent that the chart no longer represents existing conditions.

Work now in progress from Port Royal Sound to Charleston, S. C., is an example of this type.

This stretch of coast is low and sandy and includes the two large unimproved entrances, Port Royal Sound and St. Helena Sound. In addition to these, a number of inlets and streams emptying into the open ocean increase the irregular and broken character of the shore line. Each entrance has its own complex system of sand shoals, commencing inside the general trend of the shore line and spreading out as they extend seaward. These shoals are subject to constant change, and the land areas abutting on the inlets are also subject to change by either accretion or erosion. Between the inlets, in front of the continuous shore line, the contour of the bottom in shoal water is simpler in arrangement and more stable in character.

The survey now in progress was planned on account of the magnitude of the changes indicated by a recent topographical survey. The channels over the bars at St. Helena Sound and Port Royal Sound were surveyed as recently as 1914 and 1916, but the intervening water areas between them and to the northward as far as Charleston Harbor have not been examined since 1853–1863. The existence of two such fine harbors as Charleston and Savannah, one at either end of this stretch of coast, has hitherto had the effect of limiting its waterways to purely local use, with no urgent demand for new surveys. The increasing number of cruising motor boats now makes the collection of up-to-date information imperative.

### WIRE-DRAG SURVEYS.

In the four preceding types of surveys the depths in shoal water are determined by the lead line cast at regular intervals from the surveying vessel. Along the sandy portions of our coasts surveys by this method may be sufficient. This is decidedly not the case, however, in regions where there are obstructions of small area, such as

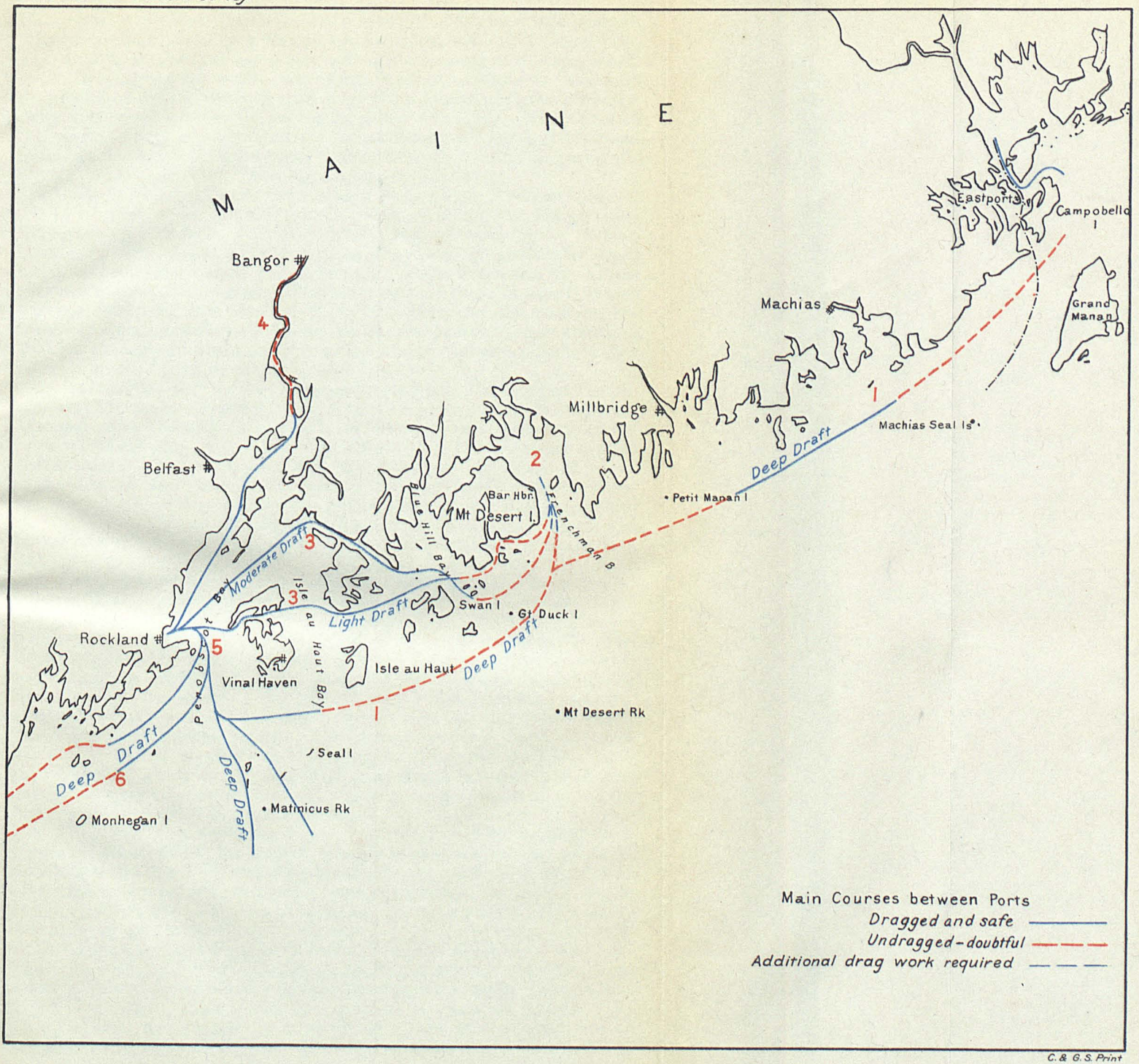
pinnacle rocks, bowlders, and sharp rocky ledges, for it is only by chance that they can be found by an ordinary hydrographic survey. The Coast and Geodetic Survey has therefore developed the apparatus known as the wire drag, which has been described in previous reports.

The work now in progress in Stephens Passage is an example of this type of survey. On this rugged coast pinnacle rocks occur in most unexpected localities. Alaska's waterways are her gateways and highways of commerce. Stephens Passage is a link in the chain of waterways which form the main steamer route in southeast Alaska. When its waters have been dragged the assurance can be given that all dangers have been found and charted for this route from the international boundary by way of Ketchikan, Wrangell, Juneau, to Skagway.

In my report for 1919, under this heading, I endeavored to show in general terms the conditions of the surveys of the important areas along our coast and the work needed to be done to bring the charts up to date for the benefit and safety of water-borne commerce. These areas were thoroughly discussed, and in order that the importance of the surveys may again be brought to your attention much of the material is again used in this report. To facilitate reference to the text and to the locality diagrams were inserted showing the important steamer courses; the courses being numbered to correspond to the paragraphs of descriptive matter. Using these sketches as base maps, I have endeavored to show the progress that has been made in the hydrographic and topographic work, using the same sequence in numbering the courses and descriptive matter pertaining thereto. As previously stated, a detailed analysis of the conditions and the progress of the work can not be given in this limited space, but I have shown on the base maps the areas covered during the past year, with supplementary notations to the original text.

1. *Deep-draft, along-shore course from the Canadian boundary to the outer limit of Isle au Haut Bay.*—The entire area that this course covers is a region of ledges and bowlders. The ledges rise abruptly from the deep water and the bowlders ordinarily lie singly or in clusters on an otherwise flat bottom, so that the navigator can not depend on the lead to avoid them. The thoroughfares affording an exit to the Bay of Fundy from Passamaquoddy Bay and St. Croix River have been wire-dragged. Also an area 15 miles in length between Machias Seal Islands and Petit Manan Island. There is still remaining a large area as yet untouched by the wire drag. There are a number of towns along this course that depend on water-borne traffic for shipping out their produce and receiving their supplies. The commerce consists in lumber, fish, and fuel, and miscellaneous merchandise, constituting the supply of the smaller and larger fashionable summer resorts, of which the largest is Bar Harbor, Me. 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 commerce over this course. (See fig. 17, opposite p. 68.)

2. *Frenchman Bay.*—This body of water lies westward of Schoodic Peninsula and eastward of Mount Desert Island. It is the approach to the town and important summer resort of Bar Harbor, Winter


MAINE
Bangor
Belfast
Rockland
Penobscot Bay
Moderate Draft
Light Draft
Deep Draft
Isle au Haut Bay
Vinal Haven
Isle au Haut
Swan I
Gt Duck I
Blue Hill Bay
Mt Desert I.
Bar Hbr.
Frenchman B
Millbridge
Petit Manan I
Machias
Machias Seal Is
Eastport
Campobello I
Grand Manan
Mt Desert Rk
Seal I
Matinicus Rk
Monhegan I
1
2
3
4
5
6
Main Courses between Ports
Dragged and safe
Undragged-doubtful
Additional drag work required

Harbor, South West Harbor, North East Harbor, and many small villages and naval coaling station on the north side of Eastern Bay. The bay is frequented by many passenger steamers, yachts, small craft, fishing vessels, and a few cargo vessels. This area has been dragged to a line extending westward from Schoodic Island whistle buoy, though not to depths 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. (See fig. 17, opposite p. 68.)

3. *Inland thoroughfares from Mount Desert Island to Rockland.*—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 in particular most 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 dangers in the use of channels that have not been dragged. (See fig. 17, opposite p. 68.)

4. *Penobscot River.*—This river, emptying into the head of Penobscot Bay, forms the approach to the towns of Bucksport, Winterport, Hamden, and Brewer, and the city of Bangor, the latter two at the head of navigation, about 24 miles above Fort Point Lighthouse at the entrance. It has considerable trade in regular steamers drawing about 10 feet, and many vessels trading to Bangor draw as much as 18 feet. Practically the entire river above Bangor is used in lumbering. From the mouth of the river to Bangor there will be no positive certainty of the absence of all dangers to navigation until the area has been dragged. (See fig. 17, opposite p. 68.)

5. *Penobscot Bay.*—In Penobscot Bay every port has benefited by the practical completeness of the wire-drag work. There are, however, some of the less-important sections 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. (See fig. 17, opposite p. 68.) 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 which was covered during the development of the wire-drag apparatus will later have to be dragged to a greater depth.

6. *Penobscot Bay to Casco Bay (deep draft).*—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, 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 rock or the large bowlders deposited during the glacial period. The lead line is not adapted to find without assistance dangers of this character. This thoroughfare presents uneven and rocky bottom between Monhegan Island and the eastern entrance to Casco Bay, which should be dragged to remove all doubt of the existence of pinnacle rocks or small ledges. (See fig. 17, opposite p. 68.)

7. *Penobscot Bay to Casco Bay (moderate draft).*—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. (See fig. 18, opposite p. 70.)

8. *Booth Bay Harbor.*—This forms the approach to the town of Booth Bay Harbor and numerous smaller summer resorts. It is frequented by many vessels and by a large number of fishing boats and pleasure craft in summer. It is one of the best anchorages on the coast of Maine, and is much used as a harbor of refuge by all classes of vessels. This area is in urgent need of a wire-drag survey. (See fig. 18, opposite p. 70.)

9. *Kennebec River.*—It is the approach to the cities of Bath and Augusta, the towns of Woolworth, Richmond, and Gardiner, and numerous smaller villages and summer resorts. The river has considerable water-borne commerce, the deepest draft being about 21 feet to Bath and 14 feet to Augusta. There is urgent need for a wire-drag survey of this river. (See fig. 18, opposite p. 70.)

10. *Casco Bay.*—Casco Bay and the approaches to Portland have been dragged with the result of finding numerous uncharted shoals, thereby furnishing important evidence of the need of carrying the survey to the eastward and westward to a junction with completed work. A resurvey of inner Casco Bay is badly needed, the glaciers having left a series of long narrow and dangerous ledges which require closer examination. (See fig. 18, opposite p. 70.)

11. *Portland Harbor and approaches.*—These have been dragged, and all dangers to navigation are shown on the charts. (See fig. 18, opposite p. 70.)

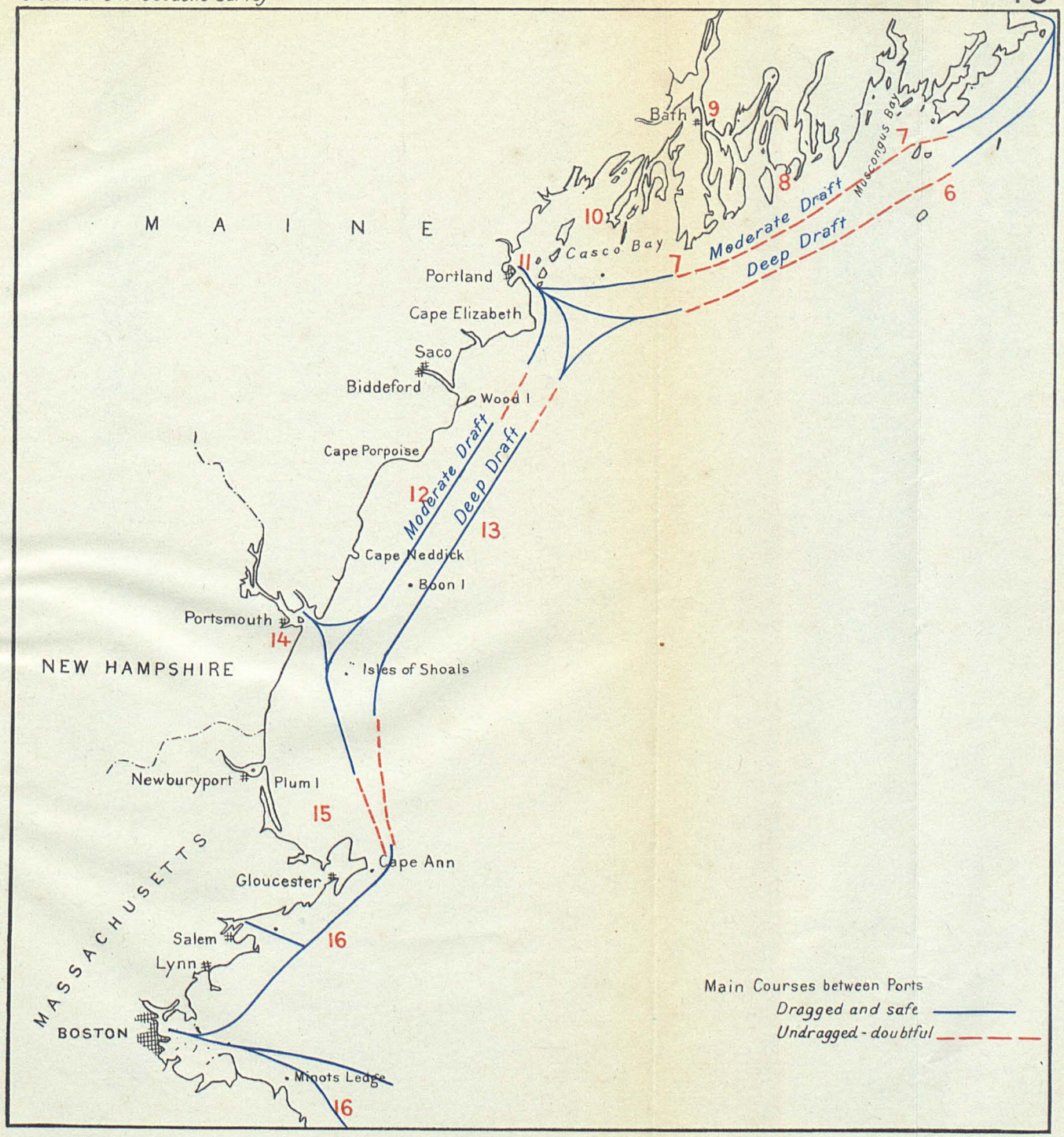
12. *Portland to Portsmouth (moderate draft).*—Westward of Portland the succession of sand beaches, of which Old Orchard is the best known, might appear to indicate an absence of rocks in this region. The depth of sand above the underlying rock is not great, however, and pinnacle rocks occur outside these beaches. There is a gap in the wire-drag surveys between Cape Porpoise and Cape Elizabeth which must be completed to make this portion safe. (See fig. 18, opposite p. 70.)

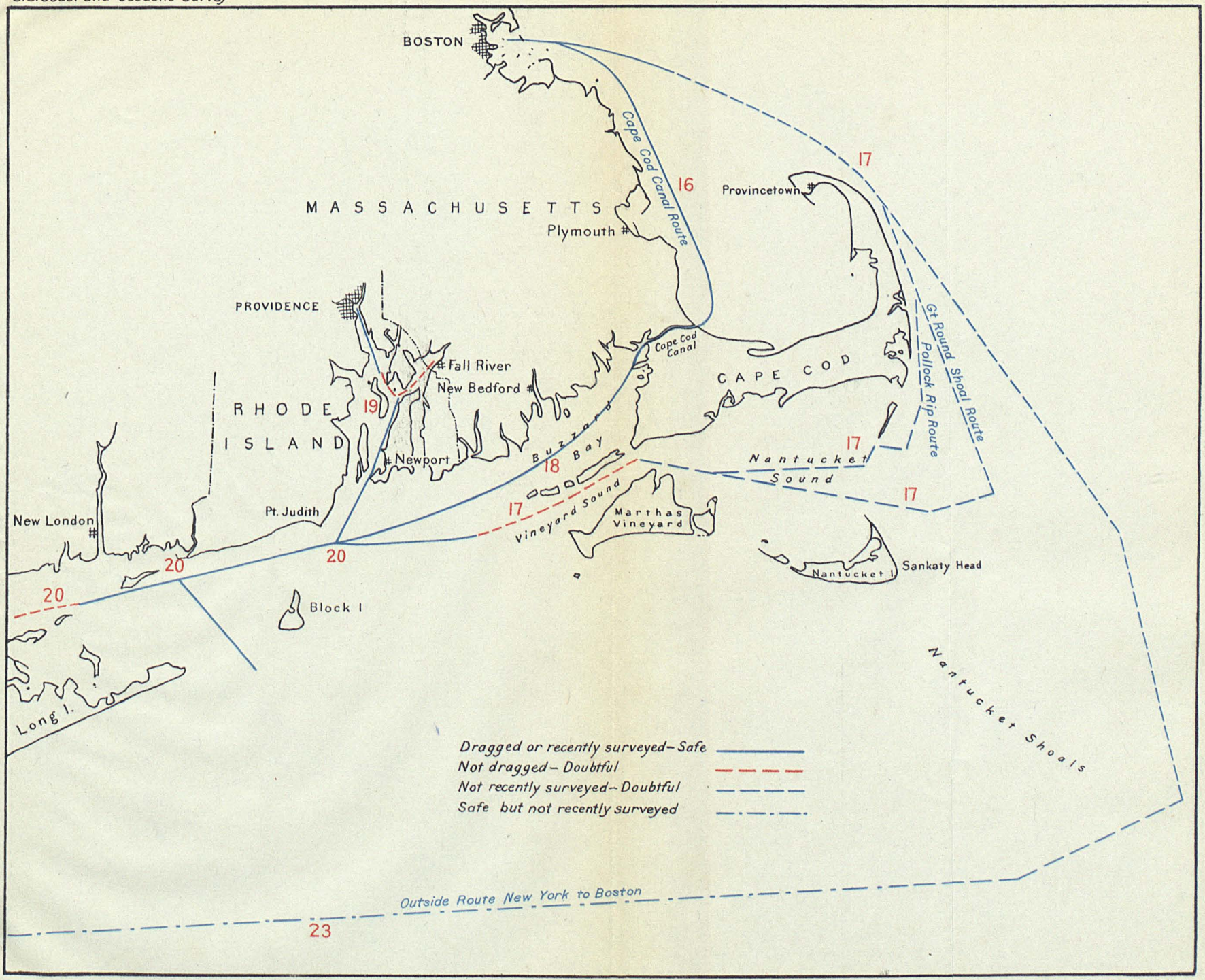
13. *Portland to Cape Ann (deep draft).*—The region from Boon Island to Isle of Shoals is very rocky, and its importance as the approach to Portsmouth is well recognized. The area has been covered by the wire drag which now forms a continuously dragged area from Cape Porpoise to within 10 miles of Cape Ann. (See fig. 18, opposite p. 70.)

14. *Portsmouth Harbor.*—This area has been dragged, and all dangers to navigation are known. (See fig. 18, opposite p. 70.)

15. *Massachusetts coast north of Cape Ann.*—From the New Hampshire border to Cape Ann the shores are entirely different from those to the north or south. There are high sand bluffs in places and low sandy shores in others. As a result, the depths along the shore are changeable, and, though they have been recently surveyed, they will need further attention. (See fig. 18, opposite p. 70.)

16. *Cape Ann to Cape Cod Canal.*—A completely dragged area extends from Cape Ann to Cape Cod Canal and from the head of Buz-


MAINE
Bath
9
Muscongus Bay
7
8
6
10
Casco Bay
Moderate Draft
Deep Draft
11
7
Portland
Cape Elizabeth
Saco
Biddeford
Wood I
Cape Porpoise
Moderate Draft
Deep Draft
12
13
Cape Neddick
Boon I
Portsmouth
14
NEW HAMPSHIRE
Isles of Shoals
Newburyport
Plum I
15
Cape Ann
Gloucester
MASSACHUSETTS
Salem
16
Lynn
BOSTON
Minots Ledge
16
Main Courses between Ports
Dragged and safe
Undragged - doubtful


BOSTON
Cape Cod Canal Route
16
17
Provincetown
MASSACHUSETTS
Plymouth
PROVIDENCE
Cape Cod Canal
Fall River
New Bedford
CAPE COD
Gt Round Shoal Route
Pollock Rip Route
RHODE ISLAND
19
Buzzards Bay
Newport
18
Nantucket Sound
17
17
17
Vineyard Sound
Marthas Vineyard
New London
Pt. Judith
20
20
20
Nantucket I
Sankaty Head
Block I
Long I.
Nantucket Shoals
Dragged or recently surveyed–Safe
Not dragged–Doubtful
Not recently surveyed–Doubtful
Safe but not recently surveyed
Outside Route New York to Boston
23

zards Bay to Sakonnet Point, R. I. With the exception of the 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, the original surveys having been made while the commerce of the region was relatively unimportant. A number of shoals were found of less than the proposed canal depth. It was important not only to find those shoals of less than the proposed canal depth, but also those which might become a menace at some future date in case it should be necessary to deepen this canal to take care of the largest vessls. With this view the drag was carried at a sufficient depth to meet such requirements. Even should a depth of 40 feet be adopted for the canal, the present surveys of the approaches will be found adequate, and where less depths have been found the information will be invaluable to the engineers making the improvement. (See fig. 18, opposite p. 70.)

17. *From Boston south outside Cape Cod.*—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 Cape Cod the surveys are not complete. In Nantucket Sound the entire route is through channels bounded by shifting sand, and requires frequent revision work. In one part of the channel most used, through Pollock Rip Slue, a shoal was formed in the last few years that has been steadily narrowing and decreasing the depth of the channel. A resurvey of parts of this route is needed every few years to insure safety to navigation. No rocks abound 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. (See fig. 19, opposite p. 70.)

18. *From Cape Cod Cannal through Buzzards Bay.*—This route has been dragged out to the eastern limit of Long Island Sound. (See fig. 19, opposite p. 70.)

20. *Entrance to Narragansett Bay, Block Island Sound, Fishers Island Sound, and eastern part of Long Island Sound.*—These areas are practically completed, with the exception of the central and western parts of Long Island Sound, which remain to be dragged. (See fig. 19, opposite p. 70.)

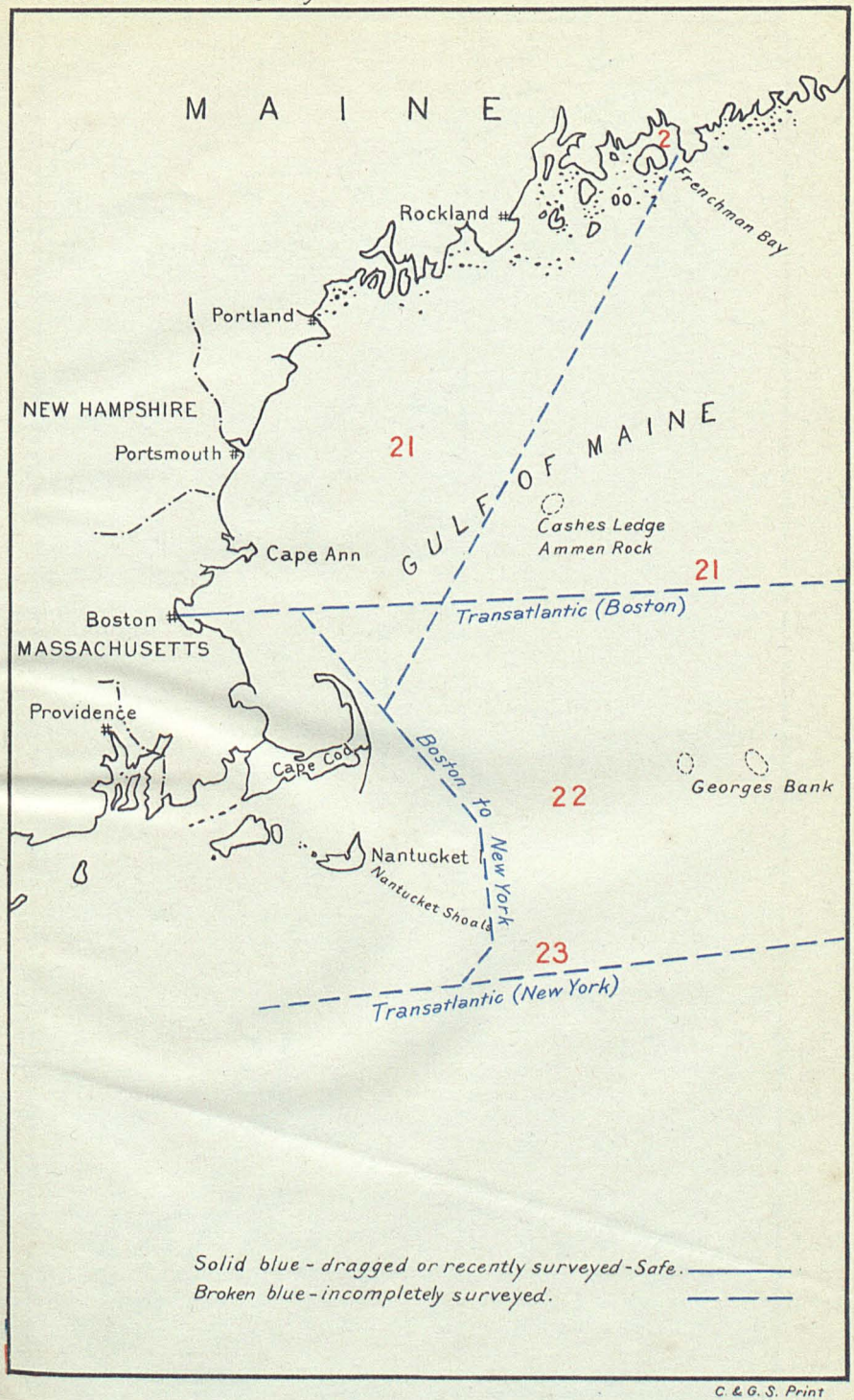
21. *Gulf of Maine.*—The portion of the Gulf of Maine of which this Bureau makes surveys may be considered as lying to the westward of meridian 67° 0′ and extending to Nantucket Shoals. This entire area has been inadequately surveyed, as it was accomplished at an early date when both the appliances and the methods were far inferior to those of the present day. 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 charts 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 of the gulf sufficiently to locate themselves

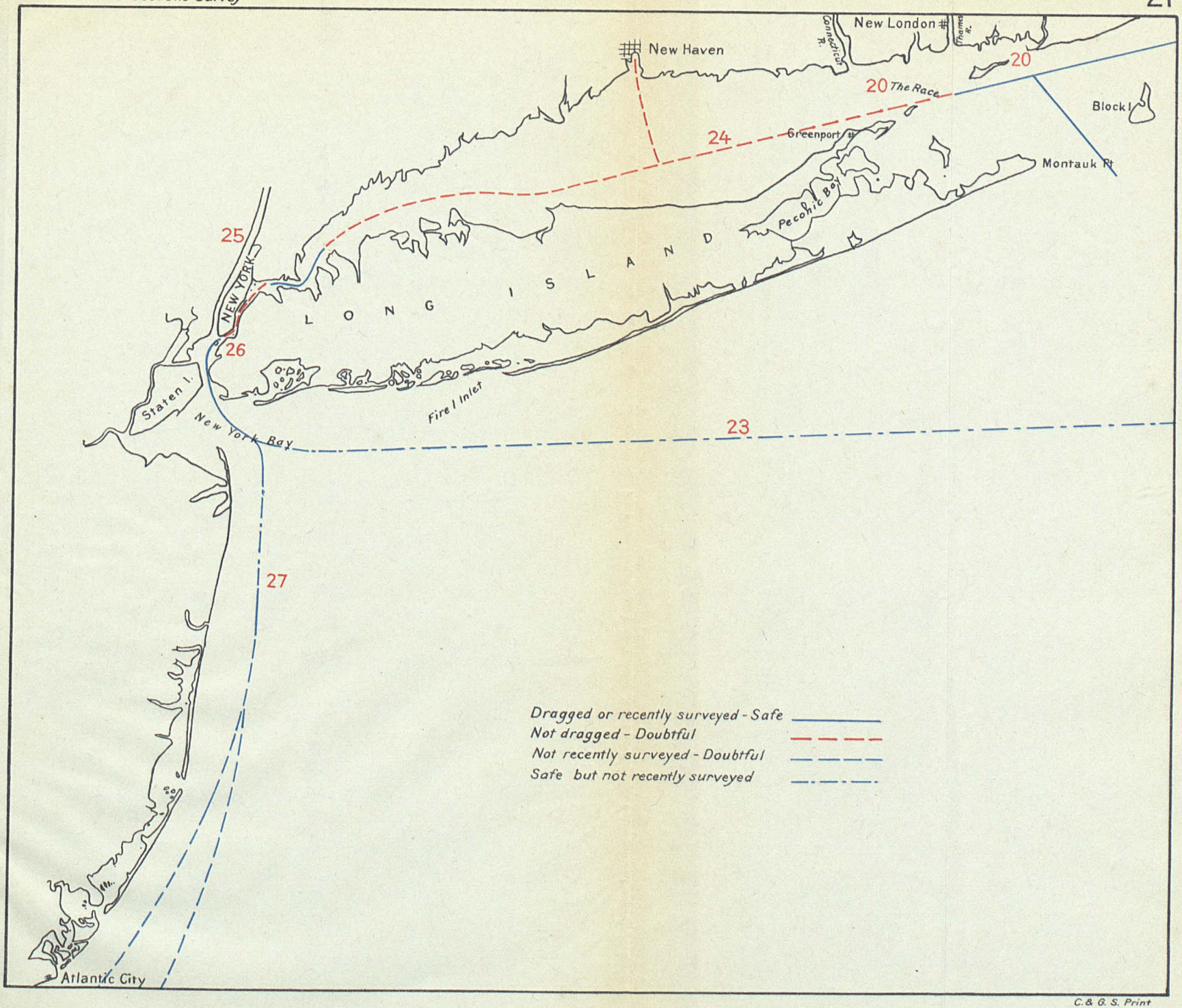
accurately by sounding. This is particularly serious during the fog of summer, which often extends far out to sea and lasts for days, and during the winter snowstorms. In addition to this, the fisheries of the Gulf of Maine are an important national asset. Not only are many important fishing banks uncharted, but the limit 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 knowledge of rocky bottom may lead to the discovery of good fishing grounds. (See fig. 20, opposite p. 72.)

22. *Nantucket Shoals to Georges Banks.*—Extending eastward from Nantucket Sound there is an immense shoal area, consisting of sandy ridges which are shifted by the waves and currents. Nantucket Shoals extend about 50 miles offshore; then there is a deep channel followed by ridges. It is readily seen that it is important to keep the channel 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 defined in order that they may 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. Due to the constant changes the existing surveys are nowhere adequate. The shoals are so numerous and the channels so intricate that a difficult problem is presented in their examination by accurate methods. The ground fishing, which has in recent years assumed large proportions, is steadily moving seaward. During the winter Nantucket Island is the headquarters of this industry. Not only do the present charts lack the needed information in the search for new ground but the absence from the charts 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. (See fig. 20, opposite p. 72.)

23. *Trans-Atlantic approach to New York.*—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. (See fig. 20, opposite p. 72.)

24. *From Point Judith to New York.*—It is almost unnecessary to go into particulars, except to make it clear that the central and western parts of Long Island Sound remain to be dragged. This work will be undertaken at the earliest opportunity. At present New York Harbor has but one exit to the sea for deep-draft vessels—by way of the Lower Bay and through Ambrose Channel over Sandy Hook Bar. The other exit, through Long Island Sound and Block Island Sound, is obstructed by ledges at Hell Gate, in the East River. The project to remove these and secure a depth of 40 feet


MAINE
Rockland
Frenchman Bay
Portland
NEW HAMPSHIRE
Portsmouth
21
GULF OF MAINE
Cashes Ledge
Ammen Rock
Cape Ann
21
Transatlantic (Boston)
Boston
MASSACHUSETTS
Providence
Cape Cod
Boston to New York
22
Georges Bank
Nantucket
Nantucket Shoals
23
Transatlantic (New York)
Solid blue - dragged or recently surveyed - Safe.
Broken blue - incompletely surveyed.


New Haven
New London
Connecticut R.
Thames R.
20
20 The Race
Block I.
24
Greenport
Montauk Pt
Pecohic Bay
25
NEW YORK
L O N G I S L A N D
26
Staten I.
New York Bay
Fire I Inlet
23
27
Atlantic City
Dragged or recently surveyed - Safe
Not dragged - Doubtful
Not recently surveyed - Doubtful
Safe but not recently surveyed

is now in progress. Before it is completed, channels of this depth in the Sound should be examined with the drag to make certain they are safe. This would also apply to Fort Pond and approaches, if the proposed trans-Atlantic terminal is located at that place. 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 limit of such depths in the eastern approach to Long Island Sound, and it is urgent that the entire area should be completed without delay. The approaches to all the harbors on Long Island Sound should be dragged. The shoaler bays are used extensively by motor boats, and the number in operation for a given area is probably greater than anywhere else in the United States. (See fig. 21, opposite p. 72.)

25. *Hudson River.*—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 part of the Hudson should be dragged. (See fig. 21, opposite p. 72.)

26. *New York Harbor.*—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. (See fig. 21, opposite p. 72.)

27. *Coast of New Jersey.*—Along the 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. Surveys from Cape Henlopen to New York are now in progress. This survey will extend out to the 100-fathom curve. (See fig. 21, opposite p. 72.)

28. *Delaware Bay.*—Delaware Bay has as its most marked characteristic a series of narrow, fairly deep channels separated by long, narrow shoals. These shoals are subject to change. A survey 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 may be issued. (See fig. 22, opposite p. 74.)

29. *Delaware Bay entrance to Chesapeake Bay.*—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 certain regions 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. The work of surveying this area was taken up in July, 1919, and carried on until the winter gales made it impracticable to continue work on the open coast. (See fig. 22, opposite p. 74.)

30. *Chesapeake Bay and tributaries.*—These have been extensively surveyed in recent years, and a large number of tributaries will not require resurveys for many years. This is also true of the Potomac River. The parts which need resurveying are parts of the bay from Cape Charles to a point opposite Annapolis, parts of the James River, and the Rappahannock and Susquehanna Rivers. The entrance has been recently surveyed, but another survey will probably be needed in 10 years. Owing to the shifting sandy bottom, the bay is greatly in need of examination at critical localities where depths are near the draft of vessels; frequent reports indicating presence of new shoals. (See fig. 22, opposite p. 74.)

31. *Chesapeake Bay entrance to Cape Hatteras.*—The diagram shows the tracks for both the light-draft and deep-draft vessels. While a resurvey is desired, the most pressing need is that the present limit of shoal areas be accurately determined. (See fig. 22, opposite p. 74.)

32. *Albemarle Sound.*—Albemarle Sound and its tributaries, with a few exceptions, have been resurveyed within the last few years and will not require resurveying 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 project for a through 10-foot channel of the inside waterway route. The Chowan River, which is the western extension of this sound, should also be finished, and then the surveys of this region would be in a most satisfactory, up-to-date condition. (See fig. 22, opposite p. 74.)

33. *Croatan Sound.*—Croatan Sound, the connecting link between Albermarle and Pamlico Sounds, has recently been 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. (See fig. 22, opposite p. 74.)

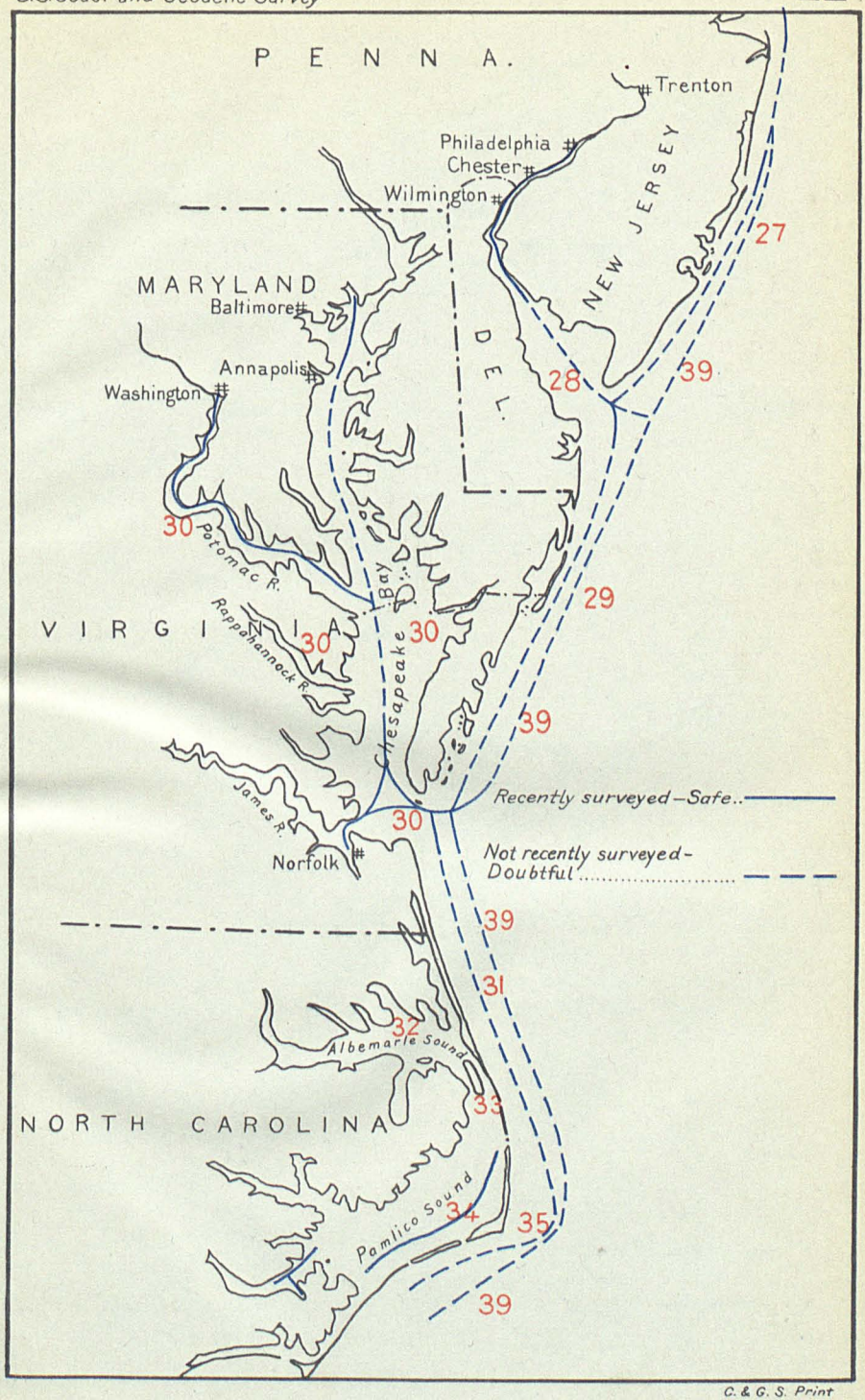
34. *Pamlico Sound.*—Pamlico Sound has additional importance owing to its relation to the inland waterway route. The eastern half of the sound is well surveyed, but the entire western half and the Neuse River, which, in addition to its local use as part of the through 10-foot channel, have not been completed; the survey is now in progress. (See fig. 22, opposite p. 74.)

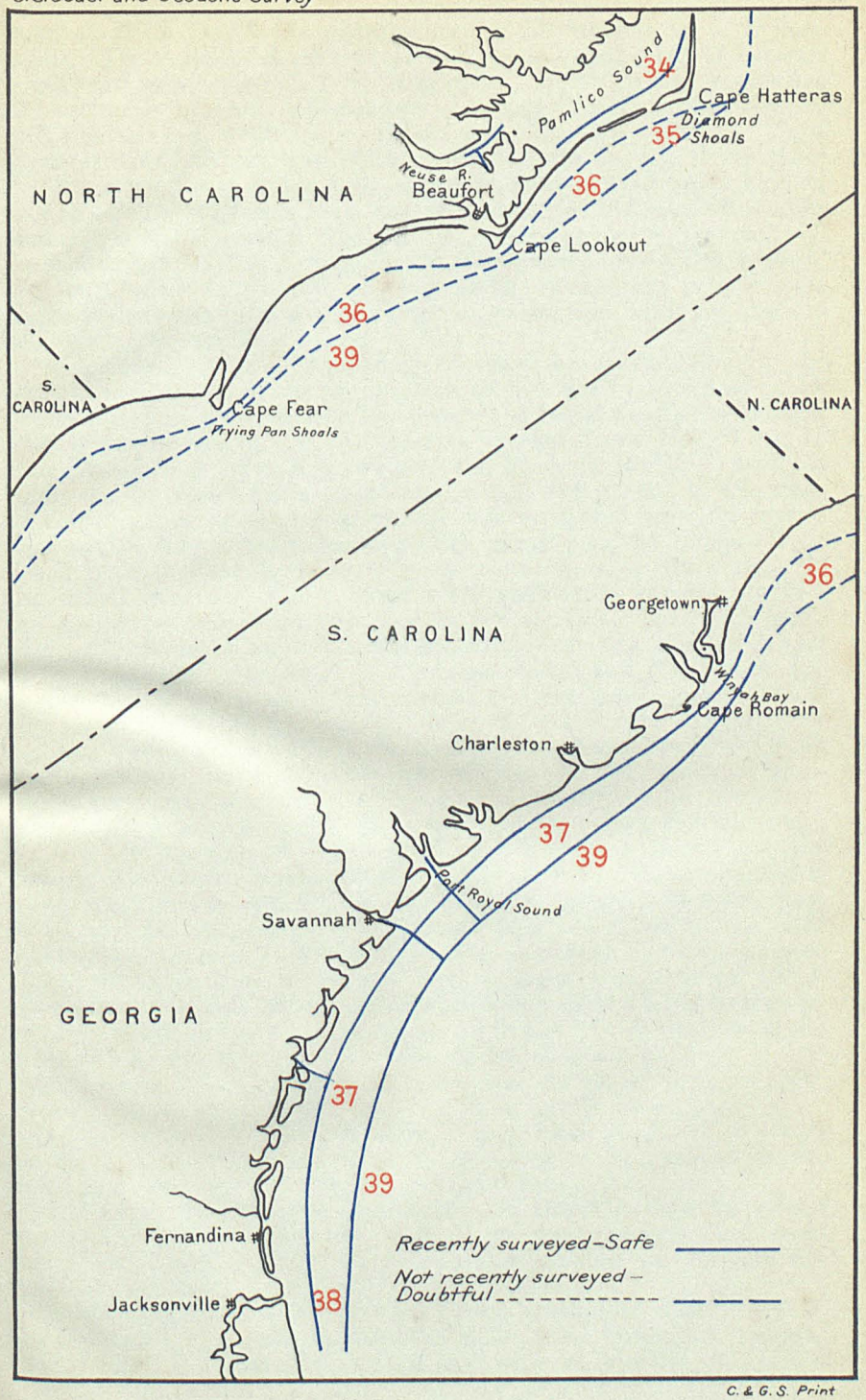
35. *Diamond Shoals.*—Diamond Shoals off Hatteras should be resurveyed chiefly to determine changes in their extent, and particularly to obtain a knowledge of the correct depths on the seaward side. (See fig. 22, opposite p. 74.)

36. *Cape Hatteras to Winyah Bay, S. C.*—Nearly the whole of this area is in need of a new survey, as those now charted are not in sufficient detail for modern navigation. Next to Diamond Shoals in importance to coastwise navigation are the shoals extending seaward from Cape Lookout and Cape Fear. They are subject to change and should be examined at short intervals. (See fig. 23, opposite p. 74.)

37. *Winyah Bay to Fernandina, Fla.*—This region has been recently surveyed, the work extending out to 100-fathom curve. (See fig. 23, opposite p. 74.)

38. *Fernandina to the Florida Reefs.*—From Fernandina to the Florida Reefs the area of moderate depths continually narrows,


PENNA.
Trenton
Philadelphia
Chester
Wilmington
NEW JERSEY
27
MARYLAND
Baltimore
DEL.
Annapolis
Washington
28
39
30
Potomac R.
Bay
29
VIRGINIA
30
30
Rappahannock R.
Chesapeake
39
James R.
Recently surveyed—Safe..
30
Norfolk
Not recently surveyed-
Doubtful.....
39
31
32
Albemarle Sound
33
NORTH CAROLINA
Pamlico Sound
34
35
39


Pamlico Sound
34
Cape Hatteras
Diamond Shoals
35
Neuse R.
Beaufort
36
NORTH CAROLINA
Cape Lookout
36
39
S. CAROLINA
Cape Fear
Frying Pan Shoals
N. CAROLINA
36
Georgetown
S. CAROLINA
Winyah Bay
Cape Romain
Charleston
37
39
Port Royal Sound
Savannah
GEORGIA
37
39
Fernandina
Jacksonville
38
Recently surveyed–Safe
Not recently surveyed–Doubtful

until at Palm Beach the distance to the 100-fathom curve is very small. The completed survey referred to in paragraph 37 extends southward to a little below 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. 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 complete inshore work in connection with the offshore surveys. (See fig. 24, opposite p. 76.)

39. *General, Atlantic and Gulf Coasts.*—An explanation of the method used in verifying the location of a vessel by sounding when objects on shore are obscured by distance or thick weather 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 one of the best known for verifying the ship's position. 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 while the charts are fairly good, they are by no means good enough to meet the full needs of navigation, but the work required to bring them up to date has been postponed, as the need for resurveys has been 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 limit as rapidly as possible. With adequate funds full advantage can be taken of the seasons and by working north in the summer and south in the winter the cost of the work will be greatly reduced. (See fig. 24, opposite p. 76.)

40. *Indian River.*—There have been no recent surveys of these waters. Revisionary work is needed. (See fig. 24, opposite p. 76.)

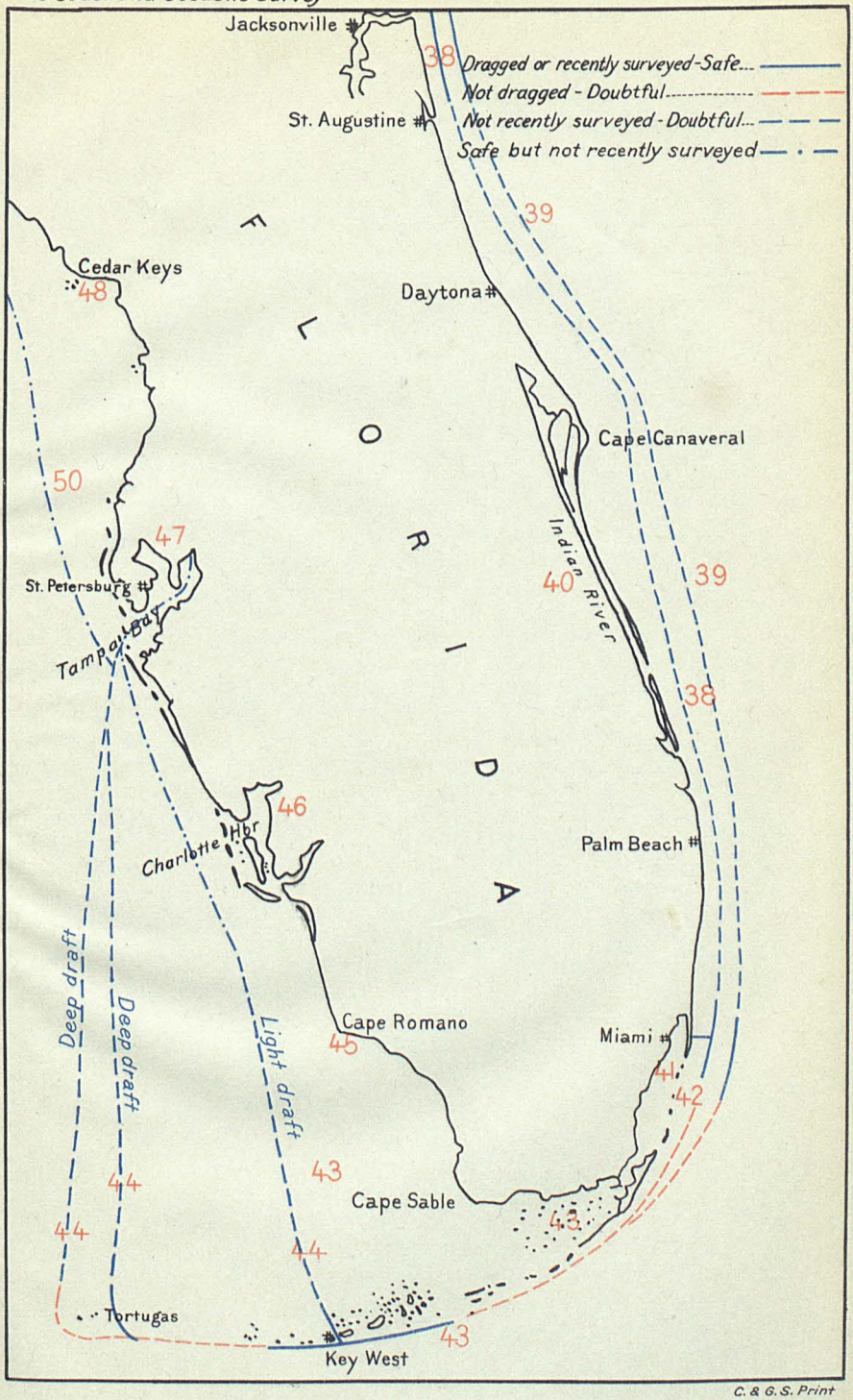
41. *Biscayne Bay.*—Recent surveys have been made of this area out to the 100-fathom curve, in the vicinity of Miami and as far south as Fowey Rocks. (See fig. 24, opposite p. 76.)

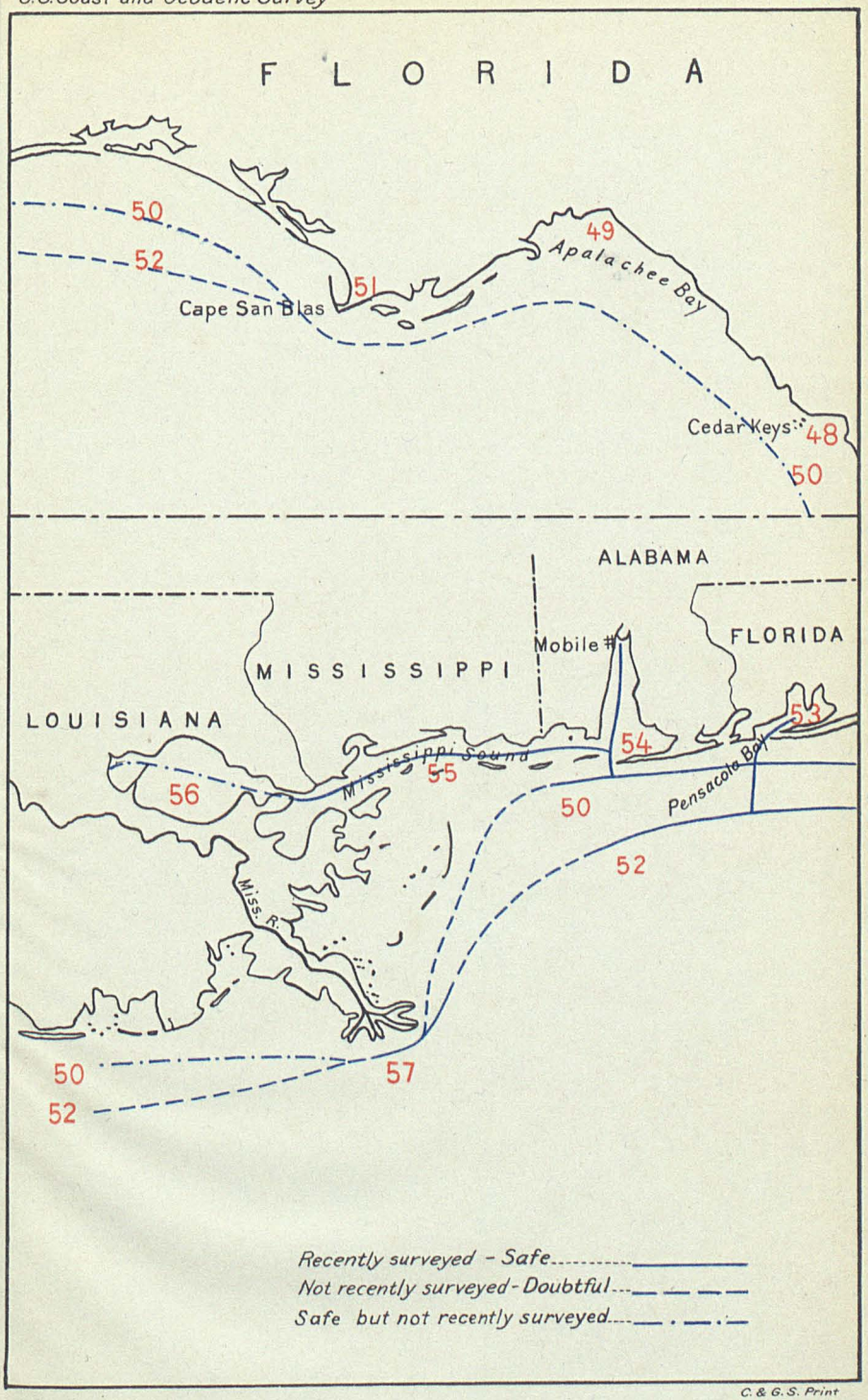
42. *Vicinity of Fowey Rocks Light.*—No recent surveys have been made. Inshore and offshore work is in progress eastward from Key West, which includes this area. The present surveys are not sufficient in detail. (See fig. 24, opposite p. 76.)

43. *Coast of Florida from Palm Beach around to Cedar Keys.*—For a distance along the shore of 567 miles from Palm Beach southward around to Cedar Keys on the west coast of Florida, coral reefs

are found, in some places more abundant than in others. Coral reefs, whether the result of disintegration, or of a building up by animal growth, are found in a great variety of forms and in vast numbers of sharp projections from the general bottom, where conditions are favorable for the growth of coral. While we are informed that an enormous number of uncharted rocks exist in this region, due to the fact that they are so numerous and that the region is so large, an effort has been made to first drag areas of the coast used by commercial and naval vessels, because of both the time and cost involved. Wire-drag work is accordingly undertaken in localities where there are commerce and naval operations. To accomplish even this will require years of work. Westward-bound vessels through the Florida Straits have to force their way against the strong current of the Gulf Stream, which in places attains a velocity of 5 miles per hour. Along the northerly edge of the stream and close to the reefs the current is very weak. There is a strong temptation to keep dangerously close to the reefs and save fuel, and this is the cause of frequent accidents. Besides the danger of running into the known reefs, which are in many places bare and are of no great depth throughout their length, another danger, the extent of which is not yet known, has been discovered in a secondary reef, parallel to the main reef, and about one-half mile outside of it. This secondary reef is found to approach the surface in places as a narrow ridge with depths as little as 25 feet. Twenty-five miles of this reef has been examined, but 200 miles remain to be examined. It is important to nearly all the great traffic entering the Gulf of Mexico that this examination be completed at the earliest possible moment. During the past year a vessel has been continuously employed on the surveys of the Florida Reefs between the Marquesas Keys and Fowey Rocks; this includes supplementary surveys of the channels through the reefs from deep water into the inside route lying between the reefs and the mainland; also the close development of the shoal area westward of Key West and southward of the Marquesas Keys. In connection with this the work has been carried out to the 100-fathom curve for a distance of 27 miles along the reefs. (See fig. 24, opposite p. 76.)

44. *Vessel courses north from Key West.*—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 has been dragged and has ample depth of water. The bank west of Tortugas should be dragged, especially as vessels making land from the westward have to cross part of it. Northward of the keys from Key West to Tortugas a doubtful area should be dragged. The necessity of this is emphasized by the fact that the U. S. S. *Ellis*, while steaming northward of the Marquesas Keys recently, struck a coral head which proved to have only 7 feet over it. This coral head was directly out of a depth of 35 feet, with no indication of its existence until struck by the naval vessel, which was severely damaged. The channel between the keys and the reef known as the Hawk Channel is important for moderate-draft vessels. It will be necessary to drag the axis of the channel to insure against dangers to the vessels making use of it.


Jacksonville
St. Augustine
Dragged or recently surveyed-Safe
Not dragged - Doubtful
Not recently surveyed - Doubtful
Safe but not recently surveyed
38
39
Cedar Keys
48
Daytona
FLORIDA
Cape Canaveral
50
47
St. Petersburg
Tampa Bay
Indian River
40
39
38
46
Charlotte Hbr
Palm Beach
Deep draft
Deep draft
Light draft
Cape Romano
45
Miami
41
42
43
44
Cape Sable
44
44
Tortugas
43
Key West


FLORIDA
50
52
51
Cape San Blas
49
Apalachee Bay
Cedar Keys
48
50
ALABAMA
Mobile
FLORIDA
MISSISSIPPI
LOUISIANA
53
54
Mississippi Sound
55
56
50
Pensacola Bay
52
Miss. R.
50
57
52
Recently surveyed - Safe
Not recently surveyed - Doubtful
Safe but not recently surveyed

45. *Cape Romano.*—This area is in need of surveys. An inspection of the existing maps and charts of the State of Florida show practically a blank area for that part of the peninsula south of Lake Okechobe. There are but few areas of the United States of like size about which so little definite information can be obtained. Northward of this unknown region drainage canals are opening up the country for development. It is not unlikely the same means will be extended southward. At the present time this Bureau should prepare to meet a demand in the near future for the delineation of a broader belt of country back of the shore from Cape Sable to Punta Rosa than is now shown on our charts. Tourists and land prospectors are now exploring this intricate system of island and waterways. (See fig. 24, opposite p. 76.)

46. *Charlotte Harbor.*—No recent surveys have been made of this area and it should be resurveyed. (See fig. 24, opposite p. 76.)

47. *Tampa Bay and approach.*—The existing surveys at present meet the needs of navigation of these waters. (See fig. 24, opposite p. 76.)

48. *Cedar Keys.*—No recent surveys have been made of this region. Wire-drag surveys are badly needed. (See fig. 24, opposite p. 76.)

49. *Apalachee Bay.*—No recent surveys have been made of this region and revision work is needed. (See fig. 25, opposite p. 76.)

50. *Inshore waters, Gulf coast.*—The chief characteristics of the west coast of Florida are the distances to which shoal water extends offshore between Cape Sable and Cape Romano and from Tampa Bay to Apalachicola and the existence of a large number of bays connected with the sea by deep channels, either natural or dredged. 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 resurveying from time to time. The Florida and Alabama coasts differ somewhat, as deep water approaches close to the shore in the latter. 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 in the area from Mobile Bay to the end of the offshore shoals 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 deposits result in rapid growth in some places and of erosion in others. Sixty miles west of the Mississippi Delta there begins an extensive shoal region which is in need of survey. The inshore region along the rest of the Louisiana coast and the Texas coast, with an important exception, has deep water fairly close to the shore. 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. Galvestion Bay also needs resurveying. (See fig. 25, opposite p. 76.)

51. *St. Josephs Bay.*—No recent surveys have been made of this area and a reexamination is needed. (See fig. 25, opposite p. 76.)

52. *Offshore waters, Florida reefs to the Mexican border.* Along the northern edge of the Florida Straits the soundings are insufficient, and they will have to be carried out somewhat beyond the 100-fathom curve. Along the west coast of Florida the distance out to the 100-fathom curve is about 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 from coral banks may come sufficiently near the surface to be a menace to navigation. Fishermen have reported several uncharted ridges, and while the somewhat incomplete surveys of the reported localities have not confirmed all the details of their reports, important differences from the charted depths have been 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 80 miles offshore at the Mexican border. This whole offshore area is badly in need of a thorough resurvey. There is no other part of the work in offshore water so likely to be productive in furnishing important changes in existing charted depths. (See fig. 26, opposite p. 78.)

53. *Pensacola Bay.*—Surveys have recently been completed in the entrance to the bay; the entire bay requires reexamination. (See fig. 25, opposite p. 76.)

54. *Mobile Bay.*—A resurvey of this bay has been completed. (See fig. 25, opposite p. 76.)

55. *Mississippi Sound.*—A resurvey of this sound has been completed. (See fig. 25, opposite p. 76.)

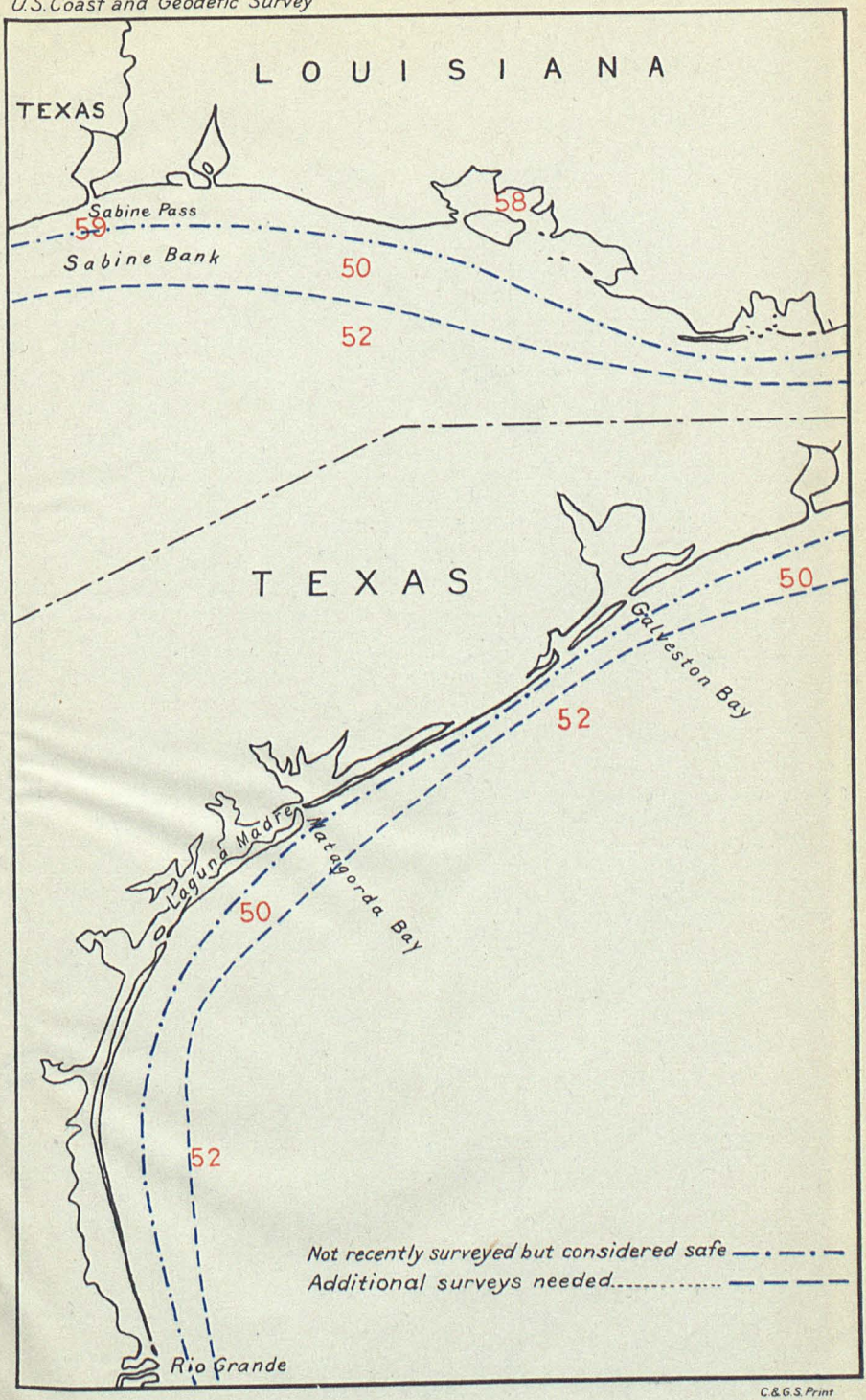
56. *Lake Ponchartrain.*—In connection with the surveys in Mobile Bay and Mississippi Sound, a recent survey has been made at the eastern end of the lake. The greater part of the lake has not been examined for 20 years. (See fig. 25, opposite p. 76.)

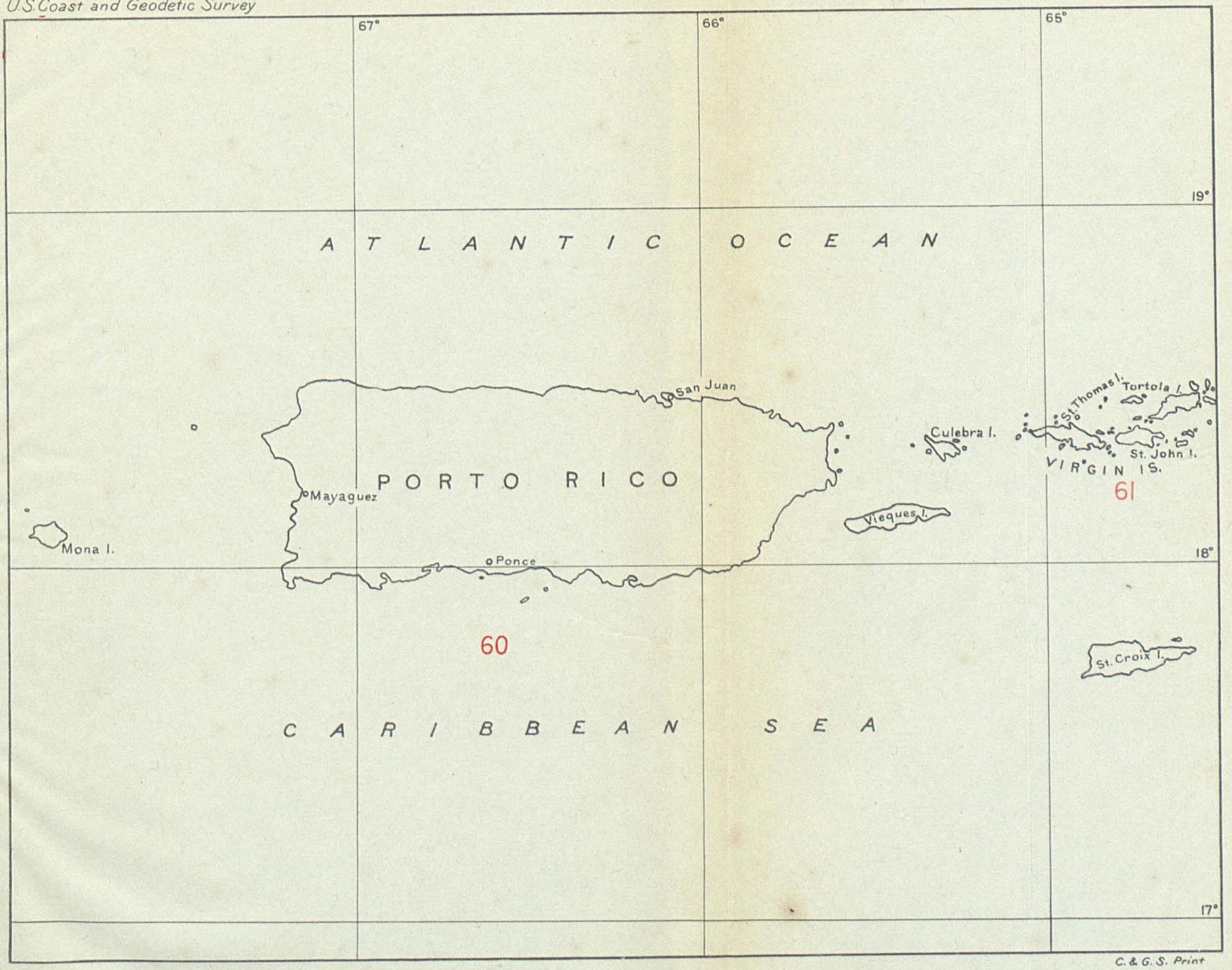
57. *Approaches to Mississippi Passes.*—Resurveys of a large area have been completed recently; further work is required. It is expected that the work now progressing westward from the entrance to Mobile Bay will reach the southwest pass in the next fiscal year. (See fig. 25, opposite p. 76.)

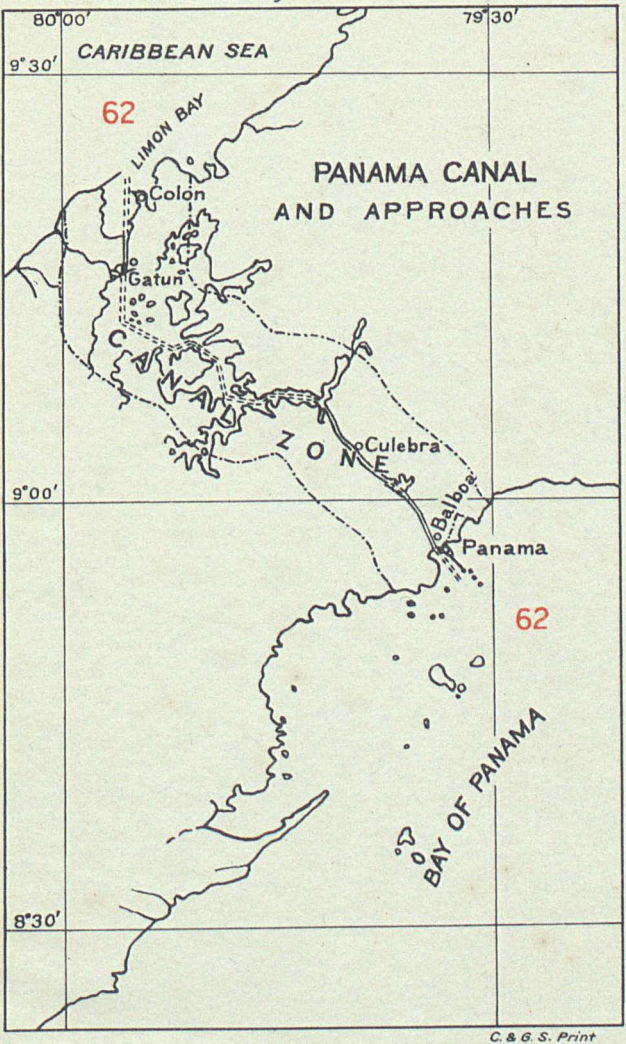
58. *Vermilion Bay and Cote Blanche.*—No recent surveys have been made of these areas. Surveys are needed. (See fig. 26, opposite p. 78.)

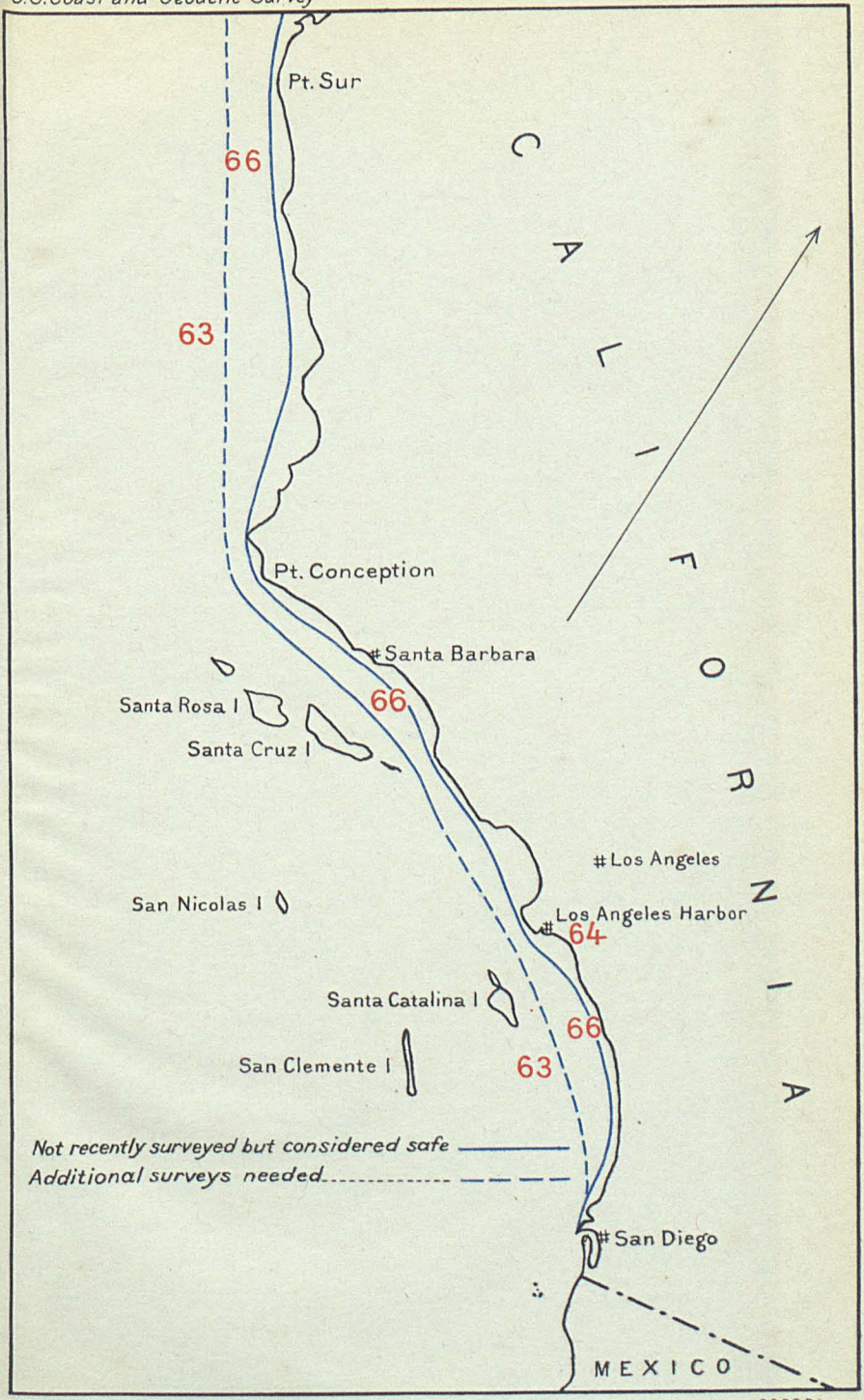
59. *Approach to Sabine Pass.*—No recent surveys have been made here; revisionary surveys are needed. (See fig. 26, opposite p. 78.)

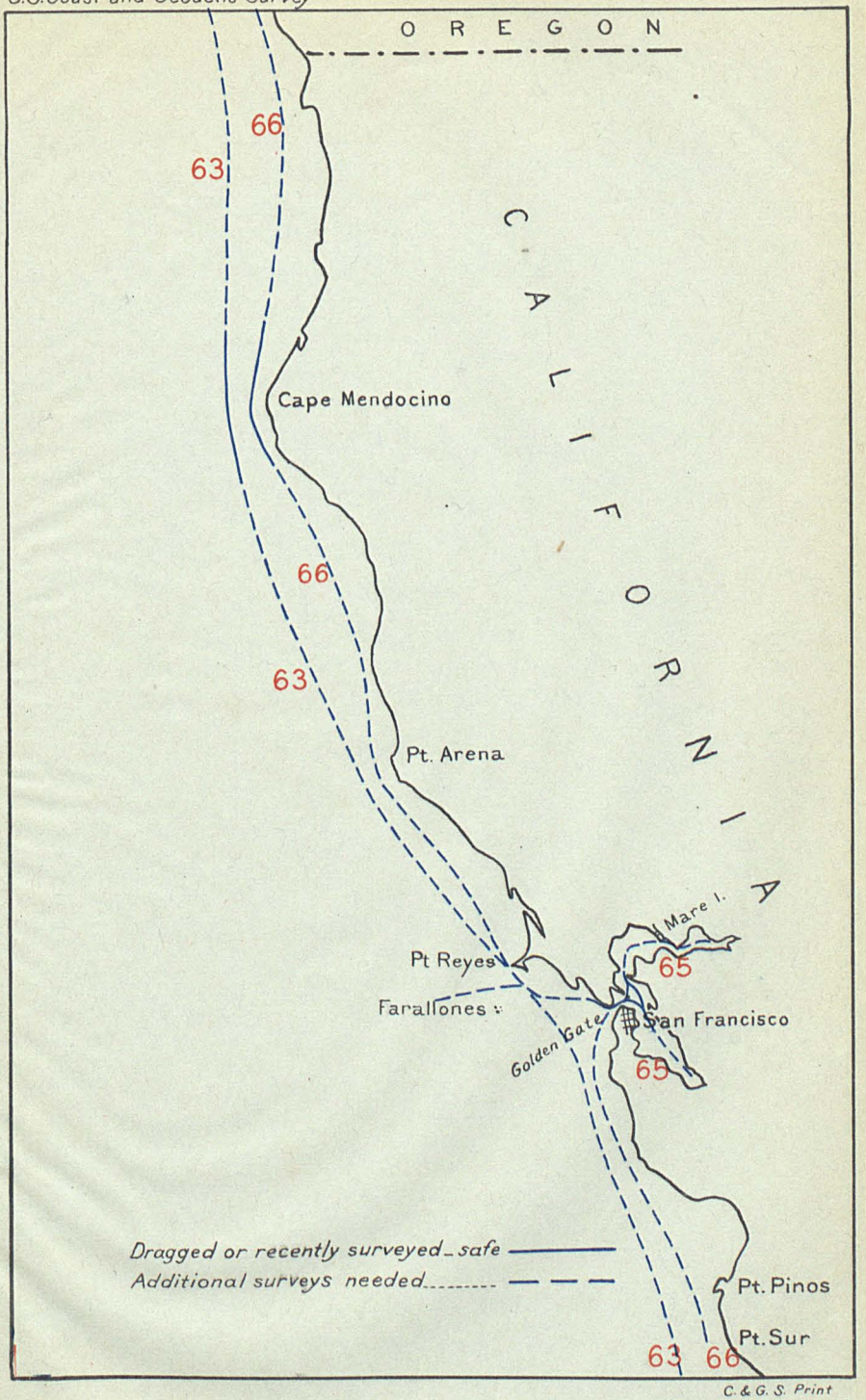
60. The surveys of Porto Rico were begun when the island came under the jurisdiction of the United States as a result of the Spanish-American War. By 1910 the surveys of the bays, channels, and inshore waters were completed and a number of deep sea soundings were taken around the island. There are, however, 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 limits. The areas on the east, south, and west are different in that there is traffic between the reef and over areas where the depth is little greater than the draft of the vessel, and the probable existence of

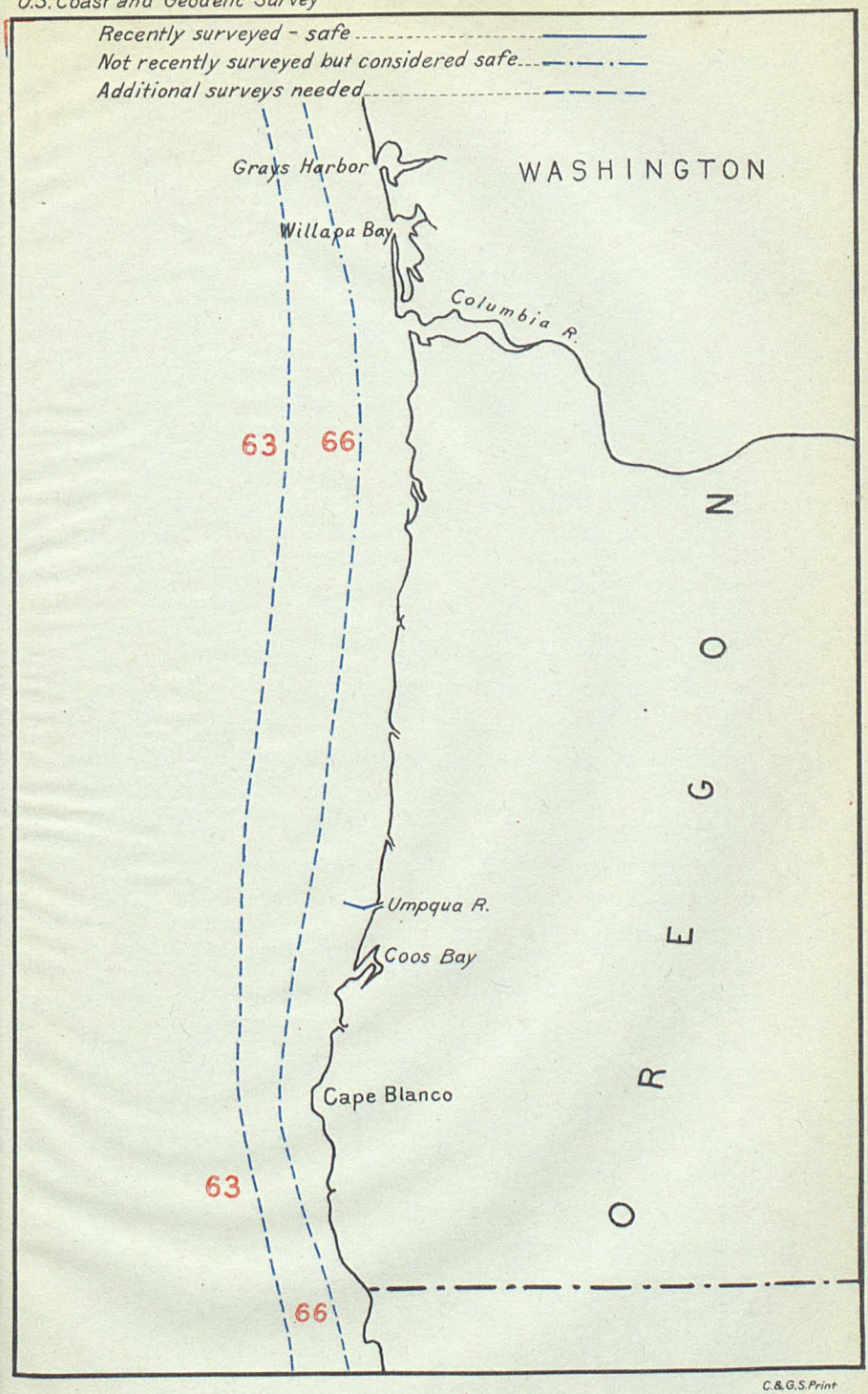

LOUISIANA
TEXAS
Sabine Pass
Sabine Bank
59
58
50
52
TEXAS
Galveston Bay
50
52
Laguna Madre
Matagorda Bay
50
52
Not recently surveyed but considered safe
Additional surveys needed
Rio Grande


67°
66°
65°
19°
18°
17°
ATLANTIC OCEAN
PORTO RICO
San Juan
Mayaguez
Ponce
Mona I.
Culebra I.
Vieques I.
St. Thomas I.
Tortola I.
St. John I.
VIRGIN IS.
61
60
St. Croix I.
CARIBBEAN SEA


80°00′
79°30′
9°30′
CARIBBEAN SEA
62
LIMON BAY
Colón
PANAMA CANAL
AND APPROACHES
Gatun
CANAL
ZONE
Culebra
9°00′
Balboa
Panama
62
BAY OF PANAMA
8°30′


Pt. Sur
66
63
C A L I F O R N I A
Pt. Conception
Santa Barbara
Santa Rosa I
66
Santa Cruz I
Los Angeles
San Nicolas I
Los Angeles Harbor
64
Santa Catalina I
66
San Clemente I
63
Not recently surveyed but considered safe
Additional surveys needed
San Diego
MEXICO


OREGON
CALIFORNIA
66
63
Cape Mendocino
66
63
Pt. Arena
Mare I.
Pt Reyes
65
Farallones
San Francisco
Golden Gate
65
Dragged or recently surveyed_safe
Additional surveys needed
Pt. Pinos
Pt. Sur
63
66


Recently surveyed - safe
Not recently surveyed but considered safe
Additional surveys needed
Grays Harbor
WASHINGTON
Willapa Bay
Columbia R.
63
66
OREGON
Umpqua R.
Coos Bay
Cape Blanco
63
66

unchartered projections is a source of danger. 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 surveys. The only work of this character that has been accomplished here is in the vicinity of Mayaguez. This work resulted in the abandonment of one channel and the rebuoying of another. (See fig. 27, opposite p. 78.)

61. *Virgin Islands.*—The Virgin Islands were purchased from Denmark, and the United States took possession in 1917. The surveys that have been made are by the British and Danish Governments. At the present time the available hydrographic data regarding these surveys are being examined with a view of determining whether they are sufficient for the needs of our naval and commercial vessels. It is certain that the coral formation in the waters touching these islands requires extensive wire-drag surveys before accurate charts can be issued. Topographic surveys of these islands were requested by the Navy Department. The triangulation was extended eastward from Porto Rico for control of the topography. St. Thomas and St. John have been completed and about 60 per cent of St. Croix completed to date. (See fig. 27, opposite p. 76, and fig. 44, opposite p. 162.)

62. *Panama Canal.*—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. 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. (See fig. 28, opposite p. 78.)

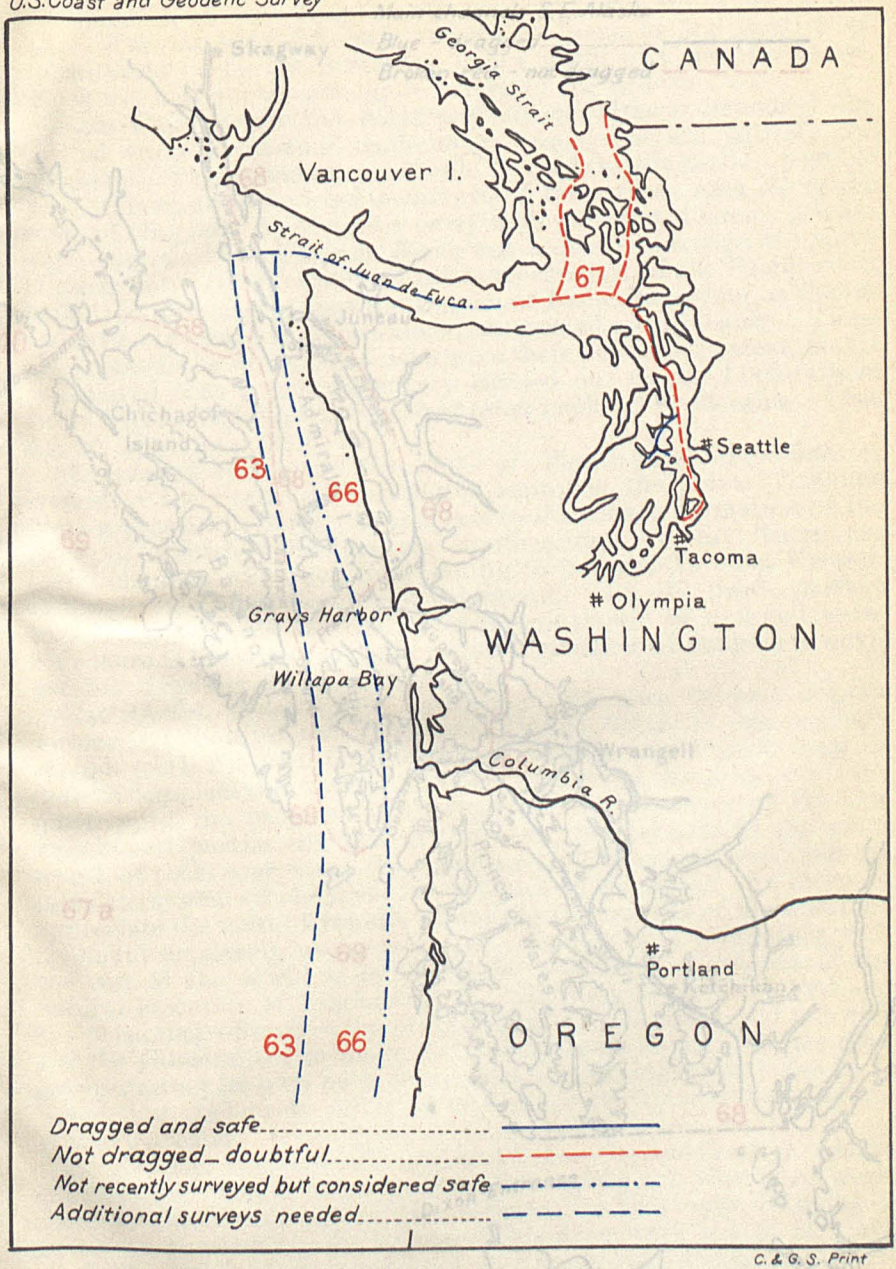
63. *Pacific coast of the United States.*—The western coast of the United States is very different from the eastern. Generally mountainous, with comparatively few harbors or inside waterways, and with comparatively deep water close to the shore, it presents little resemblance to the low shores and wide continental shelf of the Atlantic. The purpose of the survey is, then, to meet the needs of vessels approaching from seaward and coasting vessels which keep to a few comparatively narrow tracks, to insure up-to-date charts of the various harbors, to make soundings offshore, and 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 and 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 detail surveys be made to the 100-fathom curve, which is beyond the limit of soundings taken by merchant vessels. 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 extended 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. The Oregon coast is practically unsurveyed.

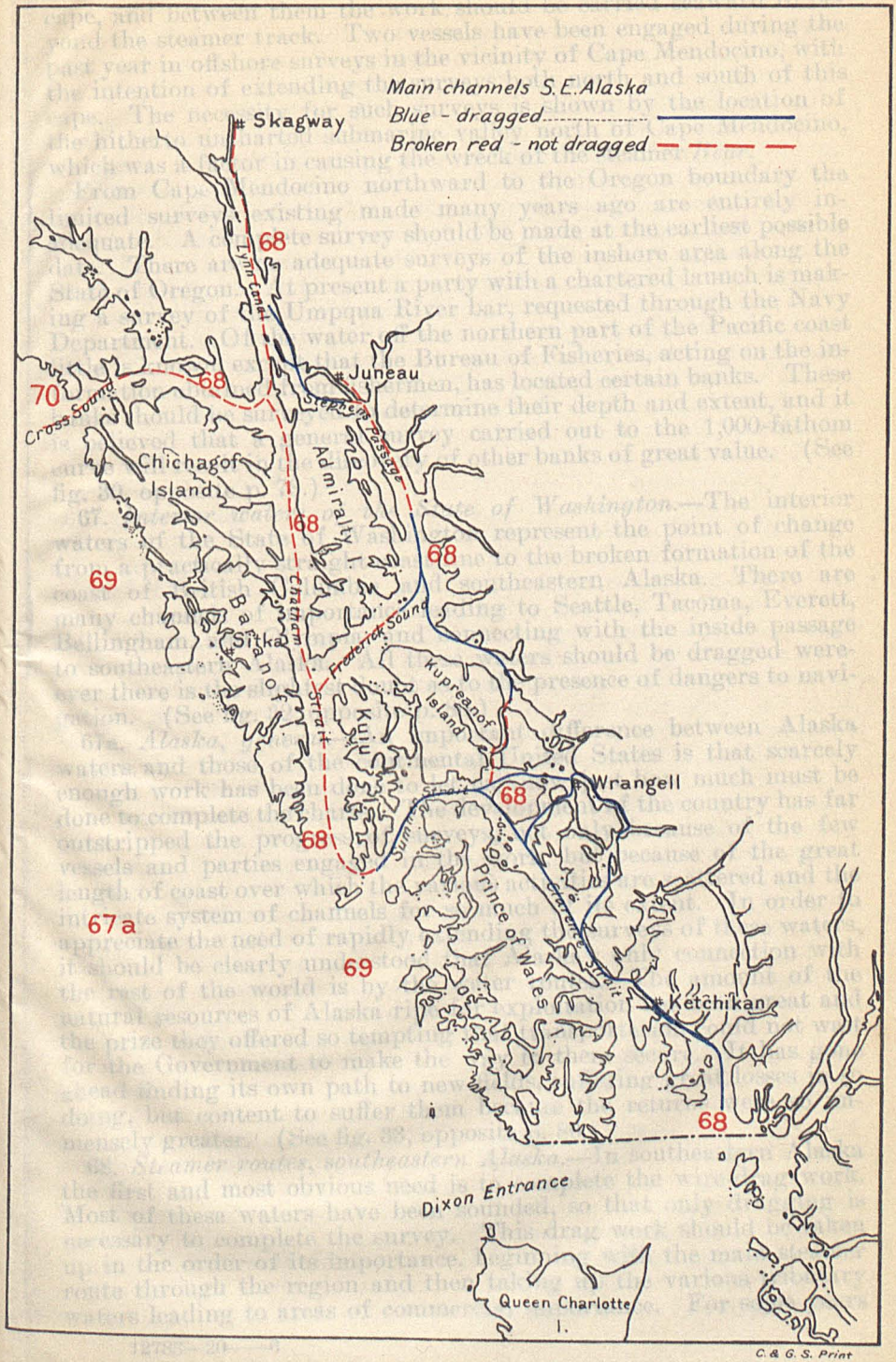
A limited amount of work was done years ago south of Cape Blanco and in the vicinity of the Columbia River, but this was not more than a reconnoissance and does not extend out far enough to be of practical value to navigators. Elsewhere no surveys have ever been undertaken until recently. Even in such 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 wholly on account of this lack of surveys. On the coast of Oregon there 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 of the Pacific coast. Yet, in spite of the 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 River have been sounded for a short distance offshore, but even in this area the soundings are too far apart to more than indicate, in a general way, the depth 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 improvement, are entirely unsurveyed. The entire Washington 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. (See figs. 29 and 31, opposite pp. 78 and 80.)

64. *Los Angeles Harbor.*—Los Angeles Harbor should be dragged. Instructions are now prepared for revision surveys of the inner and outer harbor. (See fig. 29, opposite p. 78.)

65. *San Francisco Bay.*—San Francisco Bay is of varied character of bottom and needed surveys vary to correspond. The immediate 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 the Golden Gate and inside, both northward and southward of San Francisco to the limit of the rocky area. Surveys in the southern part of the bay, where the bottom is subject to change by currents, is now in progress. (See fig. 30, opposite p. 78.)

66. *Alongshore waters of the Pacific Coast States.*—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. 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 600 fathoms. Additional detailed surveys should be made in the vicinity of each


CANADA
Georgia Strait
Vancouver I.
Strait of Juan de Fuca
67
63
66
Seattle
Tacoma
Olympia
Grays Harbor
WASHINGTON
Willapa Bay
Columbia R.
Portland
63
66
OREGON
Dragged and safe
Not dragged_ doubtful
Not recently surveyed but considered safe
Additional surveys needed


Main channels S.E. Alaska
Blue - dragged
Broken red - not dragged
Skagway
Juneau
Lynn Canal
Stephens Passage
Cross Sound
Chichagof Island
Admiralty I.
Baranof
Sitka
Chatham Strait
Frederick Sound
Kuiu
Kupreanof Island
Wrangell
Sumner Strait
Prince of Wales
Clarence Strait
Ketchikan
Dixon Entrance
Queen Charlotte I.
68
70
69
67a

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cape, and between them the work should be carried seaward to beyond the steamer track. Two vessels have been engaged during the past year in offshore surveys in the vicinity of Cape Mendocino, with the intention of extending the surveys both north and south of this cape. The necessity for such surveys is shown by the location of the hitherto uncharted submarine valley north of Cape Mendocino, which was a factor in causing the wreck of the steamer *Bear*.

From Cape Mendocino northward to the Oregon boundary the limited surveys existing made many years ago are entirely inadequate. A complete survey should be made at the earliest possible date. There are no adequate surveys of the inshore area along the State of Oregon. At present a party with a chartered launch is making a survey of the Umpqua River bar, requested through the Navy Department. Of the water 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 banks. These banks should be surveyed to determine their depth and extent, 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. 30, opposite p. 78.)

67. *Interior waters of the State of Washington.*—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 wereever there is the slightest doubt as to the presence of dangers to navigation. (See fig. 32, opposite p. 80.)

67a. *Alaska, general.*—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. 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 amount of the natural resources of Alaska ripe for exploitation has been 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 new fields, suffering great losses in so doing, but content to suffer them because the returns were so immensely greater. (See fig. 33, opposite p. 80.)

68. *Steamer routes, southeastern Alaska.*—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 the 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 routes, and this work is now about 60 per cent complete. One of these parties is now at work in Stephens Passage northward from Frederick Sound. (See fig. 33, opposite p. 80.)

69. *The outside coast waters of the islands bordering on the open Pacific.*—These and their connecting channels are largely unsurveyed and should be navigated with great caution. A navigator seeing the 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 same 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. Work on the outer coast is now in progress northward from Dixon Entrance. Surveys were also in progress in Clarence Strait and Dixon Entrance. (See fig. 33, opposite p. 80.)

70. *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 this coast. In this region the charts are very defective in the manner 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, Yukutat Bay, has some canneries, and additional surveys are needed here on this account. (See fig. 34, opposite p. 82.)

71. *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 its future must be taken into account. The approaches to Prince William Sound have been surveyed, and no resurveys for the present are needed except in the vicinity of Cape St. Elias and Middleton Island. Wire-drag work will be needed in both of 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 surveys. 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 the Government. The surveys of its approach are completed except for wire-drag work. It is probable that much of the trade originating along the line of the Government railway will be transshipped at Anchorage, at the head

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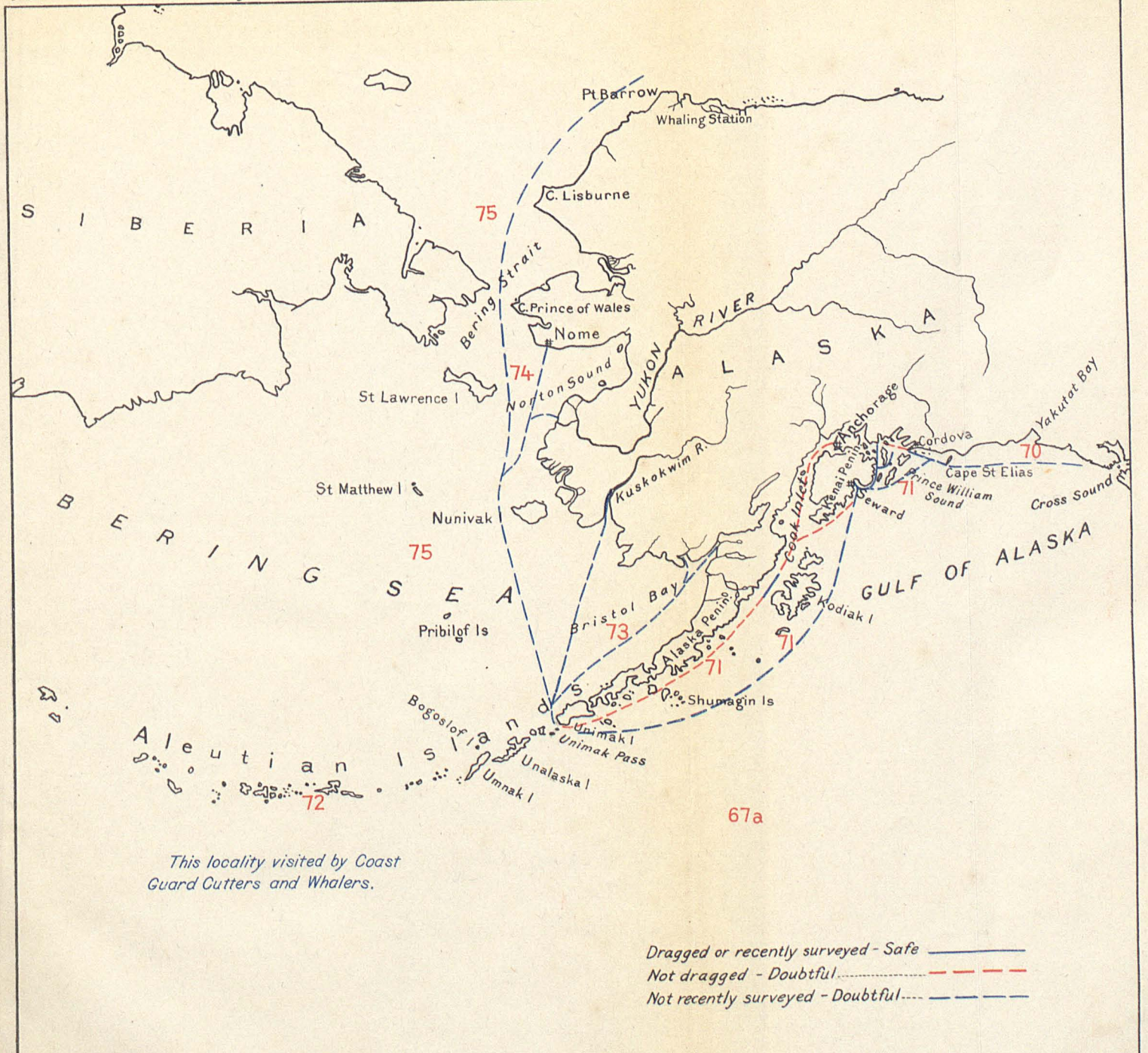


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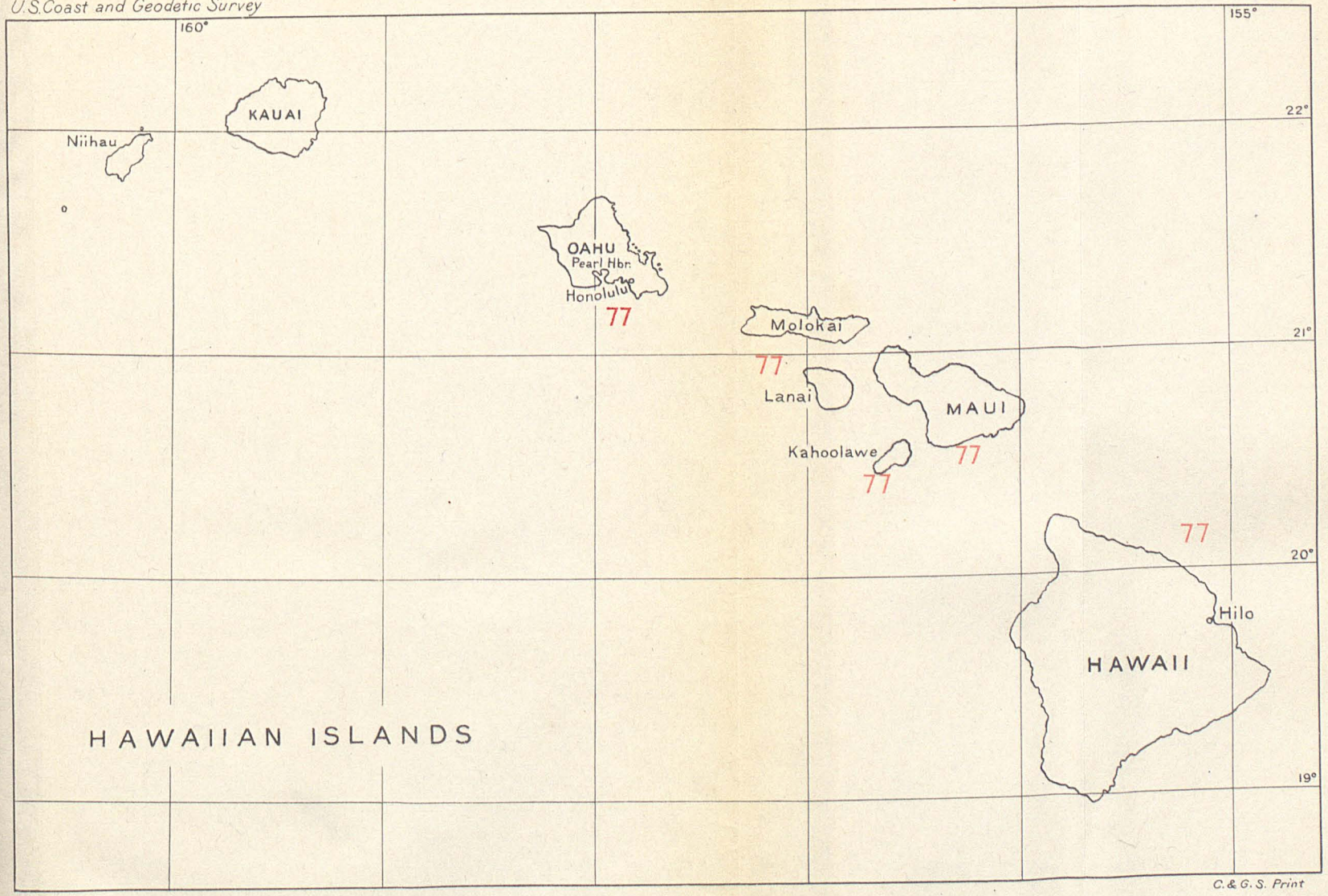


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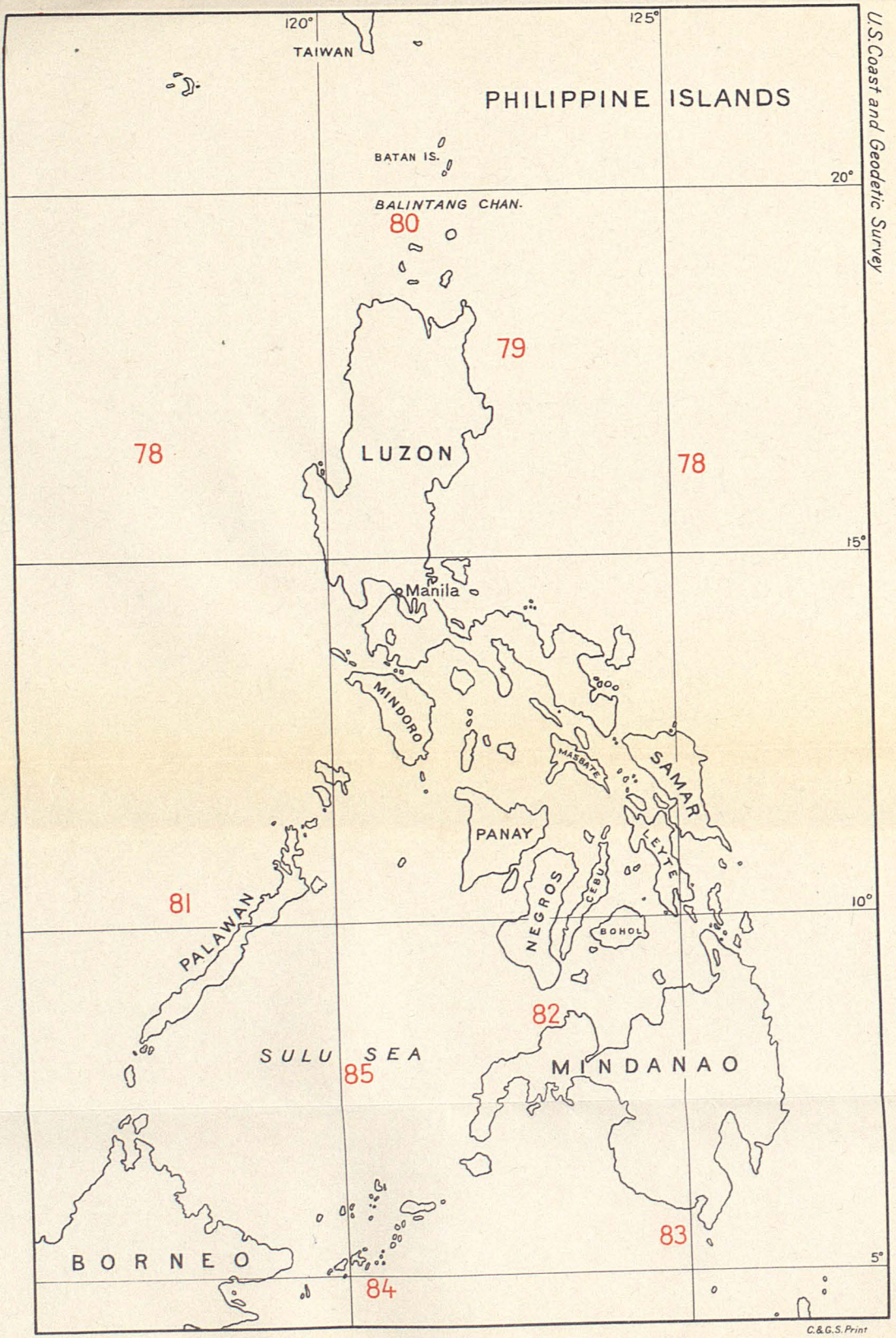


U.S. Coast and Geodetic Survey

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of Cook Inlet. Not only will this make it necessary for many 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 surveys are now in progress; only a comparatively small part has been surveyed at present. 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 island. 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 Island 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 at least further soundings be taken. (See fig. 34, opposite p. 82.)

72. *Aleutian Islands.*—The Aleutian Islands have comparatively little traffic and are without survey. It is necessary that this region be patrolled by Coast Guard vessels. The loss of one of the vessels of this service a few years ago was wholly due to the lack of adequate surveys. (See fig. 34, opposite p. 82.)

73. *Bristol Bay.*—A large part of the salmon shipped from Alaska comes from Bristol Bay. This is without surveys 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 for grazing and also in places for general agriculture. (See fig. 34, opposite p. 82.)

74. *Norton Sound.*—The importance of Norton Sound is due to the gold mining on its northern shores and as being the outlet of the Yukon delta on the southern shore. 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. (See fig. 34, opposite p. 82.)

75. *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. 34, opposite p. 82.)

76. *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 work 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.

77. *Hawaiian Islands.*—There are only two good harbors on 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, Jauai and Niihau, are practically unsurveyed. The various channels between the islands from Maui to Oahu are fairly well surveyed. The others are practically without surveys. (See fig. 35, opposite p. 82.)

78. *Philippine Islands.*—The Philippine Islands are composed of not less than 3,000 islands and islets covering an area of approximately 150,000 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 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. 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. 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 Babyan Islands, Balintang Channel, the Natan Islands, and Bashi Channel; the entire west coast of the island of Palawan; the south coast of Mindanao, from Pola Point to Malita, in Davao Gulf; the Sulu Archipelago and the Sulu Sea from the Tubbathahe Reefs south to the limit of our possessions off the coast of Borneo. (See fig. 36, opposite p. 82.)

79. *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 localities 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 of Port San Vincente, Dilasac Bay, Casiguran Sound, and Dingalan Bay. The first and third mentioned are excellent typhoon harbors. The work must, however, be done during the season of frequent typhoons, it being impossible to approach the coast at any other time of the year on account of the heavy sea caused by the northeast monsoon. (See fig. 36, opposite p. 82.)

80. *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 that are dangerous to navigation in the locality. As it is in the region visited by frequent typhoons, the work should be

undertaken during the period when the typhoons are less frequent. (See fig. 36, opposite p. 82.)

81. *West and east coast 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. (See fig. 36, opposite p. 82.)

82. *West coast of Mindanao.*—This island is of little commercial importance due to the absence of harbors and having a rugged mountainous country adjacent to the coast which is not adapted to the growth of any of the staple products. The usual steamer tracks do not approach the shore within 4 or 5 miles, a sufficient distance to avoid all dangers. For these reasons the surveys now in progress have been postponed for more important localities.

83. *South coast of Mindanao.*—This stretch of about 160 miles from Pola Point to Malita in Davao Gulf is similar in many respects to the west coast. In general, it is bold and steep, with numerous outlying reefs, which, however, do not extend a great distance from shore. The triangulation for furnishing the controlling positions for the hydrography and topography presents a difficult problem, the shore line being invisible from the peaks and ridges but a short distance back.

84. *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. Surveys in this area are now in progress. It requires a survey of the most careful and intricate character, and much of the locality must be swept with the wire drag after the present hydrographic survey is made. 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 to coordinate the work with that along the coast of Mindanao can be obtained. (See fig. 36, opposite p. 82.)

85. *Sulu Sea.*—The northern end, as far south as the Tubbataha Reefs, except certain small area, has been surveyed with a fair degree of accuracy, but owing to the coral formations, where hidden dangers frequently exist, wire-drag sweeping will be necessary in selected passages. A large part of the region to the south of the Tubbataha Reefs remains unsurveyed except for a reconnoissance with approximate locations by navigational methods. A survey of this area is now in progress. Numerous rocks and reefs dangerous to navigation are scattered throughout the sea, but certain well-defined passages have been examined with sufficient accuracy to make navigation through them reasonably safe. (See fig. 36, opposite p. 82.)

## Part III.—SUVEYING FROM THE AIR.

The great possibilities of airplane photography in connection with the water and land work of the Coast and Geodetic Survey are looming up as a potential factor in expediting the mapping of our waterways and interior surveys. This very important subject has been the object of careful study and experiments by officers of the Survey, in collaboration with the other branches of the Government, during the past year and the rapid advance in aerial photography, first seriously undertaken during the war, now promises, with proper development, a method of surveying that will probably far exceed expectations over the old methods in rapidity, economy, and minuteness of detail.

No little stress should be laid on the fact that not only are the possibilities good for an early and complete revision of our shore topography, but the opportunities that present themselves for assisting materially in our hydrographic work should not be underestimated.

With the necessary facilities and cooperation supplied by the Army and Navy Aviation Corps to the Coast and Geodetic Survey, experience has already proven the value of aerial photography over the old method of surveying in revision surveys of our coast lines.

This work, so far, is divided into two branches, *aerial phototopography* and *aerial photohydrography*, and the results are shown in the following recent practical demonstrations:

### AERIAL PHOTOTOPOGRAPHY.

In July, 1919, experiments were made at Atlantic City, N. J., to ascertain the adaptability of airplane photographs for use in topographic mapping. The area in the vicinity of Atlantic City was chosen as it is characteristic of so much of the coastal plain territory of the Atlantic coast. This project was essentially experimental in character but developed into one of practical value, as the photographs are being used in a revision of the charts of the New Jersey coast.

This work was done in cooperation with the Air Services of the Army and Navy. Both land and sea planes were used, and in addition several photographs were made from a dirigible. Three types of mapping cameras were tried out, the "L" type, K–1, and Trilens. An officer of the Survey kept in close touch with the work and furnished the ground control, constructing special targets in some cases.

A mosaic was constructed by members of the Air Service of the Army, using the photographs made with the K–1 mapping camera. These were taken at an altitude of 7,000 feet, using a lens of 10-inch focal length with a resulting scale of about 1:8,000. A rough control scheme was first laid out and the mosaic constructed over this.

This mosaic and also the individual photographs have been the subject of study by engineers of the Survey, especially with reference to control and interpretation. Various methods of reduction for chart use were tried out. A study was made of the accuracy of mosaics and individual photographs. The possibilities of control using the photographs themselves to establish a graphic triangulation have been investigated. The most important point brought out from the study of the results of the work at Atlantic City was the possibilities in revision work, especially along those sections of the Atlantic coast where the shore line is subject to frequent changes owing to the action of the sea.

## AERIAL PHOTOHYDROGRAPHY.

At the same time that the experiments at Atlantic City were being made a distinct line of investigation was being pursued at Key West, Fla. Photographs were made by the Naval Air Service to determine the possible use of aerial photographs in connection with hydrographic surveys. The primary object in view was the elimination of wire-drag work, especially in the clear waters of the Florida coast. An attempt was made to photograph small coral heads and pinnacle rocks, as it is the existence of these needlelike dangers to navigation that require the use of the wire-drag. The equipment at the air station at Key West was limited, but thorough tests were made with that available. Various types of cameras were used, as well as different combinations of filters and plate emulsions. Photographs were made at altitudes of from 200 feet up to 4,000 feet, and under various light conditions. It was hoped that some combination of the various factors involved would produce satisfactory results.

The problem of control was solved by including in each photograph two vessels of the Survey. The photographs could not be corrected for tilt with only two known points as a base, but the control as furnished by the positions of the two vessels was found to be sufficient for the experiments.

A well-surveyed area near Key West was chosen, and the vessels proceeded on parallel courses over this area at full speed, the plane flying forth and back above the course. The courses and positions of the vessels were recorded as in ordinary sounding work. The photographer in the plane recorded the exact time that each exposure was made, with other data such as altitude, exposure, plate, filter, etc. Each photograph was later oriented by plotting the positions of the vessels on the chart at the instant the exposure was made.

These experiments proved very conclusively that photographs from the air, using present-day equipment, are of little practical value to the hydrographer. When any of the underwater features did appear in the photographs, contrast in color was the most prominent, with no indication as to whether the contrast indicated shoal or deep water. Vari-colored bottom, of uniform depth, appears in the photograph as apparent difference in depth. Many charted shoals are not indicated in the photographs, while adjacent ones show clearly. Taken altogether, the results are so uncertain that the chances of eliminating field work in hydrography are very remote. Developments in the art of photography may change this viewpoint.

## REVISION OF THE COAST OF NEW JERSEY.

In March, 1920, the Army Air Service photographed the coast line of New Jersey from Cape May to Seabright. A single flight was made, using the k–1 camera. The plane flew at an altitude of 10,000 feet, and under very good air conditions. The camera was mounted in gimbals, with a lead weight at the lowest point to assist in maintaining the optical axis of the camera in a vertical position. Level bubbles were placed on the camera to aid in keeping the camera in the proper position. The photographs are being used for a revision of the charts of the coast of New Jersey. The individual photographs are 18 by 24 cm. in size, and the approximate scale is 1:10000. The photographs are mounted in strip mosaics, for convenience sake, not over 4 feet in length. The length is generally determined by the position of control points. This composite photograph is compared with the topographic sheet of the same area and control points identified. The scale of the photographic mosaic is determined, and by means of the pantograph the data are reduced to the scale of the chart and transferred from the photographs to tracing paper.

The photographing of this 120 miles of coast line took less than 2 hours' time in an airplane. The development of the films and printing took 2 days' time of one man. Two rolls of film were used, a total of 183 photographs. The work of interpreting the photographs, assembling mosaics, comparison with topographic sheets, and reduction to the scale of the chart of the outside shore line required 15 days of office work by one engineer.

## Part IV.—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 all hydrographic and topographic surveys executed by this Bureau, which supervision includes the determination of where surveys or resurveys are required, how they shall be conducted, the preparation of instructions for surveying parties, the organization of the parties, and the inspection of the field work and examination of the records. It is also charged with the construction, maintenance, and repairs of the vessels and other field equipment, except instruments; the records of the seamen employed on this work; the compilation of the Coast Pilot in the field and office; the observation of tides and currents; and compilation of tide tables.

For administrative purposes, the division is divided into four sections, known as the section of field work, section of vessels and equipment, section of Coast Pilot, and section of tides and currents. Each of these sections is under the direction of a hydrographic and geodetic engineer, who is responsible for the efficient and economical administration of his section, under the general supervision of the Chief of the Division of Hydrography and Topography.

The division also has supervision over the five field stations, located at Boston, New York, New Orleans, Seattle, and San Francisco, respectively, and over the office at Manila, P. I. The field stations are for the purpose of maintaining close relations between the Bureau and those who have occasion to use its charts, publications, and data, and to keep the Bureau informed of the needs for further work in these general localities. They are in charge of hydrographic and geodetic engineers, but undertake no surveys unless specifically directed to do so by this Office. The Manila office performs all of the functions of a field station and, in addition, has direct charge of all surveys in the Philippine Islands and much of the office work incident to these surveys. This office is in charge of a hydrographic and geodetic engineer, with the title of director of coast surveys.

This report gives a general statement of the work performed during the year under the direction of the division by the various field parties, the field stations, the Manila office, and, finally, a résumé of the work of the four sections. Detailed statements are given in the reports of the chief of parties.

### FIELD WORK, ATLANTIC COAST.

*Vessels.*—The *Bache* at the beginning of the fiscal year was at Norfolk, Va., preparing to take up work at the entrance to Chesa-

peake Bay. Some difficulty was encountered in obtaining firemen, due to the abnormal marine-labor situation, so that field work was delayed until August 11. Hydrography was then begun off the Virginia coast between Virginia Beach and Cape Henry. This work, which was all hand-lead sounding, was done outside the 3-fathom curve, extending seaward to the limit of fixed positions. During September and October simultaneous tidal observations at Fishermans Island and also at a point about 8 miles off Cape Charles were made. During November and until December 23 the vessel was undergoing repairs at Norfolk, Va. During this time a party worked from the vessel on a special hydrographic survey of the naval operating base at Norfolk requested by the Navy Department. On December 23 the vessel sailed for Pensacola, Fla., to take up work on the Gulf coast. During the period from January 1 to 20 the vessel was engaged in a search for a reported shoal off the mouth of South Pass, Mississippi River. Sounding lines were run, and enough soundings beyond the 100-fathom contour were taken to show the improbability of shoals in that locality. On January 24 the vessel returned to Pensacola to take up work in cooperation with the steamer *Ranger*. From February until May this vessel, in conjunction with the *Ranger*, was engaged on the offshore hydrography just west of the eighty-seventh meridian. The work was of the usual character for offshore hydrography on the Atlantic; soundings were fixed in position by horizontal sextant angles on shore signals and buoys to the limits of visibility for each and thence by precise dead reckoning. The weather conditions during this period were not favorable, and during the month of March little field work was done on that account. During the early part of May preparations were made to sail to Norfolk. The vessel left Pensacola during the early part of the month, arriving at Norfolk on May 14, when she was drydocked and given some minor repairs. Under date of May 26 instructions were issued for inshore and offshore hydrography from a junction with work recently completed off the Delaware Capes northward to the entrance to New York Harbor. This work was begun on June 16 and was in progress at the close of the fiscal year.

The *Isis* at the beginning of the year was in Baltimore, Md., undergoing repairs prior to taking up a hydrographic survey from and including the Delaware entrance to New York Harbor. So much repairing was necessary on the return of this vessel by the Navy on April 30, 1919, that she was not ready for survey work until August 14. Supplies were then taken on board and the vessel proceeded to Lewes, Del., arriving on August 26. The survey of the Delaware entrance was in progress until October 21, when the vessel closed this work and proceeded to Washington for special duty ordered by the Secretary of Commerce. After completing this duty she proceeded to Baltimore on November 5, where she received further repairs until December 11. The vessel then went to Norfolk for stores and supplies and on December 19 proceeded to the coast of Florida, in accordance with instructions dated December 17, 1919, to take up offshore work in the vicinity of St. Augustine. On January 15 the *Isis*, while engaged on this survey, struck the submerged wreck of the dredge *Florida* and was beached about 6 miles southeast of St. Augustine to prevent sinking, the inflow of water being too great

for control by her pumps. Immediately after the vessel had been beached temporary repairs were begun and efforts made to pump her out and float her. Meanwhile all movable property was transferred to the shore. A Coast Guard cutter was dispatched to assist the *Isis* and stood by as long as she could be of any assistance. Calm weather and a smooth sea at the time the vessel was beached gave reason to hope that she might be saved, but before adequate wrecking apparatus could be assembled and taken to the wreck an easterly storm undid all that had been accomplished. The vessel filled with water and settled steadily into the sand until it appeared useless to continue the cost of wrecking operations. She was therefore sold on January 27 with such equipment as could not be removed.

The *Ranger* at the beginning of the fiscal year was en route to Mobile, Ala., to take up a survey of the Gulf coast in that vicinity. The vessel arrived at Mobile on August 2, and on the 11th of August took up its station at Pensacola, where the work was commenced. From September 11 to 14 the work was interrupted by a hurricane which swept the Florida Keys. Good progress in hydrography was made during the first half of the month of October, but unfavorable weather conditions made work lag during the latter half of the month, which continued into November. Some progress was made, however, on the hydrographic survey from longitude 87° westward to the Mississippi Delta and from the coast out to the 100-fathom curve. During December suitable periods between bad weather were devoted to a hydrographic resurvey of the entrance to Pensacola Bay, and the work was continued until April 21. The topography of the shore line of the Gulf of Mexico was completed from the entrance to Pensacola Bay westward to the entrance to Perdido Bay, fulfilling the instructions already issued. Hydrography of the Gulf was continued off Perdido Bay entrance, and the inshore work was completed to a junction with the 1918 work on the *Hydrographer*. Bids for repairs were opened on April 17, and on the 22d the vessel was taken to the yard for repairs. Field work on the hydrography of the Gulf was resumed on May 15 and was continued to the close of the fiscal year.

The *Onward* on July 1 was engaged on a survey of Hampton Roads. This survey was completed early in September, but the vessel was not able to leave the vicinity until the 27th, owing to the difficulty of securing a chief engineer. Early in October the vessel arrived at Doboy Sound, Ga., and took up a hydrographic resurvey of that body of water and approaches from seaward. Bad weather hindered the work at its inception, but fair progress was made. On December 24 this work was completed and the vessel sailed for Savannah, arriving the next day. During January and February the vessel was undergoing repairs at Savannah, Ga. On March 8 the vessel left Savannah, arriving at Oriental, N. C., on the 22d, the delay being due to bad weather and the weakened condition of the vessel, which made it hazardous to leave protected waters during stormy weather. During April work was done on the signal building and triangulation, some topography and hydrography in Adams Creek and in the vicinity of Oriental. Rain and winds hampered the work considerably. The work in Adams Creek was completed in May, and the Oriental Harbor work and that of adjoining creeks

was completed except at the head of Kershaw Creek. On June 25 the vessel left Oriental and proceeded to Elizabeth City to make emergency repairs to the machinery.

The *Hydrographer* on July 1 was engaged on a survey of the Florida Reefs at the request of the Navy Department. The work was continued during the months of July and August and until September 9, when a hurricane swept the vicinity. The vessel dragged until the cables fouled those of the *Tuscarora*, and the two vessels hung in this position until the commanding officer of the *Hydrographer*, in order to save both vessels, ordered the cables slipped. The *Hydrographer* was then blown across the channel where she grounded on the shoals west of Key West. She was floated off this shoal by using her propeller to cut away the sand from under her bottom and was hauled out on the ways at Key West. During October, November, December, and until January 17, the vessel was undergoing repairs made necessary by this accident. The unusual length of time required for these repairs was due to inadequate facilities at Key West as a result of the storm. On January 21 field work was resumed eastward of Key West and consisted of hydrography in Hawk Channel eastward to longitude 81° 31′ and outside the channel to the 100-fathom contour. Several new shoals were found in Hawk Channel, and a survey of Boca Chica Channel was made. On account of a shortage of fresh water at Key West the vessel transferred its base to Miami for a short period during April and May and worked in the vicinity of that port, returning to Key West during May.

*Parties.*—Two wire-drag parties operated on the Atlantic coast during the first half of the fiscal year, but lack of funds and shortage of officers prevented resumption of this work during the second half of the year.

Wire-drag party No. 1 was employed on a survey of Block Island Sound, with headquarters at Block Island, R. I. A reef south of the island with only 34 feet of water over it and more than 60 fathoms around it was discovered. Seventy square miles were covered in the offshore areas east of Block Island, and some inshore work in the vicinity of Point Judith and south of Block Island was accomplished. The party closed work in Block Island Sound on November 3 and disbanded. The launches were hauled out and the dragmaster and marine engineer of the party were assigned to remain in charge of them and prepare the equipment for the next field work.

Wire-drag party No. 2 was employed on a survey along the New England coast from Portsmouth, N. H., to Portland, Me., with headquarters at Cape Porpoise, Me. On November 3 the party closed work and disbanded. The launches were hauled out and put in charge of the dragmaster and marine engineer, who were assigned to work on the drag equipment during the winter.

The topographic survey of the Virgin Islands, which was in progress at the beginning of the fiscal year, was discontinued on April 6 because there was an insufficient number of officers available to carry on the work economically, and the two officers remaining on this work were needed elsewhere. It is expected this work will be completed during the winter of 1920–21.

FIELD WORK, PACIFIC COAST.

*Vessels.*—The *Surveyor* left Seattle on July 9, 1919, to take up field work in Shelikof Strait, western Alaska. The main feature of this work was the extension of the triangulation net which terminated at Kodiak Island to a junction with the net that had been carried northeastward from Unalaska, thus providing control for past and future surveys of the Alaska Peninsula. The work also included topography and hydrography within the limits of the new triangulation. Field work in this vicinity was discontinued on October 9, and the vessel went to Sitka to make a small revision survey in Sitka Harbor. The latter work was completed on October 29, when the vessel proceeded to Seattle, arriving on November 4. During the winter the vessel was at Seattle under repairs and the party was employed in computing and plotting field records. The vessel sailed for Alaska on March 29 for continuance of work northeastward from Cape Ikti and previous work in Shelikof Strait. The steamer *Yukon*, which had been left in Alaska on the termination of work prior to the war, was used in conjunction with the prosecution of this work. An unusually early start was made this spring and, although the season was quite backward, much work was accomplished in this half of the fiscal year.

Upon the return of the *Surveyor* from duty with the Navy and vessels transferred to this Bureau from the Navy Department, plans were made to obtain deep-sea soundings in the Atlantic, Caribbean, and Pacific while the vessels were en route to their respective working grounds on the Pacific coast. The routes laid down were parallel and adjacent to the commercial route from the Atlantic to the Pacific coast ports via the Panama Canal. The routes were separated approximately 20 miles, with arrangements for soundings at intervals of 40 nautical miles. Much valuable information for charting purposes was obtained.

*Sialia.*—At the beginning of the fiscal year the vessel was at Baltimore, Md., undergoing repairs by the Navy Department, preparatory to transfer to this Bureau. The vessel was turned over to this Bureau on October 6 and sailed for Panama en route to the Pacific coast with instructions to take deep-sea soundings at stated intervals while en route. In accordance with this, soundings were obtained along the track as far south as the Bahama Banks. When down to the Bahama Banks both boilers and some auxiliary machinery failed, and the vessel proceeded in tow to Key West for repairs. The repairs continued until November 25, on which date the vessel sailed again for the Pacific coast. On that date it was reported by telegraph that the *Sialia's* condenser was leaking and pumps cracked. The vessel reported her location at Nuevitas, Cuba, and stated that the repairs by the ship's force would require one week. The repairs were continued during December, and in the early part of January the vessel left for Key West, arriving there on January 11. It was decided that she should return to Norfolk or Charleston under her own steam if this were possible, and an additional chief engineer and assistant engineer were detailed to her to insure that every possible care would be given to her machinery and boilers during the passage. She got as far as Charleston, S. C., but could not round

Hatteras because of boiler trouble. It appeared evident that this vessel was unsuitable for this service and that she did not warrant the cost of putting her in serviceable condition. Accordingly she was returned to the Navy Department on March 15.

The *Lydonia* was transferred to the Coast and Geodetic Survey from the Navy on August 7. She sailed from Norfolk on August 31 for the Pacific coast via the Panama Canal and arrived at San Francisco during October. While en route she took soundings along the steamer track from Norfolk to Panama and from Panama to San Diego. Three soundings of 178, 198, and 363 fathoms were taken, in latitude 29° 29′, longitude 117° 15′ (190 miles due south of San Diego), where the nearest soundings shown on the chart are about 2,000 fathoms. On arrival at San Francisco preparations were made for offshore hydrography off the coast of California, from Cape Mendocino to Point Arena, which work was started on November 19, 1919, at Humboldt Bay. This work was continued until February 4, when the vessel returned to San Francisco preparatory to undergoing repairs and outfitting for summer work in Alaska. On April 10 the vessel sailed for Seattle, en route to the field work in southeast Alaska, to take up topography and inshore hydrography along the west coast of Dall Island, northward from completed work in the vicinity of Cape Augustine. The launch *Cosmos* was used in this work. This work was in progress at the end of the fiscal year.

The *Arcturus*, which had been received from the Navy just prior to the beginning of this fiscal year, had been brought from New York to Norfolk, where she was laid up and her crew transferred to the *Lydonia* because of lack of personnel to operate both vessels. After a thorough survey of this vessel and with the knowledge derived from her performance on the passage south, it was decided to return her to the Navy. She was delivered on January 14.

The *Patterson* had ceased to be an efficient surveying vessel before she was taken over by the Navy for military duty, and, accordingly, when she was turned back to this service she was not put into commission. She was disposed of by sale on December 22.

The *Wenonah* arrived at San Diego, Calif., on July 17, en route from Norfolk, Va., to San Francisco. Some difficulty was experienced in obtaining coal during the passage from Panama, and because of the vessel's limited bunker capacity she was obliged to take on a small amount of coal while at sea. The *Wenonah's* track was laid down about 20 miles distant, parallel to those laid down for the vessels which preceded her to the west coast. Soundings were obtained at regular intervals throughout the voyage. After receiving stores and outfit at San Francisco the vessel took up work in the vicinity of Cape Mendocino and the survey of Humboldt Bay when weather conditions prevented outside work. A party from the vessel, using the United States Engineers' launch *Clyde*, was employed on the hydrographic survey of Humboldt Bay. A large area extending from Cape Mendocino to about the entrance to Eureka Bay and between the 20 and 200 fathom curves was completed and a few lines of soundings were taken out to a depth of 500 fathoms. This work was in progress until January, when the vessel proceeded to San Francisco for repairs and outfit for Alaska work.

At the close of the fiscal year she was engaged on hydrographic and topographic surveys in Clarence Strait, southeastern Alaska, from Dixon Entrance northward.

The *Explorer*, which had been laid up at Seattle on return from the Navy, was put into commission in February and made ready for wire-drag work in southeast Alaska. A combined operation party was organized, with the *Explorer* as a mother ship, two large ex-Navy launches, and a 30-foot tender in lieu of the hired launches used heretofore for this class of work. The launches *Scandinavia* and *Helianthus* were repaired and assigned to this party as tenders to the *Explorer*. The vessel and launches proceeded to Alaska and took up triangulation, topography, and hydrography in Stephens Passage. Excellent progress was made from the start, and the work was well under way at the end of the year.

The *Natoma* made the passage from Norfolk, Va., without accident and arrived at San Francisco on July 27, no soundings being obtained en route, as the delays incident to such work would endanger the safe passage of so small a vessel. She was then employed on an examination of Bonita Channel, requested by the commander in chief of the Pacific fleet. On completion of this work the vessel took up a resurvey of San Francisco Bay, including hydrography and revision of the shore line. This work was continued throughout the winter and until April 15, when she was being repaired and made ready for work at San Pedro, Calif. She was still undergoing repairs on June 30.

*Parties.*—From July, 1919, until March, 1920, a party was employed in Lake Washington dragging for submerged trees which, since the lowering of the level of the lake, had become a menace to navigation. The work was conducted at first in accordance with the usual wire-drag practices, but as the work developed it was found that other means were necessary for locating the trees with sufficent exactness to enable a snag boat to remove them. A special form of sweep was devised which gave excellent results. A total of 172 submerged trees were located by this party and removed by the United States Engineers. Some were over 100 feet long and one 140 feet. The tops of these trees were from 4 to 30 feet below the surface of the water. In connection with this work the triangulation and topography of the shores of Lake Washington were revised.

A party was organized during April and began on April 19 a resurvey of Umpqua River and bar, Oreg. This survey was ordered primarily because of the reported uncertainty of the depth that could be carried over the bar at the entrance to the river, but it was found that important changes had taken place within the river, and a complete survey to Gardiner was ordered. This work was in progress on June 30.

At the beginning of the fiscal year a party was at work on the coast of California, in the vicinity of Eureka, recovering old triangulation stations, erecting signals, and establishing new stations where required for the control of hydrography off this coast. This work was extended to include the coast from Cape Mendocino to Point Reyes. Work was completed in October.

## FIELD STATIONS, ATLANTIC AND PACIFIC COAST.

Field stations, each in charge of an officer of the Survey, were maintained at Boston, New York, New Orleans, Seattle, and San Francisco. At these stations the public may consult any of the charts and publications of this Bureau, the publications of the Bureau of Lighthouses, and may obtain information concerning such surveys as have been made in the district or are contemplated. Coast and Geodetic Survey charts, coast pilots, and tide tables are sold at all field stations. The inspectors in charge of the stations are required to keep themselves informed concerning changes affecting the charts of their districts and to report to the director of the Survey as to what additional surveys or resurveys are necessary to meet the requirements of navigation. The inspectors often perform many other duties in connection with the work of the Bureau in their respective districts.

The inspector in charge of the Boston field station determined the geographic position of and marked an azimuth line from the Navy radio-compass station at Chatham, Mass., on request from the Navy Department. He also did chart-revision work in that locality.

The inspector in charge of the New York field station directed a hydrographic resurvey of Gravesend Bay and a revision of the shore line. He also supervised a tidal and current survey of the waters of New York harbor from July to December, 1919. The completion of this work has been deferred to the next fiscal year because of insufficient funds during this year.

The inspector in charge of the New Orleans field station determined the geographic position of and the azimuths of lines from the Navy radio-compass stations at the mouth of the Mississippi River and at Grand Isle, La. He also verified primary azimuth measurements at Marthaville, Ga.

The inspector in charge of the Seattle field station had supervision over the tidal stations at Seattle and Olympia and the current stations on the four light vessels of the coast of Oregon and Washington. He was in charge of the Bureau's vessels and launches which were laid up at Seattle without a commanding officer and attended to the upkeep and repairs of these craft. He also cooperated with the officer in charge of the Lake Washington work and with the commanding officers and chiefs of parties operating out of Seattle.

The inspector in charge of the San Francisco field station, assisted from time to time by others of the service, performed the necessary field work and prepared for publication a pamphlet giving the ranges available in San Francisco Harbor for adjusting ship's compasses. The former publication on this subject antedated the San Francisco fire, which destroyed many of the older ranges, and since the city was rebuilt there has been need for a new edition of this work. The publication will come out during 1920.

## FIELD WORK, PHILIPPINE ISLANDS.

*Vessels.*—The *Pathfinder*, on July 1, was at the Olongapo naval station undergoing extensive repairs, upon the completion of which she on September 18 proceeded to Manila to take on supplies. After

coaling at Cavite, she sailed for her field of operations on the northwest coast of Mindanao, on September 27, and took up combined operations along the coast, from Blanca Point southwest to Coronado Point.

Actual field work began on October 1 by searching for and locating a reef in Dapitan Bay. A base line was measured in Sandigan Bay, the necessary signals built, and the work prosecuted until March, when the vessel returned to Manila for docking and to transfer commanding officers. On April 21 she again proceeded to the working ground and was engaged in deep-sea sounding work in the Sulu Sea until June 23, when she returned to Manila for docking and repairs.

On June 30 she was in the naval dry dock at Olongapo.

The *Fathomer* was at Manila on July 1 for transfer of command, and on the 9th left Manila for her working grounds. She was engaged in the survey of Cuyo West Pass and the Cagayan Islands until December 7, when she returned to Manila for repairs. Repairs were made at Engineers Island, and the vessel left Manila for the field on April 8. At the close of the year, June 30, she was still in the field, engaged in surveys along the west coast of Mindanao and Cuyo West Pass.

The "*Romblon*."—On July 1 the *Romblon* was in Ragay Gulf making a special survey of the Vinas River. This work was completed on October 7.

In the meantime the vessel was at Manila from August 15 until September 3 for minor repairs to the boiler. On October 7 the *Romblon* proceeded to the southwest coast of Palawan and resumed the work begun the previous year. This work was prosecuted until January 10, when the northeast monsoon made work in that locality impracticable. Some necessary repairs were made at Manila, and on February 20 the vessel left Manila for Zamboanga, for work on the southern coast of Basilan Island. This work was continued until its completion on April 27, when the change of monsoon permitted the resumption of work on the Palawan coast. This work was prosecuted from April 27 until June 20. The vessel then proceeded to Manila for a general overhauling and was there at the end of the year.

The *Marinduque* was returned to the Coast and Geodetic Survey by the bureau of labor of the Philippine Government on July 7. She was in a run-down condition and needed immediate repairs. Repairs were completed on September 26. Field work was begun on the west coast of Zamboanga Peninsula, from the line Lampinigan–Sangboy, and continued northward until February 21, when it was suspended and the vessel returned to Manila.

Owing to a lack of field officers, no further field work was done during the year.

*Manila field station.*—The Director of Coast Surveys in Manila directed all operations of the field parties in the Philippine Islands, had supervision of all work of the computing, drafting, and chart divisons in the field station.

## PHOTOGRAPHIC SURVEYING.

On July 1, 1919, the Bureau had an officer at Atlantic City, N. J., establishing control of airplane photographs, which were subse-

quently made by the air services of the Army and of the Navy for the purpose of determining experimentally how accurately the country could be mapped from such photographs. A mosaic of Atlantic City constructed from these photographs, together with the individual photographs, were studied with reference to the control. At the same time the party on the Survey steamer *Hydrographer* was experimenting near Key West, Fla., with airplane photographs of water areas to determine to what extent, if any, submerged objects and the nature of the bottom could be detected on such photographs. These photographs were taken by the Navy air service officers stationed at Key West.

The results obtained from the Atlantic City experiments, while inconclusive and, on the whole, rather unsatisfactory, still indicate that airplane photography may be of great assistance in mapping the land. The results of the Key West work indicate that with present photographic equipment no dependable information can be had of underwater conditions. Because of the very important part that airplane photography will certainly take in land surveying if some of the obvious difficulties can be overcome, it has been considered worth while to devote as much study to this subject as practicable. One officer has been detailed to devote his entire time to the subject and has been given the best facilities for investigation that the Bureau can supply. He has been in close communication with those who are working on this and allied subjects at Washington and elsewhere. He represented this Bureau at a series of experiments conducted last spring at Dayton, Ohio, by the Air Service of the Army. It is believed that substantial progress has been made during the year, although the disorganized condition of the air services, as the result of demobilization of the Army and Navy, has necessarily retarded experimentation.

## SECTION OF FIELD WORK.

The work of the field section was of the same general character as during the fiscal year 1919.

The plans under which the work of this section was organized were based on the necessity of adequate supervision of the topographic and hydrographic surveys and coordination of the work of the various field parties. During the year the mapping of the shore line and the hydrographic work was carried on under instructions prepared in the section.

The compilation of data from original sheets and descriptive reports of previous work was carried on with a view to determining their quality and extent. Original field notes covering areas where resurveys are necessary and where new work is contemplated were carefully reviewed in order to formulate plans and prepare the detailed instructions for the required work.

This careful preparation of the instructions and supplying of necessary data in the way of adjoining sheets and information relative to previous work in the immediate vicinity of the proposed operations has done much to promote the efficiency of the field parties and to coordinate the work of the Bureau.

Inspection of the field parties was made once during the year to insure accuracy and completeness of their work.

## SECTION OF VESSELS AND EQUIPMENT.

The work of this section during the past fiscal year was performed in accordance with its basic duties for the repair and upkeep of the vessels and launches and for the maintenance of the working equipment of the various field parties operating under the division. Inspections of practically all the vessels and launches were made by administrative officers of the division during the year. Recommendations submitted for repairs and necessary work to maintain these units were approved to the limit of the appropriation and in consideration of the requirements of the field work. The purchase of some necessary equipment was postponed on account of lack of further funds.

Recommendations were considered and plans sketched for alterations to be made to the vessels acquired from the Navy to furnish better accommodations for the crew, to enlarge the storage space, and improve the sanitary conditions on board. Such alterations when completed will enhance the value of these vessels for surveying operations during the temporary period of their use. The files of the Bureau were maintained and supplemented by current changes and additions. In these files are kept the plans of existing vessels and of launches built under the jurisdiction of the Bureau. Detailed plans and printed specifications for the construction of new vessels are on file in readiness for submission to prospective bidders when an appropriation shall be made available. There are also on file records of the seamen personnel. Data were compiled for adjustments of pay of ships' officers and men to meet changes current in marine services. Reports and returns submitted by various parties in connection with the work of this section were received and filed.

Estimates submitted for operating expenses and repairs were reviewed and prepared for the approval of the chief of the division.

*Marine services.*—Reports and returns submitted by various parties in connection with the work of this section were received and filed.

Estimates submitted for operating expenses and repairs were reviewed and prepared for the approval of the chief of the division. Allotments were made under the approved estimates or revised as the progress of the work indicated possible changes.

## COAST PILOT SECTION.

During the year this section completed work on the Philippine Islands Coast Pilot, part 1, and it was distributed in September, 1919.

The section revised and issued a new edition of the Hawaiian Island Coast Pilot Notes; the Inside Route Pilot, New York to Key West; and the Inside Route Pilot, Key West to New Orleans. Field work was done along the coast of New Jersey for a new edition of the publication covering the inland waterways of that State.

During the year such supplements and corrections were issued as were necessary to keep the information in all volumes up to date.

Reprints were obtained during the year of Atlantic Coast Pilots, Sections B, C, and D; and Pacific Coast Pilots, California, Oregon, and Washington and Alaska, part 1.

The record of the issue of coast pilots in recent years is interesting as indicating the usefulness of these publications. As these volumes

are sold at a price sufficient to defray the cost of printing (50 cents), it is obvious that the number sold furnishes an accurate measure of the public demand. Each year marks an ever-increasing demand for them. The following is the record of the issue for the fiscal years from 1913 to date:

| | | | |
|---|---|---|---|
| 1913 | 3,797 | 1917 | 7,952 |
| 1914 | 4,148 | 1918 | 12,913 |
| 1915 | 4,016 | 1919 | 13,315 |
| 1916 | 5,602 | 1920 | 15,261 |

## SECTION OF TIDES AND CURRENTS.

The prediction of tides and currents for the 1921 tide tables was made and the manuscript submitted for printing in three separate parts: Atlantic Coast Tide Tables, Pacific Coast Tide Tables, General Tide Tables.

Automatic tide gauges were kept in operation throughout the year at seven stations on the Atlantic coast, two stations on the Gulf coast, three on the Pacific coast, and two in Alaska. In addition, tidal observations in connection with hydrographic surveys were made at 114 stations with an aggregate length of 44 years.

At the principal tidal stations the relation of tide staff to bench marks was verified by spirit levels, insuring accurate data for detecting subsidence or emergence of the coast.

To make available for engineering and other purposes definite datum planes all along the coast, a tidal party was employed in New York Harbor for about three months. In addition to establishing bench marks, current observations at important points were also made.

Current observations during the year were made on 13 light vessels on the Atlantic coast, on 1 light vessel on the Gulf coast, and on 5 light vessels on the Pacific coast. In addition, short series of current observations were made at 85 stations with an aggregate length of 11 months.

The proof of the 1921 tide tables was read and the Atlantic and Pacific Coast Tide Tables were received from the printer before the end of the fiscal year; the General Tide Tables are expected by August 15. The following table, showing the number of copies of the Tide Tables issued for each year, is indicative of the increasing usefulness of these publications:

| Tide tables for year— | General tide tables. | Atlantic coast tide tables. | Pacific coast tide tables. | Total. |
|---|---|---|---|---|
| 1915 | 1,776 | 2,291 | 10,989 | 15,056 |
| 1916 | 1,195 | 2,682 | 10,565 | 14,442 |
| 1917 | 1,847 | 3,998 | 13,560 | 19,405 |
| 1918 | 3,331 | 3,997 | 13,959 | 21,287 |
| 1919 | 3,945 | 4,465 | 14,952 | 23,362 |
| 1920 (six months) | 3,181 | 4,447 | 15,122 | 22,750 |

*Pacific coast currents.*—In the safeguarding of our commerce along the Pacific coast a knowledge of the currents is of utmost importance. No matter how accurate charts and navigation instruments be made, however skillful the navigator, in thick weather grave danger of dis-

aster exists unless the direction and velocity of the currents acting upon the ship are known.

Though the problem is complex, for practical purposes it admits of solution. The Coast and Geodetic Survey has devoted considerable attention to currents. and publishes in its coast pilots and tide tables information of great value to mariners. Given sufficient observations, it will be possible to extend this information so that the mariner may know, under all conditions of weather, the direction and velocity of the currents to which his vessel may be subjected.

To realize how important an element the currents constitute, it is but necessary to remember that in the more than thousand miles of coast line from the Mexican border to the Strait of Juan de Fuca, harbors are many miles apart, sailing courses from headland to headland long, and periods of thick weather of comparatively frequent occurrence. In the long list of disasters which the difficult navigation of that coast has claimed—from 1900 to 1917, 100 vessels were wrecked along the Pacific coast of the United States—a large number were due to lack of knowledge of the effects of the currents. And it is to be borne in mind that the navigators of the Pacific coast comprise an unusually able, keen, and alert group of men.

To the present time appropriations for current observations have been so small as not to permit the maintenance of a vessel for the purpose of making a detailed, systematic study of the treacherous and little-known currents of the Pacific coast. The Survey has already made use of all other possible agencies for securing data. Current observations are being made at the five light vessels along the coast, and masters of coastwise steamers send in reports regularly. But it is obvious that a more systematic effort is necessary, since the distance between light vessels is too great for securing all data required.

The problem of the currents along the Pacific coast involves the determination of both tidal and nontidal currents; and while the tidal currents at any place may be determined with sufficient accuracy from observations covering a month or more, the nontidal current requires observations covering several years.

In its current work, at present, the Survey is primarily engaged in the practical determination of the existence and nature of the currents affecting navigation. At the same time and at the same cost, however, it is accumulating the data requisite for a comprehensive study of the problem which has an important bearing upon meteorology, climatology, and other related subjects.

For a systematic study of the currents on the Pacific coast, it is planned to continue the observations aboard the five light vessels stationed off the coast, to continue and extend the reports of voyages from masters of coastwise vessels, and to employ one Coast and Geodetic Survey vessel, equipped for anchoring at critical points between the widely separated light vessels, to secure at these points current observations of several weeks' duration.

If this project is carried out, two or three seasons' work will provide sufficient data to enable the Survey to predict the tidal current for representative regions covering the entire coast, to discover any permanent currents and their seasonal variations, and to devise rules en-

abling the mariner to make proper allowance for changes in the direction and velocity of the current due to winds.

Given the modest appropriation necessary to carry this plan into effect, a long step will have been taken toward the safeguarding of navigation of the Pacific coast.

## DIVISION OF GEODESY.

### FIELD WORK.

The details of the field work done under the direction of the division of geodesy during the year are given under the heading "Details of Field Operations."

The principal operations undertaken are here summarized as follows:

In the summer and early fall of 1919, a reconnoissance was made for primary triangulation in northern California and northeastward from the vicinity of Klamath Falls to the vicinity of Ontario, Oreg. This work was requested by the officers of the Forest Service in order that precise geographic positions might be available for the control of surveys of the national forests.

The Forest Service also requested a line of precise levels through the same area followed by this reconnoissance for triangulation, in order that precise elevations might be available for surveys and maps of national forests. The work in northern California and Oregon is also of great value to the United States Geological Survey and to the engineers and surveyors of the State of Oregon. This triangulation and the leveling form a part of the general control systems of triangulation and leveling of the United States.

In the spring of 1920 a party was organized for the purpose of carrying on the observing over the arc of precise triangulation for which the reconnoissance was made in the summer of 1919. This work was in progress on June 30, 1920.

Seven three-fourth-ton automobile trucks were purchased in the early spring for the use of the geodetic parties. Six of these trucks are being used as a means of transportation by this party through very rough country, which will furnish a thorough test of their efficiency.

On this work there were two observing parties. A subparty was engaged on preparation of stations for the observers. This preparation consisted of marking with concrete and a tablet each point at which observations were made and the erection of a substantial stand over this mark as the support of the theodolite with which the horizontal observations were made.

In the spring of 1920 a precise-leveling party began a line of precise levels in the vicinity of Klamath Falls, Oreg. The route that this party is following extends to the eastward of Klamath Falls and thence northeastward to the vicinity of Ontario, Oreg. At Klamath Falls the new leveling was connected with previously established bench marks and on completion of the line a similar connection will be made at Ontario, Oreg.

At the beginning of the fiscal year 1920 a leveling party was working on the line of precise levels which extends southward from the vicinity of Klamath Falls, Oreg. The line was completed to Rose-

ville, Calif., where a connection was made with previously established bench marks.

The party was then moved to San Jose, Calif., where a line of levels was begun, which extended southward as far as Santa Ana, Calif. At each end of this line connections were made with previously established bench marks of the United States Coast and Geodetic Survey, and with tidal bench marks established along the Pacific coast. Motor-velocipede cars were used as a means of transportation.

On the completion of the line to Santa Ana, in the late winter, the party was moved northward to Weed, Calif., from which point a line was started toward Seattle, Wash. This work was in progress in the vicinity of Portland at the close of the fiscal year 1920.

From July 1, 1919, until the end of June a subparty was engaged on levels.

About the 20th of June the charge of the party was transferred.

The leveling in California and in Oregon was requested by the United States Geological Survey in order that accurate elevations might be available for tying into the leveling of a lower grade that had been run for the control of topographic surveys and maps. This leveling is a part of the general precise-leveling net of the United States and extends through an area that has been very badly in need of accurate elevations.

After some correspondence with the Director de Estudios Geographicos y Climatologicos of Mexico, arrangements were made to connect the precise triangulation of Mexico in Lower California with that of the United States in southern California. An officer of the survey took charge of field operations, and, in cooperation with an engineer of Mexico, completed the necessary observations to connect the systems of the two countries. The geodesists of Mexico have shown a splendid spirit of cooperation with the geodesists of the United States in having the triangulation systems of the two countries connected and placed on the same datum; that is, the North American datum. This is an admirable arrangement, for it insures that the maps made along the Mexican boundary by Mexico and the United States will harmonize in geographic positions. The triangulation systems of the two countries had previously been connected in the vicinity of Brownsville, Tex.

In the latter part of the previous fiscal year triangulation had been begun in the State of Utah to supplement the precise triangulation of the transcontinental arc. The lines between stations of this arc are so long that it was impracticable to use them for forest surveys without having additional stations established. This work in Utah was continued after the beginning of the fiscal year and completed in the fall of 1918. In carrying on this arc of triangulation in Utah for the especial benefit of the Forest Service the local officials of that service rendered valuable assistance to the chief of party, and at some of the stations the observations were made by engineers of the Forest Service to supplement the work done by this party.

On the completion of the triangulation in Utah, mentioned in the preceding paragraph, the party was moved to southern Arizona and began work on precise triangulation which extends from the vicinity of Nogales, Ariz., northwestward to the vicinity of Yuma. This work was done in response to a request from the Chief of Engineers, United States Army, with a view to furnishing control stations for

maps and surveys along the boundary. The area covered by this triangulation lies between the Mexican boundary and the Texas-California arc of precise triangulation.

The officials of the Army stationed at Fort Sam Houston cooperated with the chief of this party and supplied automobile trucks for transporting the party and supplies and equipment necessary for the work. Great difficulty was experienced in obtaining the proper men as light keepers for the party. It was frequently the case that a man would be sent to a mountain peak to perform the duties of a light keeper and would abandon the station without notifying the chief of party of his action. This, together with the fact that the country is arid and the mountain peaks difficult of access made the work hard and somewhat hazardous. The party was in no way molested by anyone along the Mexican boundary, although many times work was done in the immediate vicinity of the boundary monuments.

About the end of the month the charge of the party was transferred to another officer, who completed the work and later moved the party to New Mexico.

At the beginning of the fiscal year 1920 a party which had been organized in the late spring of 1919 was in operation on triangulation in Arizona to the northward of Tucson and Phoenix, Ariz. This work was done at the request of the Forest Service for the purpose of furnishing precise geographical positions for surveys and maps in their forest areas. More stations were established than would ordinarily be the case in extending an arc of precise triangulation across the country through an area lacking such control. It was economy to establish these additional stations at the time that the main scheme observations were made in order to avoid the necessity of the engineers of the Forest Service having to make a supplemental triangulation survey for their especial purpose.

During the progress of this season's work a base line was measured to control the lengths of the triangulation in the vicinity of Prescott. Great difficulty was experienced in securing the right kind of men as light keepers and heliographers.

On the completion of the triangulation along the Mexican boundary between Nogales and Yuma the outfit and some of the members of the party were taken to Albuquerque, N. Mex., where preparations were made for the measurement of a base line in the vicinity of Belen, N. Mex., and for precise triangulation from that locality westward along the Santa Fe Railway. The base line was completed and triangulation was under way at the end of the fiscal year 1920.

At the end of the fiscal year 1919 a party was engaged on precise triangulation which extends from Waco, Tex., eastward to the vicinity of Mansfield, La. This work was continued in the early part of the fiscal year 1920 and completed to Mansfield in the early fall. After the work had reached Mansfield it was found necessary to extend the horizontal control surveys, of which this work is a part, by precise traverse to the Mississippi River. This was done because of the fact that the country through which the survey was made is heavily wooded and flat and the cost of erecting signals for triangulation would have been considerable.

The traverse work from Mansfield to the Mississippi River in the vicinity of Naples was completed.

Late in the spring of 1920 a revision was made of a small section of this traverse to detect an error that had been made in one of the traverse angles. The error was found and the correction was made in the original observations.

In the latter part of the fiscal year 1919 a precise-leveling party began a line of levels at Hillsboro, Tex., and ran eastward toward the Mississippi River. This line was carried as far as Gallatin, Tex., when the party was transferred to Mansfield, La. From that place a line was run to Shreveport, La., and connected with existing bench marks of the precise-level lines, and then from Mansfield the line of traverse was followed to Naples, La. From this line of levels a profile of the railroad was made from which grade corrections were applied to the tape measurements of the traverse. On the completion of the leveling to Shreveport and Naples the party proceeded westward from Mansfield and extended the line of levels to Tenaha, Tex.

During the progress of the work of the leveling parties in Texas and Louisiana a crossing was made of the Mississippi River in the vicinity of New Orleans, La. A novel plan of operation was adopted consisting of having two targets at known points on a level rod which were observed with the instrument on the opposite side of the river. The reading of the micrometer head was made when the central horizontal wire was placed on each of the targets, and the micrometer reading was taken when the bubble of the precise level was in the center. By a simple proportion it was possible to learn the point on the rod at which the instrument was directed when the bubble was in the center.

Simultaneous readings were made—that is, there were two rods and two instruments involved in the river crossing—in order that the effect of the atmospheric refraction could be eliminated.

The results of this crossing were entirely satisfactory to the office, and the indication is that this method will be extensively used in the future in similar work. One of the problems in precise leveling for many years has been the difficulty of making a satisfactory crossing of wide bodies of water.

The leveling, triangulation, and traverse discussed in two or three preceding paragraphs were called for by the Chief of Engineers of the United States Army, in order to furnish geographic positions and elevations for the control of military maps and surveys. A portion of the expense of this work was met by transfer of funds from the War Department. The building of signals and the preparation of stations were done by a party organized for the purpose. Upon the completion of signal building, etc., on this arc of primary triangulation and traverse, the building party proceeded to Oklahoma and began the erection of signals in that State along the Little Rock-El Reno arc.

On October 22 precise triangulation was begun and was extended westward in Oklahoma until the winter weather necessitated the suspension of the work.

Two officers were engaged during practically the entire fiscal year in the determination of the differences of longitude in Texas, Louisiana, and Arkansas. Some of the work was in western Texas, along the Rio Grande arc, some was along the Waco-Mississippi River arc,

and the remainder consisted in the connection of the last longitude station established in Louisiana with the old longitude station at Little Rock, Ark.

In the summer and early fall of 1919, a number of gravity stations were established in South Dakota, Nebraska, Wyoming, and Colorado. These stations were selected by the officials of the United States Geological Survey and the value of the intensity of gravity at each of them was expected to throw light on local geologic problems. The standard half-second pendulums were used on this work and were standardized both before and after the season's work at the office in Washington.

In the spring of 1920, a reconnoissance was begun for precise triangulation or traverse on a north-and-south line through the State of Indiana. This work had been requested by officials of the United States Geological Survey for the purpose of furnishing geographic positions for the control of their surveys and maps. After the reconnoissance had been carried some distance it was decided that the line should be entirely traverse. A traverse party for this work in Indiana was afterwards organized. The party was operating during the last few months of the fiscal year 1920.

A revision of the traverse to the northward of Griffin, Ga. On completing this work a revision was made of triangulation in the vicinity of Sanford, N. C.

During the early part of the fiscal year 1920 a revision was made of the measurements of distances of the traverse lines in North Carolina, South Carolina, and Virginia. This work was necessary because of the fact that during the war very great difficulty was experienced in obtaining engineers to make observations and to have charge of the supervision of various surveying parties. The work was carried on with inexperienced and inefficient observers, in many cases with the consequence that much of the work had to be revised.

At the close of the preceding fiscal year a precise-leveling party had completed the line between Troy and Whitehall, N. Y. The party was then moved to Rouses Point and began running a line westward through the northern portion of New York. The work was connected late in November with another line of precise levels which had been run during the summer of 1919 from the vicinity of Niagara Falls to the vicinity of Williamson, N. Y. These lines of levels were run at the suggestion of the officials of the Geodetic Survey of Canada in order to test certain lines of levels by the two nations which are joined at the international boundary. The idea of the United States Coast and Geodetic Survey and the Survey of Canada is to have the elevations in the leveling systems of the two countries harmonize wherever the leveling crosses the international boundary.

A field party was engaged during the fall and early winter of 1919 in the vicinity of Norfolk, Va., on the establishment of a speed-trial course for hydroplanes for the United States Navy. The work was difficult on account of unfavorable weather conditions and unavoidable lack of proper equipment and personnel in the party and, in consequence, was abandoned until a more auspicious time.

During the latter part of the fiscal year another officer took up the work of establishing this course for the Navy hydroplanes in the

vicinity of Hampton Roads and this work was in progress on June 30, 1920.

During the latter part of September and October, 1919, a field officer was engaged in the establishment of a speed-trial course at Rockaway Beach, Long Island, for the use of the naval air station at that place. This work was done at the request of the Navy Department.

A reconnoissance for the primary triangulation of Puget Sound, Wash., was completed during the year. It was originally intended to complete the triangulation during the fiscal year, but, on account of the great expense, this work was postponed for the time being. The triangulation is to start in the vicinity of the Tacoma base net and extend northward to the vicinity of Point Roberts. It is a part of the arc which will eventually extend from the United States through southeastern Alaska and down the Yukon River into Alaska. When it is finally completed, it will be possible to put all the geographic positions in Alaska on the North American datum.

In the spring of 1920 the geographic position of the radio-compass station at Fox Hill Island, Chatham, Mass., and the true azimuths of several prominent objects from that compass were determined. The work was done at the request of the Navy Department.

In February and March, 1920, a determination was made of the geographic positions of the radio-compass stations at Pass a Loutre, South West Pass, and Grand Isle, La. The true azimuths of several prominent objects from those stations were also determined.

In August, 1919, at the request of the Navy Department, the geographic positions of the radio-compass stations in the vicinity of Cape Lookout, N. C., were determined. A true north-and-south line through the center of the shaft of the radio-compass coil was established.

During the first half of the fiscal year two new sets of pendulums for the gravity apparatus were constructed in the instrument section. The only difference between these pendulums and the pendulums which have been used during recent years for gravity determinations is in the material of which they are made, the nickel-steel alloy called invar being used in place of bronze.

Before these new pendulums could be used in the field it was necessary to test them thoroughly in order to determine certain constants used in the computations and to find out what effect the magnetic field of the earth will have on their periods. These tests were begun in January and continued until about the first of May. Seventy-two swings, each about 12 hours in duration, were made during this time. Observations and computations to determine the magnetic conditions of the pendulums were made by the chief of the division of terrestrial magnetism.

In regard to the magnetic effect, the results show that the periods of the invar pendulums are different for different degrees of magnetization of the pendulums, a decrease of more than four millionths of a second having been found in the period of one of the pendulums after slight magnetization. This corresponds to more than four times the allowable probable error for gravity determinations.

Further experiments with these pendulums must be made in the field to determine what effect the shipping of the pendulums will

have on their magnetization and to what extent variations in the intensity of the earth's magnetic field will change their periods.

The temperature constant of the invar pendulums was found to be only one-fifteenth as much as for the bronze pendulums. This means that the former will have a great advantage over the latter at stations in out-of-the-way places where constant temperature rooms are difficult to find or construct.

During June tests were made in the instrument section on storage-battery cells in the operation of the large-size electric signal lamps employed on primary triangulation. Up to this time dry batteries have been used under field conditions. It was found that 45 pounds of storage batteries would run the large bulb which furnishes 200,000-beam candlepower for 15 hours at a proper brilliancy, while 23 pounds of batteries ran the small 3.8-volt bulb which delivers about 6,000-beam candlepower for about 100 hours.

On July 5, 1919, the chief of the division of geodesy sailed from New York for Europe to attend the meeting at Brussels, Belgium, of the International Research Council, held July 18 to 28. The idea of calling this meeting of the International Research Council was to provide for some coordination in the activities of countries in scientific matters which are of a general nature that is beyond the scope of any one country. Such work is the variation of latitude, the determination of the size and shape of the earth, etc.

The delegates to this International Research Council convention represented only countries which were allied in the war against the Central Powers. Neutral countries will be invited to join the council and its various branches. The International Research Council was organized with a central body and a number of unions. Each union is considered to cover some major subject in scientific matters, such as astronomy, geophysics, etc. The work of the Coast and Geodetic Survey comes under the general head of geophysics, and will be cared for in its international aspects by several sections of the International Geodetic and Geophysical Union, which is a branch of the International Research Council.

It had been planned to have the chief of division of hydrography and topography and the chief of the section of field records, who were in England attending the Hydrographic Conference, proceed to Brussels and attend the International Research Council, but the illness in England of the first-named officer prevented their attending, and his death occurred about the time the conference ended.

A number of American scientists were honored by election to office in the various unions and their sections. The chief of the division of geodesy was elected president of the geodetic section of the International Geodetic and Geophysical Union. He took an active part in the formation of the American Geophysical Union, which is a committee on geophysics of the National Research Council, and is called the National Committee for the United States of the International Geodetic and Geophysical Union. He was the acting chairman of the union during the first year of its existence and was elected chairman for a term of two years at the first annual meeting of the union, which was held in the National Research Council, Washington, D. C., April 23, 1920.

The United States has adhered to the Neutral Geodetic Association to the extent of paying its annual quota. There is some question

as to whether the United States is obligated further to the old association, but this matter will be definitely settled in a short time, because there will be no necessity for the existence of two geodetic associations of an international character, and it is highly probable that the geodetic section of the International Geodetic and Geophysical Union will take over the work and functions of the Neutral Geodetic Association. The latter suspended the International Geodetic Association when the convention under which the latter was working lapsed, at the end of December, 1916.

The chief of the division of geodesy is a member of the committee on geophysical sciences, Government relations, and foreign relations of the National Research Council. He is also a member of the committee on exploration of the Pacific of the National Research Council. He has given some time to the activities of these various branches of the National Research Council.

He is a member of the Board of Surveys and Maps of the Federal Government, which has as its duties the coordination of the various surveying and mapping activities of the Government. He was elected vice chairman of this board at its organization meeting in January, 1920, and is also chairman of the committee on control.

In May an officer was designated as assistant chief of the division of geodesy. About June 20, 1920, he started on an inspection trip, visiting first a party in Indiana.

An evidence of the increasing need of the surveys made by the Coast and Geodetic Survey for map control is shown by the fact that during the fiscal year the Bureau of Public Roads loaned this Bureau 10 automobile trucks. The Bureau of Public Roads in making the loan recognized the fact that the geodetic work of the Survey is essential to the proper mapping of the country, and that maps are of vital importance in the extension, maintenance, and improvement of the roads of the country.

During the spring of 1920 the city of Flint, Mich., requested the loan of an instrument for use in a survey which is to be made of the city. It is understood that the survey is to be similar to that made by the city of New York several years ago, under the direction of the Coast and Geodetic Survey. It is very likely that the computations of the triangulation will be made at this office.

An officer of the Swedish hydrographic office was for a number of weeks at the office of the Coast and Geodetic Survey studying the methods of this Bureau in carrying on its triangulation and other work connected with surveys for charting purposes. It had been hoped that this officer could visit a geodetic party in the field, but there was no such party available on the Atlantic coast, and he did not feel justified in going to the western coast for such a purpose.

## DIVISION OF TERRESTRIAL MAGNETISM.

The work of the division has been limited to the bare routine operations required by the established program.

The field work, consisting of the occupation of repeat stations for the determination of secular change and the establishment of new stations, was carried on by a single observer during the first half of the fiscal year; but by reason of the loss of one magnetic observer

early in 1920 the field work in the second half year was limited to a few stations occupied en route by an observer assigned to duty at the Porto Rico observatory.

### MAGNETIC SURVEY.

One observer was available for field work during the first half year and he was assigned primarily to the occupation of repeat stations in the eastern part of the country. Advantage was taken of the delay in securing transportation for the observer to have him make a declination survey in the vicinity of San Francisco Bay in connection with the establishment of new ranges for the use of navigators in standardizing their compasses. On the way to Vieques another observer made observations in Florida, Cuba, Santo Domingo, Virgin Islands, and Porto Rico. In all, 79 stations were occupied, of which 42 were repeat stations, 11 auxiliary stations, and 2 new stations in old localities.

### MAGNETIC OBSERVATORIES.

The observatories at Vieques, P. R.; Cheltenham, Md.; Tucson, Ariz.; Sitka, Alaska; and near Honolulu, Territory of 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 once a week, and scale value determinations once a month. A week's observations usually consisted of four sets of declinations, two sets of horizontal intensity, and two or more sets of dip.

The magnetic instruments used in the field were standardized at Cheltenham. Those used by the observer on his way to Porto Rico were also compared with the instruments at the Porto Rico observatory. Later they will be compared again at Cheltenham, and thus an indirect comparison between the instruments at the two observatories will be obtained. Magnetometer No. 40 was compared with the magnetometer at the Honolulu observatory and will be returned for further observations at Cheltenham.

Much trouble was experienced in securing satisfactory adjustments of the variation instruments at Tucson. A magnetic observer was assigned to duty there for a week in August, 1919, to give the observer in charge the benefit of his greater experience. In March and April, 1920, a field officer paid a visit of inspection to the observatory and assisted the observer in charge in a further readjustment of the instruments. In order to secure more accurate timing of the seismograms, a make-circuit chronometer, modified to mark minutes instead of half seconds, was installed in place of the time-marking clock.

A seismograph was operated continuously at each observatory, and earthquakes were recorded as follows:

| | |
|---|---|
| Porto Rico | 46 |
| Cheltenham | 34 |
| Tucson | 41 |
| Sitka | 9 |
| Honolulu | 109 |

The observatory buildings at Cheltenham, Tucson, and Sitka were painted, and those at Sitka were reshingled. Repairs and alterations were made at Tucson and Honolulu, particularly the latter. Needed repairs at Vieques were deferred until it was seen what would be the effect on the magnetic instruments of an electric-light plant about to be put in operation not far away. A light auto truck was purchased for the Honolulu observatory to take the place of the horse and wagon.

## APPROPRIATIONS.

The appropriation made by Congress for the United States Coast and Geodetic Survey in the sundry civil act for the fiscal year ending June 30, 1919, was $1,614,280, divided as follows:

| | |
|---|---|
| Field expenses | $494,600 |
| Repairs, vessels | 56,000 |
| Officers and men | 460,000 |
| Salaries, field | 256,000 |
| Office | 266,780 |
| Office expenses | 80,000 |
| Total | 1,613,380 |

For the fiscal year ending June 30, 1921, the total amount appropriated is $2,041,447, divided as follows:

| | |
|---|---|
| Field expenses | $524,280 |
| Repairs, vessels | 64,000 |
| Alterations to vessels | 14,600 |
| Officers and men | 528,000 |
| Salaries, field | 510,797 |
| Office | 308,270 |
| Office expenses | 90,000 |
| Skylight over pressroom | 1,500 |
| Total | 2,041,447 |

## DETAILS OF FIELD OPERATIONS.

### HYDROGRAPHIC AND TOPOGRAPHIC WORK, ATLANTIC COAST.

#### MAINE.

[J. H. HAWLEY.]

SUMMARY OF RESULTS.—Leveling: 2 permanent bench marks established, 1 mile of levels run. Hydrography: 1 square mile of area sounded, 29.85 miles run while sounding, 308 positions determined (double angles), 1,444 soundings made, 1 hydrographic sheet finished, scale 1 : 5,000. Wire-drag work: 198 square miles of area dragged, 363.4 miles run while dragging, 2,070 positions determined (6 angles), 62 soundings made on shoals, 1,362 supplemental soundings made, 1 tide station established.

On July 1, 1919, wire-drag party No. 2 began the survey of the coast of Maine between Portsmouth, N. H., and Portland, Me., and carried on this work during the remainder of the season, using Cape Porpoise Harbor, Me., as a working base. The work originally contemplated was the survey of this coast between the 3-fathom and 40-fathom curves from the northern limit of the work done in 1917 off Portsmouth Harbor eastward to the southern limit of the survey of the entrance to Portland Harbor made in 1914. After some progress had been made it became evident that all of this work could not be completed during the season, and as the greater part of the future work in this region lies to the eastward, the work was planned to connect with the Portsmouth entrance survey and to be extended from this junction as far to the eastward as practicable.

The work finally accomplished connects with the Portsmouth work and extends eastward over a continuous and completely dragged area as follows:

Inshore work completed from Stones Rock Spindle south of York Harbor to Timber Island east of Cape Porpoise; offshore work completed beyond the 40-fathom curve to a point abreast of Cape Porpoise; intermediate work completed to a point abreast of Wood Island. A total area of 198 square miles was dragged in this area, 59 changes in charted depths were found, none of which is dangerous to the vessels now using these waters.

For work in deep water it was found that the best results were obtained with a 6,000-foot drag controlled from the guide launch. With this length of drag fair progress could be made against a slight head current, it was frequently possible to take advantage of changes in current by reversing the drag line and the chances of loss of time due to drag failure, over those of the longer drag, were considerably decreased.

A hydrographic survey of Cape Porpoise Harbor was made during the season on a 1:5,000-scale, using the tender *Edna M.* This work consisted of a complete survey of the dredged anchorage and entrance together with some work outside the entrance done to supplement previous surveys.

The hydrographic survey of Wood Island Harbor was deferred until that harbor is used as a base for continuing wire-drag work to the eastward.

Soundings were obtained by the tender during the progress of the wire-drag work and 1,362 supplemental soundings, well distributed over the direct area, were obtained. For the greater part of this work a registering sheave was used and prior to the receipt of this sheave fairly satisfactory results were obtained by using the stranded sounding wire graduated in the same manner as a lead line and using small cloths, leather, etc., firmly attached with fine wire.

On August 4 and 5 a subparty established two new tidal bench marks at Portland, Me., and connected the automatic tide gauge there with all bench marks.

Readings on the tide staff at Cape Porpoise were obtained while hydrographic work was in progress and used for reducing the work.

It was found that a sufficient number of objects for the control of the work had been located previously, and no triangulation was done during the season.

On account of bad weather it was decided to discontinue work at the end of October, and the last day's field work was done on October 30.

## MASSACHUSETTS.

[W. C. HODGKINS.]

An officer of the Survey has continued on duty as inspector for the New England coast and in charge of the field station at Boston, Mass., with an office in the customhouse.

The work of the inspector includes the collection of information in regard to the accuracy or the need for correction of the charts of that part of the coasts included in the first and second lighthouse districts; furnishing information to the maritime and general public of information concerning the charts and coastwise navigation; the issue of charts and other publications to officers of the Government, to local agents, and by direct sale to the general public; the sale of buoy lists published by the Bureau of Lighthouses.

In addition to these duties the inspector performs such special field or office duty as may from time to time be assigned by the Director.

A small but instructive exhibit of charts and other publications was made at the Boston Motor Boat and Engine Show held in Mechanics Hall from March 29, to April 3.

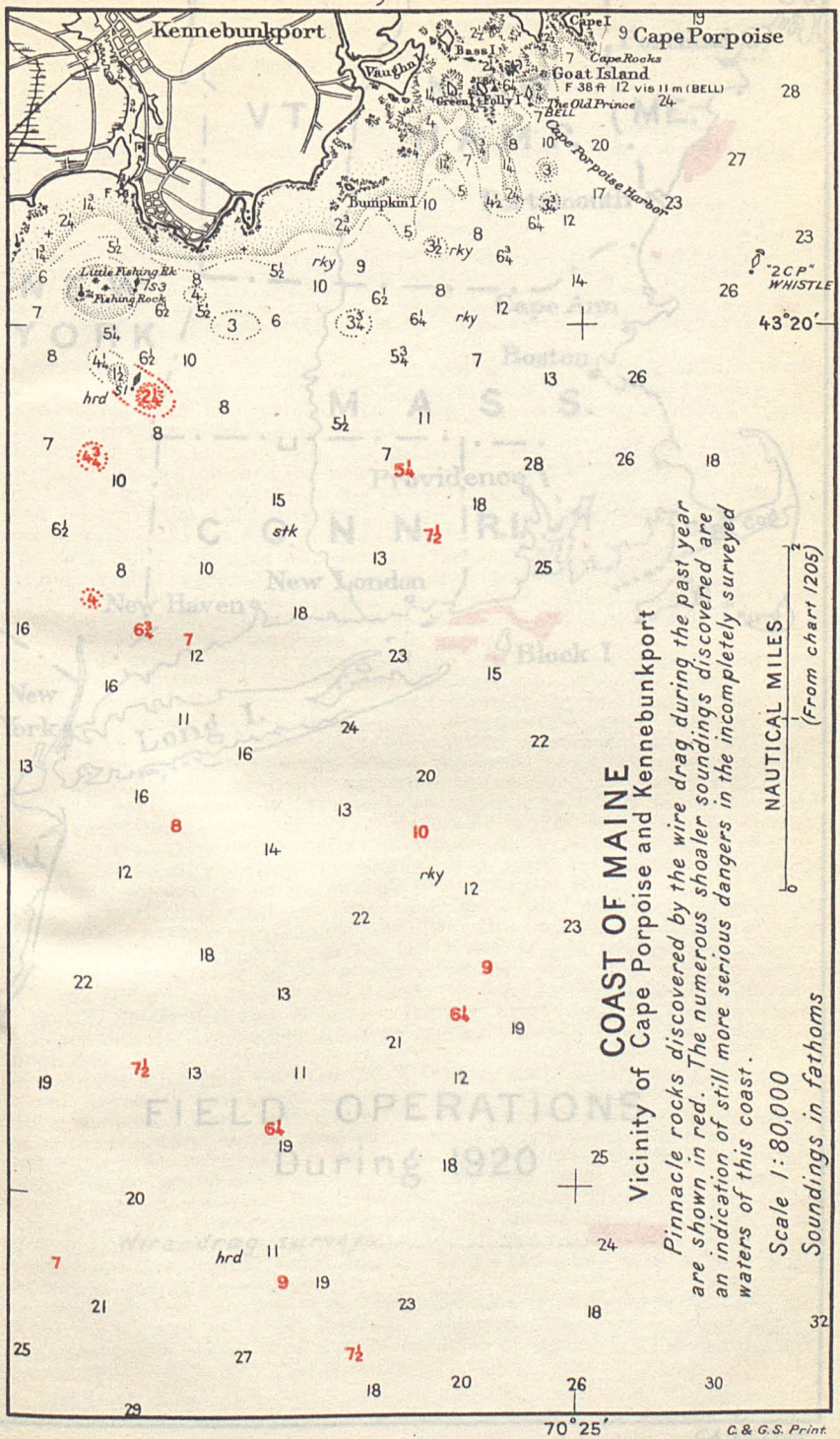
In May, at the request of the Navy Department, the position of a new radiocompass station near Chatham, Mass., was determined.

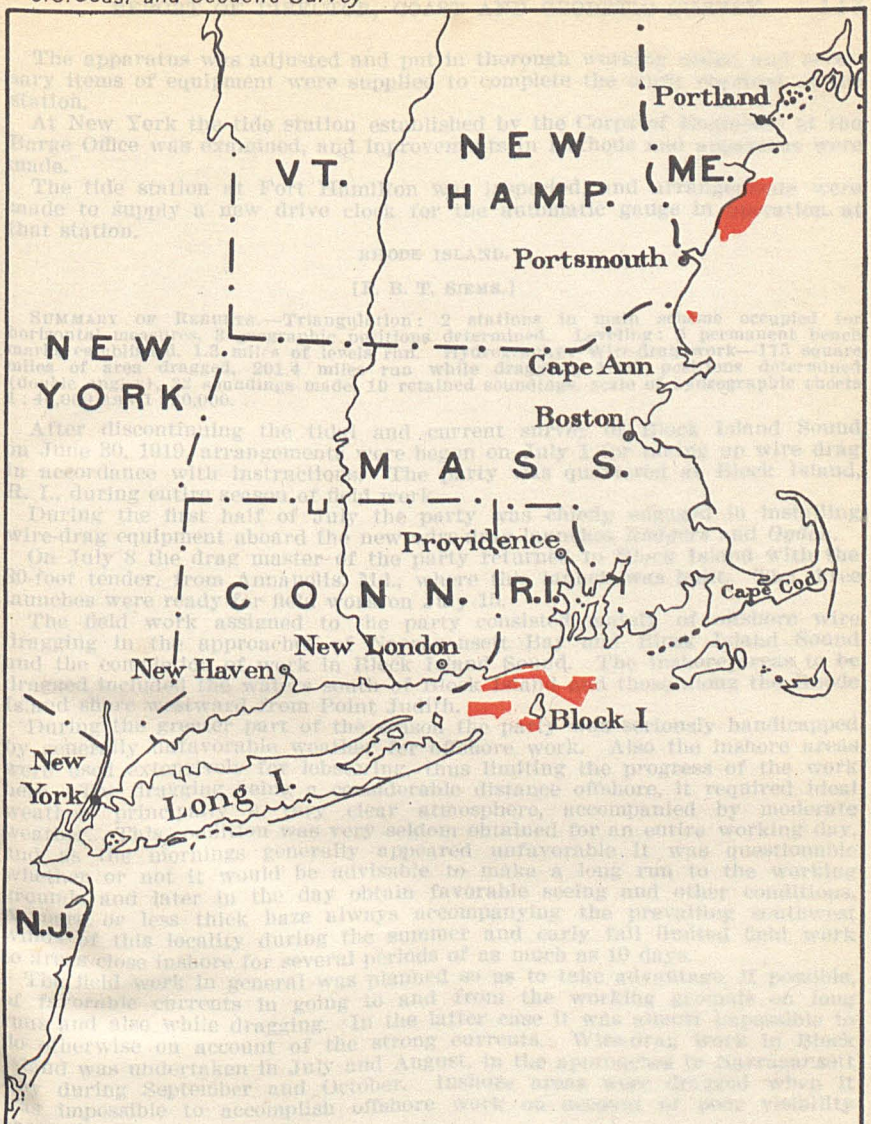
Reference marks were established to enable the triangulation station East Boston Reservoir 2 to be reestablished after its removal by reason of a change in the elevation of the embankment.

## MASSACHUSETTS AND NEW YORK.

[G. T. RUDE.]

In June, 1920, an inspection was made of the apparatus used in observing currents on the Nantucket light vessel. Through the courtesy of the Bureau of Lighthouses the officer making the inspection was taken to and from New Bedford to the station and return by a Lighthouse tender.


Kennebunkport
Cape Porpoise
Cape I
Cape Rocks
Goat Island
F 38 ft 12 vis 11 m (BELL)
The Old Prince
BELL
Bass I
Vaughn
Green I
Folly I
Cape Porpoise Harbor
Bumpkin I
Little Fishing Rk
Fishing Rock
"2CP" WHISTLE
43°20′
70°25′
rky
hrd
stk
NAUTICAL MILES
(From chart 1205)
COAST OF MAINE
Vicinity of Cape Porpoise and Kennebunkport
Pinnacle rocks discovered by the wire drag during the past year are shown in red. The numerous shoaler soundings discovered are an indication of still more serious dangers in the incompletely surveyed waters of this coast.
Scale 1:80,000
Soundings in fathoms




FIELD OPERATIONS
During 1920

Wire drag surveys

The apparatus was adjusted and put in thorough working order, and necessary items of equipment were supplied to complete the outfit required at the station.

At New York the tide station established by the Corps of Engineers at the Barge Office was examined, and inprovements in methods and apparatus were made.

The tide station at Fort Hamilton was inspected, and arrangements were made to supply a new drive clock for the automatic gauge in operation at that station.

## RHODE ISLAND.

[F. B. T. SIEMS.]

SUMMARY OF RESULTS.—Triangulation: 2 stations in main scheme occupied for horizontal measures, 3 geographic positions determined. Leveling: 5 permanent bench marks established, 1.3 miles of levels run. Hydrography: Wire-drag work—175 square miles of area dragged, 201.4 miles run while dragging, 1,347 positions determined (double angles), 32 soundings made, 19 retained soundings, scale of hydrographic sheets 1 : 40,000 and 1 : 20,000.

After discontinuing the tidal and current survey of Block Island Sound on June 30, 1919, arrangements were begun on July 1 for taking up wire drag in accordance with instructions. The party was quartered at Block Island, R. I., during entire season of field work.

During the first half of July the party was chiefly engaged in installing wire-drag equipment aboard the new wire-drag launches *Rodgers* and *Ogden*.

On July 8 the drag master of the party returned to Block Island with the 30-foot tender, from Annapolis, Md., where this launch was built. The three launches were ready for field work on July 15.

The field work assigned to the party consisted mainly of offshore wire dragging in the approaches of Narragansett Bay and Block Island Sound and the completion of work in Block Island Sound. The inshore areas to be dragged included the waters south of Block Island and those along the Rhode Island shore westward from Point Judith.

During the greater part of the season the party was seriously handicapped by generally unfavorable weather for offshore work. Also the inshore areas were used extensively for lobstering, thus limiting the progress of the work here. The dragging being a considerable distance offshore, it required ideal weather, principally a very clear atmosphere, accompanied by moderate weather. This condition was very seldom obtained for an entire working day, and as the mornings generally appeared unfavorable it was questionable whether or not it would be advisable to make a long run to the working grounds and later in the day obtain favorable seeing and other conditions. A more or less thick haze always accompanying the prevailing southwest winds of this locality during the summer and early fall limited field work to areas close inshore for several periods of as much as 10 days.

The field work in general was planned so as to take advantage, if possible, of favorable currents in going to and from the working grounds on long runs and also while dragging. In the latter case it was almost impossible to do otherwise on account of the strong currents. Wire-drag work in Block Island was undertaken in July and August, in the approaches to Narragansett Bay during September and October. Inshore areas were dragged when it was impossible to accomplish offshore work on account of poor visibility or rough sea.

The offshore wire-drag work to the 20-fathom curve south of Narragansett Bay and Sakonnet River and east-northeast of Block Island, joining with previous completed work, was completed with the exception of a few small areas to the eastward and an area of about 30 square miles surrounding east ground. The offshore areas left unfinished by previous parties in eastern half of Block Island Sound were covered with the wire drag during the season. The inshore work south of Block Island was practically completed. Some inshore work was also accomplished along the Rhode Island shore west of Point Judith; the greater amount of this work, however, remains to be done, including some dragging off Point Judith. In all 175 miles were covered with the wire drag during the season.

The new wire-drag launches with few exceptions were found to be excellent boats for the purpose for which they were designed. The ease of maneuvering the launches while towing drag and the absence of engine trouble have added immensely to the efficiency of the wire drag.

An automatic tide gauge was kept in operation throughout the season and supplemented by tide observations made at Block Island while engaged in field work. Three objects useful for control of hydrographic surveys in eastern Block Island were located by triangulation.

An important discovery by the wire drag was made in finding a 34-foot bowlder in a general depth of 66 feet about 1¾ miles south of Block Island. Several bowlders were found close inshore along the Rhode Island shore. The offshore areas dragged during the season were found to be free of obstructions.

On November 5, after a severe storm period of five days, it was considered that further resumption of field work would be uneconomical, and the party left Block Island on November 9 and proceeded to Fairhaven, Mass., for the purpose of hauling out the wire-drag launches and storing equipment for the winter.

## NEW YORK.

[ISAAC WINSTON.]

The New York field station has supervision over the coast from Narragansett Bay, R. I., to Cape May, N. J.

The duties of the inspector include the sale and distribution of publications of the Coast and Geodetic Survey and Bureau of Lighthouses.

Necessary repairs were made to the automatic tide-gauge station at Fort Hamilton, N. Y.

Tidal data and tables of sunrise, sunset, moonrise, and moonset were prepared and furnished to a number of publishers.

Preparations were made for a tide and current survey of New York Harbor.

A hydrographic survey and revision of the shore line of Gravesend Bay, N. Y., was made under the direction of the inspector using the launch *Elsie III*. This work began July 28 and ended August 19. The field work of the tide and current survey was begun August 20 and continued until December 24, when work was suspended for the winter.

This work was done in cooperation with the officers of the Corps of Engineers, United States Army, charged with deepening the water in East River from deep water in the bay to deep water in Long Island Sound.

A visit was made to Monmouth Beach, N. J., with a representation of the United States Shipping Board with a view to the proposed establishment of a speed-trial course.

Advice and assistance were furnished the attorney general of the State of New York in a case concerning the ownership of Rockaway Point.

Information for the correction of the charts, Coast Pilots, and tide tables was obtained from officers of the Government and others and transmitted to the office of the Survey in Washington.

Data relating to charts and other nautical publications was furnished in reply to numerous requests.

Assistance was furnished to the officer in charge of the motor-boat show in February and the nautical exposition in April in arranging and explaining the exhibits by the inspector, and the services of the clerk were placed at his disposal.

A compilation covering the port facilities of the principal ports of the United States was prepared for use at the nautical exposition.

The compilation of tidal data requested by the *Brooklyn Eagle* covering 10 subordinate stations on Long Island for 1921 was completed.

An inspection was made of the sales agencies for publications of the Survey in New York City, and a report on each was submitted.

SUMMARY OF RESULTS.—Physical hydrography: 19 current stations occupied, 4 tide stations occupied, 12 permanent bench marks established.

A tidal and current survey of New York harbor was made between August 20 and De ember 24, 1919, by Jack Senior, under the direction of the inspector in charge of the field station at New York.

Mr. Senior lived on the launch and had entire charge of the work and control of the launch and crew.

The work was done under very difficult, and, at times, hazardous conditions, due to the congested traffic in New York Harbor, night and day. At certain stations the current observations were made only in the day, as traffic conditions made it too difficult to work at night. On several occasions it became necessary to cut the anchor line, when the danger of collision with tows became imminent.

Buoys were attached to the anchors in anticipation of this condition, but in every case the buoy was carried away with the tows, and the anchor was lost.

The direction of the current was obtained by using floating poles immersed to a depth of 15 feet.

A self-registering tide gauge was maintained at Spuyten Duyvil at the Hudson River entrance to the Harlem River while the current observations were in progress.

Self-registering gauges were in operation in the Hudson River under the direction of the Corps of Engineers, United States Army, at Forty-second Street and Pier A, Battery, and the records at these stations were used in reducing the current observations.

Daily staff readings (once each day) were made while the current observations were in progress.

Three tide staffs were established in Kill Van Kull and readings were made while current observations were in progress in that locality.

On August 25 the first current station was occupied in the Hudson River for 51 continuous hours. The current work at first was confined to the Hudson River and the Upper Bay. The 16 stations listed in the instructions for above two localities were completed on November 13. Continuous day and night observations for 51 hours were obtained at 12 of the 16 stations; day observations of 4 days of 12 continuous hours at each day's occupation, were made at 3 of the stations; and 2 series of observations of at least 24 continuous hours each, were made at 1 station. No tidal observations other than that at Spuyten Duyvil were made by this party. There were, however, a number of automatic gauges of the city of New York and of the United States Engineers in operation during the entire period that current work was in progress, records from which are available. Following the completion of work in the Hudson River and the Upper Bay, the tide and current survey of Kill Van Kull was begun on November 14. This work was completed on December 13. The tide and current survey of New York was closed on completion of the work in Kill Van Kull.

The compass deviation was obtained on September 29 and on October 4 by the method of ranges.

SUMMARY OF RESULTS.—Triangulation: 3 stations occupied for horizontal measures, 20 geographic positions determined. Topography: 6 miles of shore line run, 13 points located by planetable hydrography; 69.5 miles run while sounding, 653 positions determined (double angles), 2,296 soundings made, 1 tide station occupied.

The launch *Elsie III* was transferred from the Navy Department to the Coast and Geodetic Survey at Boston, Mass., on June 12, 1919, and Jack Senior, who had been assigned to the party, was sent to Boston to receive the launch and bring her to New York. He performed this duty without delay and landed the launch at the lighthouse depot at Tompkinsville, Staten Island.

After some delay and difficulty a crew was employed, estimates for outfit were prepared, bids were obtained, and the outfit was purchased before June 30.

On July 9 the launch was taken to the Marine Basin and remained there until the 25th, when she proceeded to the W. F. Ruddock Yacht & Boat Works for repairs.

Under instructions dated July 7, J. H. Peters was relieved of the survey of Gravesend Bay after three triangulation stations had been occupied under his direction, and field work began on July 28 by Jack Senior under the direction of the inspector.

The topographic survey of Gravesend Bay was completed while the *Elsie III* was undergoing repairs in the Harlem River. While the *Elsie III* was in the shipyard and not available, the inshore hydrography was run with a small motor cutter loaned from the Navy. The repairs on the *Elsie III* were completed on August 8 and on August 11 the hydrography was continued with the *Elsie III*. The survey of Gravesend Bay was finished on August 16, and the tide and current work in New York Harbor was then commenced. Additional development work on the hydrographic chart, however, was deemed necessary, and instructions to that effect were contained in the Superintendent's letter of December 6, 1919. This supplementary survey was delayed for a week because of unfavorable weather conditions, but was finally completed in two days—December 20 and 21.

## DELAWARE AND MARYLAND.

[PAUL SCHUREMAN.]

In May, 1920, the automatic tide-gauge station at Lewes, Del., the operation of which had been interrupted by construction work, was reestablished, and the automatic gauge was started on the evening of May 27.

Afterwards the automatic tide-gauge station at Aberdeen, Md., was inspected, and lines of leveling were run between the various bench marks and the tide staff.

## DELAWARE AND FLORIDA.

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

SUMMARY OF RESULTS.—Hydrography: 213 square miles of area sounded; 647.6 miles run while sounding; 2,271 positions determined by angles, log, or otherwise; 9 stations occupied by ship to locate shore or offshore objects; 96 angles observed by ship to locate shore or offshore objects; 1 shore object located by angles from ship; 10 offshore buoys or objects located by angles from ship; 17 surface temperatures taken; 99 bottom specimens taken; 1 log test made; ship swung for compass deviation at 1 station; 6 current stations occupied; 111 current observations taken.

While the steamer *Isis* was undergoing repairs at Baltimore, prior to taking up the season's work off the entrance to Delaware Bay, an officer had been instructed by the Superintendent to erect such signals as might be necessary for the work. In accordance with these instructions, this officer preceded the ship to the field of work, erected two tall-type signals and located them and a number of natural objects useful for signals for the offshore work. Therefore, when the steamer *Isis* arrived on the working grounds all the signals required for the work had already been built and located.

For the use of the ship in the control of the offshore work six survey buoys were used as offshore signals. These buoys consisted of one first-class tall-type can buoy and five first-class ordinary type can buoys, loaned to the service through the courtesy of the superintendent of lighthouses at Baltimore, Md. On each buoy a 20-foot superstructure was erected, similar to those used in this class of work in past seasons, except that on each buoy an acetylene light was installed, as it was not considered safe, either to navigation or to the buoys themselves, to place them in this area, where there is considerable traffic, without some kind of light. These lights worked only fairly well, and a considerable objection to them was that the gas tank would last only about three weeks, when it then would have to be renewed.

The six survey buoys were not placed by the lighthouse tender, due to pressure of work in that service, until the 9th and 10th of September, and then it was found that the superstructures, lights, and gas tanks made the buoys so heavy that they would not stand vertical, which greatly decreased their visibility. This was finally corrected by putting a ballast ball on each buoy, but not until the latter part of the month, when the season's work was more than half over. The result was that no work offshore, which requires the best of weather, could be done prior to the 10th of September, and only with difficulty before the buoys were righted the latter part of that month, so that, during the time when the weather was favorable for offshore work, the buoys were not available, and later when the buoys were available, the weather had turned so unfavorable that work offshore was seldom possible. This of course resulted in very little offshore work being done.

Although the buoys were placed on the 9th and 10th of September, weather suitable for locating them was not obtained until the 15th. The buoys were located in the usual manner, by sextant cuts from the ship at anchor, the ship being located by sextant angles on shore objects. The six survey buoys were placed 3¼ miles apart and in a line parallel to the shore and 10½ miles from shore.

The *Isis* arrived at Lewes, Del., to take up the season's work on August 26, and left for Washington, D. C., after completing the season's work on October 21, 1919. During most of this time a large percentage of working time was lost on account of unfavorable weather conditions. Very clear weather, so desirable for work in the vicinity of the Survey buoys, was extremely rare, and there were a number of very hazy days, on which practically no work could be done. After the middle of September fresh northeasterly weather was very prevalent, and there were very few days on which even inshore work could be done and practically no days suitable for offshore dead-reckoning work.

Nearly 40 per cent of the entire time that the ship was on the working grounds was lost on account of bad weather, and during the last three weeks that the ship spent in this section, during the first three weeks of October, work could be done only on two days of each week. The hydrography done off the entrance to Delaware Bay in this vicinity was of two main classes—inshore work where the locations were on fixed objects, either shore or offshore, and offshore dead-reckoning work.

The inshore hydrography covered an area extending from the southern end on Hen and Chickens Shoal, about 2 miles south of Cape Henlopen Lighthouse, to about 2 miles north of Bethany Beach, and from about the 3-fathom curve out to about 14 miles offshore. All of the work was located by sextant angles either on shore objects or on the Survey buoys. All soundings were taken from the ship while under way and proceeding at a speed of about 4½ knots, and the method of sounding was by hand lead up to depths of about 12 fathoms, and in deeper water by means of trolley sounding apparatus, as previously used in this class of work.

In general, soundings were taken as rapidly as the lead line could be hauled in, and sounding lines were run normal to the general trend of the coast, in an easterly and westerly direction. Lines were spaced one-fourth mile apart over broken areas and in depths less than 8 fathoms, one-half mile apart in depths from 8 to 10 fathoms, 1 mile apart in depths from 10 to 12 fathoms, and 2 miles apart in greater depths. Developments were made whenever the soundings showed the necessity for it.

The inshore work from the beach out to the outer limit of visibility of the shore signals was completed before the ship left the working grounds. A large amount of the work in the vicinity of the Survey buoys was likewise completed.

The dead-reckoning work done in this vicinity was of the type recently adopted, and consisted in starting from an anchorage just outside the line of Survey buoys, located by sextant angles on the buoys, running out on course and distance in a direction normal to the general trend of the shore line, anchoring every two hours for current observations, and returning on a parallel course in like manner to an anchorage just outside the line of Survey buoys, and located by sextant angles on the buoys, the error of closure being distributed throughout the run. On these lines soundings were taken as rapidly as possible, being by means of hand lead in depths less than 12 fathoms and by means of trolley sounding apparatus in greater depths. Lines were spaced in accordance with the instructions, as explained in the previous paragraph under inshore work.

In connection with the offshore dead-reckoning work, current observations were taken at the beginning and end of each sounding-line run and at two-hour intervals on the line. Also, current observations were made whenever the ship was at anchor on the working grounds, except that during the latter part of the season the serious shortage of experienced officers made it necessary to discontinue night work after a working day.

Current observations were also in progress on Overfalls Light Vessel during the progress of the work.

In order to obtain accurate compass deviations for the correction of courses steered on offshore dead-reckoning work, the ship was swung accurately for compass deviations on August 29, 1919, off the entrance to Delaware Bay.

In order to obtain accurately the distances run in the dead-reckoning work offshore, all the patent logs were tested accurately at the beginning of the field season by running the ship at various speeds a number of round trips over a measured course, thus giving a correction for each log at different speeds of the ship.

The instructions for the season's work provided that bottom specimens should be obtained at points well distributed over the working grounds, in order to determine whether or not they might prove of value to navigation. These instructions were carefully carried out, and a large number of bottom specimens were obtained at close intervals over the area covered by soundings by means of soap placed on the bottom of the lead.

In order to facilitate and to increase the accuracy of dead-reckoning work and current observations a new compass card was installed on the standard compass, the new card being the one recently adopted by the Navy, and on which degrees are the only marks shown, points being entirely omitted. The circle is graduated all the way around to 360°. The use of the new card

demonstrated its great superiority and was approved by all the helmsmen and the officers.

On October 21, 1919, the almost continuous bad weather which the ship had experienced throughout the month made it advisable to discontinue field work in the vicinity of Delaware Bay. Accordingly the *Isis* sailed on that date for Washington, D. C., to prepare for repairs.

Repairs were in progress until December 12, when the *Isis* sailed for Norfolk, Va., to take on stores from the naval base there, taking with the ship from Curtis Bay, Md., two wire-drag tenders which were to be taken to the Pacific coast by means of naval collier. These tenders were turned over to the navy yard on December 16, stores were taken aboard on the 17th, and the *Isis* sailed for Charleston, S. C., on the 18th for the purpose of arranging for Survey buoys for the coming season's work arriving there on the 20th of December. The subsequent movements of the ship are given in the following paragraphs:

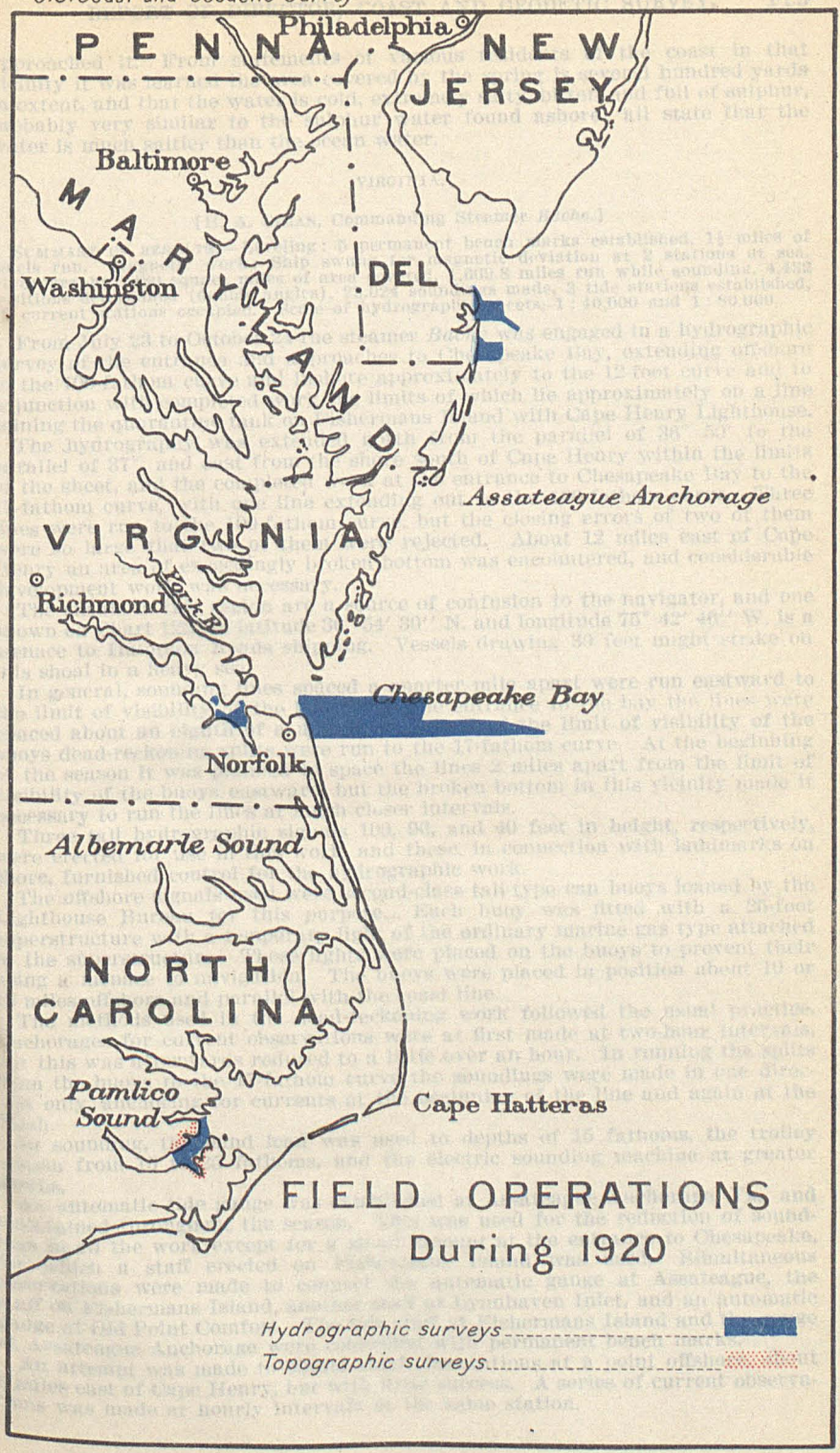
Prior to the arrival of the steamer *Isis* on the working grounds an officer had been instructed to erect such shore signals necessary for the work. In accordance with these instructions this officer was detached from the steamer *Isis* on December 9, 1919, went to Washington for detailed instructions and then went to St. Augustine, Fla., where he took up the work of erecting and locating signals.

Owing to the difficulty of obtaining labor and other causes of delay only one signal had been built and located and one other built but not located before the *Isis* was ready to start work, but three of the signals erected in 1917 were still standing. These signals made it possible for the *Isis* to start work, but only on a restricted area at the northern limit of the work.

On December 20 the *Isis* arrived at Charleston, S. C., for the purpose of arranging with the superintendent of lighthouses there for Survey buoys needed for the coming season's work. The *Isis* sailed for Jacksonville on the 30th of December, arriving there on the 31st. Five Survey buoys were made there and the *Isis* sailed for the working grounds on the 13th. One Survey buoy was dropped that day, and two more the following day. Due to a change in methods of anchoring the buoys, wire suitable for anchor wire was exhausted after the three buoys were dropped, so it was decided that on the next day patent logs should be tested if the weather was fine and that sounding work should be taken up if the weather was not fine enough for log tests.

The next day, January 15, proved to be a perfect day, so the ship proceeded inshore to lay out a course for log tests, the only place available on account of shortage of shore signals being directly abreast signal "Cres" and almost halfway between the wreck of the dredge *Florida* and the beach, where positions for locating the marker buoys would be sufficiently strong. The southern marker buoy was dropped and located and the ship headed up for the next position. When nearly up to this point a small, almost submerged, moss-covered buoy was sighted, the ship was stopped promptly, angles were taken to locate the ship, and in leaving the locality the ship struck a submerged object, probably the wreck of the dredge *Florida* incorrectly located on the chart, causing the ship to leak so badly that she had to be beached immediately to prevent her from sinking in deep water. Wrecking concerns were summoned and considerable work was done in the attempt to get the ship off and to salvage Government property aboard the vessel. However, bad weather coming up early in the morning of January 20 drove the wrecking concerns away from the ship and made it necessary for all officers and members of the crew to leave the ship and camp on the beach abreast the vessel. Continued attempts were made to get wrecking assistance, but without avail, and meanwhile the condition of the ship became such that on January 26 instructions were received to abandon the vessel, and on January 28, 1920, the wreck of the steamer *Isis* was sold to a salvage concern.

About 4 miles north-northeast of Matanzas Inlet on the Florida coast the chart shows a spring, with a depth of 21 fathoms, surrounded by depths of about 9 fathoms. This spring was near the northern limit of the work assigned to the *Isis*, and although no investigations were made before the *Isis* was lost, it was plainly seen from the ship on the evening preceding the day of the accident and also on the morning of the accident to the *Isis*. The sea was quite smooth at the time, and the spring was indicated by a considerable disturbed area, caused probably by the bubbling of the spring. It could be seen plainly from a distance of two or three miles, which was the nearest the *Isis*


Philadelphia
PENNA.
NEW JERSEY
Baltimore
MARYLAND
DEL
Washington
Assateague Anchorage
VIRGINIA
Richmond
York R.
Chesapeake Bay
Norfolk
Albemarle Sound
NORTH CAROLINA
Pamlico Sound
Cape Hatteras
FIELD OPERATIONS
During 1920
Hydrographic surveys
Topographic surveys

approached it. From statements of various residents of the coast in that vicinity it was learned the area covered by the spring is several hundred yards in extent, and that the water is cold, extremely salty, bitter, and full of sulphur, probably very similar to the sulphur water found ashore; all state that the water is much saltier than the ocean water.

## VIRGINIA.

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

SUMMARY OF RESULTS.—Leveling: 5 permanent bench marks established, 1½ miles of levels run. Magnetic work: Ship swung for magnetic deviation at 2 stations at sea. Hydrography: 480 square miles of area covered, 1,669.8 miles run while sounding, 4,432 positions determined (double angles), 23,024 soundings made, 3 tide stations established, 79 current stations occupied. Scale of hydrographic sheets, 1 : 40,000 and 1 : 80,000.

From July 23 to October 24 the steamer *Bache* was engaged in a hydrographic survey of the entrance and approaches to Chesapeake Bay, extending offshore to the 100-fathom curve and inshore approximately to the 12-foot curve and to a junction with completed work the limits of which lie approximately on a line joining the quarantine tank on Fishermans Island with Cape Henry Lighthouse.

The hydrography was extended north from the parallel of 36° 50′ to the parallel of 37°, and east from the shore south of Cape Henry within the limits of the sheet, and the completed work at the entrance to Chesapeake Bay to the 17-fathom curve, with one line extending out to the 100-fathom curve. Three lines were run to the 100-fathom curve, but the closing errors of two of them were so large that two of them were rejected. About 12 miles east of Cape Henry an area of exceedingly broken bottom was encountered, and considerable development work was necessary.

The shoals in this region are a source of confusion to the navigator, and one shown on Chart 1222 in latitude 36° 54′ 30″ N. and longitude 75° 42′ 46″ W. is a menace to Hampton Roads shipping. Vessels drawing 30 feet might strike on this shoal in a heavy sea.

In general, sounding lines spaced a quarter mile apart were run eastward to the limit of visibility of the buoys. At the entrance to the bay the lines were spaced about an eighth of a mile apart. East of the limit of visibility of the buoys dead-reckoning splits were run to the 17-fathom curve. At the beginning of the season it was planned to space the lines 2 miles apart from the limit of visibility of the buoys eastward, but the broken bottom in this vicinity made it necessary to run the lines at much closer intervals.

Three tall hydrographic signals 100, 96, and 40 feet in height, respectively, were erected for use in this work, and these, in connection with landmarks on shore, furnished control for the hydrographic work.

The offshore signals used were second-class tall-type can buoys loaned by the Lighthouse Bureau for this purpose. Each buoy was fitted with a 25-foot superstructure with a temporary light of the ordinary marine gas type attached to the superstructure. These lights were placed on the buoys to prevent their being a menace to navigation. The buoys were placed in position about 10 or 12 miles offshore and parallel with the coast line.

The methods used in the dead-reckoning work followed the usual practice. Anchorages for current observations were at first made at two-hour intervals, but this was afterwards reduced to a little over an hour. In running the splits from the buoys to the 17-fathom curve the soundings were made in one direction only, anchoring for currents at the beginning of the line and again at the finish.

In sounding, the hand lead was used to depths of 15 fathoms, the trolley system from 15 to 25 fathoms, and the electric sounding machine at greater depths.

An automatic tide gauge was established at Assateague Anchorage, Va., and maintained throughout the season. This was used for the reduction of soundings in all the work except for a small amount at the entrance to Chesapeake, for which a staff erected on Fishermans Island was used. Simultaneous observations were made to connect the automatic gauge at Assateague, the staff on Fishermans Island, another staff at Lynnhaven Inlet, and an automatic gauge at Old Point Comfort. The tide staff at Fishermans Island and the gauge at Assateague Anchorage were connected with permanent bench marks.

An attempt was made to obtain tidal observations at a point offshore, about 8 miles east of Cape Henry, but with little success. A series of current observations was made at hourly intervals at the same station.

Frequent tests were made during the season of the logs used in determining the ship's run.

[T. J. MAHER, Commanding Steamer *Sialia*.]

After undergoing repairs at Arundel Cove, Md., the steamer *Sialia* was taken to the naval operating base, Hampton Roads, Va., arriving October 1. On October 6 the *Sialia* was transferred by the Navy Department to the Coast and Geodetic Survey. Supplies were obtained, and on October 9 the vessel got under way, and after compasses were adjusted the vessel proceeded to sea under instructions to run a line of soundings along meridian 70° 25′, starting at latitude 36° N. and ending at 23° N. off Tiburon Bay, sounding was to be resumed and continued until the coast of Panama was reached. Soundings were also to be carried from the Pacific end of the Canal to San Diego Bay, Calif.

Nine soundings were taken, the first on October 10 in latitude 35° 48′ N., and the last on October 14 in latitude 25° 13′ N. Owing to trouble with the boilers the *Sialia* was unable to proceed under her own power, and on October 18 was taken in tow by the Coast Guard cutter *Tuscarora* and taken to Nassau, Bahamas, and afterwards to Key West, Fla., for repairs.

After leaving Key West for Haiti by way of the north coast of Cuba further trouble with the engines forced the vessel to put into Nuevitas Bay, Cuba, where additional repairs were undertaken.

## VIRGINIA.

[L. A. POTTER, Commanding Steamer *Onward*.]

SUMMARY OF RESULTS.—Leveling: 4 permanent bench marks established. Topography: 3 square miles of area surveyed, 6 miles of shore line of rivers surveyed, 7 miles of shore line of creeks surveyed, 20 miles of roads surveyed, 2 topographic sheets finished, scale 1:10,000. Hydrography, 22.25 square miles of area covered, 389.2 miles run while sounding, 2,592 positions determined (double angles), 18,564 soundings made, 6 tidal stations established, 2 hydrographic sheets finished, scale 1:10,000.

From July 1 to September 9 the steamer *Onward* was engaged on a hydrographic and topographic survey of Hampton Roads and tributaries. On September 9, the vessel left Hampton and was detained at Norfolk, Va., waiting for a chief engineer to report. One day of hydrography and work on the field records was done while at Norfolk.

Work on the hydrographic sheet, including the south side of Hampton Roads, was taken up on July 9 and completed September 18. This sheet covers the south side of Hampton Roads from Nansemond River to Elizabeth River and a section of Elizabeth River and Tanners Creek.

Work on a hydrographic sheet off the wharves of Newport News was taken up August 21 and completed September 4. This work was done in order to make the hydrography on Chart No. 400 complete.

One day of hydrography was done on July 29, in searching for a 29-foot sounding in the records of the steamer *Hydrographer* during the previous season. The sounding was disproved.

Work was in progress on June 30, on a topographic sheet, covering the east side of Hampton Roads and Elizabeth River, and another on the south side of Hampton Roads and a portion of Elizabeth River. These sheets were completed in August.

Six tidal stations in Hampton Roads were occupied in connection with the hydrographic work. Under orders dated June 20, tidal readings were made at Lynnhaven Inlet from July 28 to 31, inclusive, simultaneously with readings by the steamer *Bache* at Smith Island and with automatic tide gauge readings at Assateague Anchorage and Old Point Comfort.

Work was continued during the entire period covered by this report, in overhauling the vessel and her equipment, making minor alterations, and other work in connection with fitting her for survey duties. Considerable repair work on the vessel was done by United States Shipping Board yard in Hampton.

Four large launches, the *Mikawe*, *Wildcat*, *Scandinavia*, and *Lydia III*, were cared for during most of the period covered by this report. Considerable time was required in pumping them out, wetting down decks, and other work in connection with their maintenance. On August 1, the *Scandinavia*, *Wildcat*, and *Lydia III* were towed to Norfolk Navy Yard for shipment to Puget Sound by a Navy transport. The *Lydia III* and *Wildcat* were afterwards returned to Hampton. The *Scandinavia* was shipped. The *Mikawe* was loaned to the

authorities at the Army hospital at which the *Onward* was tied up at Hampton, and the *Wildcat* and *Lydia III* were transferred to the charge of a ship's officer on September 5.

## VIRGINIA.

[J. D. POWELL.]

In December, at the request of the Navy Department, a survey had been begun by the steamer *Bache* along the west shore of the naval base at Hampton, Va.

When the *Bache* left Norfolk for Pensacola, Fla., instructions were issued placing this work in charge of J. D. Powell, who was detached from the *Bache* for the purpose of continuing the survey.

At the time when the work was turned over to Mr. Powell on December 19, soundings had been made from the north side of the Ferry wharf at Pine Beach along the west shore of the naval base nearly to the north end of the submarine basin. Several small areas were left unsurveyed on account of obstructions existing at the time.

After that date hydrographic work was done on one day when 3 miles of soundings were run extending off the north shore of the base. Planetable work was done to furnish additional signals which were necessary for continuing the work, and spirit levels were run connecting the tide gauge with mean low-water datum.

Owing to unfavorable weather and the difficulty of obtaining the assistance required in sounding, on February 5 instructions were issued to the officer in charge of the work to suspend operations and report at the office of the Survey in Washington.

## NORTH CAROLINA.

[J. H. HAWLEY, Commanding Steamer *Onward*.]

SUMMARY OF RESULTS.—Triangulation: 63 square miles of area covered, 21 small and 10 large signal poles erected, 8 stations in main scheme occupied for horizontal measures, 2 stations in supplemental schemes occupied for horizontal measures, 13 geographic positions determined. Leveling: 6 permanent bench marks established, 2 secondary bench marks established, 1 mile of levels run. Topography: 40 miles of shore line of rivers run, 75 miles of shore line of creeks run, 2 topographic sheets finished, scale 1:20,000. Hydrography: 76 square miles of area covered, 602 miles run while sounding, 2,733 positions determined (double angles), 24,106 soundings made, 3 tide stations established, 1 hydrographic sheet finished, scales of hydrographic sheets 1:5,000, 1:10,000, and 1:20,000.

On January 29, 1920, the command of the steamer *Onward* was transferred to J. H. Hawley.

From January 24, 1920, until March 8, 1920, the steamer *Onward* was undergoing repairs at Savannah, Ga. Repairs were completed at noon on the 8th, and the vessel left Savannah immediately after completion of repairs bound for Neuse River, N. C., to take up Survey work in accordance with instructions.

The vessel arrived at Oriental, N. C., which had been selected as headquarters, on March 22, 1920, after a stop at Charleston, S. C., for coal and to transfer supplies and equipment from the steamer *Sialia*, and after considerable delay at Charleston and Southport, N. C., due to bad weather.

On March 23 the vessel proceeded to New Bern, N. C., for coal and other supplies, returning to Oriental on the 25th. While in New Bern a consultation was had with the Army Engineers relative to the work to be done in Neuse River and vicinity.

In order to obtain water at Oriental it was found necessary to lay a 700-foot pipe line to the railroad dock, and this work was done after returning from New Bern.

Field work in the Neuse River was begun on March 26, 1920, and continued until the 23d of June. This work was interfered with considerably by the heavy winds that are encountered in this region, by the scarcity of coal at New Bern, and by the poor quality of the water obtainable, which necessitated frequent cleaning of boiler.

From April 6 to May 6, 1920, certain alterations were made in the arrangements of the vessel.

Twenty-one stations established by the Engineer Corps, United States Army, and by the Coast and Geodetic Survey in Adams Creek were recovered and small pole signals erected. At the entrance to Adams Creek the stations Alpha, Adams, and Great Neck Point were recovered and the line Alpha to Great Neck Point used to locate stations Daw and Sand Beach 3 on the opposite bank of

the river, the latter to replace the old station Sand Beach 2 which could not be recovered. From these stations Garbacon beacon and Adams Creek entrance beacon were located.

Large tripod signals were built over all stations for hydrographic use.

For the topographic work projections with the same limits as the old projections were used when practicable. On these projections the old shore line was shown in pencil. A topographic traverse was run along the shores of the creeks and the river to determine changes in shore line, particular attention being paid to the various points. During the course of this traverse small signals for inshore hydrographic work were established at intervals of about 400 meters. These signals consisted of whitewashed trees, whitewashed slats nailed in various forms on trees, etc. Control for the work in Broad Creek was established by planetable triangulation.

On the south bank of the river the shore line revision was carried from Great Neck Point eastward to Rattan Bay, including Adams Creek. On the north bank the revision was carried from station Daw, on the first point east of Dawson Creek to Maw Bay including all creeks.

Hydrographic work was started with the survey of Adams Creek after which the work in Neuse River was taken up. The general plan of work used was to run the lines in the river outside the 12-foot curve with the Navy launch or ship and to run the lines inside the 12-foot curve and in the creeks with launch *No. 5*, a flat bottomed boat. This arrangement proved to be very satisfactory, and the use of the ship for hydrography especially so.

The hydrography of Adams Creek was completed except for a few lines of development work, and one day's work was done in the entrance to Oriental Harbor. In the Neuse River the hydrographic work was started from the line, outside the 12-foot curve, to the mouth of the river. The inshore work on the south bank was extended eastward to Brown Creek and on the north bank eastward to, but not including, Broad Creek.

An automatic tide gauge was placed in operation at Oriental on March 29 and continued to the end of the year. Three standard bench marks were established.

A tide staff was installed on the outer range beacon off Cedar Creek in Adams Creek, and observations obtained when hydrographic work was done in the creek. Three standard bench marks were established.

On May 12 a tide staff was installed at Neuse River Lighthouse and continued in operation for the remainder of the year.

## GEORGIA.

[H. A. MARMER.]

In May and June, 1920, the apparatus and methods used in observing currents on the Brunswick and Frying Pan Shoals light vessels were inspected and the instruments and apparatus put in good working order.

Transportation was furnished by the Lighthouse tender *Cypress*.

## FLORIDA.

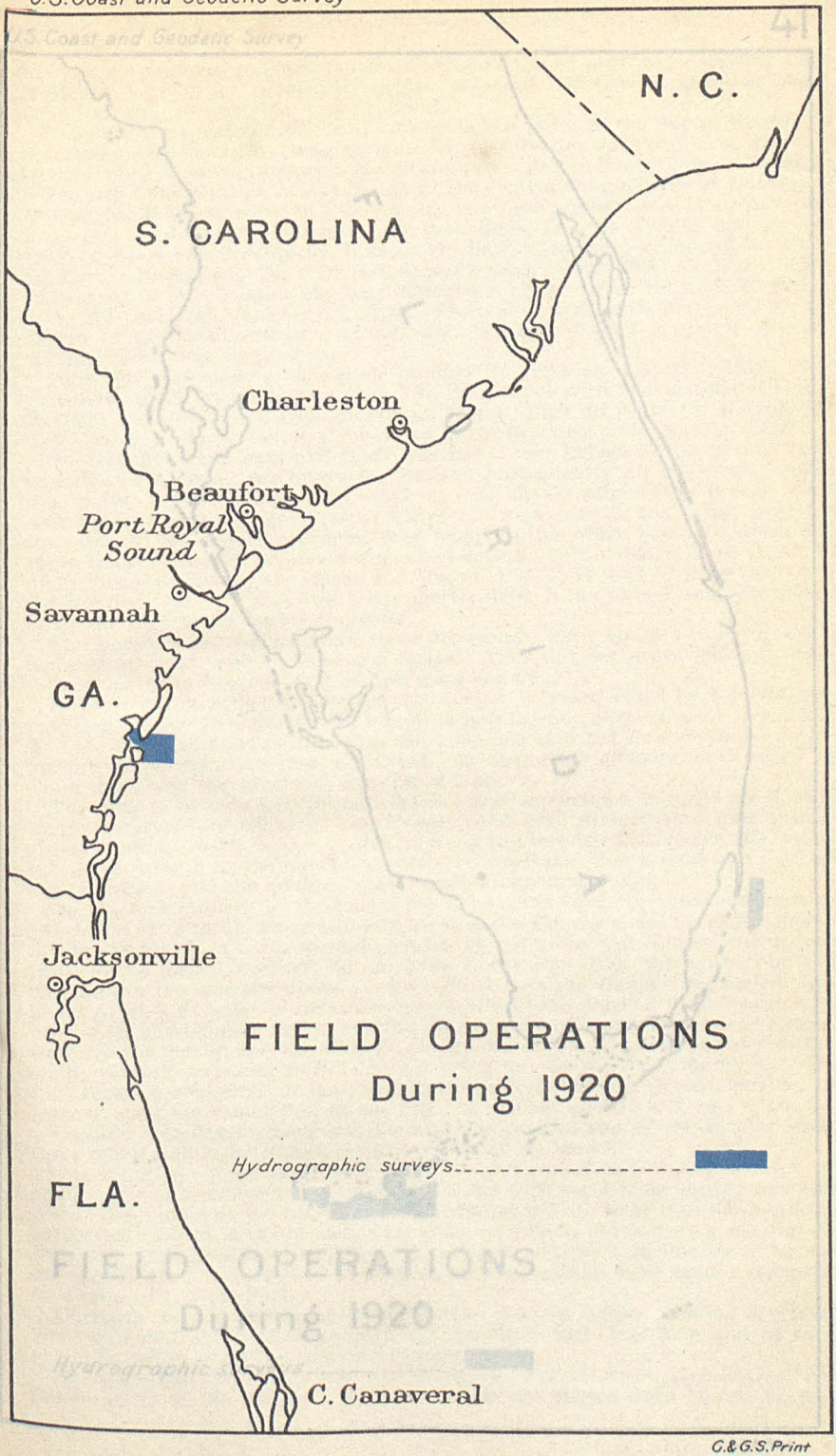
[H. A. SERAN, Commanding Steamer *Bache*.]

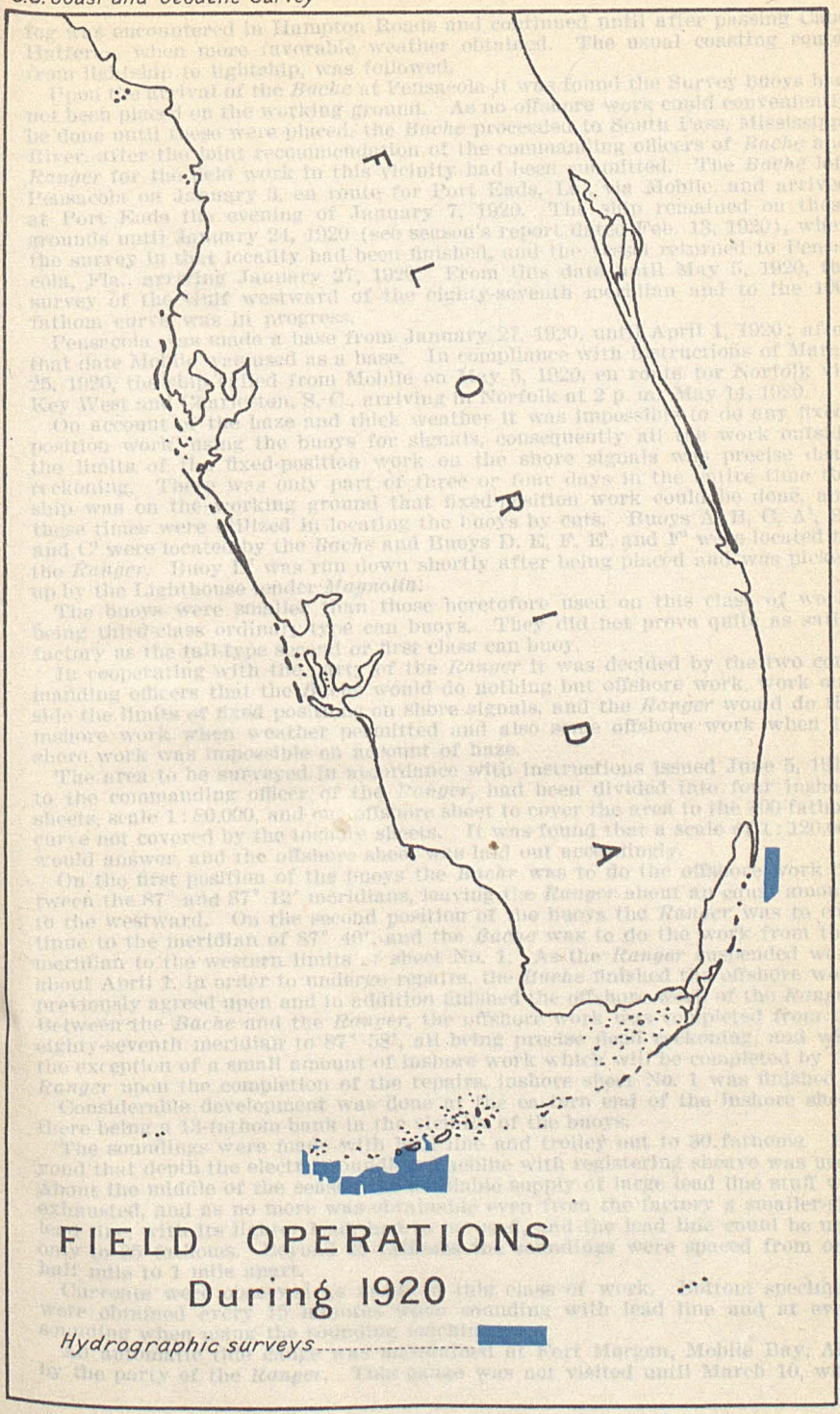
Summary of results.—Hydrography: 1,551 square miles of area covered, 1,610.1 miles run while sounding. 5,644 soundings made, 159 current stations occupied, scale of hydrographic sheets, 1 : 80,000 and 1 : 120,000.

Instructions issued November 24, 1919, directed that the *Bache* proceed to Pensacola, Fla., and cooperate with the party of the *Ranger* in a survey of the Gulf coast from the eighty-seventh meridian westward to the Mississippi Delta; if it were found inadvisable to immediately take up this work on the arrival of the *Bache* at Pensacola to proceed to the mouth of the Mississippi River and survey the position of reported shoals in that vicinity; and after the completion of this survey to return to Pensacola and the work indicated above.

Supplemental instructions issued March 25, 1920, directed the suspension of work in the Gulf of Mexico about May 1, 1920, and the return of the *Bache* to Norfolk for incidental repairs preparatory to taking up work on the Atlantic coast.

The ship sailed from Norfolk, 2 p. m., December 23, 1919, en route to Pensacola via Key West and arrived at Pensacola, 10 p. m., January 1, 1920. Heavy


N. C.
S. CAROLINA
Charleston
Beaufort
Port Royal Sound
Savannah
GA.
Jacksonville
FIELD OPERATIONS
During 1920
Hydrographic surveys
FLA.
C. Canaveral


FLORIDA
FIELD OPERATIONS
During 1920
Hydrographic surveys

fog was encountered in Hampton Roads and continued until after passing Cape Hatteras, when more favorable weather obtained. The usual coasting route, from lightship to lightship, was followed.

Upon the arrival of the *Bache* at Pensacola it was found the Survey buoys had not been placed on the working ground. As no offshore work could conveniently be done until these were placed, the *Bache* proceeded to South Pass, Mississippi River, after the joint recommendation of the commanding officers of *Bache* and *Ranger* for the field work in this vicinity had been submitted. The *Bache* left Pensacola on January 3, en route for Port Eads, La., via Mobile, and arrived at Port Eads the evening of January 7, 1920. The ship remained on these grounds until January 24, 1920 (see season's report dated Feb. 13, 1920), when the survey in that locality had been finished, and the vessel returned to Pensacola, Fla., arriving January 27, 1920. From this date until May 5, 1920, the survey of the Gulf westward of the eighty-seventh meridian and to the 100-fathom curve was in progress.

Pensacola was made a base from January 27, 1920, until April 1, 1920; after that date Mobile was used as a base. In compliance with instructions of March 25, 1920, the ship sailed from Mobile on May 5, 1920, en route for Norfolk via Key West and Charleston, S. C., arriving in Norfolk at 2 p. m., May 14, 1920.

On account of the haze and thick weather it was impossible to do any fixed-position work, using the buoys for signals, consequently all the work outside the limits of the fixed-position work on the shore signals was precise dead reckoning. There was only part of three or four days in the entire time the ship was on the working ground that fixed-position work could be done, and those times were utilized in locating the buoys by cuts. Buoys A, B, C, $A^1$, $B^1$, and $C^1$ were located by the *Bache* and Buoys D. E, F, $E^1$, and $F^1$ were located by the *Ranger*. Buoy $D^1$ was run down shortly after being placed and was picked up by the Lighthouse tender *Magnolia*.

The buoys were smaller than those heretofore used on this class of work, being third-class ordinary-type can buoys. They did not prove quite as satisfactory as the tall-type second or first class can buoy.

In cooperating with the party of the *Ranger* it was decided by the two commanding officers that the *Bache* would do nothing but offshore work, work outside the limits of fixed positions on shore signals, and the *Ranger* would do the inshore work when weather permitted and also some offshore work when inshore work was impossible on account of haze.

The area to be surveyed in accordance with instructions issued June 5, 1919, to the commanding officer of the *Ranger*, had been divided into four inshore sheets, scale 1 : 80.000, and one offshore sheet to cover the area to the 100-fathom curve not covered by the inshore sheets. It was found that a scale of 1 : 120,000 would answer, and the offshore sheet was laid out accordingly.

On the first position of the buoys the *Bache* was to do the offshore work between the 87° and 87° 12′ meridians, leaving the *Ranger* about an equal amount to the westward. On the second position of the buoys the *Ranger* was to continue to the meridian of 87° 40′, and the *Bache* was to do the work from that meridian to the western limits of sheet No. 1. As the *Ranger* suspended work about April 1, in order to undergo repairs, the *Bache* finished the offshore work previously agreed upon and in addition finished the offshore work of the *Ranger*. Between the *Bache* and the *Ranger*, the offshore work was completed from the eighty-seventh meridian to 87° 58′, all being precise dead reckoning, and with the exception of a small amount of inshore work which will be completed by the *Ranger* upon the completion of the repairs, inshore sheet No. 1 was finished.

Considerable development was done at the eastern end of the inshore sheet, there being a 13-fathom bank in the vicinity of the buoys.

The soundings were made with lead line and trolley out to 30 fathoms. Beyond that depth the electric sounding machine with registering sheave was used. About the middle of the season the available supply of large lead line stuff was exhausted, and as no more was obtainable even from the factory a smaller-size lead line, with its lighter lead, had to be used, and the lead line could be used only to 25 fathoms. Beyond 25 fathoms the soundings were spaced from one-half mile to 1 mile apart.

Currents were observed as usual in this class of work. Bottom specimens were obtained every 15 minutes when sounding with lead line and at every sounding when using the sounding machine.

An automatic tide gauge was maintained at Fort Morgan, Mobile Bay, Ala., by the party of the *Ranger*. This gauge was not visited until March 10, when

it was found to be out of order with no record since December 30, 1919. Arrangements were made to secure the tidal observations made at Biloxi, Miss., by the Mississippi River Commission for the period when the Fort Morgan gauge was out of order.

Before any field work was done the standard compass was adjusted until its maximum deviation was about 50′, the quarter-deck compass which is used in the current observations was also adjusted until its maximum deviation was about 3°, and the steering compass was adjusted by nailing magnets on the bottom of shelf until its maximum deviation was about 7°.

The log factor was determined by runs between two launches placed about 4 miles apart. An officer on each launch observed currents at 10-minute intervals, and an average current was applied to the distance over the ground, as determined by three-point fixes from shore positions at the beginning and ending of each run, in order to arrive at the distance through the water.

[G. C. MATTISON, Commanding Steamer *Hydrographer*.]

SUMMARY OF RESULTS.—Leveling: 0.2 mile of levels run. Topography: (planetable triangulation) 2.5 square miles of area surveyed, 0.3 mile of detailed shore line surveyed. Scale of topographic sheet 1 : 15,000. Hydrography: 165.1 square miles of area covered, 1,234.9 miles run while sounding, 732.6 positions determined (double angles), 37,196 soundings made, 1 hydrographic sheet finished, scale of hydrographic sheets 1 : 15,000 and 1 : 40,000.

On July 1 field work by the steamer *Hydrographer* was in progress in the vicinity of Key West, Fla., and it was continued to September 1, without much interruption. Repairs to the engine were in progress in the early part of September, and while the engine was in a weakened condition owing to the absence of the low-pressure piston, the vessel was blown ashore in the hurricane of September 8 and 9. The vessel was floated on the 20th of September. During the remainder of the year repairs were in progress. The repairs proceeded very slowly owing to hurricane damage to the shops and also to other causes, such as epidemics of dengue fever, colds, etc. During the time the vessel was repairing, the crew was employed in overhauling ship's gear and equipment. Much minor repair work was done by the ship's force. Some field work was done during this period, recovering old stations, leveling tide staffs, and cutting in signals in Key West Harbor by planetable triangulation. Office work was in progress during the time repairs were made.

Triangulation station "Rock Point" was recovered. Stations "Saddle Hill" No. 1 and No. 2, could not be found, probably due to a change in the shore line during the hurricane.

Hydrographic signals in Key West Harbor were located by planetable triangulation.

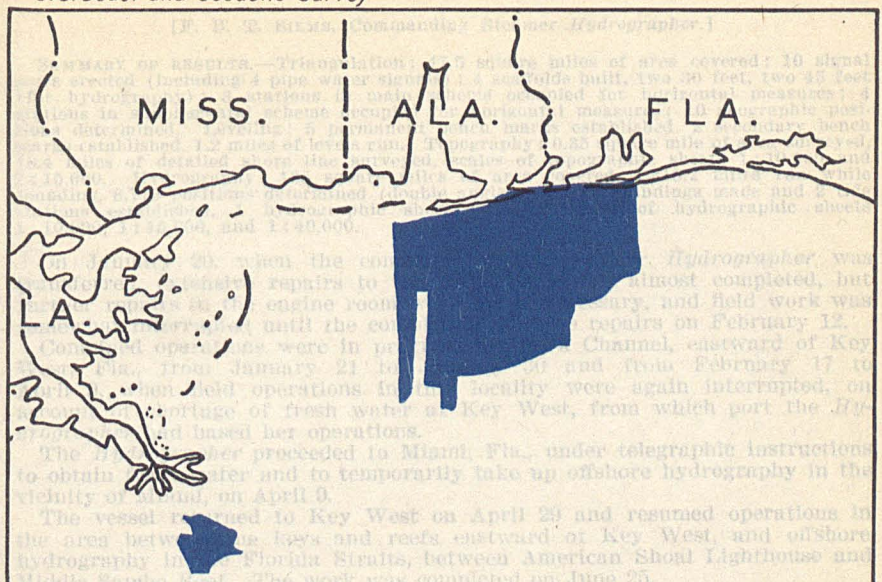
On sheet No. 1 the ship did work on four different days, completing the area from the limits of launch work to longitude 81° 44′. Some shoals have not been developed in this area. On sheet No. 2 all ship work was completed. On sheet No. 3 unfinished areas were completed, with the exception of a strip about 2 miles wide on the center of the sheet. On sheet No. 4 the area between longitude 81° 39′ and 82° 05′ was completed.

Launch hydrography: On sheet No. 1 the small area between the wire-drag limits and the ship's work was completed. On sheet No. 2 all unfinished areas were filled in, but there were still some shoals to develop. On sheet No. 3 all areas allotted to the launch were completed and shoals developed. However, there were some shoals found by the ship which were not developed.

Experiments in aerial photography were conducted in cooperation with the Navy Air Service, in order to see if it were feasible to locate coral heads and shoals by means of photographs taken from aeroplanes. The work was completed.

With the exception of a short period following the hurricane, tide observations were made at Sand Key Lighthouse. The automatic gauge at Key West was in operation the whole period, with the exception of a few days after the hurricane. Tide observations were made at Marquesas Key while sounding was being done on sheet No. 3.

Shortly after the hurricane it was necessary to dry-dock the vessel for repairs. After repairing the damage done by the hurricane, orders were received to have general repairs made, which were afterwards completed.




# FIELD OPERATIONS
## During 1920

*Hydrographic surveys*

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

SUMMARY OF RESULTS.—Triangulation: 47.5 square miles of area covered; 10 signal poles erected (including 4 pipe water signals); 4 scaffolds built, two 30 feet, two 45 feet (for hydrography); 3 stations in main scheme occupied for horizontal measures; 4 stations in supplemental scheme occupied for horizontal measures; 10 geographic positions determined. Leveling: 5 permanent bench marks established 2 secondary bench marks established, 1.2 miles of levels run. Topography: 0.35 square mile of area surveyed, 18.4 miles of detailed shore line surveyed, scales of topographic sheets 1:10,000 and 1:15,000. Hydrography: 135 square miles of area covered, 1,318.2 miles run while sounding, 8,779 positions determined (double angles), 52,816 soundings made and 2 tide stations established, 1 hydrographic sheet finished, scales of hydrographic sheets 1:10,000, 1:15,000, and 1:40,000.

On January 20, when the command of the steamer *Hydrographer* was transferred, extensive repairs to the vessel had been almost completed, but further repairs in the engine room were found necessary, and field work was somewhat interrupted until the completion of these repairs on February 12.

Combined operations were in progress in Hawk Channel, eastward of Key West, Fla., from January 21 to January 30 and from February 17 to April 9, when field operations in this locality were again interrupted, on account of shortage of fresh water at Key West, from which port the *Hydrographer* had based her operations.

The *Hydrographer* proceeded to Miami, Fla., under telegraphic instructions to obtain fresh water and to temporarily take up offshore hydrography in the vicinity of Miami, on April 9.

The vessel returned to Key West on April 29 and resumed operations in the area between the keys and reefs eastward of Key West, and offshore hydrography in the Florida Straits, between American Shoal Lighthouse and Middle Sambo Reef. The work was completed on June 25.

During the remainder of the fiscal year preparations and signal building, in connection with a special survey of a shoal northwest of Marquesas Keys, reported by the U. S. S. *Ellis*, were in progress.

The triangulation executed in Hawk Channel was tertiary in character and was based on the line Rock Point No. 2 and American Shoal Lighthouse. The purpose of the triangulation was to locate all hydrographic signals excepting those determined by planetable for work close inshore.

Six signals were built on the reefs and islands between American Shoal Lighthouse and Western Sambo Reefs, requiring special construction, due to the exposed location.

The hydrography completed in the area between the keys and the reefs eastward of Key West, from longitude 81° 45′ to longitude 81° 39′, consisted of a close general development, and on days when seeing conditions were favorable careful searches for shoals were made. Numerous uncharted coral shoals were found. A channel 30 feet deep was found to exist between Western and Middle Sambo Reefs, with a stretch of deep water 34 to 37 feet leading from it to within 2 miles off Boca Chica Harbor. Boca Chica channel and harbor and Saddle Bunch channel, harbor, and approaches were thoroughly surveyed. The waters surrounding the reefs in the area mentioned were also covered by the close development.

The offshore hydrography off Miami, Fla., and off the Florida Reefs between Middle Sambo Reef and American Shoal Lighthouse consisted of sounding lines spaced 1 mile apart to the 100-fathom curve, one-half mile apart to the 50-fathom curve, and further development of the area within the 20-fathom curve.

The harbor improvements made by the Florida East Coast Railway were surveyed, including the dredged area between Fleming Key and Key West; further survey work to the eastward along the north shore of Key West is required.

The topography of the shore line was carried from East Martello Tower to Saddle Bunch Harbor, principally to locate signals for inshore hydrography. A magnetic meridian was determined.

An automatic tide gauge was kept in operation at Saddle Bunch Harbor. Tide staffs were read at American Shoal Lighthouse and at Sand Key Lighthouse.

[J. H. PETERS, Commanding Steamer *Ranger*.]

SUMMARY OF RESULTS.—Triangulation: 65 square miles of area covered; 46 signal poles erected: 1 observing tripod built, 15 feet in height; 1 observing scaffold built, 12 feet in height; 6 stations in main scheme occupied for horizontal measures; 25 stations in supplemental scheme occupied for horizontal measures; 63 geographic positions determined. Leveling: 5 permanent bench marks established, 1 mile of levels run. Magnetic work: Ship swung at 6 stations at sea. Topography: 22 square miles of area surveyed, 138 miles of detailed shore line surveyed; 2 topographic sheets finished, scale 1:20,000. Hydrography: 1,652 square miles of area covered; 2 928 miles run while sounding; 6,219 positions determined (double angles); 32,982 soundings made; 14 tall signals erected for offshore work, total height 1,610 feet; 76 current stations occupied; 2 hydrographic sheets finished, scales 1:10,000 and 1:80,000.

On July 1, 1919, the steamer *Ranger* was at Brooklyn, N. Y., outfitting for offshore hydrography; during this period a small scheme of triangulation was done in Gravesend Bay to control a revision of the hydrography of the bay. From July 16 to August 2 the vessel was on its way from New York to Mobile, Ala., to take up field work on the Gulf coast. From August 3 to August 18, minor repairs were being made, the sounding equipment installed, and buoys fitted out for offshore work. From August 19, 1919, to April 14, 1920 the vessel was engaged principally on the inshore and offshore hydrography of the Gulf of Mexico, the erection of tall signals for the control of hydrography and the necessary triangulation or measurements to locate the signals. Between April 15 and May 14 the *Ranger* was undergoing repairs at Pensacola, Fla., and on May 15 the vessel resumed offshore hydrography and was engaged in that work until the end of June.

The result of the work for the fiscal year was a very close hydrographic resurvey of the Gulf coast from the shore to the 100-fathom curve and from the eighty-seventh meridian to the eighty-eighth meridian excepting such of the offshore hydrography as was done by the *Bache* and a small strip of inshore work which had recently been done by the *Hydrographer*. The hydrography extended into Pensacola Bay to a point abreast the naval air station. Current and tidal observations were carried on in connection with the hydrography. The triangulation was extended up Pensacola Bay to Emanuel Point. The topography of the outer coast was completed from longitude 87° to longitude 87° 34′ and a resurvey of the pier line of the city of Pensacola was made.

[L. M. MOWER.]

SUMMARY OF RESULTS.—Triangulation: 4 stations occupied for horizontal measures, 2 geographic positions determined. Signal building: 2 tall hydrographic signals erected, height 70 feet; 2 small signals erected, height 15 feet.

In December a party was organized to build tall hydrographic signals on the coast of Florida for the use of the steamer *Isis* and to locate these and any prominent natural or artificial objects by triangulation.

Headquarters for the party were established first at St. Augustine and afterward at Summer Haven, Espanola, and Ocean City.

The building of signal Scott was begun January 1, and completed January 9. This signal is 70 feet in height and is surmounted by a pole 10 feet in height. It is 100 feet above sea level, not including the 10-foot pole.

On January 19 the small signal Campbell was built and on January 21 signal Range was completed. These signals are 15 feet in height.

Only two of the triangulation stations established in 1872 on the coast between Mantanzas Inlet and Ocean City were recovered intact, these being Campbell and Virgil. A few others were recovered and subsequently marked.

## LOUISIANA.

[J. B. BOUTELLE, July 1, 1919, to Feb. 9, 1920. E. B. LATHAM, Feb. 10, 1920, to June 30, 1920.]

An officer has continued on duty at the field station at New Orleans, La., and has answered calls for information relating to the work of the Survey and also gathered information for the correction of the charts, Coast Pilots, and tide tables.

For the convenience of the public, a stock of the charts and nautical publications of the Survey is maintained at the field station for reference and sale. Charts and publications of the Survey are furnished without charge to Government officers for official use.

At the request of the local inspectors of steam vessels men were examined for certificates as lifeboat men.

In February the positions of certain naval radio-compass stations on the Gulf coast were determined.

In May the inspector went to Marthaville, La. to remeasure certain angles in the primary azimuth between two triangulation stations.

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

SUMMARY OF RESULTS.—Hydrography: 225 square miles of area covered; 723.7 miles run while sounding; 75 positions determined (double angles); 189 soundings made; 18 current stations occupied; 1 hydrographic sheet finished, scale 1 : 60,000.

Between January 7 and January 27, 1920, an examination was made by the steamer *Bache* for a shoal reported to exist off the entrance to the Mississippi River, and approximately 18 miles SE. (magnetic) from the entrance to South Pass.

As reports of a shoal in this vicinity had been received at the branch Hydrographic Office of the Navy Department in New Orleans intermittently for the past 12 years, that office was visited in order to secure any late reports before field work was begun. The most recent report on file was dated in 1917.

In the search for the reported shoal special attention was paid to the bearing of S. 46 E. true, from East Jetty Lighthouse. In this immediate vicinity four sounding lines were run, the outer limits of the outside lines being about 1½ miles from each other. The soundings are staggered in such a way that, in the commanding officer's opinion, this section is absolutely covered.

On each sounding, bottom specimens were obtained and each specimen was soft sticky clay. The bottom was soft and so sticky that on several occasions the sounding machine would not break the lead out of the mud and it was necessary to go ahead with the ship to break it out. Neither sand nor broken shells were encountered on any of the soundings.

Each of the lines shows a uniform slope from the 100-fathom curve to the outer limits of the lines, with no indications of any shoals. The soundings on each line check the soundings on either side and also check the soundings made by the party on the *Bache* in 1917. From 200 to 350 fathoms of water were found at each of the reported shoal soundings. For a shoal, such as reported by the steamships *Picton* and the *Floridian*, to exist between soundings would require such a steep slope that it could not endure in this bottom with the strong currents of that vicinity. A 30-foot spot in 300 fathoms of water would cause a breaker large enough to be seen readily. Vessels drawing 30 feet are not at all uncommon in the New Orleans traffic and if such a shoal existed some one of them would probably have struck it.

The result of this survey made with the greatest care shows conclusively that no shoal exists in the locality in question.

## HYDROGRAPHIC AND TOPOGRAPHIC WORK, PACIFIC COAST.

### CALIFORNIA.

[R. R. LUKENS, Commanding Steamer *Wenonah*.

SUMMARY OF RESULTS.—Triangulation: 1 geographic position determined. Leveling: 12 permanent bench marks established, 2 miles of levels run. Topography: 17 miles of detailed shore line surveyed; 15 miles of roads surveyed; 2 topographic sheets finished, scale 1 : 10,000. Hydrography: 350 square miles of area sounded; 625 miles run while sounding; 2,282 positions determined (double angles); 9,063 soundings made; 5 tidal stations established; 3 hydrographic sheets finished, scales 1 : 12,000 and 1 : 10,000. Physical hydrography: 1,100 miles of deep-sea soundings run, 37 deep-sea soundings made.

At the beginning of the fiscal year the steamer *Wenonah* was at Panama, Canal Zone, where she had stopped on her way to the Pacific coast to take on coal, water, and supplies.

On July 1 the vessel steamed out of Panama Bay. A point of departure was taken off Otoque Island and a course followed to take up the line of soundings assigned to the party. This line led close to a dangerous coast, and as the currents in the lower bay are strong and uncertain a very close watch was kept to guard against setting inshore. Land was made out dead ahead shortly after midnight, and a course was set due west to clear this land, which proved to be an island, and the vessel was then headed to pass close to Cape Mala. The sounding line was continued without interruption until July 6, when the last sounding was taken off the coast of Guatemala.

Although inside of 1,500 fathoms on the chart, very deep water was found; on the last sounding the register showed 3,008 fathoms, when the wire parted. The results of these soundings are very interesting, as they show that a deep submarine valley exists between the high mountains of Guatemala and the general floor of the ocean.

A supply of coal was obtained at Salina Cruz, and the vessel got away at 8 a. m. on July 9.

Off Magdalena Bay a further supply of coal was obtained from the British S. S. *Astyamax*, and this was transferred at sea by the *Wenonah's* lifeboat.

The vessel reached San Diego at 7 p. m. July 17, and tied up at the Navy coal dock. At San Diego the vessel was cleaned up and given two coats of paint. Leaving San Diego July 28 the vessel arrived at San Francisco, 8.45 a. m. on July 31. Here necessary repairs were made to the boilers and the crew was recruited.

On August 27 the vessel steamed for Humboldt Bay, arriving at Eureka, Calif., August 28.

An automatic tide gauge was established on September 2, and a practically continuous record of the tides was obtained during the continuance of the work.

On September 4 the *Wenonah* proceeded to sea to take up the offshore hydrography. Although the haze was so thick that no shore objects could be seen, two lines were run by dead reckoning, which established the existence of a reported submarine valley north of Cape Mendocino. By September 11 several well-located lines of soundings had been run, giving a fair development of the head of the submarine valley.

On September 16 preparations were made to take up the survey of Humboldt Bay and bar. By this time it was apparent that the days on which signals could be seen offshore were very rare, and, therefore, it was planned to work in the bay during hazy weather and go outside whenever the weather gave promise of clearing. For work in the bay the launch *Clyde* was chartered from the United States Engineers. The work of hydrography and topography was begun September 18 and fair progress was made. On November 15 the hydrographic and topographic revision of Humboldt Bay was finished and the *Clyde* was turned back to her owners.

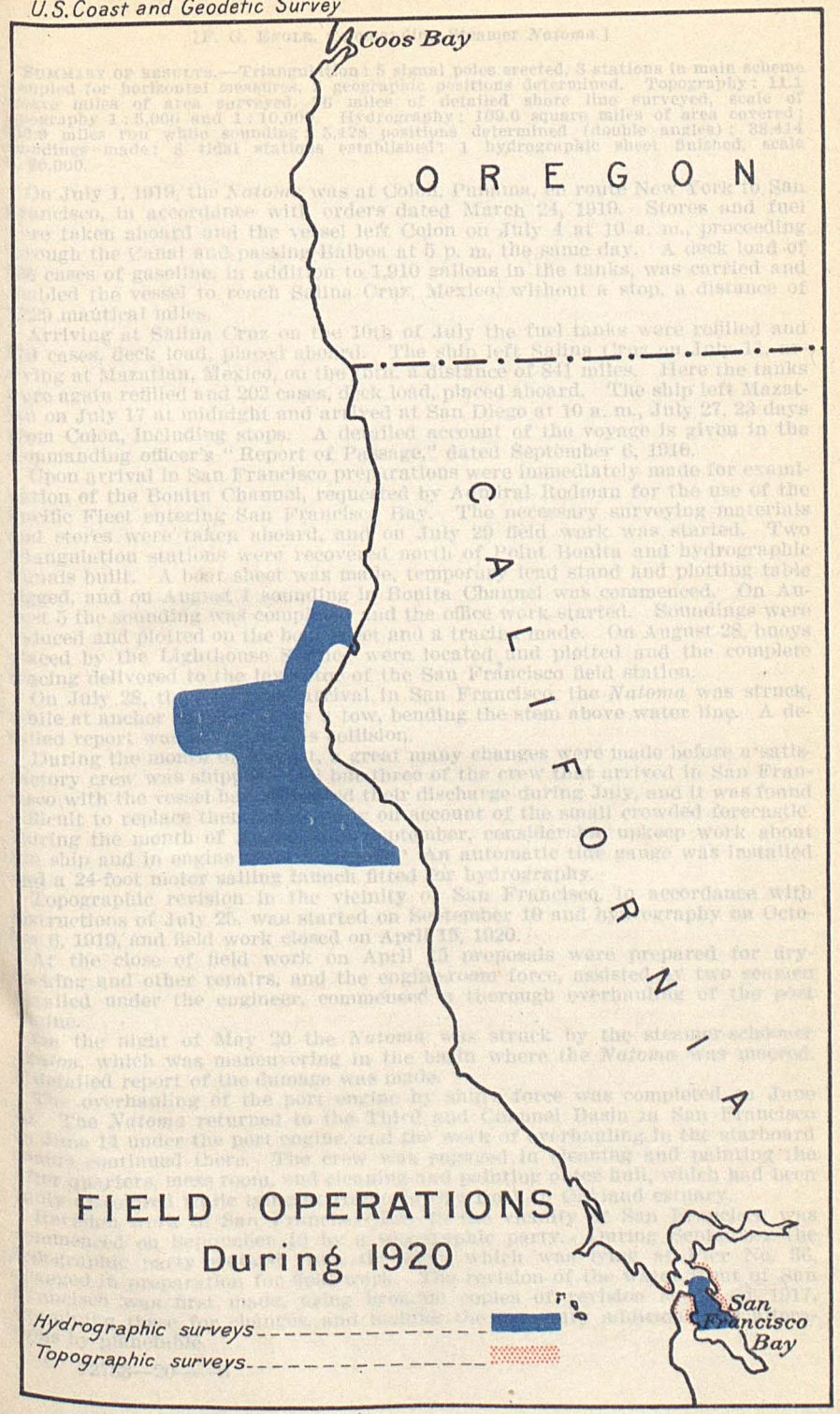
No triangulation was done by the party. The geographic positions in Humboldt Bay were supplied by the field party of E. B. Latham, and the positions of the mountain peaks were taken chiefly from the old triangulations.

The topography of Humboldt Bay was revised so as to show all changes in shore line and improvements. The west shore of the bay was surveyed from the South Jetty to a point above Samoa, and the eastern shore was surveyed from Fields Landing to a point in Eureka. Only minor changes in topography were noted. The work is plotted on two sheets on the scale of 1: 10,000.

The hydrographic work in the bay included the bar, entrance, and all important channels. This work is on two sheets on 1: 10.000 scale. Except for the area around the jetties only slight changes in depths were noticed. The bar appears to be improving gradually and a deep channel was found to have cut across the former big shoal between the inner ends of the jetties. Tide-staff readings were taken at North Jetty, South Jetty, Eureka, Arcata Wharf, and Fields Landing. The automatic gauge was established at the North Jetty, which was taken as the base station.

The offshore hydrography was the important work of the season and its first object was to develop the submarine valley northwest of Cape Mendocino. This submarine valley is of great importance, as it has been the indirect cause of the wrecking of two ships, the *Bear* and the *Tricolor*, and has probably misled other vessels. A fairly good development of this valley was obtained with up and down soundings and rigid fixes. As the 100-fathom curve is of extreme importance to navigators efforts were directed toward tracing it to a satisfactory connection with the old work to the north rather than extending a small section out to the 1,000-fathom curve.

The 100-fathom curve was traced from False Cape northward for a distance of about 35 nautical miles. The steamer *Lydonia* was working to the southward of False Cape, and the combined work of the two ships will give a delineation of the 100-fathom curve from the old work south of Blunts Reef to a connection with the old work 40 miles north of Cape Mendocino, which will amply meet the demands of navigators for more soundings around this important cape.


Coos Bay
OREGON
CALIFORNIA
San Francisco Bay
FIELD OPERATIONS
During 1920
Hydrographic surveys
Topographic surveys

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

SUMMARY OF RESULTS.—Triangulation: 5 signal poles erected, 3 stations in main scheme occupied for horizontal measures, 2 geographic positions determined. Topography: 11.1 square miles of area surveyed, 76 miles of detailed shore line surveyed, scale of topography 1:5,000 and 1:10,000. Hydrography: 109.6 square miles of area covered; 966.9 miles run while sounding; 5,428 positions determined (double angles); 38,414 soundings made; 8 tidal stations established; 1 hydrographic sheet finished, scale 1:20,000.

On July 1, 1919, the *Natoma* was at Colon, Panama, en route New York to San Francisco, in accordance with orders dated March 24, 1919. Stores and fuel were taken aboard and the vessel left Colon on July 4 at 10 a. m., proceeding through the Canal and passing Balboa at 5 p. m. the same day. A deck load of 168 cases of gasoline, in addition to 1,910 gallons in the tanks, was carried and enabled the vessel to reach Salina Cruz, Mexico, without a stop, a distance of 1,229 mautical miles.

Arriving at Salina Cruz on the 10th of July the fuel tanks were refilled and 110 cases, deck load, placed aboard. The ship left Salina Cruz on July 11, arriving at Mazatlan, Mexico, on the 15th, a distance of 841 miles. Here the tanks were again refilled and 202 cases, deck load, placed aboard. The ship left Mazatlan on July 17 at midnight and arrived at San Diego at 10 a. m., July 27, 23 days from Colon, including stops. A detailed account of the voyage is given in the commanding officer's "Report of Passage," dated September 6, 1910.

Upon arrival in San Francisco preparations were immediately made for examination of the Bonita Channel, requested by Admiral Rodman for the use of the Pacific Fleet entering San Francisco Bay. The necessary surveying materials and stores were taken aboard, and on July 29 field work was started. Two triangulation stations were recovered north of Point Bonita and hydrographic signals built. A boat sheet was made, temporary lead stand and plotting table rigged, and on August 1 sounding in Bonita Channel was commenced. On August 5 the sounding was completed and the office work started. Soundings were reduced and plotted on the boat sheet and a tracing made. On August 28, buoys placed by the Lighthouse Service were located and plotted and the complete tracing delivered to the inspector of the San Francisco field station.

On July 28, the day after arrival in San Francisco, the *Natoma* was struck, while at anchor off Pier 32, by a tow, bending the stem above water line. A detailed report was made on this collision.

During the month of August, a great many changes were made before a satisfactory crew was shipped. All but three of the crew that arrived in San Francisco with the vessel had requested their discharge during July, and it was found difficult to replace them, principally on account of the small crowded forecastle. During the month of August and September, considerable upkeep work about the ship and in engine room was done. An automatic tide gauge was installed and a 24-foot motor sailing launch fitted for hydrography.

Topographic revision in the vicinity of San Francisco, in accordance with instructions of July 25, was started on September 10 and hydrography on October 6, 1919, and field work closed on April 15, 1920.

At the close of field work on April 15 proposals were prepared for drydocking and other repairs, and the engine-room force, assisted by two seamen detailed under the engineer, commenced a thorough overhauling of the port engine.

On the night of May 20 the *Natoma* was struck by the steamer-schooner *Avalon*, which was maneuvering in the basin where the *Natoma* was moored. A detailed report of the damage was made.

The overhauling of the port engine by ship's force was completed on June 10. The *Natoma* returned to the Third and Channel Basin in San Francisco on June 14 under the port engine, and the work of overhauling in the starboard engine continued there. The crew was engaged in cleaning and painting the after quarters, mess room, and cleaning and painting outer hull, which had been badly discolored while lying at Hanlon's Dry Dock in Oakland estuary.

Revision work in San Francisco Bay in the vicinity of San Francisco was commenced on September 10 by a topographic party. During September the topographic party worked from the ship, which was lying at Pier No. 36, engaged in preparation for field work. The revision of the water front of San Francisco was first made, using bromide copies of revision sheets of 1917, examining these for changes, and making the necessary additions and alterations by planetable.

Sheet No. 3661 extends from Point Avisadero to Union Iron Works. Union Iron Works to Pier 41 is covered by the harbor commissioner's plan, which was examined and corrected; Pier 41 to Exposition Grounds is covered by a small revision sheet of 1917, and from the Exposition Grounds to 1 mile below Point Lobos is covered by sheet No. 3659. A map of the city and county of San Francisco, in two sections, was obtained from the city engineers, for the purpose of showing additions to streets and other improvements. A topographic sheet on scale of 1:40,000 was made for the purpose of tying in the city map. The examination of this map in the field was deferred.

On October 6 the work between Point Avisadero and Point San Bruno was commenced. A topographic sheet, scale 1:10,000, was made, covering this section, and a hydrographic sheet covering the area south of hydrographic sheet No. 3928 was made to extend to a line between South San Francisco and Mulfords Landing. An automatic tide gauge was established at Union Iron Works on September 25 and connected with the old bench marks there. It was kept in continual operation thereafter. A staff was established at Hunters Point, connecting with old bench marks, and another staff and bench marks established at South San Francisco. This staff was compared with Union Iron Works by a 48-hour simultaneous series. Tidal observations were made at these stations when sounding in the vicinity.

The motor sailing launch which had been fitted during September with plotting board and lead stand was used for sounding the inshore and shoal areas, extending its work out to the 20-foot curves and wire-drag limits.

It was found desirable to have a triangulation station for use of hydrography and topography in the vicinity of Belair Island. The old station was recovered by first recovering Station Guano Island from which, together with other recovered stations, Station Sierra Point was recovered, and later, Station Belair Island.

On November 12, work on the east side of the bay in the vicinity of Bay Farm Island was started, a signal was built at Station Bay and triangulation stations established at Mulford's Landing and at Robert's Landing. The two last were cut in from Station Point Avisadero, Station Sierra Point, and Station Guano Island. Topography was started on November 17, at Station Bay, on a new sheet to revise the shore line and establish signals for the inshore hydrography. This topographic sheet extends from Mulford's Landing to Government Island, Oakland estuary.

On November 26, in a heavy northeast gale the motor sailer was swamped in shallow water off South San Francisco where she was endeavoring to enter for shelter. The stern sank into the soft mud, making it impossible to raise her by ship's force, and it was necessary to engage a wrecking derrick. She was returned to the ship on December 6 and the engine was overhauled and the launch cleaned of the mud which filled the bottom. This work was completed on the 18th. During this time repairs were made to the ship's rail by crew, where it had been damaged on December 4 by the ship rolling against the dock in a southeast gale.

Sounding with launch was resumed on December 20 in the vicinity of Bay Farm Island. Staff gauges and bench marks were established off Mulford's Landing, San Leandro Bay, and Alameda, and compared with Union Iron Works by 48-hour series. The old bench marks established at Alameda were connected with the new staff. These gauges were used for the reduction of soundings in their vicinities.

During February the central area on the lower sheet was sounded by the ship, and the topography, which had been carried to the north side of Oakland estuary, was suspended to carry on the ship hydrography and to do topography in Golden Gate, required for hydrography called for by instructions. This work was completed on March 4, and the office work, which consisted of plotting soundings and making a tracing for city engineer, was finished on the 16th. While the office work was in progress the ship was painted.

Field work was resumed on the 15th and carried on to April 15, when work was stopped in accordance with instructions. to prepare bids for repairs. The ship hydrography was carried to Hampton Shoal Lighthouse, splitting the lines run in 1917, in the dragged area, north and south of Goat Island, and making a 200-meter line development along the east shore into the 6-foot curve. The launch work extended only to the Oakland Mole, where it was discontinued on the detachment. The revision of shore line was extended to Point San Pablo.

The eastern shore, north of Bay Farm Island, was done by a subparty living and subsisting ashore and reporting to the ship each week, as the nature of the

approaches to the shore rendered it impracticable to pick up the party and land them each day.

[E. H. PAGENHART, Commanding Steamer *Lydonia*.]

SUMMARY OF RESULTS.—Hydrography: 1,350 square miles of area covered, 535 miles run while sounding, 576 soundings made, 1 tide station established, 1 hydrographic sheet finished, scale 1:120,000. Leveling: 1 mile of levels run.

On November 19, 1919, the *Lydonia* began hydrographic work off the northern coast of California between Cape Mendocino and Point Arena.

By February 4, 1920, this work was completed southward from the vicinity of Cape Mendocino to latitude 39° 40′ and westward to longitude 124° 55′, and the vessel returned to San Francisco for repairs.

SAN FRANCISCO FIELD STATION.

[E. F. DICKINS, July 1 to July 7, 1919. FREMONT MORSE, July 8, 1919 to June 30, 1920.]

Inspection duty for the coast of California was continued by an officer of the Survey in charge of the field station of the Survey at San Francisco.

The duties of the station have to do chiefly with the collection and distribution of nautical information and publications.

An inspection was made of the agencies for the sale of charts and nautical publications of the Survey in San Francisco.

The tide station at Morro Bay, Calif., was visited, levels were run to the different bench marks, and the station was discontinued.

Field work was done for the purpose of obtaining data for magnetic ranges in San Francisco Bay.

A stock of charts was maintained at the field station for sale and reference; the tide observations at the Presidio station supervised; arrangements were made for forwarding freight to the field station of the Survey at Manila, and various other duties were attended to.

CALIFORNIA.

[FREMONT MORSE.]

SUMMARY OF RESULTS.—Triangulation: 8 stations in main scheme occupied for horizontal measures, 12 geographic positions determined. Magnetic work: 9 new auxiliary stations on land occupied, 1 old station occupied, ship swung at 2 stations at sea.

In September, 1919, instructions were issued for a redetermination of compass ranges in San Francisco Bay for the use of navigators.

The work directed included the collection of information for a new edition of Special Publications No. 1—Compass Ranges, San Francisco Bay, the selection and determination of the necessary ranges, and the preparation of the results in a form suitable for publication. The field work involved the making of magnetic observations at a number of points about San Francisco Bay and ship swings at the entrance to the Golden Gate, in the channel off Rincon Point, and at two other intermediate points. For this purpose the steamers *Natoma* and *Lydonia* were to be utilized.

The necessary observations at stations on land were made by an observer then at San Francisco awaiting transportation to the Hawaiian Islands.

The old range objects had been nearly all destroyed in the earthquake and fire of 1906, and it was therefore necessary to select new ranges, which was done on October 2. Triangulation observations for the determination of the positions of the selected range points were begun November 17 and completed December 26.

Photographs of the ranges were afterwards obtained.

The necessary ship swings were made by the *Lydonia* and the *Wenonah* on April 8 and May 7, completing the field work required.

[E. B. LATHAM.]

SUMMARY OF RESULTS.—Triangulation: 2 signal poles erected, 10 observing tripods built, 6 stations in main scheme occupied for horizontal measures.

Work was continued after July 1, 1919, on the triangulation, recovery of stations, and building signals from Punta Gorda to the mouth of the Klamath River, Calif. The following old stations south of Eureka were recovered: King Peak, Bear Ridge, Bagley, Four Mile Creek, Two Rocks, Windy Point, Oil Creek and Old Lighthouse tower (Humboldt Bay Lighthouse, 1869).

Subparties were organized for the search for old triangulation stations and sent to Petrolia, Cape Town, and Requa.

A triangulation was made from the base King's Peak, Bear Ridge, and a check distance carried to a connection with this base from the old line Bear Ridge–Oil Creek, on the common line, from both bases of the line Bear Ridge–East Twin. A further check was had on the position of Humboldt Bay Lighthouse (Old Tower Light station).

The triangulation by the Engineer Corps, United States Army, supplemented by additional observations, was used for stations on Humboldt Bay.

The old stations north of Eureka were recovered in sufficient numbers to make additional observations unnecessary except for determining the position of hydrographic station Mid, west of Arcata. All new stations were marked and additional marks were placed at all old stations. Signals were erected as required for the hydrography.

This work was completed August 10.

[E. B. LATHAM.]

SUMMARY OF RESULTS.—Triangulation: Length of scheme 100 miles, 100 square miles of area covered, 25 signals erected, 24 stations occupied for horizontal measures.

The triangulation, recovery and marking of triangulation stations and erection of signals for hydrography between Punta Gorda and Point Arena were begun by a subparty August 10, 1919.

Old triangulation stations were recovered, additional points were determined both by triangulation and by plotting points on the original topographic sheets, and the necessary signals were erected for the region Kings Peak to Usal Creek, and the party moved to Greenwood, Calif., September 19.

From Westport the work was completed to a junction with the work of the subparty to the southward of that place.

Work in the vicinity of Fort Bragg was done between September 9 and 15, and the main party moved to Mendocino.

Old stations were recovered as far south as Saddle Point and sites for new stations were selected. A signal-building party was organized with headquarters at Little River, and the observation of angles in the triangulation were then taken up. As few of the old stations between Laguna Point and Cabrill Point were recovered, numerous new stations were established and determined in position.

Work from Cuffeys Cove to Point Arena was begun by the subparty September 22 and completed October 6. Several new points were determined south of Cuffeys Cove, including the Point Arena Light station, rebuilt in 1907 or later.

From October 11 to the close of the season the whole party was located at Point Bragg.

Additional observations were made for the identification of stations Gordon and Pine Grove. This work and the observations to determine the positions of stations between South Noyo and Kent 2 were completed October 20, and from that date to the close of the season the party was engaged in computing results, the preparation of data for the use of the steamer *Lydonia*, and closing party affairs.

## WASHINGTON.

[N. H. HECK.]

SUMMARY OF RESULTS.—Triangulation: 50 square miles of area covered, 45 signal poles erected, 36 stations in main scheme occupied for horizontal measures, 9 stations in supplemental scheme occupied for horizontal measures, 95 geographic positions determined. Topography: 50 square miles of area surveyed; 110 miles of general coast line surveyed; 5 topographic sheets finished, scales 1:10,000 and 1:20,000. Hydrography: 5 square miles of area dragged; 40 miles run while dragging; 1,742 positions determined (double angles); 118 soundings made; 2 tidal stations established; 192 trees located for removal; 2 hydrographic sheets finished, scales 1:10,000 and 1:20,000.

Between July 24, 1919, and March 26, 1920, a wire-drag survey was made of Lake Washington and Lake Union, Washington, with such triangulation and topography as was required for the purposes of the survey.

The work undertaken included the revision of shore line and topography, Lake Washington; wire-drag work, Lake Washington and Lake Union; work on launches to prepare for Lake Washington and Alaska seasons; and development of new methods.

Triangulation: The necessity of anything but a slight revision of existing triangulation was not contemplated, as it was believed that much of the 1902 work would be available. This was found to be a mistaken assumption, owing in part to poor marking of stations and in part to the natural improvements and changes in the vicinity of a large city. Practically no stations were recovered in addition to those recovered in 1915. The lowering of the lake seems to have hastened the disappearance of the wooden stakes with which the old stations were marked.

In order to carry out instructions, a complete revision of the triangulation became necessary, and it was decided to carry a comprehensive scheme around Mercer Island.

At first it appeared likely that single triangles would have to be used, but a study of the conditions showed that quadrilaterals could be used with little extra cost. Owing to the precipitous shores, which had been left wooded to prevent slides, and to the sweeping curves of the shore line characteristic of a glaciated area, it was difficult to find sufficient intervisible points. It was found necessary to extend the triangulation from a diagonal, and in some cases the conditions were so rigid that moving one station slightly made it necessary to move at least three others. Conditions not evident on inspection, but which caused difficulty, included the presence of houseboats which shut off the line of sight from points behind them, and excavations in progress which in some cases made it impossible to utilize the logical points.

The stations were all carefully marked and described, and it is believed that they will prove of use to engineers.

The number of main scheme stations was 36; supplemental stations, 6; range beacons and lighthouses, 5; and prominent objects, 40.

Reports were prepared on the earlier triangulation, which involved investigation of more than 100 points.

The statistics in regard to recovery of the 1902 triangulation best show the conditions. Out of 90 stations and objects, 15 were recovered, of which 10 had been previously recovered, and 11 stations were remarked. Seventy-one were gone beyond question, and 4 were possibly capable of recovery by more extended search than the party could make. Of the recovered stations only half were in the part of the lake where revision work was done, and one of these would have required extensive cutting to utilize.

The topography included the new shore line of Lake Washington as left by the lowering of the lake when the Lake Washington Ship Canal was opened. All wharves and other improvements were located, and in the water front of Seattle proper enough street ends were located to utilize city maps in correcting the existing chart. In many parts of the lake conditions near the shore have not changed much as the shores have been left in their original condition to prevent slides.

The conditions on Union Bay, the work on which was left till last, are peculiar. This area, which consists of vegetable muck of specific gravity nearly 1, was disturbed in equilibrium by the excavation of the canal. It has not yet recovered stability. Islands are constantly forming and the shores are extending.

The topographic character of Lake Washington varies considerably. In general there is a shelf left by the lowering of the lake backed by a more or less steep bluff of glacial material. This has slid down in numerous places, especially in the vicinity of the submerged forests. There are two areas of swamp besides Union Bay. In two places débris from coal mines which is being excavated to make into briquets is characteristic. Bowlders of moderate size are found along the shore in places.

The revision of Lake Union was begun. Portage Bay was completed and about half of Lake Union. Changes have occurred and are about to occur in the remaining half.

Owing to reasons given later, it was not possible to start the wire-drag work till the middle of November. Practically nothing was known about the best means of locating trees for removal, and new methods became necessary.

Instructions were to drag areas of submerged forest to a depth of 45 feet wherever practicable. It soon developed that in addition to this general program something else must be done in order that the proposed work might be of any value. It was further learned that the parts outlined on the charts were only part of the area needing investigation.

The following method of work was developed: The local United States Engineers' office which had cleared out the trees in Lake Washington, which appeared when the lake was first lowered, arranged to temporarily assign the snag boat

*Swinomish* from time to time, as she could be spared from her regular work on the rivers, to remove trees in Lake Washington. The arrangements were made locally between the engineer officer for the district and the inspector at Seattle, this plan leaving considerable latitude as to the times and methods of cooperation. This feature was especially desirable, as both parties had to discontinue work for short periods for various reasons.

The methods first used were not satisfactory. Work was begun in the extensive submerged forest east of Mercer Island. It was first attempted to drag to 30 feet, the least depth charted, but it was found that the snagboat could not catch trees a greater depths than 20 feet. A definite program of sweeping this area to the depth of 20 feet was adopted, and as the trees nearly all leaned to the northeast the approach was made from that direction. On the first occasion the entire length of a 600-foot drag including towlines, buoys, and weights became caught so that none of it could be removed. The trees were then so thick that sounding could usually locate them. This work was done by the chief of party personally, and it required all of his experience to find what were practically needle points. At this time the most essential thing was to plan the work of the party so as to keep the snag boat busy, as failure in this would have disrupted the work.

The snag boat passed her cable around individual trees by the simple method of towing it between two boats until the bight caught, then slipping a shackle on one end over the cable and letting this shackle slide down as the boats pulled rapidly ahead, thus getting a noose around the tree. If possible the trees were pulled up, but usually the use of dynamite was necessary. At this time the shots were often failures because, in spite of the ingenious method used in placing the dynamite, it was frequently placed between two trees instead of against the trunk of one.

It was found that the wire drag was too slow and too comprehensive a method in that it covered too large an area. The next step was to get the drag caught on some trees; then a single dinghy was taken and a lead line towed astern. Though the original hydrographic survey failed to find evidence of this forest, four or five trees were located by this method.

It was then thought that in the absence of current two lead lines connected together by marline might prove useful, and this proved a useful and valuable method; which was adopted by the United States Engineers' snag boat. Even where there is current it is thus possible to actually develop shoal areas found by the drag, rather than to sound a little and then pass a long drag over the shoals. The new method also makes repeated attempts to get the least water on a shoal by means of the drag unnecessary and proved to be the real solution of the problem.

Thereafter all areas of tree groups were examined with the marline sweep. It became possible to actually count the individual trees and find the depth on each. An officer of the party introduced a valuable idea in that after catching a tree the process used by the snag boat to pass the cable around the tree was used with the marline, and the buoy was accordingly attached to the tree to be removed. The wire drag was used thereafter quite extensively, both to locate the tree groups and to prove other areas clear, and also to prove that all trees had been removed. Time and again the drag was passed over the area, always catching, until finally the only trees left were actual needle points. Finally the drag was passed over the area and it was made safe for all vessels which should properly attempt to navigate this particular area. The area west of Mercer Island and a small area to the south of the island were found to be dangerous and were cleared. The areas at the north end of the lake were all examined and cleared.

This work was absolutely necessary and of great importance and value. In every area trees 6 feet or less beneath the surface were found. In the area of the thickest trees where a steamer and launch were formerly lost, several dangerous trees were found directly in the path of excursion steamers.

Another dangerous tree with 4 feet of water over it was found directly in the path of tow boats engaged in towing rafts of spruce logs from Lake Washington to Lake Union. On the west side of Mercer Island two dangerous trees were found, one directly in the customary path of a steamer, with 4 feet least depth; and another close to shore, with the same depth, was found by striking it with the *Scandinavia*, fortunately running at slow speed.

A tree with 4 feet on it in 120 feet of water in the north end of Lake Washington was perhaps the most remarkable find. Some of the trees removed

were leaning, and several were nearly 140 feet in length. As nearly 200 trees in all were removed, the size of the project becomes evident.

The cooperation in this work was excellent. The engineer in charge of the work of the snagboat did everything to make the work a success. The officer in command of the *Swinomish* found opportunity to use every part of his extensive experience, and their work, development of methods, and results were most efficient and of the greatest interest to all who observed the work in progress.

In addition to the location and removal of trees, a considerable portion of the lake was dragged and proved free from obstruction. A dangerous log, which had been struck by an excursion steamer, was found and removed later by the snagboat.

Little hydrography was done except to sound on places where the drag struck bottom and where the charts indicated greater depth. The most important case was a shoal area in the region of submerged forest, with depths of 16 to 22 feet where the chart indicated at least 30 feet.

In Lake Union the light beacon and ranges, as well as some prominent objects, were located by triangulation to meet the needs for revision of the topography.

The topography of the shores of Portage Bay and about one-half of Lake Union was revised.

A search was made with the drag for a reported snag, which was not found. The bridge site at northwest end of lake was partly examined with a marline sweep.

Of the new methods developed during this season, the adaptation marline sweep was the most useful. The procedure is simple. A length of from 50 to 200 feet of marline is used according to conditions. This is made fast to ordinary lead lines just above the lead.

One of the dinghies should have an outboard motor to be used in getting to position, but all towing should be done with oars. An officer in each boat holds the lead line at the proper depth, or a little deeper if it is desired to go faster. When any obstruction is found it is felt at once. The depth of catching may be checked by bringing the ends together and finding how much is under water, half of this being depth to point of catching. This sweep is usually cleared by letting go one end and pulling it through.

This sweep, though simple, can do some things that the wire drag is not suited for. Very narrow channels, the immediate vicinity of wharves and buoys, can be readily investigated. It has, of course, always been available, but it is doubtful if its value is understood.

A single vessel sweep was prepared by members of the party for use in locating trees when only one launch was available. Though far from perfected its usefulness was demonstrated. It seems to have great possibilities, both when used from vessels and from launches. Its particular value would seem to be for inshore development as it makes it possible to send the sweep closer to the shore than it is safe for the launch to go. It also would greatly increase the safety of a vessel which is obliged to search for a pinnacle rock or wreck in conditions where a launch drag is not possible. In this case the vessel in passing a given area once will sweep an area 400 to 500 feet wide and thereby reduce the chance of striking itself.

Very little was done to develop wire-drag methods in general. As it was constantly necessary to take up and set out the drag, a method which proved advantageous was to use the standard bottom wire for the lower bridle instead of the larger size. The latter was retained for the upper bridle and the straightaway. The advantages are that it is unnecessary to wind two parts of the bridle on the same compartment of the reel, and thereby twisting and fouling is prevented. Both bridles come off the reel at the same time, however, just as before. Another unexpected advantage is that the lower bridle tends to coil up to a certain extent when the launch is at rest and is, therefore, not nearly so likely to catch on bottom.

## GEODETIC WORK.

### LOUISIANA AND TEXAS.

[CLEM L. GARNER.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 100 miles, 10 square miles of area covered, 54 lines of intervisibility determined, 60 points selected for scheme. Base lines: 1 primary, 5,900 meters in length. Triangulation: 10 square miles of area covered; 60 observing tripods and scaffolds built, height 10 feet; 40 stations in main scheme occupied for horizontal measures; 6 stations occupied for vertical measures; 55 geographic positions determined. Latitude, longitude, and azimuth work: 4 azimuth stations occupied, azimuth observed on 6 nights.

The primary triangulation from the ninety-eighth meridian triangulation in the vicinity of Gatesville, Tex., to the eastward, which had been requested by the chief of Engineers, U. S. Army, was in progress at the beginning of the fiscal year.

Primary triangulation was carried as far as Mansfield, La., where the country was in general densely wooded, flat, and where the roads were very few and in very bad condition. At this point the scheme narrowed down to a line of primary traverse following the Texas & Pacific Railway to the southeast as far as Alexandria, La., and then following the Louisiana Railway & Navigation Co.'s railway to Naples, La., where connection was made to the Mississippi River triangulation. That part of the traverse from Alexandria to Naples, La., was transferred on September 30 to another party.

On July 1 the work was at the Texas–Louisiana State line, and on July 14 the triangulation was completed to Mansfield, La., where the traverse was begun.

There were eight stations occupied from July 1 to July 14, two of which were azimuth stations, with one a LaPlace station.

At the close of this work the party was assembled at Mansfield, and after two days of overhauling and packing outfit the party was sent to Jacksonville, Tex., for the purpose of clearing the Jacksonville base and preparing the base for measurement.

The chief of party moved to Jacksonville as soon as the base was prepared and was in charge of the measurements for the entire line.

The actual measurements for the base of approximately 9,000 meters was made in 12 hours of actual time, not including the time taken out for lunch but including all such delays as changing tapes, the crossing of about 30 wire fences, and other obstructions which consumed considerable time.

Upon the completion of the base the party was transferred to Mansfield, La., where a larger party for the traverse work to the east was organized. Several days were occupied overhauling motor cars (velocipedes) and putting the outfit in order and training men for the new duties.

As was to be expected the progress of the work at the beginning was rather slow, but later on as the men became familiar with the work a decided improvement was obtained, and in September the party traversed a distance of about 75 miles. The work was started on August 18, and on September 30 the party was at Alexandria, La., a distance of 95 miles, 19 kilometers of which was over stakes.

Motor-velocipede cars were used in this work.

Under instructions of July 23, a building party was operating; from August 1, the work was the erection of signals along the arc of primary triangulation to the west of the ninety-eighth meridian in the vicinity of Oklahoma City. Signals were completed to station Self, but the signal at this station has blown down.

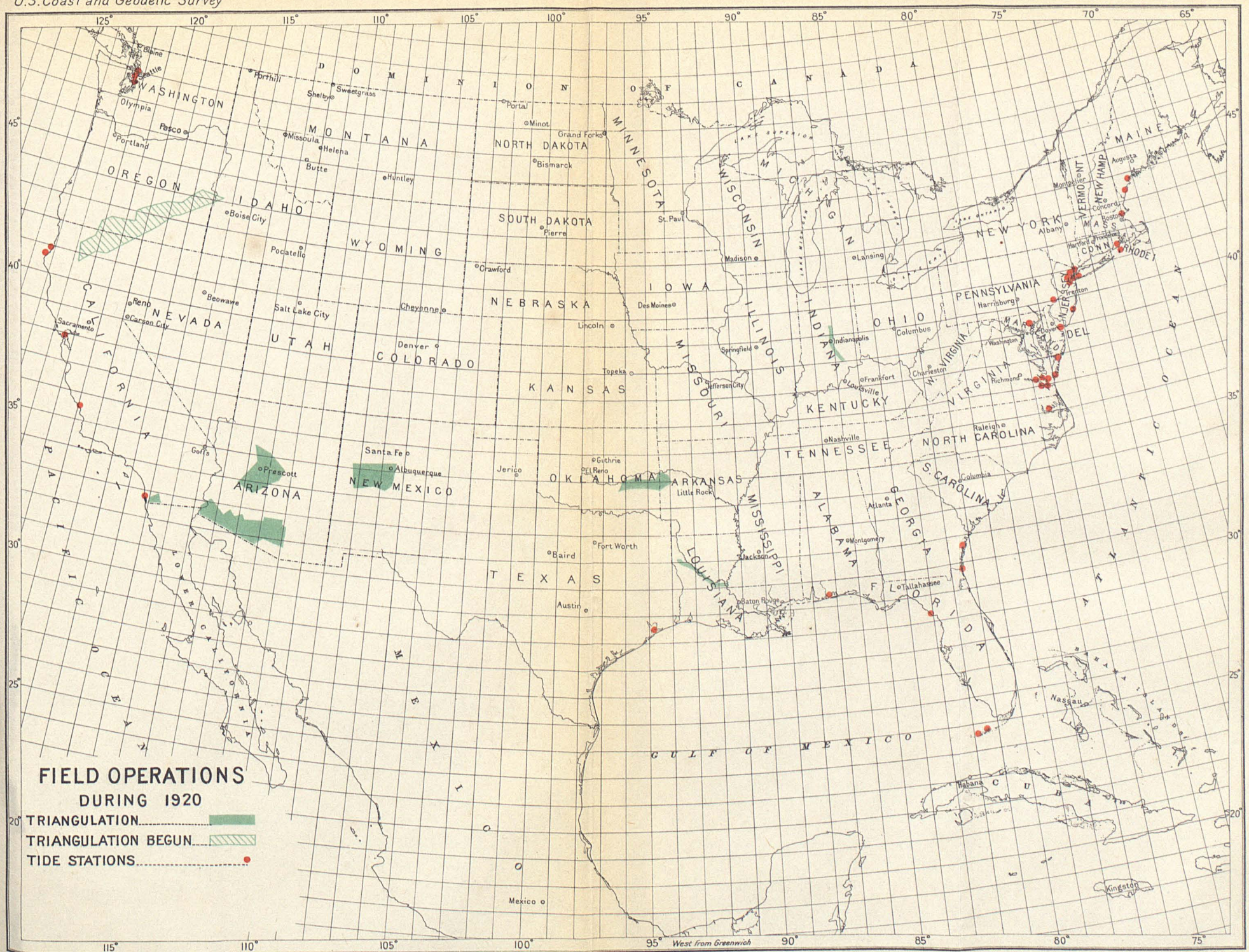
On September 30 the traverse party was transferred to another officer, and the chief of party left for Fort Smith, Ark., to take up work on the arc of primary triangulation to the west of Little Rock, Ark.

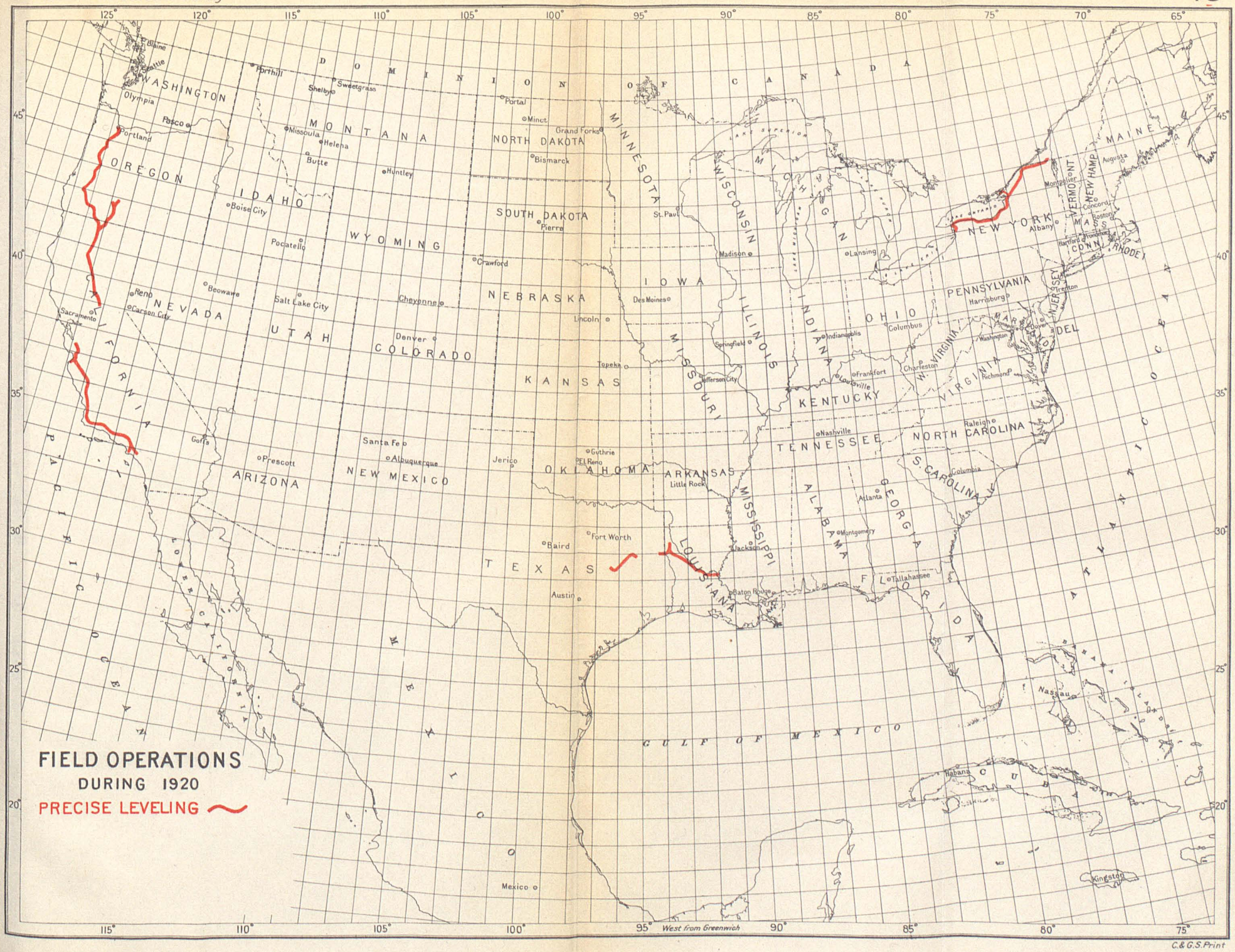
### GEORGIA AND NORTH CAROLINA.

[E. D. BROMLEY.]

In June, 1919, a party had been organized to remeasure the angles on the primary traverse line from Macon to Forsyth, Ga. This work was continued after July. Thirty-two stations were occupied for observation of angles after June 30, and azimuth was determined at Bolingbroke and Forsyth, Ga.

On the completion of this line the party moved to Griffin, Ga., and check measurements were made between Griffin and Barnesville. The remeasure-


FIELD OPERATIONS
DURING 1920
TRIANGULATION
TRIANGULATION BEGUN
TIDE STATIONS
DOMINION OF CANADA
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
S. CAROLINA
NORTH CAROLINA
VIRGINIA
W. VIRGINIA
PENNSYLVANIA
NEW YORK
VERMONT
NEW HAMP.
MAINE
MASS.
CONN.
RHODE I.
NEW JERSEY
MARYLAND
DEL.
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
LOWER CALIFORNIA
CUBA
BAHAMA ISLANDS
Blaine
Seattle
Olympia
Pasco
Portland
Sacramento
Reno
Carson City
Beowawe
Goffs
Prescott
Porthill
Sweetgrass
Shelby
Missoula
Helena
Butte
Huntley
Boise City
Pocatello
Salt Lake City
Cheyenne
Denver
Santa Fe
Albuquerque
Portal
Minot
Grand Forks
Bismarck
Pierre
Crawford
Lincoln
Topeka
Jerico
Guthrie
El Reno
Fort Worth
Baird
Austin
Mexico
St. Paul
Des Moines
Madison
Springfield
Jefferson City
Little Rock
Jackson
Baton Rouge
Lansing
Indianapolis
Columbus
Frankfort
Louisville
Nashville
Atlanta
Montgomery
Tallahassee
Charleston
Richmond
Raleigh
Columbia
Washington
Dover
Harrisburg
Trenton
Albany
Montpelier
Concord
Boston
Augusta
Hartford
Providence
Nassau
Habana
Kingston
West from Greenwich
C.&G.S. Print


FIELD OPERATIONS
DURING 1920
PRECISE LEVELING
DOMINION OF CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
WYOMING
NEVADA
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
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S. CAROLINA
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PENNSYLVANIA
NEW YORK
VERMONT
NEW HAMP.
MAINE
MASS.
CONN.
RHODE I.
NEW JERSEY
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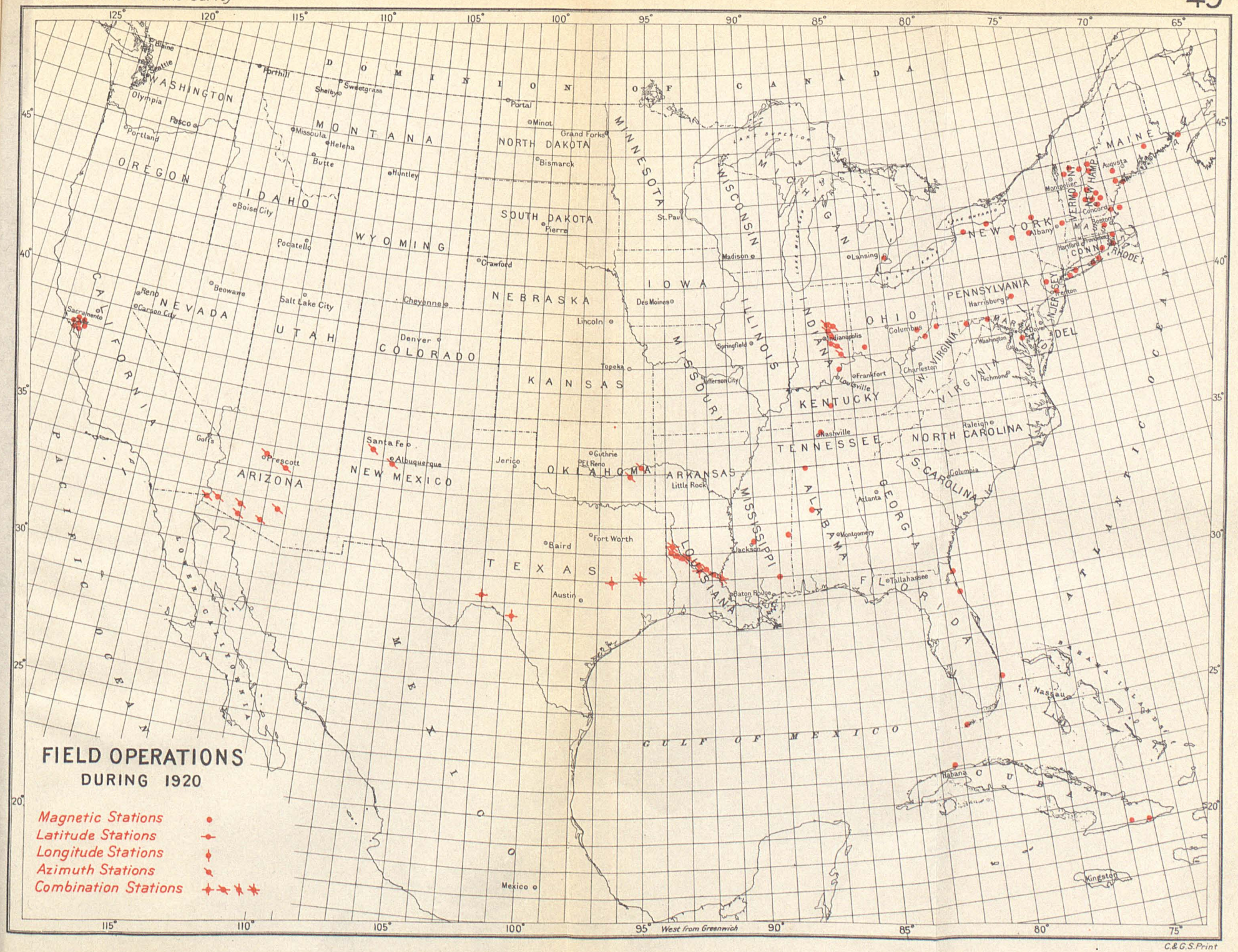
GULF OF MEXICO
ATLANTIC OCEAN
MEXICO
CUBA
West from Greenwich


FIELD OPERATIONS
DURING 1920
Magnetic Stations
Latitude Stations
Longitude Stations
Azimuth Stations
Combination Stations
DOMINION OF CANADA
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
S. CAROLINA
NORTH CAROLINA
VIRGINIA
W. VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VERMONT
NEW HAMP.
MASS.
CONN.
RHODE I.
N. JERSEY
MARYLAND
DEL.
LOWER CALIFORNIA
MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
CUBA
BAHAMA ISLANDS
Seattle
Olympia
Pasco
Portland
Blaine
Porthill
Sweetgrass
Shelby
Missoula
Helena
Butte
Huntley
Boise City
Pocatello
Beowawe
Reno
Carson City
Sacramento
Salt Lake City
Cheyenne
Denver
Goffs
Prescott
Santa Fe
Albuquerque
Jerico
Guthrie
El Reno
Baird
Fort Worth
Austin
Mexico
Portal
Minot
Grand Forks
Bismarck
Pierre
Crawford
Lincoln
Topeka
Des Moines
St. Paul
Madison
Springfield
Jefferson City
Little Rock
Jackson
Baton Rouge
Nashville
Atlanta
Montgomery
Tallahassee
Columbia
Raleigh
Charleston
Frankfort
Louisville
Indianapolis
Columbus
Lansing
Washington
Dover
Harrisburg
Trenton
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Concord
Boston
Hartford
Providence
Augusta
Nassau
Habana
Kingston
West from Greenwich
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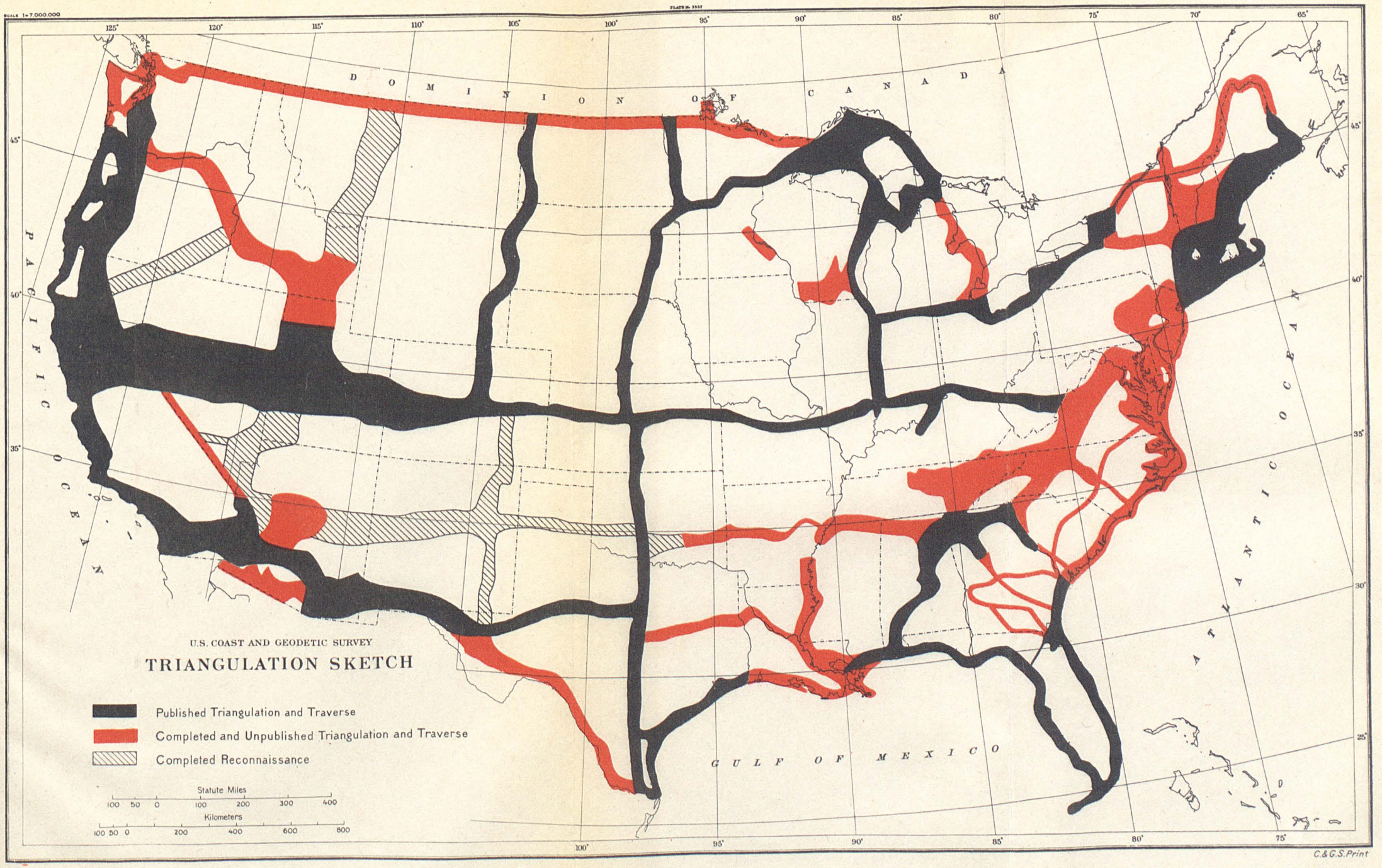

SCALE 1:7,000,000
PLATE No. 3552
DOMINION OF CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
U.S. COAST AND GEODETIC SURVEY
TRIANGULATION SKETCH
Published Triangulation and Traverse
Completed and Unpublished Triangulation and Traverse
Completed Reconnaissance
Statute Miles
100 50 0 100 200 300 400
Kilometers
100 50 0 200 400 600 800
125° 120° 115° 110° 105° 100° 95° 90° 85° 80° 75° 70° 65°
45° 40° 35° 30° 25°
C.&G.S.Print

ments checked closely with the previous measurements, and no appreciable error was discovered.

The party then proceeded to Sanford, N. C., to remeasure certain angles in the arc of primary triangulation from Sanford to the oblique arc.

As most of the observing towers had been destroyed a party was organized to rebuild them and to clear the intervening ridges. When this had been accomplished the observation of angles was begun. Acetylene lights were used, and the observing was done at night.

The revision work extended from the connection of the primary triangulation at Sanford, N. C., to the line Asheboro–Climax.

A LaPlace azimuth was observed at Sanford, N. C.

The chief of party and a recorder then proceeded to Stuart, Va., where the angles in the quadrilateral joining on the oblique arc were to be remeasured, but owing to continued unfavorable weather this was not completed, and work was closed for the season under instructions, December 19.

## LOUISIANA.

[LEONARD H. ZEMAN.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 65 miles, 8 square miles of area covered (including loops only), 75 points selected for scheme. Primary traverse: 53 signal poles erected; 31 observing tripods built, heights from 4 to 30 feet; 36 observing scaffolds built, heights from 4 to 30 feet; 60 stations in main scheme occupied for horizontal measures; 15 stations in supplemental schemes occupied for horizontal measures. Leveling: 15.5 miles of levels run.

The party engaged in running a precise traverse in Louisiana which had been begun by Clem L. Garner, was transferred to Leonard H. Zeman, October 1, 1919. The party was then in the vicinity of Alexandria, La., having brought the traverse down to this point from Mansfield, La.

The plan adopted was to carry the traverse through Alexandria, La., to Naples, La., over the tracks of the Louisiana Railway & Navigation Co. The Atchafalaya River was crossed by triangulation and the traverse resumed on the other side of the river. The route taken was along the level of the old river, and the traverse was measured over stakes until connection was made with the triangulation points of the Mississippi River Commission, completing line from Waco, Tex., to the Mississippi River. The Waco (Tex.) to Mississippi River line was carried by primary triangulation from the vicinity of Waco, Tex., to South Mansfield, La., and from South Mansfield, La., to the Mississippi River by primary traverse.

[E. B. LATHAM.]

In May, 1920, a remeasurement was made of the angles at stations along the line of traverse between stations Sodus and Peanut, in which certain discrepancies had been discovered.

This work began May 12 and was completed May 27.

## ARKANSAS AND OKLAHOMA.

[CLEM L. GARNER.]

SUMMARY OF RESULTS.—Triangulation: 1,900 square miles of area covered; 1 observing tripod and scaffold built, height 5 feet; 18 stations in main scheme occupied for horizontal measures; 18 stations occupied for vertical measures; 25 geographic positions determined; 20 elevations determined trigonometrically. Latitude, longitude, and azimuth work: 2 azimuth stations occupied, azimuth observed on 2 nights.

Between October 1 and December 22, 1919, primary triangulation was executed in the States of Arkansas and Oklahoma in continuation of a scheme carried on in 1916–17, and was taken up at the point where that work was closed in the vicinity of Fort Smith, Ark.

In the latter part of October a building party, which had been operating in Oklahoma, was transferred to this work.

Observations were begun October 15 and ended December 14, when 18 stations had been occupied. It was not necessary to reoccupy any station. Due to the mountainous country and the fact that the outfit had to be packed to all stations, except at the last part of the work, it was not possible to make more than one station every two days under the best of conditions. This average was obtained for periods of several days at a time, but could not be maintained during long periods on account of unfavorable weather and the

resulting bad roads. Several periods of rainy weather, and, at times, foggy weather, caused delays of many days.

The work was brought to a close in the vicinity of McAlester, Okla., just after all of the stations in the Savanna base net had been occupied. When work is resumed in this locality the chief of party recommends that the base line be measured before proceeding with the triangulation. McAlester affords best facilities for the organization of a party of any place in this locality, and from there the base line is easily accessible.

The base is an old base line of the Geological Survey, but the north base station has been destroyed, and as the reference marks are somewhat indefinite the check on the Geological Survey base will be rough. In order to avoid building a 30-foot signal the new north base station (as established by the Coast and Geodetic Survey party) was placed about 25 meters distant from the position of the Geological Survey mark.

## ARIZONA.

[CLEM L. GARNER.]

The primary triangulation between Nogales and Yuma, Ariz., which had been carried on by George D. Cowie, was completed after May 22, 1920, by Clem L. Garner, who occupied the three triangulation stations necessary to make connection with the Texas-California arc of primary triangulation.

This work was done at the request of the War Department.

Mr. Garner took up the work near Welton, Ariz., and closed work at Yuma, Ariz., March 30.

After returning property belonging to the Army the party on April 7 left by truck for Albuquerque, N. Mex., by way of Prescott, Ariz., to take up work under another assignment.

## NEW MEXICO AND ARIZONA.

[CLEM L. GARNER.]

SUMMARY OF RESULTS.—Base lines: 1, 11.5 miles in length. Triangulation, primary: 6,650 miles of area covered, 6 stations in main scheme occupied for horizontal measures, 6 stations occupied for vertical measures, 22 geographic positions determined, 18 elevations determined trigonometrically. Azimuth: 3 stations occupied for determination of azimuth.

Between April 1 and June 30, 1920, a primary base line was measured and primary triangulation was done in the general vicinity of Belen, N. Mex. This triangulation is a link in the arc which will eventually extend from Little Rock, Ark., to the Texas-California triangulation just to the south of Williams, Ariz.

The party started to the field on May 3 from Albuquerque to the Belen base line, a distance of 55 miles. Camp was established in the center of the base line 22 miles south of Belen, and actual work on the base line was begun May 7. The base is approximately 11.5 miles, or 18,300 meters in length.

As soon as the base measurements were completed on May 26 the observation of angles was begun. A subparty was organized to occupy the stations on the south side of the scheme while the chief of party made the observations on the north side of the scheme.

All stations west of and including North Base and South Base were occupied, and by June 30 the work was completed to the line Taylor-Alegros, 6 stations having been occupied by this time.

## INDIANA.

[J. S. BILBY.]

SUMMARY OF RESULTS.—Primary traverse: Reconnoissance and signal building completed, 115 miles, observing 100 miles, taping and traverse completed 65 miles, 75 principal stations occupied for horizontal measures, 10 supplemental stations occupied for horizontal measures. Azimuth: 7 stations occupied for determination of azimuth.

In the latter part of March preparations were made for making a reconnoissance for primary triangulation or primary traverse approximately through the center of the State from north to south. The triangulation was planned to start from the transcontinental triangulation and to connect at its northern end with the triangulation of the United States Lake Survey.

On April 25 the actual work on the reconnoissance and building was started. Tripp, a station on the transcontinental arc, 1 mile to the westward of North Vernon, was the initial point from which the work was started. The reconnoissance and building only were in operation until May 7; an observing party was then organized, and the reconnoissance, building, and observing were in operation to June 8. This part of the work was completed to a point 3 miles north of Noblesville, a distance of 90 miles. The combined party then moved back to North Vernon and started the tape measurements. By June 22 about 40 miles of the measurement were completed, and work was resumed on the reconnoissance and building, and by June 30 all work was in full operation.

Work had been completed by that date as follows: Reconnoissance and building, from Tripp station to Kokomo, distance 115 miles; observing of angles and azimuth, from Tripp to Tipton, distance 100 miles; tape measurements, including grade levels, angles at A and B stations and all incidental work necessary to complete the traverse, from Tripp to near Pendleton station, in northeast Indianapolis, distance 65 miles.

The work was started from Tripp, a station on the transcontinental arc, about 1 mile to the westward of North Vernon, and about 850 meters south of the Baltimore & Ohio Railroad track. The tape measurement was on stakes from Tripp to the Baltimore and Ohio Railroad; then on the Baltimore and Ohio Railroad east 1 mile to the junction of the Baltimore & Ohio and the Pennsylvania Railroads to Troy Street, thence east 2 miles (on concrete pavement) on Troy Street to Sherman Drive, thence north on (concrete) Sherman Drive 2 miles to Prospect Street, thence east 1 mile on (concrete) Prospect Street to Emerson Avenue, thence north 5 miles on (concrete) Emerson Avenue to Thirty-eighth Street, thence west 2 miles on (concrete) Thirty-eighth Street to Keystone Avenue, thence north on stakes along Keystone Avenue 1½ miles to the Lake Erie & Western Railroad, thence northward on the Lake Erie and Western Railroad through Noblesville to Kokomo.

At the close of the fiscal year, June 30, 1920, the reconnoissance, building, observing, tape measurements, and grade levels were in progress.

### INDIANA AND CALIFORNIA.

[C. V. HODGSON.]

In June, 1920, an inspection was made of the primary traverse party operating in Indiana. The section of the party engaged in measures with tape was doing good work and making satisfactory progress. Part of the traverse was run through the outskirts of the city of Indianapolis. The traverse was run over the concrete pavements of the city with certain slight modifications in the existing methods.

Four or five days were spent with the forward section of the party which was engaged in reconnoissance, signal building, and observing horizontal angles. There, also, favorable conditions regarding progress of the work were encountered. The party was then covering well over 100 miles per month, which was regarded as very good.

The party engaged in primary triangulation in California was next visited. Here the conditions were found to be less favorable, owing both to the topography of the country and the difficulty of obtaining the necessary labor. Progress was therefore slow. A double observing party had just been organized which had previously been prevented by lack of men.

The officer making the inspection left California July 17, and reported at the office of the Survey in Washington, July 26.

### OKLAHOMA, CALIFORNIA, AND OREGON.

[J. S. BILBY.]

SUMMARY OF RESULTS.—Reconnoissance for triangulation: Length of scheme 375 miles, 22,700 square miles of area covered, 37 points selected for scheme, 22 supplemental points selected for scheme. Base lines: 1 primary 9 miles in length.

Field work of reconnoissance and signal building on the arc of triangulation in Texas and Louisiana was completed on June 30, 1919, and the outfit and such members of the party as were needed were moved to Fort Smith, Ark., from which place work on the Arkansas-Oklahoma arc of triangulation was taken up.

During the season of 1916 this triangulation had been extended from the vicinity of Little Rock westward, the observing party reaching Hartford, Ark., in the vicinity of the Arkansas-Oklahoma State line. At the close of the same season signals had been built and stations prepared to the vicinity of Ada, Okla., and 27 stations remained to be occupied.

These unoccupied stations were now inspected, and signals were repaired and plumbed over the station marks. By August 1 the 27 unoccupied signals had been repaired and 1 new signal built.

The signals erected in 1916–17 were all standing except one which had been removed. From others some of the braces had been removed. No signal had been damaged by storms.

During the progress of the work in Oklahoma plans were made for work assigned in California and Oregon.

On August 12 the chief of party left Fort Smith, Ark., to take up the work in California in the region of Mount Shasta, stopping at Salt Lake City to confer with G. D. Cowie in regard to the work and to obtain a motor truck for the use of the party.

The shipment of the trucks ordered had been delayed, and it was necessary to make other arrangements for transportation.

The chief of party arrived at Redding, Calif., August 21. While arranging for transportation and other details of the work the district engineer of the Forest Service and the forest supervisor of the Mount Shasta National Forest were consulted, and a plan of work was outlined in accordance with the needs of the Forest Service.

By September 15 the reconnoissance for the Mount Shasta region had been completed and the results transmitted to the office of the Survey in Washington.

By the request of the assistant district engineer the Mount Shasta project was extended eastward to connect and furnish primary control for the surveys now being made by the engineers of the Forest Service in the Modoc National Forest. The headquarters office of the Modoc Forest is at Alturas, Calif. The forest supervisor at Alturas will cooperate in the work done in the Modoc Forest.

Provision was made for several stations in the Klamath National Forest to furnish control for surveys planned by the Forest Service. The headquarters office of the Klamath Forest is at Yreka, Calif., and the forest supervisor of the Klamath district will cooperate in the work.

A connection was provided for with triangulation stations established by the United States Geological Survey in Shasta and Lassen Counties, Calif.

Stations Bally and Bolivar, with Mears as third station, were used as a base for the Mount Shasta project. These are stations of the California-Washington arc of primary triangulation.

On the completion of the Mount Shasta survey the reconnoissance for primary triangulation was extended across the State of Oregon in a northeasterly direction to a connection with the Utah-Oregon arc of primary triangulation in Oregon and Idaho, in the vicinity of Nyssa, Oreg.

The reconnoissance for the California-Oregon arc was extended from stations of the Mount Shasta survey, following the most practicable routes and being always within reach of fairly good roads, so that no difficulty was found in driving the motor truck within walking distance of all stations. The country is fairly well supplied with water, and there are many small stores at which gasoline, oil, and other supplies can be purchased, so that it was not necessary to carry a large amount of such supplies.

The scheme of work passed through the Fremont National Forest, and in addition to the stations in the main scheme several secondary stations were provided which will furnish good control in easy reach of all parts of the Fremont Forest district. The headquarters office of the Fremont National Forest is at Lakeview, Oreg. There is no timber on the peaks and very little timber of any kind to the eastward of the Fremont Forest. There are a few scrub cedars and junipers in the draws and canyons.

The reconnoissance was completed to a connection with the Utah-Oregon arc October 19, and the chief of party left Nyssa, Oreg., October 20, to carry the reconnoissance outfit to Osgood, Ind.

## UTAH AND ARIZONA.

[GEORGE D. COWIE.]

SUMMARY OF RESULTS.—Reconnoissance for triangulation: Length of scheme 125 miles, 6,250 square miles of area covered by reconnoissance. Triangulation: 2,000 square miles of area covered, 9 stations in main scheme occupied for horizontal measures, 15 stations in supplemental schemes occupied for horizontal measures, 24 stations occupied for vertical measures, 40 geographic positions determined, 40 elevations determined trigonometrically.

On July 1, 1919, work was in progress on the scheme of triangulation in Utah; undertaken at the request of and in cooperation with the United States Forest Service.

The reconnoissance had been completed and observing stands erected, and observations of horizontal and vertical angles had been begun.

Observations had been begun at the southern end of the scheme and were computed about October 18. Difficulty was experienced on account of the light keepers not showing promptly on long lines and on account of deep snows and cold weather in the latter part of the season.

The average elevation of the peaks occupied was 11,000 feet, but no great difficulty was experienced in packing to the peaks, as pack horses could be obtained usually within 30 miles of the stations.

The area surveyed was about 2,000 square miles, and numerous tertiary points were located to control a planetable survey.

At the close of the season the party was transferred to southern Arizona, and after a short time spent in reconnoissance began observations on the line from Nogales to Yuma. The work was undertaken at the request of the United States Army Engineers.

Observation of angles was begun about December 1, and by the end of the year three stations, one of which was an azimuth station, had been occupied. The line starts from stations Baldy and Catalina of the Texas-California arc, follows the general course of the Mexican border, and is about 30 miles north of it. Several points on the border will be tied into the work.

During the season transportation was by rented cars and one Coast and Geodetic Survey motor truck, and by pack animals hired locally.

On September 29 instructions were issued for the execution of certain triangulation in Arizona which had been requested by the Chief of Engineers, United States Army, the work to be taken up on completion of surveys in Utah then in progress.

The expenses of this work were partly provided for by funds allotted by the Chief of Engineers.

After the close of field operations in Utah at the end of October such members of the party as were required, with the necessary equipment, were transferred to Nogales, Ariz.

On November 18 the entire party started out to erect the primary stands and secondary poles in the first quadrilateral, which was rather large for the needs of the Army, but necessarily so on account of the long line of the Texas-California arc of triangulation from which this work had to start. In one week sufficient building had been completed to permit primary observation to begin, and the light keepers were placed on their stations, the observing party going to Mount Baldy on November 26. A blizzard and failure of light keepers to show properly delayed the party several days at this station.

Several other stations were completely covered with snow, making climbing difficult and cold, and frequently keeping the higher peaks in dense clouds, Mount Baldy being completely covered for 10 days at a time.

Once off the first quadrilateral, progress was better, the country being lower and drier.

Throughout the season local men had to be hired as light keepers, and not one of them finished the season. At least a dozen men quit or were discharged, after working from 3 to 20 days; without notice, leaving their stations unattended.

Toward the end of the season, the building party having completed work and joined the main party, the experienced men were used as light keepers and the work progressed rapidly. During this last month six difficult stations were occupied before the 21st and three more by the end of the month.

At only two stations could pack burros be used to carry outfit, the rest being stations requiring from one to five hours back-packing with about 50 pounds per man. Water was scarce and roads poor, but in many places trucks could

be driven close to the foot of the mountain. Light keepers were supplied with kegs of water and supplies to run them nearly one month.

Transportation was by means of 3 or 4 ¾-ton trucks, and one half-ton Dodge loaned by the Army.

There were about 17 main stations, with about 7 boundary monuments occupied, and 12 secondary points, and in addition nearly 25 intersection stations at which signal poles were erected besides numerous natural objects. At 5 stations azimuth was observed in connection with the regular work. An effort was made to determine a point in every 15 miles.

As many of the mountains were difficult and dangerous to climb, the light keepers and the observing party occasionally slept at the station in a blanket or the observing tent or else sat by a fire until daylight rather than attempt coming down at night.

The entire work covered a distance of 250 miles, with a width of about 50 miles, and ended in California on a station of the Texas-California arc.

## WASHINGTON.

[A. M. SOBIERALSKI.]

SUMMARY OF RESULTS.—Reconnoissance for primary triangulation: Length of scheme 117 miles, 914 square miles of area covered, 65 points selected for scheme. Base lines, reconnoissance: 2 sites selected for base lines 5,300 and 3,600 meters in length.

Under instructions dated July 31 and September 12, 1919, a reconnoissance was made for a scheme of primary triangulation extending from Puget Sound to the international boundary line to connect with triangulation executed by the Canadian Government surveyors.

The launch *Audwin*, formerly a submarine patrol launch, was assigned for the use of the party but required extensive repairs to the engine and hull before being put in commission. Repairs were completed October 1, and October 2 field work was begun. Work was closed and the party disbanded January 11, 1920.

The Puget Sound country is heavily wooded, the trees attaining a height of 175 to 200 feet, and a dense underbrush makes it difficult to travel away from the trails. Few lines can be found that are not obstructed by trees, and there are no prominent hills until the San Juan Islands are reached. Clearing is almost out of the question, and the great height of the trees makes scaffold building equally difficult. For these reasons the triangulation is necessarily confined to the shores.

The shores are generally faced by steep gravel bluffs varying in height from 50 to 300 feet. These bluffs are continually being eroded, and in many places are receding quite rapidly, often making it necessary to abandon houses built near the edge. Under these circumstances it is difficult to find a place for a permanent station, and most of the old stations have been destroyed. A special effort was made to recover two adjacent stations of the old scheme, but without success.

The scheme adopted follows closely the original scheme of 1856. Some difficulty was experienced in finding enough of the primary stations in the vicinity of Tacoma for a line on which to start. The line Dron–Smelt was the only one available.

A reconnoissance was made for two base lines, one in the vicinity of Seattle and one in the vicinity of Port Townsend. A site was finally selected along the West Seattle ridge and another along the shore of Admiralty Bay from Fort Casey eastward. These are 5,300 and 3,600 meters in length, respectively.

The azimuth station at Port Townsend was recovered and provision made for a connection with the main scheme.

A connection with the triangulation by the United States Army Engineers was provided for in the vicinity of Protection Island.

## CALIFORNIA.

[E. W. EICKELBERG.]

SUMMARY OF RESULTS.—Triangulation: 375 square miles of area covered. 21 observing stands erected, 4 stations in main scheme occupied for horizontal measures, 5 stations occupied for vertical measures, 7 geographic positions determined, 7 elevations determined trigonometrically. Leveling: 2.6 miles of levels run. Azimuth: 1 azimuth station occupied, observations for azimuth made on 1 night.

In June, 1920, a party was organized for carrying on the primary triangulation from the vicinity of Mount Shasta, Calif., northeastwardly across Oregon

to the vicinity of Ontario, Oreg., following a reconnoissance made during the season of 1919.

This work was undertaken in cooperation with the Forestry Service.

Field work was begun June 12 at Redding, Calif., and was in progress at the close of the fiscal year.

### ARIZONA AND CALIFORNIA.

[C. V. HODGSON.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 45 miles; 1,350 square miles of area covered; 10 lines of intervisibility determined; 4 points selected for scheme. Base lines, one 10 miles in length. Triangulation: 8,650 miles of area covered; 42 observing tripods and scaffolds built, heights, one 42 feet (others instrument stands); 14 stations in main scheme occupied for horizontal measures; 1 station in supplemental scheme occupied for horizontal measures; 15 stations occupied for vertical measures; 18 geographic positions determined; 18 elevations determined trigonometrically. Azimuth: 2 stations occupied for determination of azimuth.

At the beginning of the fiscal year work was in progress in Arizona on the triangulation undertaken for the purpose of furnishing control stations for topographic work by the Forest Service in the Arizona National Forest. Observation of angles had been begun June 8.

The progress of the work was slow, owing to the difficulty of obtaining suitable labor and by reason of unfavorable weather; and on October 9 the chief of party was directed to discontinue observations, measure the Prescott base, and proceed with the connection of the California-Mexico triangulation in vicinity of San Diego, Calif. The measurement of the Prescott base was completed October 25. After consultation with Mr. Urquijo, who had charge of the triangulation party on the Mexican side, and making the necessary preliminary arrangements, observations were begun on the California-Mexican connection on November 8, and the work of the American observers was completed November 14, but owing to large closures it became necessary for the Mexican observer to reoccupy all of his stations and for the light keepers to remain at their stations until he had finished. The final results showed a satisfactory closure.

Field operations were completed November 23, and the party left San Diego on the following day.

### NEW YORK.

[O. W. FERGUSON.]

SUMMARY OF RESULTS.—Precise leveling: 481 permanent bench marks established, 131 temporary bench marks established, 319 miles of leveling run.

At the beginning of July, 1919, work was in progress on the line of precise levels westward from Rouses Point, N. Y., and 9.8 miles of leveling had been completed.

The work was done on foot, but the party and equipment were transported to and from the locality of the work by automobile.

The route followed was along the Rutland Railroad, surmounting a high summit at Churubusco, to Norwood, then southwestward through Potsdam, Canton, and Waterford, skirting the Adirondacks. A 30-mile spur line was run to Cape Vincent and Tibbets Point, then back to Watertown and continuing through Richland, Pulaski, Oswego, Scriba, Sodus, Williams, and many smaller towns. The line presented many steep grades. The region traversed is mostly cleared and occupied by dairy farms.

Connections were made whenever practicable with Geological Survey and railroad bench marks. Two hundred and twenty-four such bench marks were recovered and connected with the line of precise levels after June 30.

The average progress made was 66 miles a month, and the greatest length of line run in one day was 10.68 miles.

Work was closed November 25, 1.5 miles west of Williams, Wayne County, N. Y. connection having been made with the line of precise levels run by Paul M. Trueblood eastward from the vicinity of Niagara Falls, N. Y.

## TEXAS AND LOUISIANA.

[C. M. DURGIN.]

SUMMARY OF RESULTS.—Precise leveling: 168 permanent bench marks established; 360 miles of leveling run between July 1, 1919, and January 6, 1920. Precise leveling was done as follows: July 1, 1919, to August 20, 1919 between Jewett and Gallatin; August 20 to November 14, 1919, between Stonewall and Naples, La.; November 14 to 22, 1919, river crossing with precise levels at New Orleans, La.; November 22, 1919, to January 6, 1920, in Texas and Louisiana between Stonewall, La., and Tenaha, Tex., with spur line from Keithville to Shreveport, La.

The line of precise levels from Hillsboro, Tex., to Naples, La., followed the Trinity & Brazos Valley Railway and Houston & Texas Central Railroad from Hillsboro to Jewett, Tex. From Jewett to Palestine, Tex., the line of levels was carried along the International & Great Northern Railway, and from Jacksonville to Gallatin, along the Texas & New Orleans Railroad. The Texas & Pacific Railway was used between Shreveport and Alexandria, La.; The Louisiana Railway & Navigation Co. between Alexandria and Naples, La.; and the Houston East & West Texas Railway from Keithsville, La., to Tenaha, Tex. A short spur line between 3 and 4 miles long was run north from Alexandria, La., along the Missouri Pacific Railroad to give grade corrections for the precise traverse which had already been started toward Natchez, Miss., before it was decided to carry the traverse to Naples from Alexandria, La.

One 12 BM Buda motor velocipede and one Mudge E6K were used to transport the party to and from and during the work, from July 1 to November 14, 1919. The instrument was mounted upon the Buda car. This is a very satisfactory arrangement, as the Mudge can be used by the recorder and one rodman during the work in moving from one instrument station to another. From November 14 until the end of the season two Mudge motor cars were used. After December 14, on account of the high charge for services of conductor, hired automobiles instead of motor cars were used for transporting the party.

On August 20, 1919, the party was transferred from Jacksonville, Tex., to Mansfield, La., in order to follow closely the party which was carrying precise traverse from that point to the Mississippi River. In leveling in connection with the precise traverse, connection had to be made with points on the track opposite traverse stations, mile poles, railroad stations, water tanks, trestles, section houses, etc., and also on the top of the rail at the top and bottom of grades, in order that inclination corrections might be computed for the taping done by the traverse party.

Connection was made with triangulation stations which could be easily reached in order to give a horizontal control to the triangulation. Nearly all traverse stations were connected with and these served as permanent bench marks.

In order to keep from having that part of the line of precise levels between Mansura and Naples, La., a spur line, a river crossing was made across the Atchafalaya River between Naples and Barbres Landing. At Barbres Landing connection was made with two bench marks of the Engineers, U. S. Army.

A river crossing across the Mississippi River near New Orleans, La., was made for the second time.

Between Jewett and Gallatin, Tex., and between Tenaha, Tex., and Naples, La., a distance of 360 miles, 168 permanent bench marks were established, an average of 1 permanent bench mark for every 2.1 miles.

Conductors were required to pilot motor cars on the following railroads: International & Great Northern Railway, Texas & New Orleans Railroad, Houston East & West Texas Railway.

## CALIFORNIA AND OREGON.

[C. A. EGNER.]

SUMMARY OF RESULTS.—Precise leveling: 237 permanent bench marks established, 293 secondary bench marks established, 382.9 miles of levels run.

On July 1, 1919, work was in progress on the line of precise levels along the line of the Southern Pacific Railroad from Kirk, Oreg., toward Roseville, Calif. Permanent and temporary bench marks had been set from Lelu, Oreg., southward to Ady, Oreg., a distance of 26 miles, and leveling had been done on two days. Work on the spur line to connect with the Geological Survey bench

marks at Klamath Indian Agency was assigned to a subparty, while the main party continued southward from Klamath Falls, using two motor cars. In August one of these cars was damaged by a wreck in a tunnel near Dorris and the party was deprived of its use for a month. Proceeding with one car fair progress was made in spite of heavy grades below the summit at Grass Lake, Calif., so that by Labor Day that part of the work on the section north of Weed was completed and the two parties were ready for leveling on the main line down the Sacramento Valley.

At this time two additional motor cars were received and inspection was made of the work by an officer from Washington. Some delay was caused by another wreck and the caving in of a tunnel on the Southern Pacific Railroad.

The season's work closed at Roseville, Calif., November 23, and the party proceeded to San Jose to take up another line.

The officials and employees of the Southern Pacific Railroad cooperated with the leveling party in every way practicable.

## CALIFORNIA.

[C. A. EGNER.]

SUMMARY OF RESULTS.—Precise leveling: 240 permanent bench marks established, 481.6 miles of levels run.

Between December 1, 1919, and March 19, 1920, a line of precise levels was run from San Jose, Calif., along the coast line of the Southern Pacific Railroad to Santa Ana, Calif., with spur lines from Del Monte Junction to Monterey and from Los Angeles to San Pedro, Calif.

Having closed the previous season's work at Roseville, Calif., late in November, the two sections of the party were immediately transferred to San Jose, Calif., and Salinas, Calif., the chief of party running his equipment through to the former place to make connection there with Coast and Geodetic Survey bench marks of the 1912 work which were to provide the elevation to be carried through, one subparty being instructed to start leveling at Salinas and to work south. Plans having worked out as desired, both sections were ready to start leveling on December 1. As several trained men remained with the party through the transfer from a party in Louisiana, the equipment was likewise excellent.

Connection was made with the work of the subparty near Salinas, Calif., as well as the spur line to Monterey, there to tie onto a previously established tidal bench mark and connect with tidewater.

The leveling moved onward with accelerated speed throughout January. By the end of the month the subparty had moved south to Ventura, Calif., for the final stretch. There, in spite of discouraging ill fortune with wrecks, injuries to men, etc., work was continued in February, and the greatest amount of progress was made in that month. The desert country along the coast from San Luis Obispo south furnished an incentive for speed, and Santa Barbara was reached by the main party early enough for us to move to Los Angeles by Washington's Birthday. Here were encountered the usual difficulties incident to work with a large city, and it was a real relief to move on down the line to complete the work near Santa Ana. Conditions here approached the ideal, and with favorable weather the connection with the previous work at Santa Ana, as well as the spur line to San Pedro, was carried out promptly. A subparty was meanwhile approaching Los Angeles from the north, so that both sections completed their part of the field work simultaneously. The season's work was closed at Burbank, Calif., on Friday, March 19, the records having been mailed on that date, the equipment shipped, and the party en route to the new line in northern California.

Connection with tidewater was made at Monterey, and at San Pedro, Calif. Previously established bench marks at Gaviota and San Pedro, Calif., with which it had been intended to connect, were not found.

Motor-velocipede cars were used in this work for the transportation of personnel and equipment. Greatest progress made in one day was 25.5 miles of single line on March 9, an amount that has not been exceeded in work of this class.

Connection was made throughout with bench marks established by the U. S. Geological Survey.

The officials of the Southern Pacific Railroad cooperated in the work.

## CALIFORNIA AND OREGON.

[C. A. EGNER.]

SUMMARY OF RESULTS.—Precise leveling: 199 permanent bench marks established, 265 temporary bench marks established, 325.7 miles of levels run.

Between March 22 and June 13, 1920, precise leveling work was done on a line along the route of the Southern Pacific Railroad from Weed, Calif., northward toward Portland, Oreg. After June 13 the work was continued by another officer. In order to expedite the work two men were detailed to set bench marks for that portion of the work from Weed, Calif., to Portland, Oreg., a distance of 425 miles. This work was satisfactorily accomplished.

The route during March was over the most difficult portion of the road. The summit of the Siskiyou range of mountains, more than 4,000 feet above sea level, rises near the California-Oregon State line, and here the combination of exceedingly heavy grades, dangerous curves, and bad weather retarded progress. In the latter part of April and throughout May the weather was more favorable, and good progress was made.

The charge of the party was transferred to another officer on June 13.

## OREGON.

[CASPER M. DURGIN.]

SUMMARY OF RESULTS.—Leveling: 55 miles of levels run, 24 permanent bench marks established.

On May 5, 1920, the work was begun of organizing a party to run a line of precise levels across the State of Oregon from the vicinity of Klamath Falls to Ontario, Oreg. A subparty was organized in order to expedite progress in this work.

Automobile trucks were used for the transportation of the party.

The work was in progress at the end of June.

## TEXAS AND LOUISIANA.

[W. B. FAIRFIELD and J. E. MCGRATH.]

SUMMARY OF RESULTS.—Latitude and longitude: 6 primary latitude stations established, 9 differences of longitude (telegraphic) determined.

During the period between July 1 and December 31, 1919, differences of longitude were determined between La Place, Tex. (Eagle Pass), and Johnstone, Tex.; Dryden, Tex., and Johnstone, Tex.; Dryden, Tex., and Stanton, Tex.; Tehuacana, Tex., and Austin, Tex.; Tehuacana, Tex., and Jacksonville, Tex.; Mansfield, La., and Jacksonville, Tex.; Mansfield, La., and Boyce, La.; Torras, La., and Boyce, La.; Torras, La., and Little Rock, Ark.

Latitude was determined at Dryden, Tex.; Johnstone, Tex.; Tehuacana, Tex.; Jacksonville, Tex.; Boyce, La.; and Torras, La.

On April 23, in accordance with instructions, certain test measurements were made at Weaver triangulation station, La.

Field operations were closed for the season on April 28.

The Western Union Telegraph Co., as usual, rendered assistance in the use of their lines and making necessary connections.

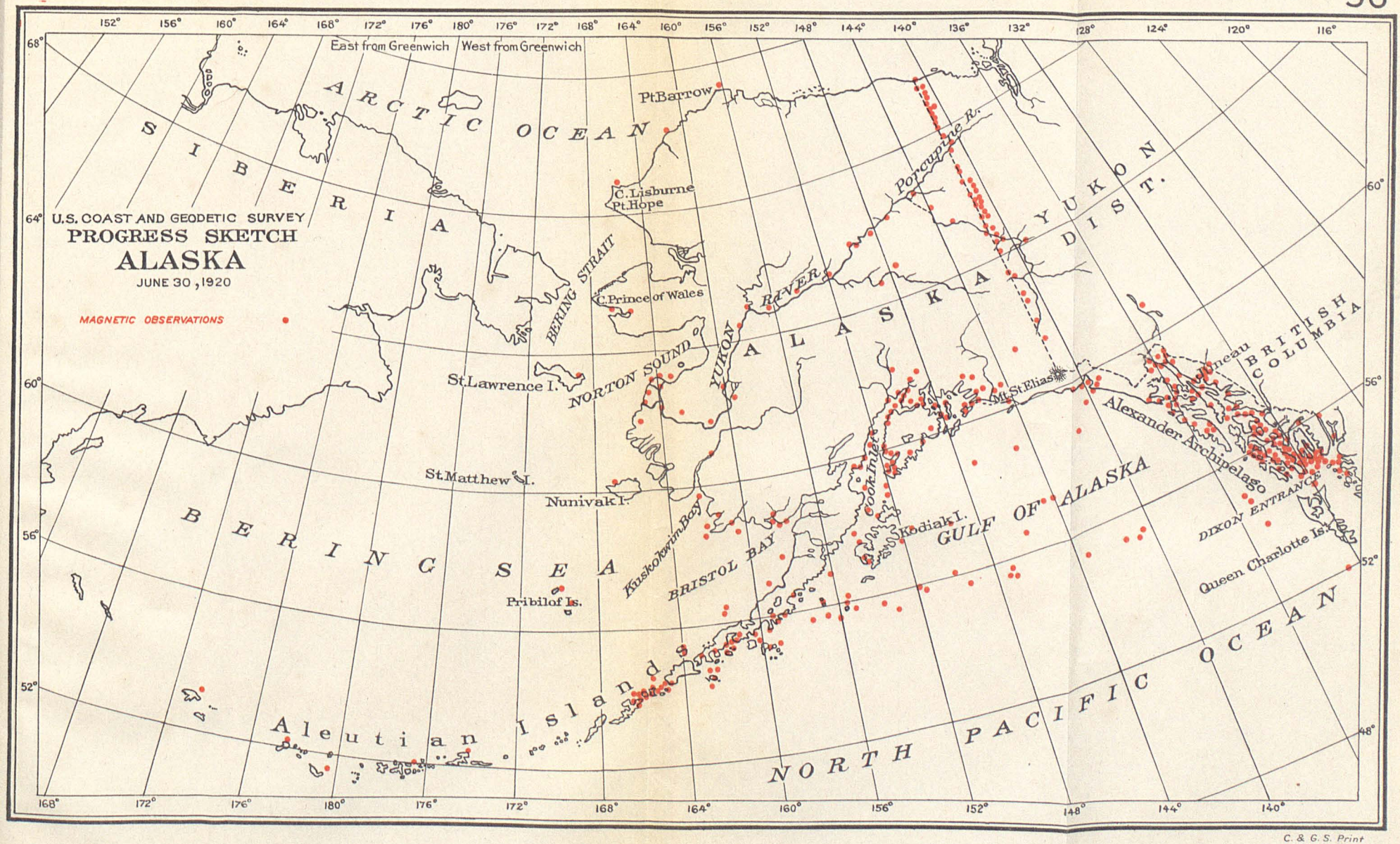
## COLORADO, NEBRASKA, SOUTH DAKOTA, AND WYOMING.

[E. W. EICKELBERG.]

SUMMARY OF RESULTS.—Eight stations occupied for relative determinations of gravity.

Between October 6 and December 5, 1919, determinations were made of the relative force of gravity at stations in South Dakota, Nebraska, Wyoming, and Colorado.

The usual method of observing was followed. Pendulums were swung in 12-hour periods, timed by two sidereal chronometers, whose rates were determined daily from the Western Union time signals. Pendulums were wiped before swinging. An extra pendulum was placed in the corner of the case in order that it might attain the proper temperature before swinging. At each


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1920
MAGNETIC OBSERVATIONS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
NORTON SOUND
St. Lawrence I.
YUKON RIVER
Porcupine R.
YUKON DIST.
ALASKA
BRITISH COLUMBIA
Juneau
Mt. St. Elias
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
Cook Inlet
Kodiak I.
GULF OF ALASKA
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BRISTOL BAY
BERING SEA
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN

C. & G. S. Print

station one pendulum was swung 24 hours and a second pendulum 48 hours. The same pendulums were never used at succeeding stations.

The pendulums were standardized at the beginning of the season and re-standardized at its close.

Eight stations were occupied during the season.

### DISTRICT OF COLUMBIA.

[E. W. EICKELBERG.]

Between January 21 and April 23, 1920, a determination was made at Washington, D. C., of the constants of invar pendulums.

In order to be able to take observations in the field at such places where the temperature control is poor, pendulums were constructed of invar on account of the low coefficient of expansion of that metal.

For the determination of temperature constants each pendulum was swung two days each at low and high temperatures, the pressure being held constant. Thus the difference in period obtained was due to the change in temperature. The dummy pendulum carrying the thermometer in invar filings was in the case and a third pendulum in the corner of the case. Swings were 12 hours in duration, the time being obtained from two chronometers corrected daily by Western Union Naval Observatory time. The pendulums were swung on knife-edge B1 in "B" receiver and also "A" receiver. The "B" receiver developed an air leak at high temperatures, which was finally located in the knob on the cover.

For the determination of the pressure constant each pendulum was swung for one day at high pressure and one day at low pressure.

The detailed results obtained from the pressure and temperature swings were tabulated. The change in period for 1° change in temperature with the aluminum-bronze pendulums is 41.5 in the seventh place. With the invar pendulums the change in period is 2.8 or about one-fifteenth that of the bronze. The pressure constant was found to be 10 per cent less than that of the aluminum-bronze pendulums.

## MAGNETIC WORK.

### MARYLAND (CHELTENHAM MAGNETIC OBSERVATORY).

[GEORGE HARTNELL.]

The regular work of the Cheltenham Magnetic Observatory has been satisfactorily continued throughout the year.

Earth inductor No. 26, after undergoing repairs in the instrument section of the Survey, was remounted and observations with it were begun January 5, observations with the substitute earth inductor No. 22 being discontinued. Earth inductor No. 26 has worked satisfactorily.

After three years' service without adjustment, Z variometer No. 5 was removed for cleaning, June 17. For the purpose of special investigations, it was mounted on a frame attached to pier B in the W wing. New pivots were inserted, measurements and deflections were made, and periods were observed. Many interesting facts were brought to light, and doubtless a report on this work would prove of value and interest to others. In general the performance of Z No. 5 has been exceptionally satisfactory.

The painting of the observatory buildings was completed in the middle of June. At the present time all the observatory buildings are in a good state of repair.

### ALABAMA, CONNECTICUT, INDIANA, KENTUCKY, MAINE, MARYLAND, MASSACHUSETTS, MICHIGAN, MISSISSIPPI, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, OHIO, PENNSYLVANIA, RHODE ISLAND, TENNESSEE, VERMONT, WEST VIRGINIA.

[W. W. MERRYMON.]

STATIONS OCCUPIED.—Alabama: Florence,* Tuscaloosa.* Connecticut: New London. Indiana: New Albany. Kentucky: Bowling Green.* Maine: Bangor,* Eastport,* Harrison,‡ Hiram,‡ Portland.* Maryland: Oakland.* Massachusetts: Newburyport †, Worcester.* Michigan: Detroit.* Mississippi: Jackson,* Meridian,* Wiggins. New Hampshire: Bradford,† Claremont Junction,‡ Contoocook,‡ Danbury,‡ Hanover,* Hillsboro, Windham Depot.‡ New Jersey: Trenton.* New York: Albany,* Buffalo,* Greenport, Ithaca,* Jamaica, Mineola, Norwich, Riverhead, Rochester,* Utica.† Ohio: Cincinnati,* McConnellsville.† Pennsylvania: Easton,* Harrisburg.* Rhode Island: Kingston,* Providence.* Tennessee: Nashville,* Vermont: Burlington,* Cambridge,‡ Hardwick,‡ Rutland,* St. Johnsbury,* West Burke.‡ West Virginia: Berkeley Springs, Middlebourne, Parkersburg.

Between July 1 and December 22, 1919, the three magnetic elements were determined at the places named. Old stations were reoccupied at the places marked by an asterisk (*). New stations were established and permanently marked at places marked by a dagger (†). Stations were occupied but not permanently marked at places marked by a double dagger (‡).

In the course of the work many local surveyors and engineers were met who showed much interest in the magnetic observations. Many requests for magnetic data were received.

### ARIZONA (TUCSON MAGNETIC OBSERVATORY).

[WILLIAM H. CULLUM.]

At the Tucson observatory the magnetic instruments have been in continuous operation except for short periods when it was necessary to adjust the instruments or make minor repairs.

Scale value observations were made at frequent intervals.

Absolute observations were made once each week.

The Bosch-Omori seismograph was in continuous operation except during the period from August 23 to November 16, when it was necessary to make certain repairs. Twelve earthquakes were recorded during the year.

Meteorologic observations were made daily.

Time signals for the correction of chronometers were obtained each week from the observatory at Mare Island, Calif.

### CUBA, FLORIDA, HAITI, PORTO RICO, SANTO DOMINGO, AND VIRGIN ISLANDS.

[WM. W. MERRYMON.]

STATIONS OCCUPIED.—Cuba: Guantanamo Bay, U. S. Naval Station, Habana (Casa Blanca Station), Habana (Jesuit Villa magnetic station), Brunell,† Fort Lauderdale,† Florida: Key West.* Haiti: Port au Prince.† Porto Rico: Mayaguez.† Santo Domingo: Porta Plata.†

While on his way to take charge of the magnetic observatory at Vieques, P. R., the observer assigned to that duty made magnetic observations at the stations named above.

Old stations reoccupied are indicated by an asterisk (*). New stations established and permanently remarked are indicated by a dagger (†).

The stations at Habana, Cuba (Jesuit Villa magnetic station), and Mayaguez, P. R., were approximately reoccupied.

### CALIFORNIA.

[H. E. MCCOMB.]

STATIONS OCCUPIED.—California: Alcatraz Island, Alameda, Angel Island, Fort Baker, Hunters Point, North Point, Point Bonita, Point Lobos, Red Rock, Sausalito and Yerba Buena Island (Goat Island).

Between October 31 and November 15, observations of the three magnetic elements were made at the stations in vicinity of San Francisco named above.

This work was done in connection with the laying out of compass ranges for San Francisco Bay.

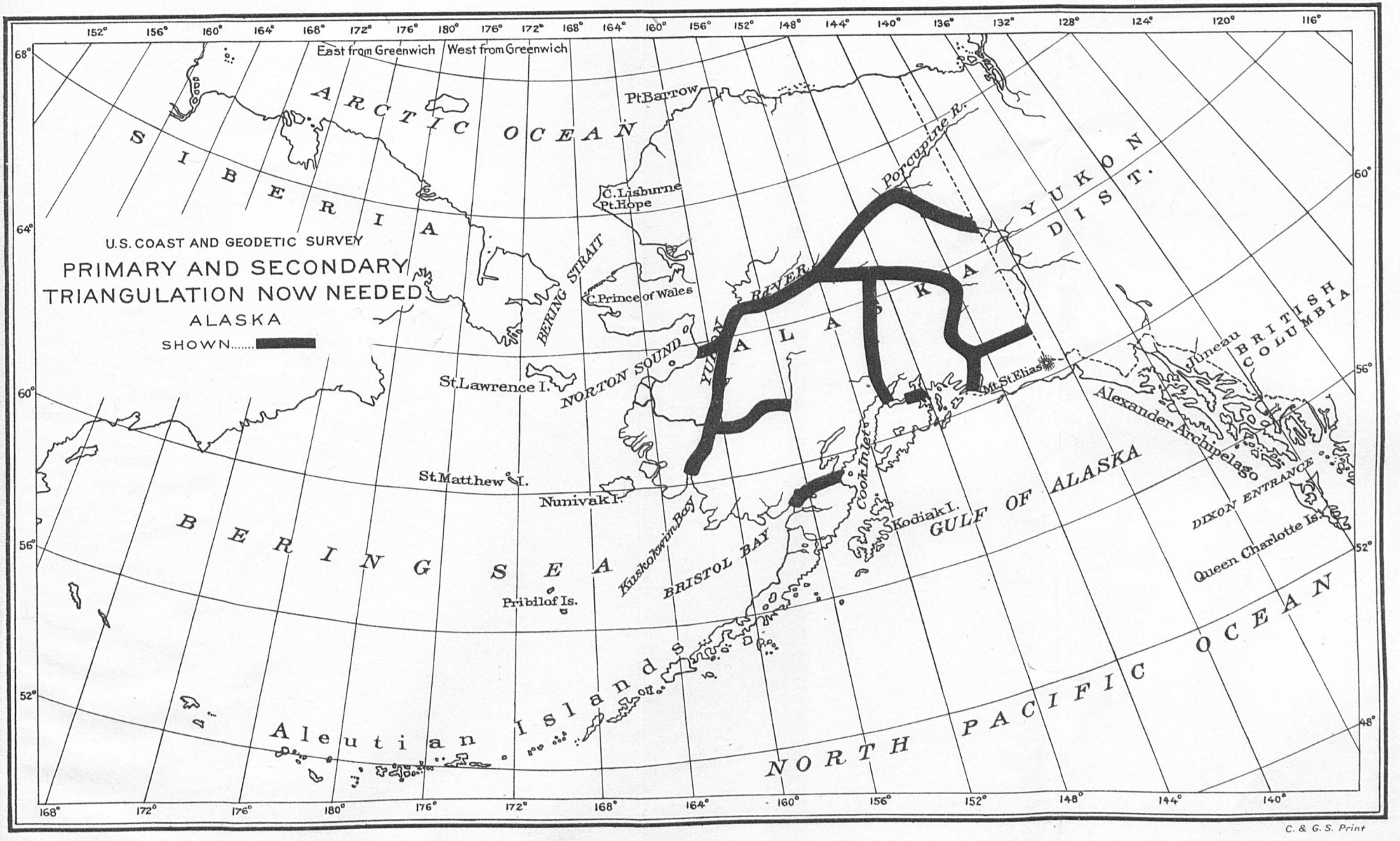
At Yerba Buena Island and Hunters Point comparison observations were made with magnetometer No. 40 and compass declinometer No. 4. Intensity observations were also made at Yerba Buena Island.

### ALASKA.

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

SUMMARY OF RESULTS.—Triangulation (secondary): 1,870 square miles of area covered, 24 signal poles erected, 12 observing scaffolds and tripods built, 18 stations in main scheme occupied for horizontal measures, 3 stations in supplemental schemes occupied for horizontal measures, 18 stations occupied for vertical measures, 59 geographic positions determined, 20 elevations determined trigonometrically. Topography: 28 miles of detailed shore line surveyed; 2 topographic sheets finished, scale 1:20,000. Hydrography: 305 square miles of area covered; 438 miles run while sounding; 194 positions determined (double angles); 296 soundings made; 2 tidal stations established; 1 hydrographic sheet finished, scale 1:20,000. Physical hydrography: 380 miles run in deep-sea sounding, 4 deep-sea soundings made, 3 specimens of bottom preserved.

The *Surveyor* left Seattle for Alaska on July 9, 1919. On July 12 the vessel stopped at Metlakatla and took on some dories which were needed for the


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

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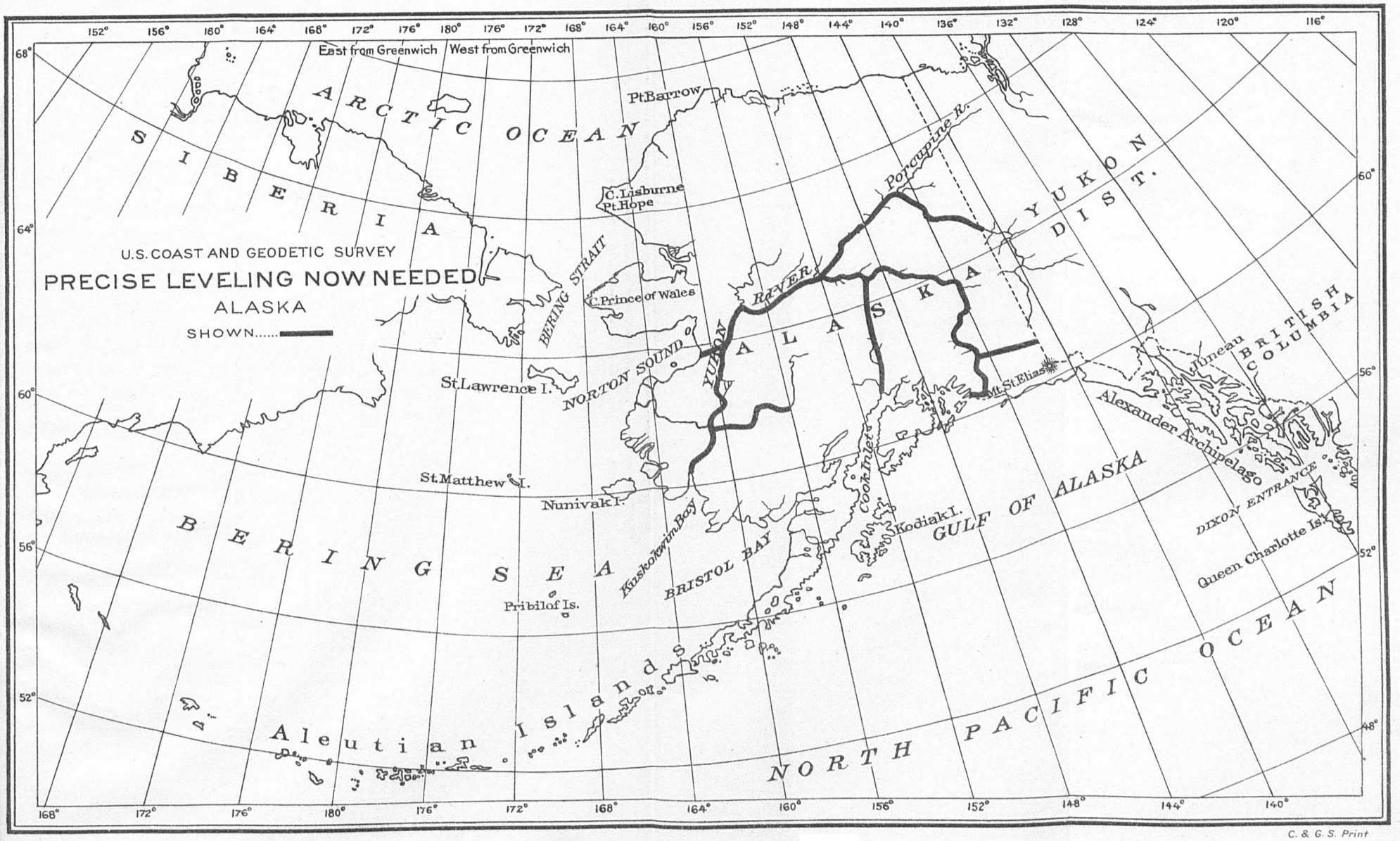
U.S. COAST AND GEODETIC SURVEY
PRECISE LEVELING NOW NEEDED
ALASKA
SHOWN.....
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
NORTON SOUND
St. Lawrence I.
YUKON RIVER
Porcupine R.
ALASKA
YUKON DIST.
BRITISH COLUMBIA
Juneau
Mt.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

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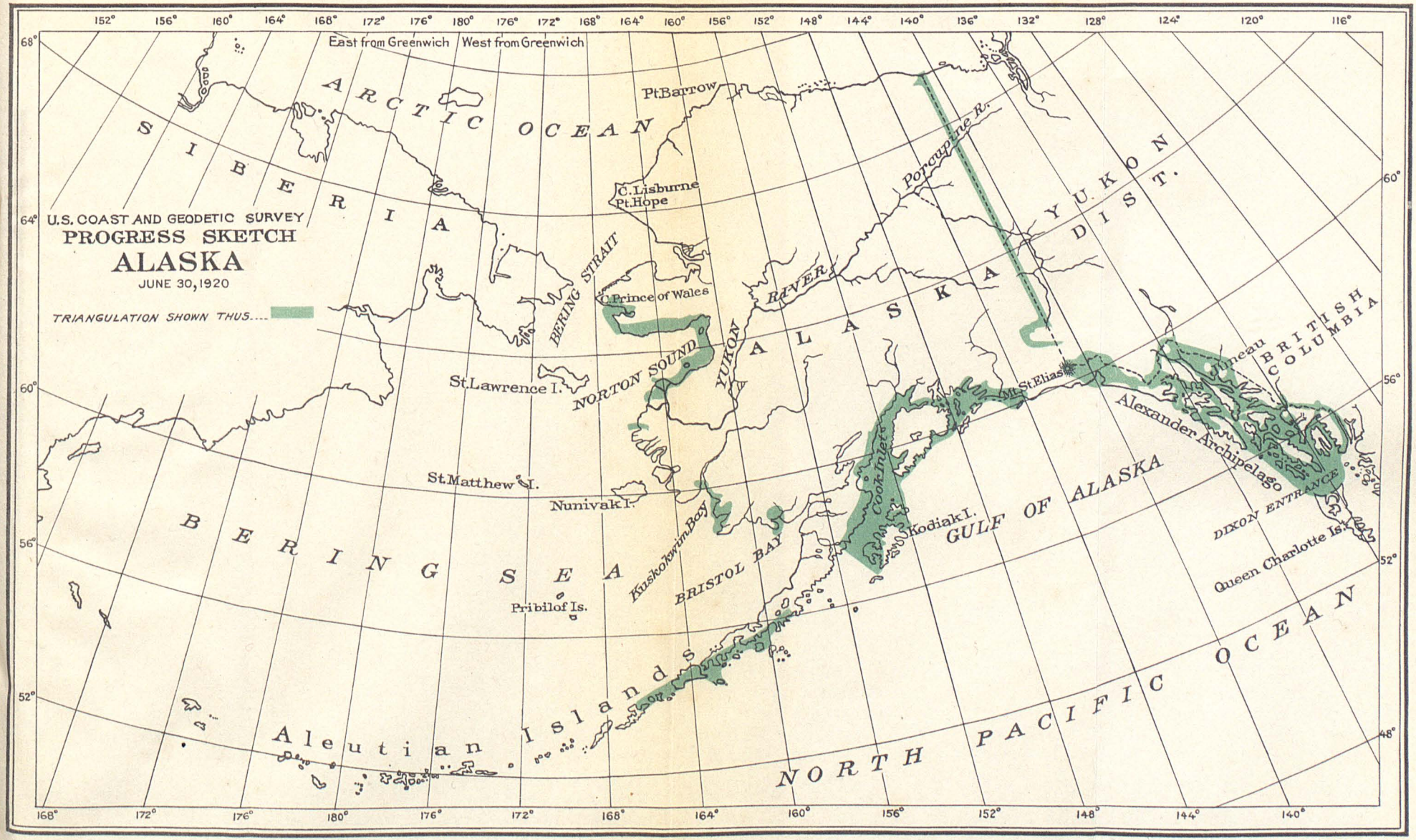
U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1920
TRIANGULATION SHOWN THUS....
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
YUKON RIVER
Porcupine R.
YUKON DIST.
ALASKA
BRITISH COLUMBIA
Juneau
Mt. St. Elias
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
NORTON SOUND
St. Lawrence I.
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BRISTOL BAY
Cook Inlet
Kodiak I.
GULF OF ALASKA
BERING SEA
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN

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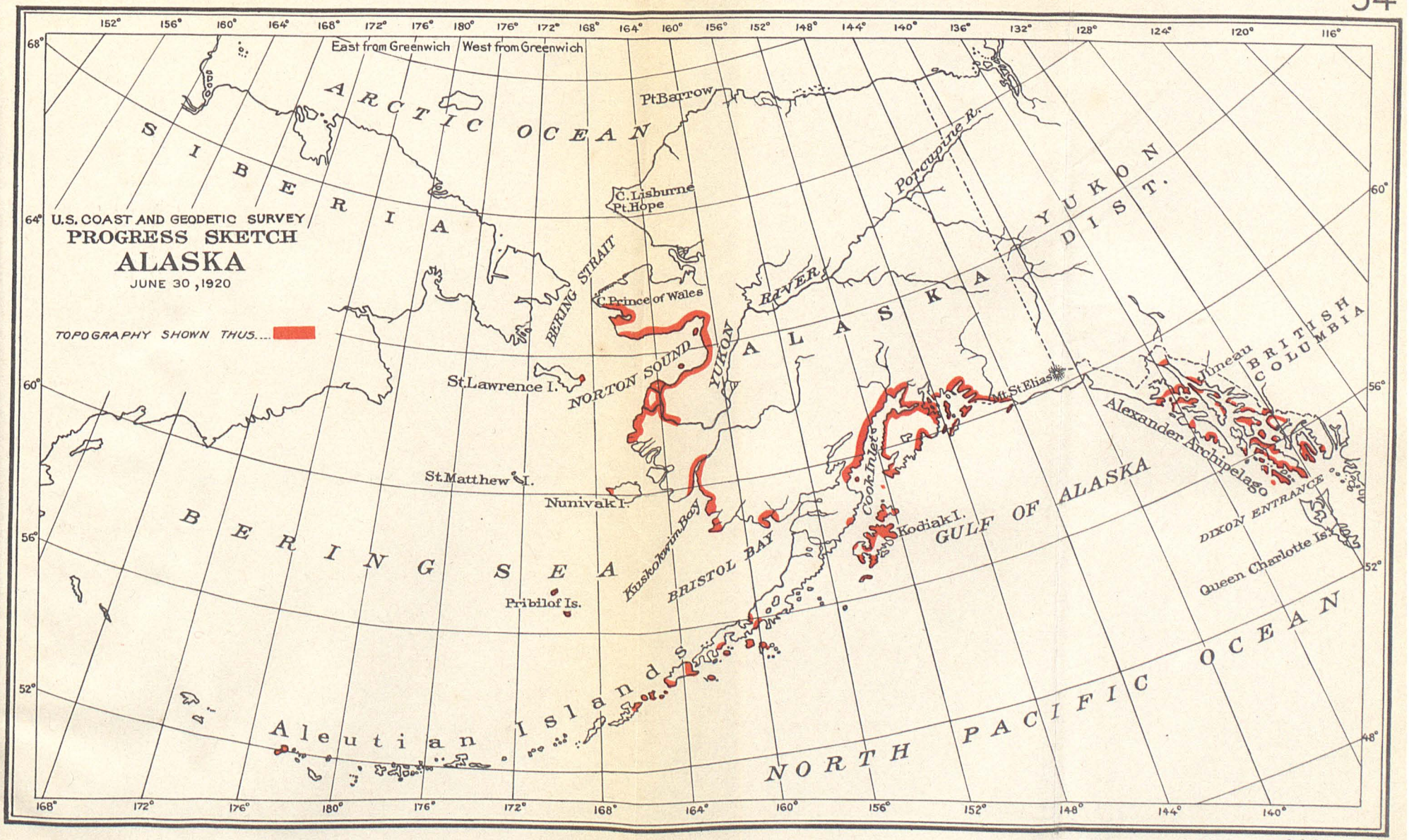
U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1920
TOPOGRAPHY SHOWN THUS....
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
NORTON SOUND
YUKON RIVER
Porcupine R.
YUKON DIST.
ALASKA
BRITISH COLUMBIA
Juneau
Mt. St. Elias
Alexander Archipelago
St. Lawrence I.
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BERING SEA
BRISTOL BAY
Cook Inlet
Kodiak I.
GULF OF ALASKA
DIXON ENTRANCE
Queen Charlotte Is.
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN

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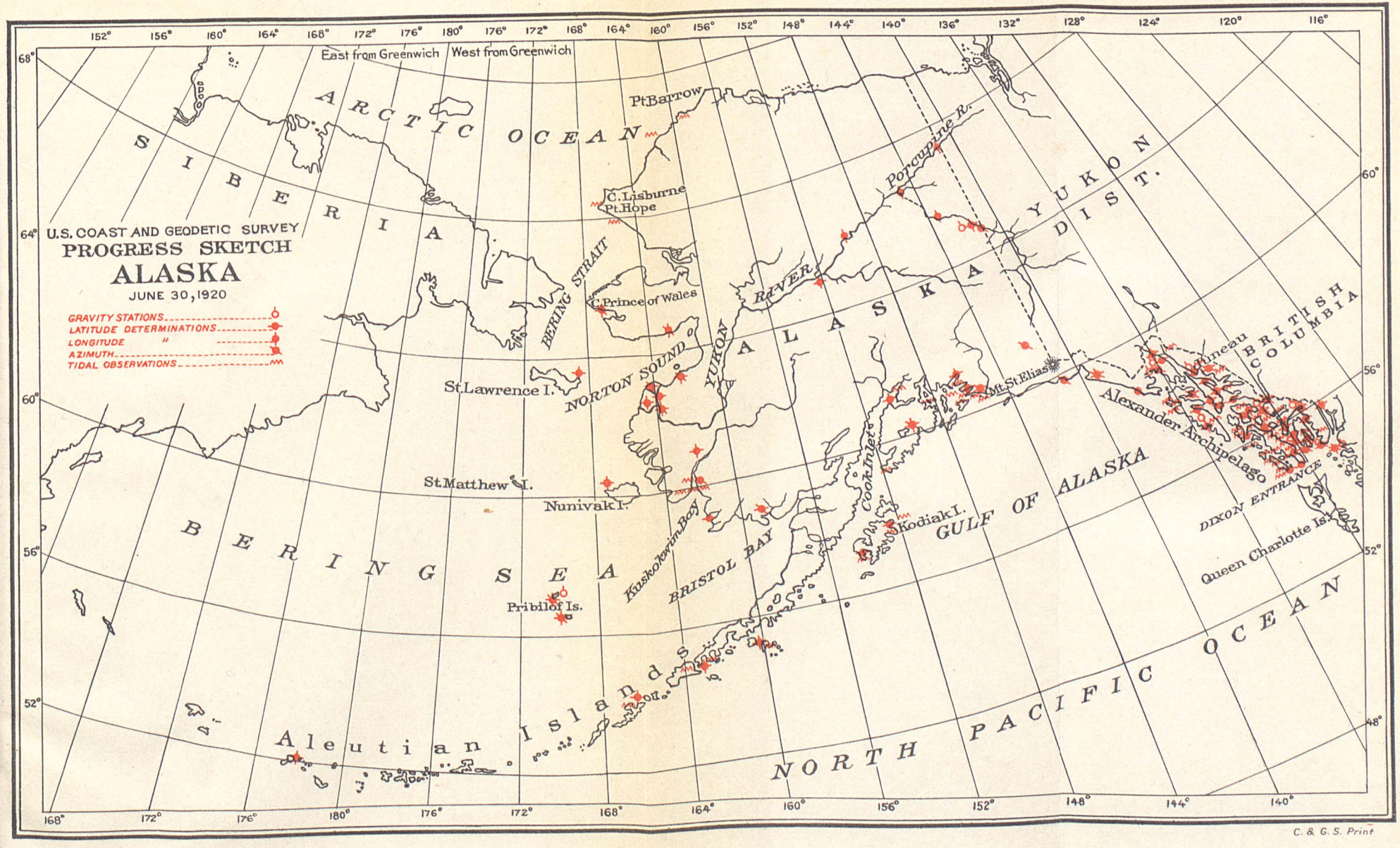

U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1920
GRAVITY STATIONS
LATITUDE DETERMINATIONS
LONGITUDE "
AZIMUTH
TIDAL OBSERVATIONS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
St. Lawrence I.
NORTON SOUND
YUKON RIVER
Porcupine R.
YUKON DIST.
ALASKA
Mt. St. Elias
Juneau
BRITISH COLUMBIA
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
Cook Inlet
Kodiak I.
GULF OF ALASKA
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BRISTOL BAY
BERING SEA
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN

C. & G. S. Print

season's work. On July 14 the first deep-sea sounding was taken. Work was completed in the vicinity of Shelikof Straits on October 9, and the vessel left Kodiak on the following day for revision work at Sitka, which was commenced on the 27th and completed on the 28th of October. The vessel sailed for Seattle October 29, and arrived November 4.

In accordance with instructions a line of deep-sea sounding was carried across the Gulf of Alaska from Cape Ommaney to Kodiak Island. These soundings were located by sights and dead reckonings. On the return trip only one sounding was taken. The soundings were taken with a Sigsbee deep-sea sounding machine.

It was planned to keep as many parties in the field as the complement and surveying equipment on board would allow. For this reason a subparty was operating from a camp in Kuiukta Bay extending the triangulation to the eastward. This scheme was necessarily made up of small figures needing neither heliotropes nor night signals. Four observers were kept in camps during the greater part of the season, observing in the main scheme in Shelikof Straits. The executive officer did some observing and most all of the reconnoissance, while other observers were carrying forward the work. At no time did the reconnoissance, which by no means was easy, interfere with the progress. During the last part of the season while four observers were occupying stations of the last quadrilateral in Shelikof Straits, the executive officer with a subparty made the reconnoissance and built and marked the stations for connecting the work in Alitak Bay with that of Shelikof Straits. When no delay would be caused to the work of carrying forward the triangulation the ship was used for hydrographic work, and at all anchorages current observations were made. On runs from Shelikof Straits to Alitak Bay and also to Kuiukta Bay reconnoissance soundings were made. As the supply of oil which could be furnished by the Pacific Steamship Co. was limited and the cost great, the vessel was used as little as possible in other than triangulation work.

The principal work called for in the instructions was the connection of triangulation extending from the work previously done in Shelikof Straits with that which had been done as far east as Mitrofania. This was a stretch of shore line of approximately 175 miles. The work was commenced when the days were becoming appreciably shorter. The season was a very short one. It was desired to accomplish this work if possible. Owing to the short time available the only possible way of doing this during the season was to find a point on Kodiak Island which would be intervisible with one of the Semidi Islands, or possibly by expanding to a line from a point on the main land to the triangulation station Dome located on the highest point on Sitkinak Island. Although the available heights indicated that the Semidi Islands would not be intervisible from any point on Kodiak Island or any of the Trinity Island group, it was reported from local sources that a man who spent a number of seasons on the Semidi Islands stated that on clear days he often saw the mountain ranges on Kodiak Island from the highest point of Aghiyuk Island. With the possibility that they might see one of the group of Semidi Islands a reconnoissance party was left on Sitkinak Island for a period of approximately 10 days, but during that time they had very bad weather, and they were finally picked up and this plan given up. As only four observers could be used on the main scheme in extending the work of triangulation of 1908 in Shelikof Straits, and in view of the number of observers and instruments available, it was decided to put a subparty in Kuiukta Bay to extend the work done by the party on the *Patterson* in 1914 through to Chignik Bay. This party was provisioned for four weeks and the motor whaleboat, the only dependable launch, with the exception of the motor sailboat, was left with them.

The last line determined in the triangulation of 1908 was from Kubugakli to Karluk. The former station was recovered as described, but the latter station had been caried away by the eroding of the cliff forming Cape Karluk. This necessitated reoccupying Ilktugitak and Uyak, and observing directions to the new station established on Cape Karluk. The next quadrilateral was from the line Kubugakli, Karluk (1919), to line Kekurnoi, Ridge. Ridge was selected so that it could be used for the connection of the triangulation in Shelikof Straits with the independent triangulation done in Alitak Bay in 1906. To find a point to meet these requirements necessitated two or three days of reconoissance, as the land south of Cape Kekurnoi is quite high and irregular. Karluk as seen from Ridge shows through a gap in these hills, and the party was very fortunate in being able to locate any station which would meet the double requirements mentioned above. The next figure was to

have extended from the line Ridge, Kekurnoi to a triangulation point on Cape Unalishagvak to Ikolik. The side Ridge to Ikolik was used for a base from which to extend a scheme to join the triangulation done in Alitak Bay. The strength of the determination of this side was increased by a supplementary chain of figures extending down the west coast of Kodiak Island and including Sturgeon, Grant, and Middle. Two points were selected on Cape Unalishagvak to make a base from which a scheme of quadrilaterals could be extended in small figures down the Alaska Peninsula to join the work of 1914. This base would be only 3½ miles in length, and it is short for going ahead. There is a mountain about 4 miles back from Cape Unalishagvak that could and probably will be used which gives a base of 7 or 8 miles. A camp was established at Kubligakli on October 15, and on the following day an observing party was landed at Ikolik and on the succeeding day on Unalishagvak. Observation parties had been in camp at Ridge since August 21. These parties were constantly at the station during any good weather, but although they were in camp 25 days no observer succeeded during that period in seeing a heliotrope at any station across the straits. As it was getting late in the season the strength of the whole party was occupied in completing the connection of the triangulation with that in Alitak Bay, and there were no days after these camping parties were picked up until leaving the working grounds when any of the long lines of the quadrilateral could have been observed.

Kuiukta Bay: The triangulation was carried from the line Village-Gray to the line Portage-Mud, which looks down Chignik Lagoon. However, Mud was marked only by a small nail driven in the top of a 3 by 3 stake and its location is too weak. Mud was built in foggy weather, and it was hoped that it would see Bobby. Bobby sees a part of Chignik Lagoon. Determination of Mud can be strengthened by the interlocking of figures and observed from Bobby, Castle, and Portage. The portage from Kuiukta Bay to Chignik Lagoon is made by five or six natives with two light skiffs in two days. The walk across is hard, wet, and a half day's job. The observing was done with a 7-inch repeating theodolite. Except at Village only one set was taken. Because of the time required to reach stations (due to elevation and distance two sets and a round of angles could not be taken at one trip. Castle and Kuiukta were observed on days that were thick till noon and in a strong wind. Portage was observed after the ship had come during the forenoon. The fog bank was within a half mile when observing finished at Bobby. The only good days lost were in trying to climb stations Let and Gray from Foote Bay. Much of the signal building and marking of stations was done on rainy or thick days.

Four observers were used in the completion of this work, which was accomplished in four days. The distance between the two bases was 30 nautical miles. The country is high and travel difficult.

A limited amount of hydrography was accomplished from Cape Uyak south to Halibut Bay. The equipment for taking soundings at 100 fathoms or thereabouts was incomplete. Reconnoissance sounding lines were run along the south shore of Kodiak Island and between Kodiak Island and Chignik.

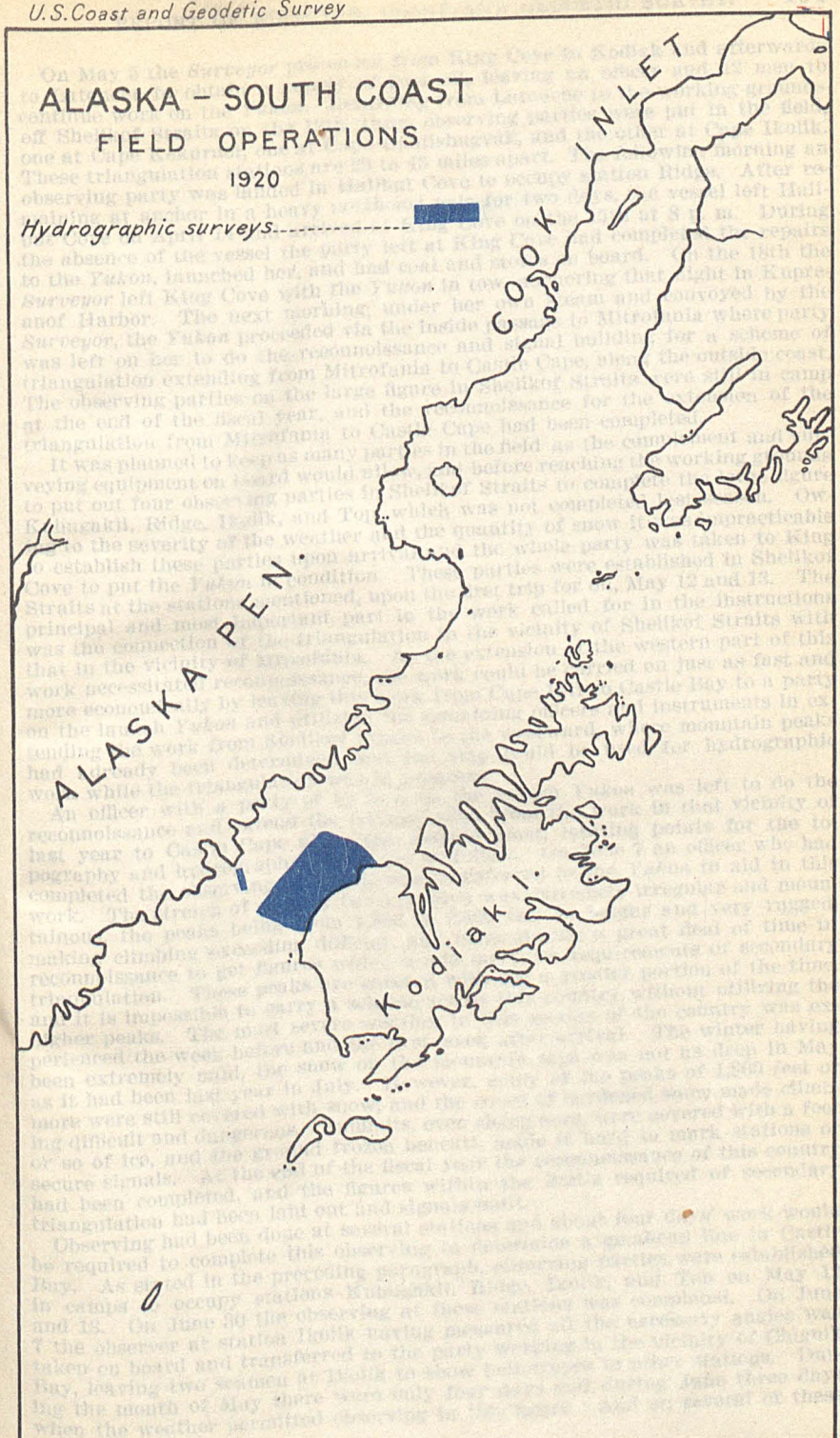
Automatic tide gauges were established and observers employed at Kodiak and Baralof Bay. The old bench marks at Kodiak were connected by levels to tide staffs installed and two new ones established. In Baralof Bay three bench marks were established and connected with a line of levels to the tidal station.

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

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 60 miles, 500 square miles of area covered, 25 lines of intervisibility determined, 16 points selected for scheme. Triangulation: 825 square miles of area covered, 14 signal poles erected, 8 stations in main scheme occupied for horizontal measures, 4 stations occupied for vertical measures. Magnetic observations: Ship swung at 1 station at sea. Hydrography: 350 square miles of area covered, 179.9 miles run while sounding, 240 positions determined (double angles), 240 soundings made, 2 tide stations occupied.

From January 1 to March 30, 1920, the *Surveyor* was at Seattle, Wash., undergoing repairs and outfitting for the season's work in Alaska.

The vessel sailed for the working grounds in Alaska March 31, and arrived at Ketchikan April 4. Leaving Ketchikan April 10, the *Surveyor* arrived at Kodiak April 15, and thence proceeded to Uyak and Baralof Bay to where a tidal gauge was put in operation, and a supply of fresh water was obtained. On April 19 the *Surveyor* proceeded to King Cove, and work was begun of putting the launch *Yukon* in commission.


ALASKA – SOUTH COAST
FIELD OPERATIONS
1920
Hydrographic surveys
COOK INLET
ALASKA PEN.
Kodiak I.

On May 5 the *Surveyor* proceeded from King Cove to Kodiak and afterwards to Latouche to obtain a supply of fuel oil, leaving an officer and 12 men to continue work on the *Yukon*. Returning from Latouche to the working grounds off Shelikof Straits on the 12th, three observing parties were put in the field, one at Cape Kekurnoi, one at Cape Unalishagvak, and the other at Cape Ikolik. These triangulation stations are 25 to 45 miles apart. The following morning an observing party was landed in Halibut Cove to occupy station Ridge. After remaining at anchor in a heavy northeast gale for two days, the vessel left Halibut Cove on April 14 and arrived at King Cove on the 15th at 8 p. m. During the absence of the vessel the party left at King Cove had completed the repairs to the *Yukon*, launched her, and had coal and stores on board. On the 18th the *Surveyor* left King Cove with the *Yukon* in tow, anchoring that night in Kupreanof Harbor. The next morning, under her own steam and convoyed by the *Surveyor*, the *Yukon* proceeded via the inside passage to Mitrofania where party was left on her to do the reconnoissance and signal building for a scheme of triangulation extending from Mitrofania to Castle Cape, along the outside coast. The observing parties on the large figure in Shelikof Straits were still in camp at the end of the fiscal year, and the reconnoissance for the extension of the triangulation from Mitrofania to Castle Cape had been completed.

It was planned to keep as many parties in the field as the complement and surveying equipment on board would allow, and before reaching the working grounds to put out four observing parties in Shelikof Straits to complete the large figure Kubugakli, Ridge, Ikolik, and Top, which was not completed last season. Owing to the severity of the weather and the quantity of snow it was impracticable to establish these parties upon arrival and the whole party was taken to King Cove to put the *Yukon* in condition. These parties were established in Shelikof Straits at the stations mentioned, upon the first trip for oil, May 12 and 13. The principal and most important part in the work called for in the instructions was the connection of the triangulation in the vicinity of Shelikof Straits with that in the vicinity of Mitrofania. As the extension of the western part of this work necessitated reconnoissance, the work could be carried on just as fast and more economically by leaving this work from Cape Ikti to Castle Bay to a party on the launch *Yukon* and utilizing the remaining officers and instruments in extending the work from Shelikof Straits to the westward, where mountain peaks had adready been determined and the ship could be used for hydrographic work while the triangulation was in progress.

An officer with a party of 12 men on the launch *Yukon* was left to do the reconnoissance and extend the triangulation from the work in that vicinity of last year to Castle Cape along the outside coast, locating points for the topography and hydrography which was to follow. On June 7 an officer who had completed the observing at Ikolik was transferred to the *Yukon* to aid in this work. The stretch of country to be covered was extremely irregular and mountainous, the peaks being from 1,800 to 2,400 feet in height and very rugged, making climbing exceeding difficult, and necessitating a great deal of time in reconnoissance to get figures which would meet the requirements of secondary triangulation. These peaks are covered with fog a greater portion of the time, and it is impossible to carry a scheme across this country without utilizing the higher peaks. The most severe weather in this section of the country was experienced the week before and the first week after arrival. The winter having been extremely mild, the snow on the mountain tops was not as deep in May as it had been last year in July. However, many of the peaks of 1,800 feet or more were still covered with snow, and the cones of hardened snow made climbing difficult and dangerous. Summits, even sharp ones, were covered with a foot or so of ice, and the ground frozen beneath made it hard to mark stations or secure signals. At the end of the fiscal year the reconnoissance of this country had been completed, and the figures within the limits required of secondary triangulation had been laid out and signals built.

Observing had been done at several stations and about four days' work would be required to complete this observing to determine a go-ahead line in Castle Bay. As stated in the preceding paragraph, observing parties were established in camps to occupy stations Kubugakli, Ridge, Ikolik, and Top on May 12 and 13. On June 30 the observing at these stations was completed. On June 7 the observer at station Ikolik having measured all the necessary angles was taken on board and transferred to the party working in the vicinity of Chignik Bay, leaving two seamen at Ikolik to show heliotropes to other stations. During the month of May there were only four days and during June three days when the weather permitted observing in this figure. And on several of these

days at one or more of the stations it was impossible owing to weather conditions to either observe or show heliotropes. At least three sets and in most cases five sets of six repetitions each were measured from each angle. In only one case was the signal pointed on, in all other heliotropes were observed. The average closure was 4.8 seconds, barely in the limits of tertiary work. The same instructions as were furnished to observers last year were furnished this year and complied with. Upon the completion of this figure a base of moderate length can be determined on Cape Unalishagvak from which the work can be extended to the southward and westward.

The area of Shelikof Straits from Cape Uyak south to Halibut Cove not covered by the hydrography of last year was completed during this fiscal year. Tide gauges at Kodiak and Barilof Bay were repaired.

[N. H. HECK, Commanding Steamer *Explorer*.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 50 miles, 405 miles of area covered, 66 lines of intervisibility determined, 22 points selected for scheme. Triangulation (tertiary): 350 square miles of area covered, 31 signal poles erected, 16 stations in main scheme occupied for horizontal measures, 9 stations in supplemental scheme occupied for horizontal measures, 35 geographic positions determined. Leveling: 9 permanent bench marks established. Magnetic work: 15 land stations occupied for magnetic declinations. Topography: 1.5 square miles of area surveyed, 41 miles of general coast line surveyed, scale of topographic sheets 1:20,000. Hydrography: 127.5 square miles of area dragged, 190.4 miles run while dragging, 3,351 angles measured, scale of hydrographic sheet 1:40,000.

In the latter part of February, 1920, preparations were begun to fit the steamer *Explorer* and launches for work on the coast of Alaska. It was intended to use the *Explorer* for transporting the wire-drag party.

The launches *Scandinavia* and *Helianthus* and tender were also prepared for this work.

Preparations being finally completed the vessels and launches left Seattle on April 16. On the way to Juneau, Alaska, a brief stop was made at Ketchikan to make repairs to the *Scandinavia*. At Ketchikan courtesies, including the use of the new lighthouse dock, were extended by the inspector of lighthouses for that district. On the way to Juneau the sales agency at Petersburg was inspected.

After completing the necessary preparations at Juneau field work was begun on June 6 and was in progress at the end of that month.

The triangulation included the main scheme of the proposed primary triangulation connecting the work of two parties in 1917. The reconnoissance was thus primary in character, though the triangulation to be executed was tertiary. There was only one point of serious difficulty near Point Lookout. After testing out various apparent possibilities a short line appeared the only solution. All figures of the scheme are quadrilaterals of the required strength. It is of interest to note that the points just south of Taku Harbor, where the last line of the previous work was located as selected by the *Explorer's* party, were found to have been already marked though not cleared or occupied.

Signal building has been completed for the entire main scheme and for the supplemental scheme south of the line Port Windham-Port Hugh, except possibly for a little work in the vicinity of Cape Fanshaw, where a little unfinished wire-drag work and topography of a previous season remains to be done.

Triangulation has been completed for all but a few of the main scheme stations. The supplemental scheme has been completed south of the line Port Windham-Port Hugh.

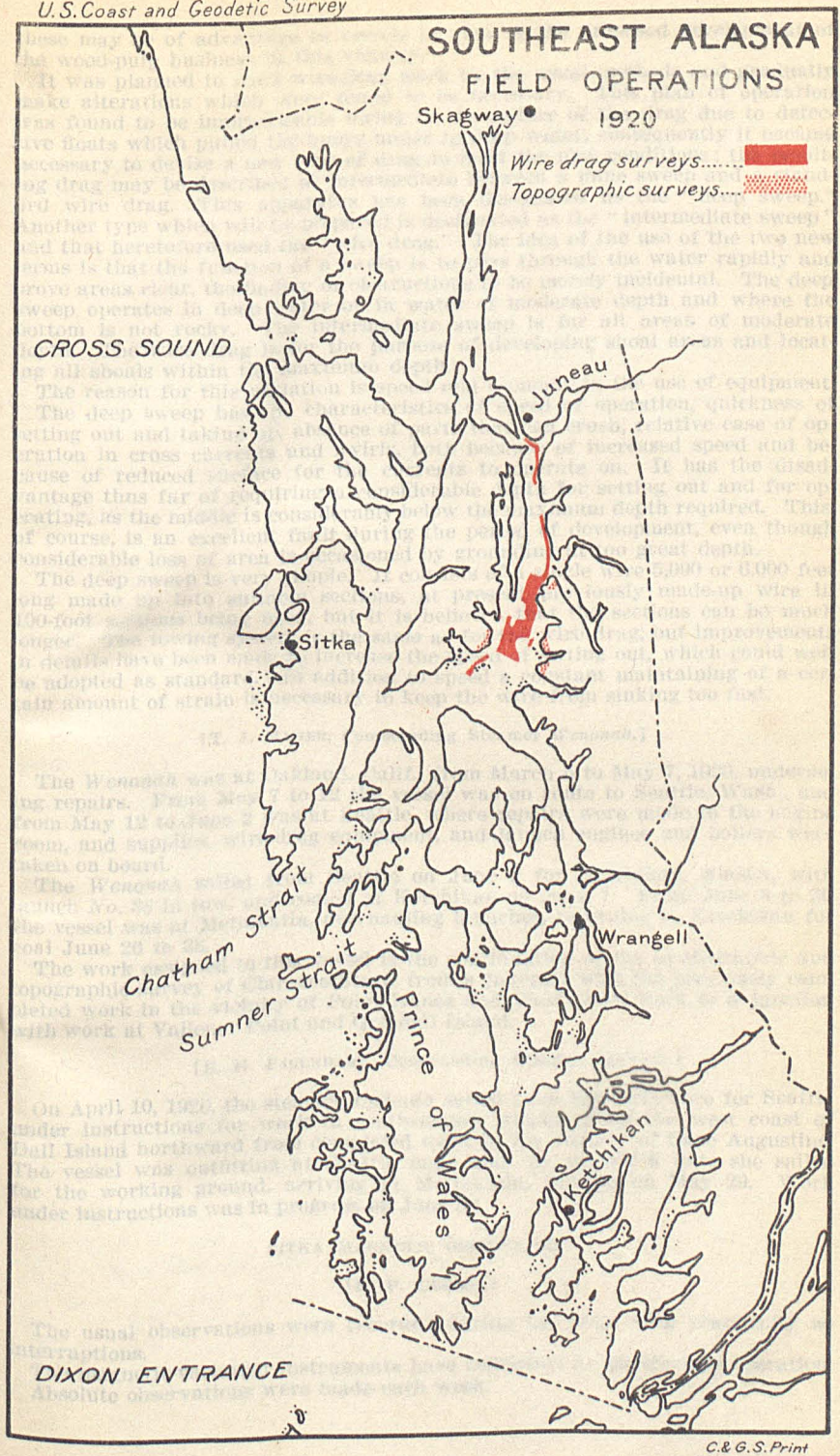
The topographic sheet from Pybus Bay to Seymour Canal is nearly finished. The sheet Port Hobart to Port Windham is well under way. Work has begun on the sheet Port Hugh to Port Coke. It has been necessary for the topographic party to work in the vicinity of the vessel and this explains the change of sheets instead of following the more desirable policy of finishing a sheet at a time.

Magnetic declination has been measured at all of the main scheme stations occupied.

An automatic tide gauge has been in operation at Taku Harbor since May 15. This locality was selected because of the possibility of constant attention by a careful observer at a moderate cost, possibility of satisfactory installation on a suitable wharf which would make it possible to continue the series if desired beyond the limits of the present season, and because of the prevalence of ice at times in all parts of the entrance to Holkam Bay.

Two staff gauges were installed and others made ready for installation.

A record of all important details in regard to anchorages used was kept. Good weather anchorages are more numerous than the chart indicates, and


SOUTHEAST ALASKA
FIELD OPERATIONS
1920
Skagway
Wire drag surveys
Topographic surveys
CROSS SOUND
Juneau
Sitka
Chatham Strait
Sumner Strait
Prince of Wales
Wrangell
Ketchikan
DIXON ENTRANCE

these may be of advantage to vessels in view of the proposed development of the wood-pulp business in this vicinity.

It was planned to start wire-drag work by the usual methods and gradually make alterations which were found to be necessary. This plan of operation was found to be impracticable owing to the failure of the drag due to defective floats which pulled the buoys under in deep water, consequently it became necessary to devise a new type of drag to meet the new conditions; the resulting drag may be described as intermediate between a mine sweep and a standard wire drag. This apparatus has been designated as the "deep sweep." Another type which will be prepared is designated as the "intermediate sweep" and that heretofore used the "wire drag." The idea of the use of the two new terms is that the function of a sweep is to pass through the water rapidly and prove areas clear, the finding of obstructions to be merely incidental. The deep sweep operates in deep water or in water of moderate depth and where the bottom is not rocky. The intermediate sweep is for all areas of moderate depth. The wire drag is for the purpose of developing shoal areas and locating all shoals within the maximum depth.

The reason for this variation is speed and economy in the use of equipment.

The deep sweep has the characteristics of speed of operation, quickness of setting out and taking up, absence of parts that can crush, relative ease of operation in cross currents and swirls, both because of increased speed and because of reduced surface for the currents to operate on. It has the disadvantage thus far of requiring a considerable depth for setting out and for operating, as the middle is considerably below the maximum depth required. This, of course, is an excellent fault during the period of development, even though considerable loss of area is occasioned by grounding at too great depth.

The deep sweep is very simple. It consists of a single wire 5,000 or 6,000 feet long made up into suitable sections, at present previously made-up wire in 100-foot sections being used, but it is believed that the sections can be much longer. The towing system is the same as for the wire drag, but improvements in details have been made to increase the speed of setting out, which could well be adopted as standard. In addition to speed a constant maintaining of a certain amount of strain is necessary to keep the wire from sinking too fast.

[T. J. MAHER, Commanding Steamer *Wenonah*.]

The *Wenonah* was at Oakland, Calif., from March 5 to May 7, 1920, undergoing repairs. From May 7 to 12 the vessel was en route to Seattle, Wash., and from May 12 to June 2 was at Seattle, where repairs were made to the engine room, and supplies, wire-drag equipment, and launch engines and boilers were taken on board.

The *Wenonah* sailed from Seattle on June 2 for Ketchikan, Alaska, with launch *No. 38* in tow, and coaled at Ketchikan on June 7. From June 8 to 30 the vessel was at Metlakatla, overhauling launches, returning to Ketchikan for coal June 26 to 28.

The work assigned to this vessel is the continuation of the hydrographic and topographic survey of Clarence Strait from a junction with the previously completed work in the vicinity of Point Nunez and West Devil Rock to a junction with work at Vallenar Point and Grindall Island.

[E. H. PAGENHART, Commanding Steamer *Lydonia*.]

On April 10, 1920, the steamer *Lydonia* sailed from San Francisco for Seattle under instructions for work in southeastern Alaska along the west coast of Dall Island northward from completed work in the vicinity of Cape Augustine. The vessel was outfitting at Seattle until May 25, on which date she sailed for the working ground, arriving at Metlakatla, Alaska, on May 29. Work under instructions was in progress on June 30.

## SITKA MAGNETIC OBSERVATORY.

[F. P. ULRICH.]

The usual observations were recorded during the year, with practically no interruptions.

The magnetic-variation instruments have continued in satisfactory operation. Absolute observations were made each week.

Time corrections were obtained weekly at the local cable office of the United States Signal Corps.

The seismograph was kept in continuous operation, and seven shocks were recorded during the year.

Meteorological observations, including temperature and barometer readings, state of the weather, and other phenomena, were continued.

Necessary repairs were made to the observatory buildings.

## HAWAIIAN ISLANDS.

### HONOLULU MAGNETIC OBSERVATORY.

[FRANK NEUMANN, July 1, 1919, to Nov. 24, 1919. H. E. MCCOMB, Nov. 25, 1919, to June 30, 1920.]

At the magnetic observatory at Ewa, Hawaii, a practically continuous record was obtained of the magnetic declination and horizontal and vertical intensity.

Absolute observations for the reduction of these records were made weekly.

Meteorologic observations were made daily, and time observations for the correction of chronometers were made every week or 10 days.

The Milne seismograph was kept in continuous operation.

In May and June comparison observations were made with magnetometers Nos. 36 and 40.

Necessary improvements and repairs were made to the observatory buildings and grounds.

## PHILIPPINE ISLANDS.

[HUGH C. DENSON, Director of Coast Surveys.]

The four steamers in the service of the Bureau were kept at work in the field continuously, except when repairs became necessary. The time so lost to field work was utilized in bringing up the office work of computations and drawings.

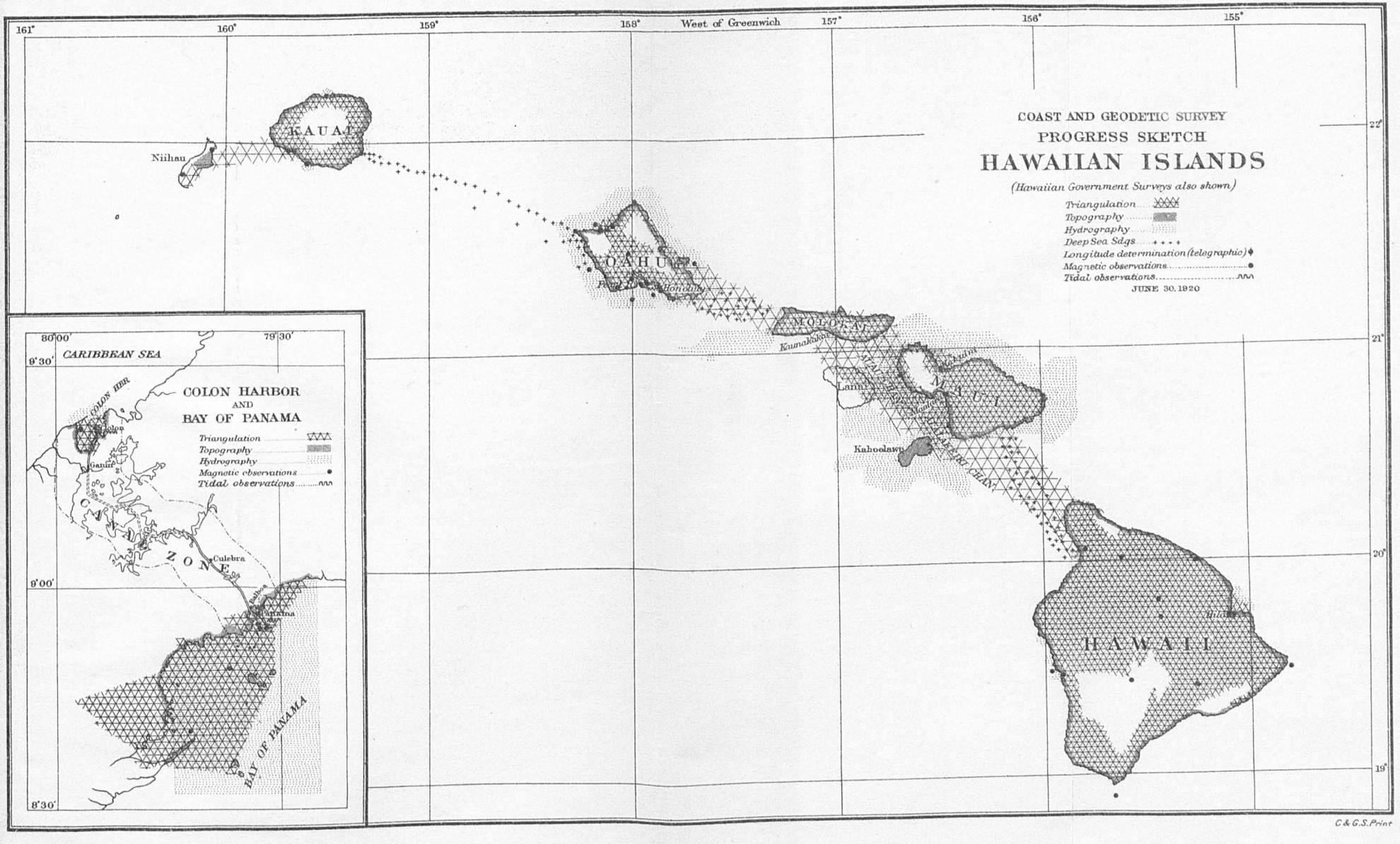
Owing to the fact that the unsurveyed regions of the islands are at greater distances from bases of supply than those regions already surveyed, it is evident that the cost of operations in the future will increase, chiefly on account of the higher price of coal. The inability to obtain bottoms to transport coal to the outlying districts necessitates longer runs of the surveying vessels to supply stations. This condition causes a great loss of time from field operations and greatly adds to the expense of operation. The privilege, as heretofore granted, of obtaining coal from the Navy has been discontinued by orders from the Navy Department, and the Bureau is now compelled to purchase coal for its vessels either from the Bureau of Supply, at a high price, or from Sandakan, Borneo, at which place an inferior grade of coal may be obtained at lower price.

At the request of the governor of the Department of Mindanao and Sulu, two vessels, the *Pathfinder* and *Marinduque*, were assigned for work on the west coast of Mindanao between Dapitan and Zamboanga. This work was made possible by the cooperation of the governor, who agreed to furnish coal to the surveying vessels from the Government coaling station at Caldera Bay, near Zamboanga.

On account of the inadequate allotment for party expenses made by the Federal Government for the period January 1 to June 30, it was necessary for the vessel whose operating expenses are paid from this fund to engage in work convenient to the Sandakan coaling station. The Philippine Government has made an ample appropriation for this Bureau to meet the present conditions.

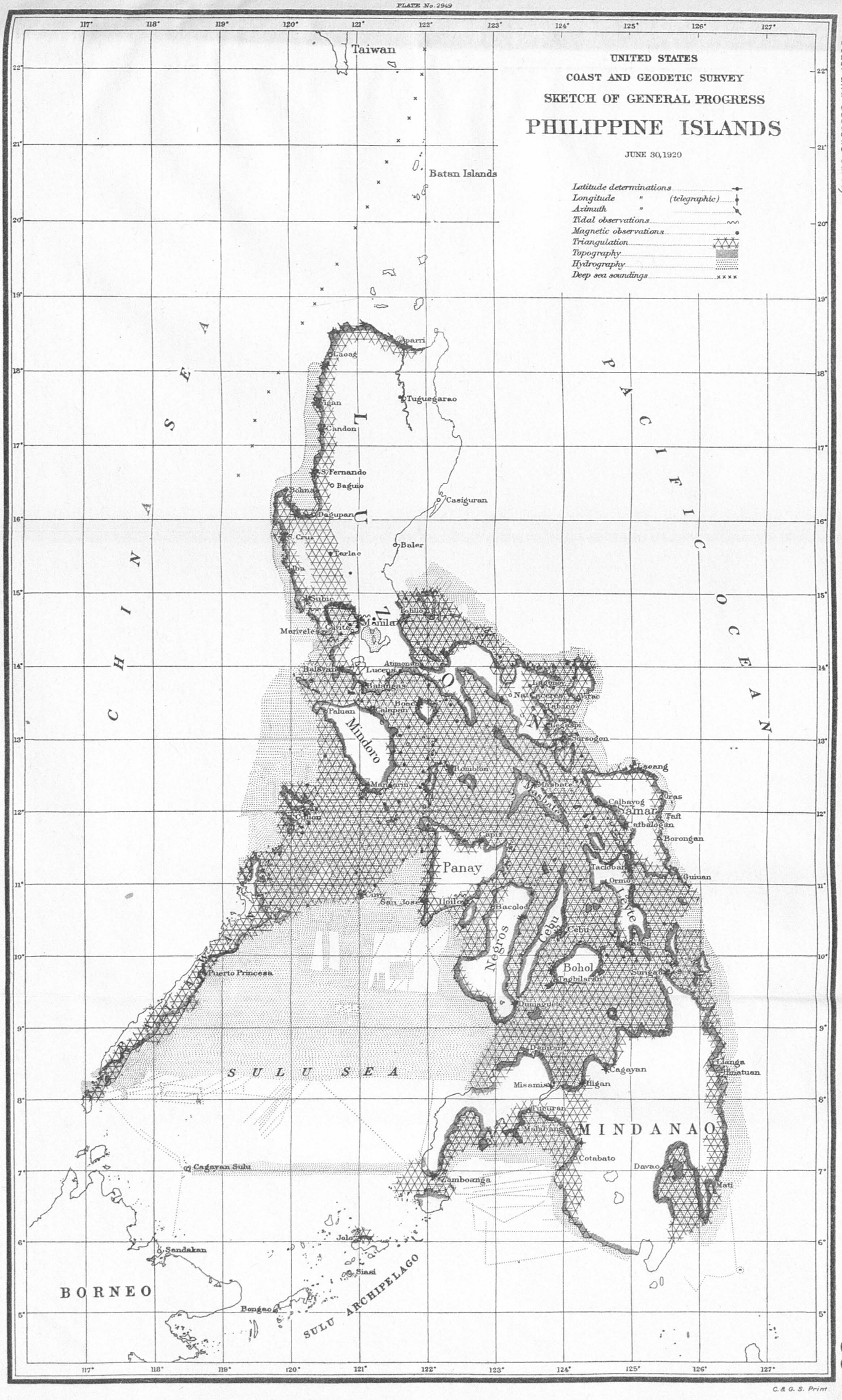
The steamer *Marinduque* was transferred to the insular Bureau of Labor on March 19, 1918, and was returned on July 7, 1919, to the Bureau of Coast and Geodetic Survey. While in charge of the Bureau of Labor the *Marinduque* was used as an interisland cargo carrier, and many alterations were made to the interior of this vessel to adapt it to this usage.

The condition of the vessel when returned to the Bureau of Coast and Geodetic Survey, was not found as good as expected, and much time was occupied in partially restoring the vessel to such a condition that it would be fitted to resume the work of this Bureau in which it had been previously engaged. The work of repairs completed was only such as placed the vessel in a sea-


COAST AND GEODETIC SURVEY
PROGRESS SKETCH
HAWAIIAN ISLANDS
(Hawaiian Government Surveys also shown)
Triangulation
Topography
Hydrography
Deep Sea Sdgs.
Longitude determination (telegraphic)
Magnetic observations
Tidal observations
JUNE 30, 1920
West of Greenwich
161°
160°
159°
158°
157°
156°
155°
22°
21°
20°
19°
KAUAI
Niihau
OAHU
Pearl Harbor
Honolulu
MOLOKAI
Kaunakakai
Lanai
MAUI
Kahoolawe
HAWAII
Hilo
COLON HARBOR
AND
BAY OF PANAMA
CARIBBEAN SEA
80°00'
79°30'
9°30'
9°00'
8°30'
COLON HBR
Colon
Gatun
CANAL ZONE
Culebra
Balboa
Panama
BAY OF PANAMA
Triangulation
Topography
Hydrography
Magnetic observations
Tidal observations

C & G.S. Print

PLATE No. 2949






C. & G. S. Print

worthy condition; but much additional work yet remained to be done in order to put the vessel in an equally good condition as before turning it over to the Bureau of Labor. Though the *Marinduque* was returned to the Bureau of Coast and Geodetic Survey on July 7, it was not until September 26 that the work of urgent repairs was completed.

The Philippine Legislature at its last session, in accordance with an estimate prepared by this Bureau, made appropriations for the purchase and installation of a photolithographic printing plant to be operated by the Bureau of Coast and Geodetic Survey. Provision was also made for sending to the United States two Filipino employees of the Bureau to take up the study of advanced method in photolithography.

Liberal appropriations were made for carrying on all the activities of the Bureau, and additional sums over former annual appropriations were made available to meet the advanced cost of all commodities used in the prosecution of our work. All surveying vessels on this station will soon be equipped with radio sets, as an allotment was made for the purchase and installation of a radio equipment for the steamer *Marinduque*.

As before mentioned, the localities in which the vessels have been operating have been selected after taking into consideration the accessibility to coaling stations.

This has resulted in operations being confined to the Sulu Sea; that part of Palawan near the coaling station of Sandakan, Borneo; and the west coast of Mindanao. While operating along the west coast of Mindanao coal could be obtained from the Department of Mindanao and Sulu at its Caldera Bay coaling station at a price much lower than at other Government coaling stations; however, this preferential rate was given only while the coast of Mindanao was being surveyed.

During the past fiscal year the steamer *Pathfinder* was engaged in surveying duties only 228 days, or 62.5 per cent; the remainder of the time was occupied in work of repairs to the vessel. On account of the numerous demands made upon the naval stations for repairing vessels of their fleet, and the congested condition of the local commercial shipyards, work of repairs to the vessels of this Bureau is accomplished under many difficulties and with much consumption of time.

On account of unexpected demands being made upon the naval dry dock and the inability of commercial yards to undertake the work, the *Pathfinder* returned to the working ground on April 21 with instructions to continue on surveying duties until some definite date could be given by the naval authorities for docking the vessel.

From April 21 to June 23 the *Pathfinder* was engaged in deep-sea sounding in the Sulu Sea, and during this time satisfactorily completed that area between 8 and 9° north latitude.

The *Pathfinder* returned to Manila on June 25, and at the close of the year was in dry dock at Olongapo.

During the first part of the fiscal year, from July 9 to December 7, the *Fathomer* was engaged in the survey of Cuyo West Pass and the Cagayan Islands.

From December 8 to April 8 the *Fathomer* was at Engineers Island, Manila, undergoing repairs, and from this latter date to June 30 was engaged in surveying duties on the west coast of Mindanao and Cuyo West Pass.

During the past year and on account of the great delay in making repairs by the Government shipyard at Engineers Island, Manila, the *Fathomer* was engaged in surveying operations only 234 days (64.1 per cent).

On July 7 the *Marinduque* was returned to the Coast and Geodetic Survey by the Philippine Bureau of Labor. On account of the neglecting of the upkeep of this vessel by the Philippine Bureau it had greatly deteriorated, and a great deal of time and money was spent during the year to restore the vessel to a condition whereby it would be fit for surveying duties.

Of the entire year only 147 days (40.3 per cent) were occupied by this vessel in surveying operations; the remainder of the time was spent in work of repairs.

The *Romblon* has been occupied in the field 254 days, or 69.9 per cent, of the year; during the remainder of the time, work of repairs was being performed at Engineers Island, Manila. The field work accomplished by the party of this vessel is as follows: Detailed survey of Vinas River, Ragay Gulf; Holland Harbor, Basilan Island; and work along the southwest coast of Palawan Island.

[E. R. HAND, Commanding Steamer *Pathfinder*.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 88 miles, 1,625 square miles of area covered, 17 lines of intervisibility determined, 7 points selected for scheme. Base lines: Secondary 1, 1,895.5 meters in length. Triangulation: 460 square miles of area covered; 9 signal poles erected; 6 observing tripods and scaffolds built, heights 65 and 50 feet; 2 stations in main scheme occupied for horizontal measures; 6 stations in supplemental schemes occupied for horizontal measures; 3 stations occupied for vertical measures; 8 geographic positions determined. Leveling: 3 permanent bench marks established, 3 miles of levels run. Hydrography: 0 4 square mile of area covered; 12 miles run while sounding; 134 positions determined (double angles); 527 soundings made; 2 tidal stations established; 1 hydrographic sheet finished, scale 1 : 20,000.

At the commencement of the period covered by this report, the *Pathfinder* was undergoing repairs at Olongapo Naval Station. On September 18, being ready for sea, she left the station for Manila, where the vessel was fumigated and supplies were taken aboard. On September 26 this ship steamed to Cavite, coaled, took on board certain supplies that were not obtainable at Olongapo, and on the night of September 27 sailed for the next field of operations, northwest Mindanao. The vessel arrived at Dapitan, Mindanao, on the 30th of the month.

The orders under which the work was done were dated September 17, 1919, and called for combined operations over the area between Blanca Point, at the northeast end (limit of former survey), to Coronado Point, at the southwest end, or as far beyond this latter point as necessary to effect a junction with the party coming up from the south. They also required an investigation of a reported reef in Dapitan Bay.

October 1, the day after arrival, saw the initial activities of this field season begun with a search for the reported reef in the bay. It was found after a close launch development, and proved to be a serious menace.

A preliminary reconnoissance was first made, which included entering with the ship of ports Talaguilong (Dapitan Bay) and Santa Maria (southwest of Coronado Point), and building ranges at both places; then with a typhoon refuge at each end of the work the erection of triangulation signals was begun for the scheme chosen. A few days later, October 14, the *Pathfinder* was obliged to seek shelter from a severe typhoon in the first-named harbor.

All signals for the proposed control were erected with the exception of the southwest corner of the Coronado Point quadrilateral. The original plan was to have one figure depending from the base Sansalan-Talinga, and with its opposite side resting on the north shore of Sibuguey Bay. But a most careful reconnoissance failed to reveal a peak adaptable to the requirements of the southeast corner, so no better way was found than to use the triangle Dansalan-Talinga-Quipit for coming over to the Coronado Point quadrilateral. The great figure Siatondisacan-Talinga-Dansalan, which brings the going-ahead line down on Mindanao from the base that spans the straits, promised great difficulties at first; but finally the intervisibility of all the stations was proved and observations completed at two of them, Disacan and Talinga. It was necessary to use heliotropes, for the longest line of this figure is 66 miles, but was carried out with an apparatus devised by the chief of party especially to meet the conditions of this kind of signaling in the islands.

Past experience in the Philippines had indicated two reasons for unsuccessful results with the instrument as furnished for this purpose: Mirror too small, and failure of the operator in maintaining accurate aim, this last due in part to the short distance between the standards that determine the line of sight. The fact is that mirrors will not reflect in this humid climate as they would in a country with a drier atmosphere; for instance, in the great trigonometric survey of India comparatively small mirrors were used over lines of unusual length. But here the uneven refraction causes the reflected beam to wink, and to go out momentarily in the most erratic manner. It had been found that sending messages by heliotrope was out of the question, but with the special apparatus referred to it was thought at least single code letters might be got across; but even this was not possible, due to the blinking just mentioned.

The heliotrope devised for the purpose was constructed and operated as follows: Mirrors 1 foot square were so set in horizontal and vertical axes that however turned the center would remain over the station mark. Through the inch wood backing a funnel-shaped peephole was chiseled, letting direct through the silver in the exact center of the glass. At any one station a frame holding two crossed lengths of marline was set up, about 15 feet in front of heliotrope mirror; then placed in alignment with the peephole and distant station to which

about to show, as soon as vagrant flashes from this last indicated its location. Subsequent procedure entailed merely careful attention on the part of the operator in holding the patch of light on the marline cross wires.

[R. R. LUKENS, Commanding Steamer *Pathfinder*.]

SUMMARY OF RESULTS.—Hydrography: (Deep-sea and launch) 18,176 square miles of area covered; 33.1 miles run while sounding; 137 positions determined (double angles); 634 soundings made; 2 hydrographic sheets finished, scale 1:400,000 and 1:100,000.

On April 1, 1920, the *Pathfinder* was at anchor off Manila. Preparations were immediately begun to complete the necessary repairs and outfit the vessel for sea.

During the time, from April 1 to 20, parties from the vessel made hydrographic and topographic surveys of the junction of the Pasig River and Laguna de Bay, and of the naval anchorage off Cavite. The latter work was desired in order that the commandant might lay out anchorages for the division of destroyers due early in May.

On April 21 the *Pathfinder* sailed for the working grounds, and at daybreak on April 24 started the first line of deep-sea soundings running westward from the coast of Negros. The work went along as well as could be expected as a beginning, until the following day when the rim of the Sigsbee reel split off the drum and threw the machine out of commission.

After tying in the line on the north islet of Tubbataha the ship was headed for Sandakan for bunker coal. That evening a radio was received stating that no coal could be supplied at Sandakan and that the vessel would have to go to the mine at Sebattik, about 300 miles down the Borneo coast. After calling in at Sandakan for 20 tons the *Pathfinder* proceeded to Sebattik, arriving there at noon, April 29.

The run was a trying one, due to the many reefs and strong currents. Pearl Bank light was extinguished, but the submarine sentry gave warning and the vessel hove to for an hour on the very edge of the reef awaiting daylight.

After taking on 245 tons of coal at Sebattik the *Pathfinder* sailed for the working grounds at 6 p. m., April 30. A line of soundings was picked up off Cagayan Sulu Island and carried due east to the Mindanao coast, from whence the vessel proceeded to Zamboanga for mail and supplies. Due to a strike in the interisland merchant marine food stocks in Zamboanga were nearly exhausted, and only a little could be obtained for the ship. The *Pathfinder* left Zamboanga May 7, and on the following day started a sounding line westward from northern Mindanao. With the exception of a day spent on the Palawan coast obtaining fresh beef the ship was engaged continuously in deep-sea sounding until May 29, when the last available sounding reel was crushed. As the fuel was nearly exhausted the ship started for Sandakan via Zamboanga for mail and supplies. A sounding line was run between Zamboanga and Cagayan Sulu, and Sandakan was reached at 4 a. m., June 4.

While the ship was being coaled a new reel for the Lucas machine was cast at the local shipyard, and a Cosmos reel was reinforced with solid cast disks fitted to the rim on each side of the spokes.

At 1.55 p. m., June 7, the *Pathfinder* sailed for the working grounds via Cagayan Sulu, where a stop was made to obtain fresh beef, and at daybreak, June 9, started a sounding line eastward from the Palawan coast. Sounding was continued until June 21, when, in accordance with radio instructions from the Director, the vessel proceeded to Manila, where she arrived at 5.30 a. m., June 24.

Arrangements had been made with the Olongapo Naval Station to dock the *Pathfinder*, so she sailed for Olongapo at 8.30 p. m. of the same date, and immediately upon arrival the following morning was placed in dry dock.

During the season an investigation was made of several dangers to navigation, including Tubbataha Reefs, the reported Rosalia Reef, and Nicholson Reef. Of the two last-named reefs no indications were found, although sounding lines were run over to supposed localities of these reefs.

[S. D. WINSHIP, Commanding Steamer *Fathomer*.]

SUMMARY OF RESULTS.—Base lines: Secondary, 1, 818.58 meters in length. Triangulation: 70 square miles of area covered, 15 stations in main scheme occupied for horizontal measures, 21 geographic positions determined. Leveling: 3 permanent bench marks established, 1.1 miles of levels run. Magnetic work: 2 sea stations at which ship was completely swung. Topography: 15.6 square miles of area surveyed, 47.4 miles of general

coast line surveyed, 1 topographic sheet finished, scales of topographic sheets 1 : 20 000 and 1 : 5,000. Hydrography: 2,183 square miles of area covered; 1,587.4 miles run while sounding; 6,487 positions determined (double angles); 22,815 soundings made; 1 tide station established; 3 hydrographic sheets finished; scales of hydrographic sheets 1 : 200,000, 1 : 80,000, 1 : 40,000, 1 : 20,000, and 1 : 5,000.

At the beginning of the fiscal year the *Fathomer* was at Manila awaiting transfer of the command. An officer and seven men were in camp on one of the Cagayan Islands. The command of the vessel was transferred to A. S. Hallberg on July 3, but was retransferred to S. D. Winship, July 7, and the vessel sailed for the working ground July 9.

After coaling, the vessel left Sandakan and ran into bad weather; course was laid for Cagayan Islands, and three days were spent there measuring a base. A change of wind made the anchorage there unsafe, so a run was made to Cuyo, although it was very evident that there were two distinct typhoons operating near by. On arrival at Cuyo the weather report showed three distinct storm centers, one east of the Visayas, one over northern Luzon, and the worst one in the China Sea west of Palawan. On account of the latter, it seemed advisable to remain at Cuyo rather than change the run to Araceli. On the 29th shortage of coal forced a move to Sandakan. The sphere of influence of all the storms was left behind after two days' run to the south, but, according to the weather observer at Cuyo, conditions there did not improve for a week, making a total of 19 days' low barometer in succession.

After coaling, the vessel started north and ran into the same kind of weather as before. It was necessary to stop 24 hours at Cagayancillo to water and provision the party there, after which course was set for Araceli.

Before reaching that port it became necessary to slow down for several hours till a change of tide improved the conditions somewhat. The vessel lay at Araceli for seven days, during which three typhoons followed each other in close succession up the west coast of Palawan. Wind of force 5—6 was almost constant in the anchorage, and outside a great sea was running.

Fortunately, the weather improved just about the time that coal shortage made it necessary to leave for Sandakan again.

The remainder of August showed fair weather, and a little ship sounding was done.

On the 1st of September the vessel arrived at Sandakan, and on the 7th proceeded to Jolo for a supply of fresh water. Arriving again at the Cagayan Islands on the 13th, there was every indication of bad weather to the northward, so the ship worked in the vicinity of the Cagayan Islands until the 16th, when she returned to Cuyo and Sandakan.

During all this time every effort was made to sound whenever possible. Sometimes only 5 miles were completed in a day. In all, during July, August, and September the ship sounded 13 days, or parts thereof, for a total of 305 miles.

During October and November slightly better weather prevailed, but the handicap of a 600-mile run for coal held the party down to 11 days' ship sounding, for a total of 452.4 miles.

During the entire period a camp party consisting of one officer and from four to eight men was maintained on the Cagayan Islands. This party completed the necessary triangulation there with the exception of occupying station Calusa, the occupation of which was attempted several times but prevented by bad weather. The topography of the group was completed except Anuling Island, and a considerable amount of hydrography completed. On a 1 : 5,000 sheet a development was made of the area between the reef and shore on the south side of Cagayancillo Island, which was used as a ship anchorage when in the vicinity.

On September 23 an automatic tide gauge was installed at the Cagayan Islands. For 40 days continuous tides were observed, after which the continuity of the observations was broken several times for short periods. The gauge was maintained in as good running condition as possible until the camp party broke up.

On November 23 the appearance of inuflenza in Cagayancillo caused the camp party to be abandoned, and it was not reestablished.

Whenever possible while en route to and from Sandakan a deep-sea line was run to fill in the area from 10° 21′ north to the Cagayan Islands. On account of bad weather these lines could not be controlled by astronomic fixes as well as would be desired, the result being that many lines cross and recross. In all 14 lines were run.

On the 1st of December the appropriation for coal ran out, and the vessel proceeded to Manila for repairs, supplies, etc., arriving there on the 7th.

Two days after a launch party of one officer and seven men left for Laguna de Bay to complete the hydrography there. This was accomplished by the 20th, when all hands returned.

[H. B. CAMPBELL, Commanding Steamer *Romblon*.]

SUMMARY OF RESULTS.—Triangulation: 0.27 square miles of area covered; 11 signal poles erected; 13 observing tripods and scaffolds built, height about 10 feet; 20 stations in main scheme occupied for horizontal measures; 26 geographic positions determined. Leveling: 3 permanent bench marks established, 0.5 mile of levels run. Topography: 7.8 square miles of area surveyed; 3.8 miles of general coast line surveyed; 67.7 miles of shore line of rivers surveyed; 10 miles of shore line of creeks surveyed; 7 topographic sheets finished, scales 1 : 10,000 and 1 : 5,000. Hydrography: 130.4 square miles of area covered; 1,382.1 miles run while sounding; 8,698 positions determined (double angles); 46,495 soundings made; 3 tide stations established; 9 hydrographic sheets finished, scales 1 : 5,000, 1 : 20,000, and 1 : 60,000.

On July 1 the *Romblon* was in Ragay Gulf, engaged on a special survey of the Vinas River. This work was completed on October 7.

In July cholera broke out at various places on the river, most seriously at its mouth. In the immediate locality of work there were about 60 deaths from this cause during the month. Smallpox was also reported, but it is doubtful if there were more than a few isolated cases. All possible precautions were taken by the field party to prevent contagion, and field work was continued.

A passing typhoon late in July prevented leaving for coal until August 2, when the supply was reduced to the approximate quantity required to reach Manila. On account of the cholera epidemic no parties were left in camp. The vessel arrived in Manila on August 15, being delayed by rough weather due to an unusual series of typhoons east of Luzon.

At Manila from August 16 to September 3 the boiler was cleaned, coal and general stores taken, and minor repairs to the boiler effected. Leaving Manila, September 4, the vessel arrived on the working grounds on the 5th. Field work was continued at once and completed in this locality on October 7.

Under instructions from the Director of Coast Surveys, the vessel left at once for Romblon where enough coal was taken to reach Sandakan, via Southern Palawan. A stop was made at Puerto Princesa for stores. During this run the *Romblon* was delayed by the passage of two typhoons. After receiving stores, the field work on the southeast coast of Palawan, where it had been broken off the year before, was taken up. On December 31 the *Romblon* was still on these working grounds.

The only triangulation done by this party during the period covered by this report was that on the Vinas River. This consisted of a very small scheme which was run up the banks of the river. There were no unusual features involved except the very short lines, and the number of observing tripods built in the mud and water. No base line was measured.

The topography done on the Vinas River was of an unusual and difficult nature. The greater part was done on a 1 : 5,000 scale, and unusual accuracy was required. The planetable only was used on the main stream, where the banks were for much the greater part of mangrove, overhanging soft mud and water.

For about 4½ miles above the triangulation, a planetable traverse was made to the approximate head of navigation. This part of the work was carried on with difficulty, as considerable cutting had to be done because of the nature of the banks.

All side streams, creeks, and sloughs were run in using the sextant and compass for directions, and the rod readings for distances.

On the Palawan coast the main shore line had already been located, and the only topography done was on rivers and creeks with a few contours. The method just described was used in surveying these rivers.

The hydrography of the Vinas River was completed. The system of 25-meter lines, required by the instructions was done entirely with a whaleboat. An attempt was made to use the launch for the channel lines, but it proved impracticable.

Off Palawan the greater part of the work remaining was hydrography. During the season of 1918 the weather was such that it was impossible to complete the development on the inshore ship sheets. During the season special attention was paid to this work with the result that both of these sheets are to be

turned in as completed. The little remaining work on one of them will be done on a small section of the boat sheet.

The launch continued the inshore hydrography in the locality of Island Bay. This party was laid up a good share of the time by the weather, which even prevented much work in this bay.

The hydrography of the rivers surveyed was completed as soon as the topography was done, a pulling boat and the motor whaleboat being used.

The work of the party was hindered to a considerable extent by the unusual weather. During the year about 26 typhoons are reported to have passed close enough to the islands to affect the weather in the locality of the work.

[H. B. CAMPBELL, Commanding Steamer *Romblon*.]

SUMMARY OF RESULTS.—Leveling: 3 permanent bench marks established, 0.3 mile of levels run. Topography: 305.6 square miles of area surveyed; 1 topographic sheet finished, scale 1:40,000. Hydrography: 258.3 square miles of area covered, 1,318.4 miles run while sounding, 5,797 positions determined (double angles), 21,655 soundings made, 2 tide stations established.

From February 24 to March 1 the *Romblon* was at Caldera Bay, endeavoring to obtain a supply of coal. Leaving Caldera Bay March 2, the vessel arrived on the working grounds on the same date. Camp parties were put out, and the ship proceeded to Sandakan for coal.

The work in this locality was continued until April 21, at which time the work required by the instructions was completed, and the monsoon had changed enough, apparently, to permit work to advantage on the Palawan coast.

The *Romblon* left Basilan Island on April 22 and proceeded to Palawan by way of Jolo and Sandakan.

From April 27 to June 20, work was continued on the Palawan coast. During this period coal was obtained at Sandakan, but owing to the presence of bubonic plague in that port the vessel was obliged to go to Puerto Princesa for water.

Leaving the working grounds on June 20, the *Romblon* proceeded to Manila, arriving on June 24.

During the remainder of the month a general overhauling was started, and preparations were made for transfer of command.

The only triangulation done by this party during the period covered by this report was on the west and southwest side of Basilan Island. The scheme to the north of the island was extended around the west coast to the locality of Maluso Bay. The work done furnished control for the local survey of Maluso Bay and forms a part of the scheme that will eventually encircle the island.

The topography done on Maluso Bay consisted of one 1:10,000 sheet, which was completed, and a small subsheet on a scale of 1:5,000 of Port Holland. The greater part of this work was done ahead of the triangulation and was later adjusted where necessary, to agree with triangulation intersection stations.

On the Palawan coast a very little topography was done on the creeks in the locality of Island Bay in January, using stadia distances with directions determined by the sextant and compass.

During May and June the contours were determined of the peaks lying south of Island Bay as far as triangulation stations Mant and Pici. This work was done on a 1:40,000 scale, and it is believed with a degree of accuracy that will fill all requirements. Owing to the distance inland of the peaks, it was necessary to occupy two tree tops and the peak Addison to obtain planetable locations and elevations of the prominent points. The rest of the locations and the sketching of contours was done by the use of the sextant from the ship and anchored whaleboats.

At Maluso Bay the hydrography was done entirely with launch and whaleboat, the whaleboat being used in the harbor development and on shoals.

On the Palawan coast the route usually followed by vessels running coastwise was completed to a juncture with the *Pathfinder's* work in the locality of Island Bay. Inside of this is a small area of launch work remaining to be developed, which will be of little practical importance because of the foulness of the bottom. Offshore, however, there is a considerable area and a number of shoals which should be developed on as large a scale as practicable.

At Maluso Bay an automatic tide gauge was kept in operation for about two months, and in addition a simultaneous comparison was made with Zamboanga.

Tides were read or an automatic gauge was used in Island Bay while work was being done off the Palawan coast.

No currents were measured.

Weather conditions were found to be very favorable during March and April on the south coast of Basilan.

[KENNETH T. ADAMS, Commanding Steamer *Marinduque*, July 1, 1919, to Feb. 29, 1920, and Steamer *Fathomer* from Mar. 1, 1920, to June 30, 1920.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 28 miles, 390 square miles of area covered, 11 lines of intervisibility determined, 4 points selected for scheme. Triangulation: 1,544 square miles of area covered; 21 signal poles erected, 7 observing tripods and scaffolds built, average height 54.5 feet; 12 stations in main scheme occupied for horizontal measures; 16 stations in supplemental schemes occupied for horizontal measures; 27 stations occupied for vertical measures; 70 geographic positions determined; 52 elevations determined trigonometrically. Magnetic work: 4 land stations occupied for magnetic declination, ship swung at two stations at sea. Topography: 8 miles of general coast line surveyed, scale of topography 1:20,000. Hydrography; 546.4 square miles of area covered, 1,825.15 miles run while sounding, 3,116 positions determined (double angle), 8,865 soundings made, 1 tide station reoccupied; scale of hydrography 1:80,000.

The main-scheme triangulation on the west coast of the Zamboanga Peninsula was started from the line Lampinigan–Sangboy of the former triangulation. The first advance was made through a large three-sided central-point figure to the line Sangboy–Patag. The next figure was also a large three-sided central-point figure giving an advance to the line Pata–Pincan. The first figure was a four-sided central-point figure with one diagonal observed, giving an advance to the line Siokun–North End.

All of the above work was accomplished on the U. S. S. *Marinduque*, except the building of a signal at station Siokun and the occupying of North End. This included also the building and locating of the supplementary stations—Batal, Pona, Limasun, Morog, Botot, Parang, and Kauit—and also the building of signals at Bald, Siraguay, and Jaro.

The above work was done under extreme difficulties; the party was small, and the officers were not experienced in this type of work. During the months of October and November cloudy and rainy weather was so prevalent that even reconnoissance was mere guesswark. The highest peaks were always surrounded by clouds. Practically nothing was known about the topography of the peninsula, and all stations were located by local reconnoissance. In December the weather cleared somewhat, but the bulk of the above work was done in January.

The entire country is heavily wooded, even the highest summits; and not a main-scheme station, with the single exception of San Ramon, was established without a great deal of clearing. The topography of the country was such that the stations had to be put on the highest peaks, two at least of which were quite a distance inland, and local guides in most cases were found quite useless.

The U. S. S. *Fathomer* resumed this work on April 8, 1920; three main-scheme stations were built, the reconnoissance of which had been previously completed by the U. S. S. *Marinduque*, and five main-scheme stations were completely occupied and two main-scheme stations reoccupied. This completed the four-sided central-point figure Patag–Pincan–North End–Siokun, and the next figure was a large four-sided central-point figure, with one diagonal observed, advancing from line Siokun–North End to the line Labuk–Quipit.

Seven supplementary stations were built by the U. S. S. *Fathomer* and eight stations were located, leaving two stations incompletely located—Basuk and Dikul.

The northern part of this work was rushed primarily to locate hills and mountain peaks to be used by the U. S. S. *Pathfinder* in offshore deep-sea sounding.

Thus it will be seen that in the total work nine new main-scheme stations were built and occupied, two stations reoccupied, and Quipit occupied, forming four large figures. The strength of these figures is very good, considering the topographic conditions. The difficulties of the topography of the country may be realized when it is remembered that in no one of these figures could a quadrilateral, with both diagonals observed, be formed.

In the total work 17 supplementary stations were built and 15 of these located. Here it will be seen that the figures are sometimes weak and that various expedients were resorted to to get these stations located. The topography of this coast made the location of these signals very difficult.

In addition to the above supplementary stations seven intersection stations, all unmarked, some of them without a check, have been located for the assistance of the topographer.

A more or less complete scheme of vertical angles was observed over the entire scheme of triangulation, more complete in the northern part of the work.

The elevations of all triangulation stations were determined, and a practical adjustment of the results has been made.

In connection with the vertical measurements, direct elevation connections were made with the sea at the following stations: Parang, Jaro, Siraguay, Panob, Balili, Basuk, and Dikul, and an elevation connection by vertical angles was made at Santa Maria and Biasong.

On the U. S. S. *Fathomer* three magnetic stations were occupied on the Zamboanga Peninsula, Limasun, Sickun, and Dikul. And to date one station has been occupied in the vicinity of the Cuyos, Dib, Maducang Island.

The topography on the Zamboanga Peninsula was barely started, a few days' work only being done on one sheet, and that very incompletely.

No hydrography was done on the Zamboanga Peninsula work.

Ship hydrography was begun in the Cuyo West Pass on May 21, 1920, and was in progress at the close of the fiscal year. Satisfactory progress was made, all the work at the south end of sheet P1445 being completed up to the latitude 10° 50′ north and the work to the westward being completed east to longitude 120° 12′ east.

Numerous patches of 20 to 25 fathoms were found, but no dangers or indications of dangers were discovered.

## VIRGIN ISLANDS.

[O. W. SWAINSON.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 5 miles, 12 square miles of area covered, 6 points selected for scheme. Triangulation: 10 square miles of area covered; 20 signal poles erected; 2 observing tripods; 2 observing scaffolds built, height 16 feet; 5 stations in main scheme occupied for horizontal measures; 4 stations in supplemental schemes occupied for horizontal measures, 9 stations occupied for vertical measures; 45 geographic positions determined; 4 elevations determined trigonometrically. Magnetic work: 1 station on land occupied for magnetic observations. Topography: 50 square miles of area surveyed; 44 miles of detailed shore line surveyed; 10 miles of shore line of ponds surveyed; 180 miles of roads surveyed; 4 topographic sheets completed, scale 1 : 10,000.

On July 1, 1919, work was in progress on the detailed survey of the Virgin Islands undertaken at the request of the Navy Department.

On that date the survey of the islands of St. Thomas and St. John had been completed. The latitude and longitude had been carried to the island of St. Croix, and the triangulation on St. Croix from the western end of Christiansted had been finished. No topography had been done on St. Croix.

The work was continued in the same manner as in previous seasons. More accuracy and detail was obtained in the survey of St. Croix than in the case of the other two islands for the reason that St. Croix was more cultivated, less wooded, and the estate boundaries were better defined. Consequently better topographic sheets were obtained.

The topography of the island of St. Croix was begun July 8. The first sheet embraced the area from 1 mile east of Christiansted to 3 miles west of that place. Control for this sheet had been furnished by triangulation and plane-table determinations of positions of flags placed on the hills. The elevations of most of the points determined by triangulation had been determined with the theodolite and computed.

The topography on the sheet covering the western end of the island was begun August 28, from which date, except during November, two topographic parties were constantly in the field.

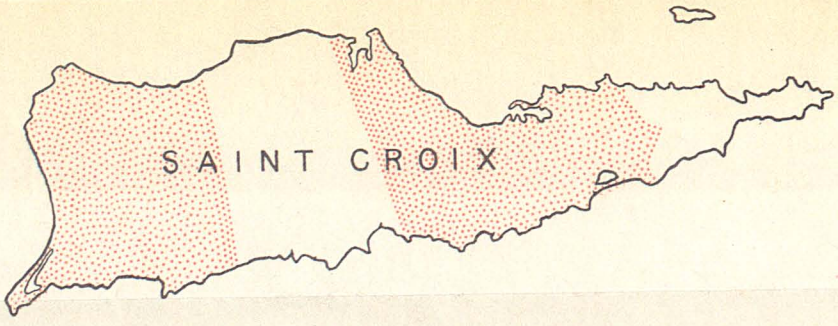
Practically all of the estate boundary lines were located, as well as the roads and many of the fences. Twenty-foot contours were used.

By December 31 the topography of the area from Seven Hills to the Diamond Ruby estate and two-thirds of that from Mount Pleasant to the western end of the island was completed.

The triangulation was continued as required to the eastward as far as Seven Hills. The scheme was laid out and signals erected to the eastern end of the island.

# VIRGIN ISLANDS
## FIELD OPERATIONS
## 1920

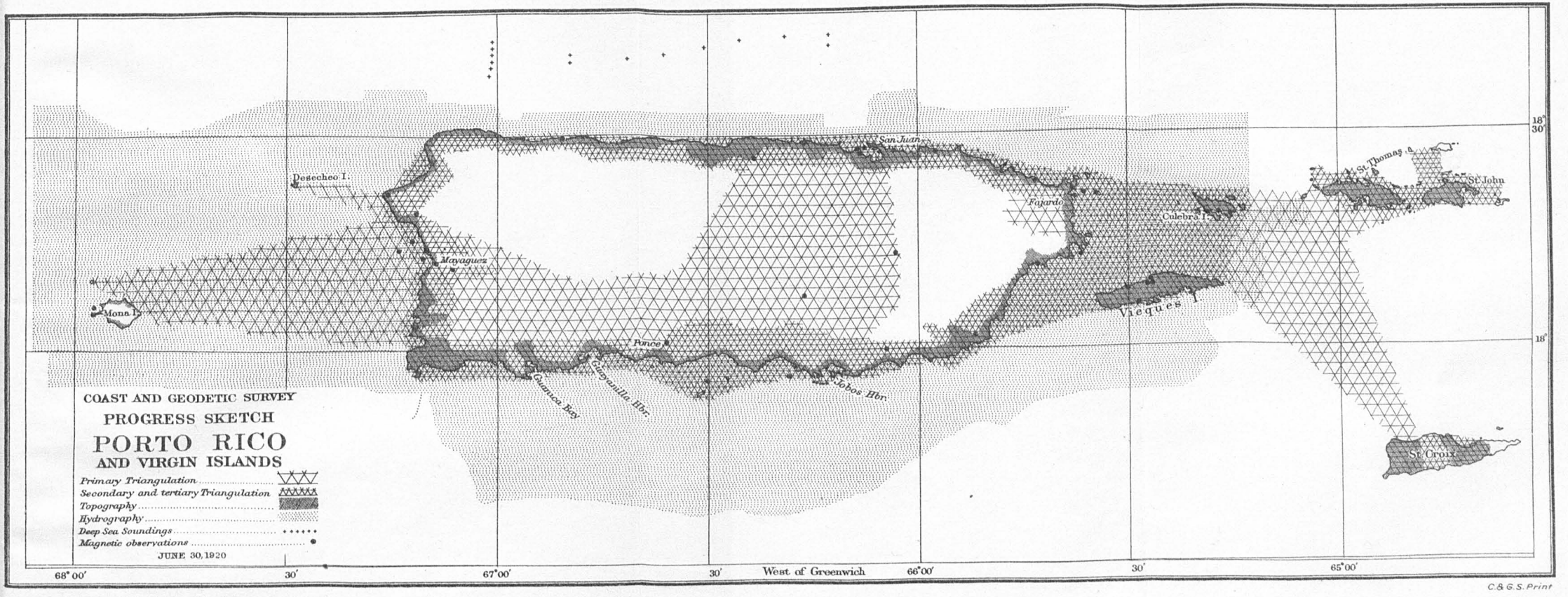
*Topographic surveys*




U.S.Coast and Geodetic Survey



C.&G.S.Print


COAST AND GEODETIC SURVEY
PROGRESS SKETCH
PORTO RICO
AND VIRGIN ISLANDS
Primary Triangulation
Secondary and tertiary Triangulation
Topography
Hydrography
Deep Sea Soundings
Magnetic observations
JUNE 30, 1920
Desecheo I.
Mayaguez
Mona I.
Ponce
Guanica Bay
Guayanilla Hbr.
Jobos Hbr.
San Juan
Fajardo
Culebra I.
Vieques
St. Thomas
St. John
St. Croix
18° 30'
18°
68° 00'
30'
67° 00'
30'
West of Greenwich
66° 00'
30'
65° 00'

C.&G.S. Print

The geographic positions of 180 objects between the western end of the island and the Green Cay estate were determined. The elevations of most of these objects were also determined by triangulation.

The magnetic station at Christiansted was recovered and occupied with the declinometer.

Instructions were received on January 8 to discontinue the survey at a point where it could be conveniently resumed at a later date by another party. As considerable work remained to be done on one sheet to finish it, and it being inadvisable to leave the sheet uncompleted, and as the other sheet was in such condition that after only a few more days of work it could be readily left for another party to finish, the personnel belonging to one field party was discharged January 15 in order to conserve funds for the completion of the second sheet.

Thereafter every effort was made to finish the second sheet with the least possible expenditure and in the least amount of time.

The weather was unfavorable for field work during a large portion of the months of January and February. The wind was very strong. The work was frequently interrupted by heavy showers. The amount of rainfall was unusual for this time of the year.

On March 1 the field work on the second sheet was completed with the exception of blocking in the town of Frederiksted. The officer in charge of the sheet proceeded to block in the town while the chief of party completed the first sheet to a point decided upon.

By March 20 the services of the officer attached to the party could be dispensed with, so he was detached in order to proceed to Washington and there complete the office work on his sheets. The chief of party remained to take the launch and its gear to St. Thomas for storing with the naval authorities and to finish the details incident to closing the field work.

While in St. Thomas the chief of party called upon the governor and the important naval and Marine Corps officials and notified them of his intended departure and the state of completeness of the survey. Gratification and satisfaction with the work was expressed by all. The governor desired that when the survey was resumed the same character of work be done.

Endeavor was made to secure a blue print or other data regarding the dredged area in St. Thomas Harbor. No trace of the existence of such data could be found. The harbor master had the original working sheet used by the dredge, but it was incomplete. He said that he had checked up the dredged area when the work was completed and found it to be as specified. He also said that the limits as shown on the present chart were correct. The chief of party checked the chart roughly with the dredge's working sheet and found them to be similar.

Sextant angles were taken in the vicinity of Scorpion Rock on the range for entering the harbor. It was found that the correct entrance bearing was one or two degrees different from that shown on the chart and that the position on the chart of both beacons was in error. They are shown correctly on the topographic sheet covering this area.

Two wireless towers were located that had been erected in St. Thomas since the triangulation in that vicinity was completed.

The chief of party sailed for New York on April 6.

## PORTO RICO.

### VIEQUES MAGNETIC OBSERVATORY.

[WALLACE M. HILL.]

A practically continuous record with the magnetic instruments was obtained at the Vieques Observatory.

A good record was obtained of the very strong magnetic storm of August 11, especially of the total intensity. This storm received considerable attention to places as far distant as Australia.

The magnetograms were scaled for each hour recorded, and computations were made for base line, scale values, and time. Observations were taken at proper intervals for absolute values, scale values, and time.

It was necessary to adjust the variometer several times for what appeared to be a change of level of the supporting piers.

The seismograph was kept in continuous operation, and in addition to a few earthquakes recorded from a distance, several very small shocks were recorded which seemed to be centered about the island of Porto Rico.

On December 15, 16, and 17, and January 5 a large spot was noted on the sun. During this period a search was made for magnetic storms but only small disturbances were noted.

## SPECIAL DUTY.

### MASSACHUSETTS.

[W. C. HODGKINS.]

SUMMARY OF RESULTS.—Triangulation: 12 square miles of area covered, 6 signal poles erected, 7 stations in main scheme occupied for horizontal measures, 27 geographic positions determined. Topography: 2 miles of general coast line run, scale of topography, 1 : 20,000.

Between May 10 and 22, 1920, at the request of the Navy Department, a determination was made of the geographic position of the radio-compass station at Fox Hill Island, Chatham, Mass., and of the azimuths of several prominent objects from the compass station.

The commandant of the navy yard at Boston detailed two civilian employees of the navy yard to assist in the work.

Two triangulation stations, Chatham and Strong, were recovered, and from these stations as a base a scheme of triangulation was developed which included the radio-compass station. This scheme was covered far enough to the southward to redetermine the position of the Chatham Congregational Church spire and the Chatham South Lighthouse, which were desirable as checks on the recovery of the two base stations. The positions of a number of conspicuous objects, churches, water tanks, chimneys, and Coast Guard stations, likely to prove useful aids in case of any future surveys in that vicinity, were determined incidentally.

The radio-compass station is situated almost upon the line between the base stations. The building has a small tower with a square pyramidal roof. Pointings were made upon a mark fixed to the apex of the pyramid, and a platform was built upon the roof on which a theodolite was mounted for the observation of directions to all prominent objects in the vicinity.

Extensive changes having taken place in the outer beach in recent years, topographic sketches of the shore were made and checked at intervals by sextant angles.

The naval force at the air station furnished a small boat and two seamen, by which means access to Strong Island and the ocean beach was obtained.

### FLORIDA.

[J. H. PETERS, Commanding Steamer *Ranger*.]

In accordance with instructions issued April 13, 1920, the party on the *Ranger* determined the geographic position of the United States Naval Radio Compass Station at Camp Shauflee, Santa Rosa Island, Fla., and five azimuths from it to prominent stations within sight.

As the position of a wireless tower at Camp Shauflee, which has now been taken down, had been determined previously, it was only necessary to measure directly the distance and direction from it to the compass station. For this purpose the compass station was occupied with theodolite and directions taken to Deer Point Beacon and to Quarantine Station water tank, these being the only objects visible, owing to fog at the time. As the officer in charge of the installation was awaiting azimuths in order to complete the work, and was satisfied with these three objects, it was not advisable to await clearing until more prominent and distant objects were visible. For future use the azimuths to Pensacola Lighthouse and to the observation tower at the naval air station were computed and furnished to him.

### DELAWARE AND NEW JERSEY.

[O. W. FERGUSON.]

SUMMARY OF RESULTS.—Triangulation: 20 square miles of area covered; 6 signal poles erected; 3 observing tripods built, total height 60 feet; 3 observing scaffolds built, total height 10 feet; 10 stations main scheme occupied for horizontal measures; 30 geographic positions determined.

Between May 25 and 31, 1920, at the request of the Navy Department, the geographic positions of the naval radio compasses at Cape May, N. J., Cape

Henlopen, and Bethany Beach, Del., were determined by triangulation. Azimuths were determined to various conspicuous objects and north and south lines laid out at each of the compasses.

### EXHIBIT OF THE UNITED STATES COAST AND GEODETIC SURVEY AT THE NATIONAL MOTOR BOAT SHOW, NEW YORK CITY.

[D. B. WAINWRIGHT.]

An officer was detailed to take charge of an exhibit furnished by the Bureau at the annual motor boat show held in New York City from February 18 to March 1.

Valuable assistance was rendered by the inspector in charge of the field station at New York, in installing and caring for the exhibit.

While the material for the exhibit was furnished by the Survey the entire expense was paid by the officials in charge of the show.

The results of the exhibit were highly satisfactory both from the large attendance and the interest manifested in the charts, Coast Pilots, and other publications exhibited.

The exhibition was held in the Grand Central Palace, and ample space was provided on the mezzanine floor for the Survey exhibit.

A selection of characteristic charts was shown of localities of special interest, including New York Harbor, Long Island, Boston Harbor, Hampton Roads, and the Delta of the Mississippi. A number of the nautical publications of the Survey and a collection of photographs illustrative of the methods and results of the Survey and of some of the surveying vessels were exhibited. A small model of the wire drag was also shown.

Information was furnished verbally to persons interested by the officer in charge as to the necessity for charts for navigation, with suggestions as to their practical use.

Much interest was shown in the exhibit, particularly by nautical men, yachtsmen, and owners of motor boats.

## NEW YORK.

### SPEED TRIAL COURSE FOR SEA PLANES.

[C. G. QUILLIAN.]

In September, 1919, a 5-mile speed trial course for seaplanes was established off Rockaway Beach, N. Y., at the request of the Navy Department.

The work included the recovery of sufficient triangulation stations to furnish accurate distances, the establishment of two ranges delineating the limits of the course, computations of the angles required for placing the buoys, placing in position a buoy at each end of the course, and placing also two approach buoys and four marker buoys at mile intervals along the course. In addition a number of prominent objects, which will be of use in future surveys, were located by triangulation in the course of the work.

A brief preliminary description of the course was furnished to the commanding officer of the United States Naval Air Station, Rockaway Point, N. Y.

The trial course was to be 5 miles in length, straightaway, for use of seaplanes. It was desired on the Atlantic Ocean side of Rockaway Beach. The planes were to be flown at low altitude, viz, 25 to 50 feet above the water. The course was not to approach too colsely to the bathing beaches, especially off the Edgemere Hotel. The course also was not to be so near the breakers as to endanger a plane forced to alight or with engine trouble drifting into the breakers.

The problem was to select such a place for the course, place two buoys 5 miles apart, place marker buoys on the course at mile intervals, furnish data for replacing the marker buoys, and furnish data for replacing the end buoys, marking the limits of the course, exactly 5 miles apart.

The most suitable place for the east-end buoy of the course was found to be off Coast Guard Station No. 91. Even here the location of the front range was limited by the buildings which almost shut in the Coast Guard station. Likewise the same general features limited the distance between the eastern ranges and thereby limited the distance offshore of the course.

Coast Guard Station No. 91 was selected as the east-rear range. A tripod was erected on the beach for the east-front range and a point on this range

selected for the east-end buoy. This point was selected from the chart and the distance to the buoy scaled off the chart. The angle at the buoy between the range and the Edgemere Hotel was computed and the distance altered so that the angle at the buoy was an even number of degrees and minutes, 61° 03′ being selected.

Using the above data the proposed geographic position of the east-end buoy was computed. This proposed position of the east-end buoy was considered final and the buoy finally placed in this position.

At the west end of the range the triangulation was extended from two recovered points to C. G. No. 92 and an old Coast Guard station tower, these two points being visible over most of Fort Tilden, where the western ranges were to be located.

Permission was obtained from the Coast Artillery Corps to erect range towers.

An auxiliary station (Aux) was then established near where the west-front range was expected to fall. The geographic position of Aux was determined and the distance and azimuth between Aux and east-end buoy computed by an inverse position computation.

At the time of selecting the proposed position of east-end buoy the general direction of the course was also adopted as bearing 250° (azimuth 70°).

The data now at hand gave the azimuth of the course; the length of the course, 5 nautical miles or 30,401.35 feet, the distance and azimuth between east-end buoy and Aux.

The right-angled triangle east-end buoy, west-end buoy, west-front range was now solved, the following being known: Distance from west-end buoy to east-end buoy 5 nautical miles; the right angle at west-end buoy, and the angle at east-end buoy, the differences in azimuth between the course and Aux. The point west-front range to be on, or on the prolongation of the line Aux to east-end buoy. The distance and azimuth from Aux to west-front range were now available, and the line was laid out by turning off the angle at Aux and taping the distance. West-rear range was placed by setting up at west-front range, turning off the required angle to the proposed west-end buoy, and plumbing and placing the point on the line.

The proposed position at west-end buoy was computed and the angle at west-end buoy between the range and C. G. No. 92 computed, viz, 43° 07′.

The proposed positions of the marker buoys were determined by computing the geographic positions at mile intervals along the course and computing inversely the azimuth to various known points from which the angles at the buoy required to place same were known.

The end buoys were easily placed in position by steaming up on the ranges until the angles were on the sextant and dropping the sinker.

Placing the marker and approach buoys was more difficult, as only one sextant was available and the tug had to be kicked round until both angles taken in rapid succession were on.

Later two approach buoys were dropped and one of the marker buoys shifted, using a standard motor sailer.

After dropping the buoys additional triangulation was done to locate the range towers and the end buoys. Certain delays in building the range towers and the fixed date for obtaining the tug made it impracticable to check the range towers before dropping the buoys.

The triangle locating the end buoys contained the angles observed at two-shore stations and the sextant angle observed at the buoy. The distance was obtained by computing the geographic positions and then the inverse computation between the buoys. The distance between the buoys is 3.6 feet in excess of 5 nautical miles, or 5.00059 nautical miles. This also was the check.

## MARYLAND.

[E. Duvall Bromley.]

Under instructions issued February 3 and November 8, 1920, an officer was directed to make preliminary investigation of the boundary survey for the Aberdeen Proving Ground, through the officials of the War Department and the commanding officer of that post, to ascertain the necessary data relative to establishing the boundary limits of the reservation.

In compliance with the above-mentioned instructions, an investigation was made of the records of the former surveys made by the county surveyor under the supervision of the land commission appointed by the Secretary of War, the

personnel of which had been abandoned at the termination of the war, leaving the boundary limits doubtful in certain sections.

It was the intention of the proving-ground officials to have monuments placed along the boundary limits as near as possible to the former surveys as made by the country surveyor, and to connect these monuments with the scheme of triangulation of the range towers, running secondary traverse around the boundary limits, then to have a new proclamation issued by the President to conform to these new results. The boundary monuments to be used for control points on any part of the reservation for range-firing work, topography, and levels.

After completing this investigation of records and submitting detailed estimates at the request of the commanding officer of the proving ground for the completion of the survey, it was decided that this work should be done by the Army Engineers, and the officer of the Survey detailed for the work was detached.

While on this work a base line determined by the Signal Corps was checked and connected to the triangulation scheme of range towers through the assistance of the proof section of the post.

Upon completion of this and upon the final decision of the Army Engineers the work was abandoned by the Coast Survey.

## VIRGINIA.

[CHARLES SHAW.]

SUMMARY OF RESULTS.—Triangulation: 10.4 square miles of area covered, 6 signal poles erected, 2 stations in main scheme occupied for horizontal measures, 2 geographic positions determined.

In June, 1920, arrangements were begun for laying out for the Navy a triangular speed-trial course for airplanes in the vicinity of Hampton Roads, Va. Field work was begun June 25, and the remainder of the month was used in recovering and rebuilding the necessary signals.

A flight was taken by the observer over the working grounds in one of the Navy seaplanes, by which means the time required in recovering signals was much shortened.

## NORTH CAROLINA.

[C. G. QUILLIAN.]

SUMMARY OF RESULTS.—Triangulation: 3 stations occupied for horizontal measures, 4 geographic positions determined, 1 radio compass located, 1 radio compass oriented.

Between August 30 and September 5, 1919, the geographic position of the Naval Radio Compass Station at Cape Lookout, N. C., was determined, the compass oriented, and a true north and south line established at the compass station for furnishing bearings to vessels.

The radio compass consists of a series of vertical wires wound on a square frame about 6 feet square; through the center of the frame a vertical axis passes and extends through the floor to the receiving room on the floor below. At the foot of the shaft and rigidly secured to the same is a dial with a pointer extending entirely across the dial. Immediately beneath this dial is set a plate graduated in degree from 0 to 360. This plate is secured to the operator's table at center of the shaft and the zero set at north. The reading of the dial on the circle is the bearing of the radio signal.

The operation room is screened in on all sides with a copper mesh to cut off distracting influences.

The direction of the radio signal is determined by maximum and minimum sound received, and the coil itself is at right angles to the direction. When the coil is set exactly on north the pointer should read 90°. The important thing is to lay the north and south line so that the position of the coil may be referred to it.

The triangulation station at Fort Macon was recovered, a signal erected, and angles observed. At Cape Lookout Lighthouse an auxiliary point was selected from which Cape Lookout Lighthouse, the Coast Guard station near the radio compass, and the compass station could be seen. At this auxiliary point a signal pole was erected. The Coast Guard tower was then occupied eccentrically, and the auxiliary station cut in. The lighthouse was occupied and the auxiliary station cut in, but observations were not completed on account of haze. The observer then returned to the compass station and turned off the

angles to the compass from the auxiliary station and marked the line on the floor of the station. Computations were made to obtain the azimuth.

As a check the auxiliary station was occupied and observations made on Polaris and on the compass station.

From the direction at the Coast Guard station and Cape Lookout Lighthouse the azimuth to the auxiliary station was obtained, and then the azimuth of the line joining the auxiliary station and the compass station. The north line was afterwards laid off by tangents and marked on the compass deck, and Cape Lookout Lighthouse was reoccupied.

## LOUISIANA.

[E. B. LATHAM.]

SUMMARY OF RESULTS.—Base Lines, primary, 2, 63, and 317 meters in length. Triangulation: 10 signal poles erected; 3 observing tripods and scaffolds built, heights 30 feet; 8 stations in main scheme occupied for horizontal measures; 15 geographic positions determined.

Between February 18 and February 23, 1920, a determination was made by triangulation of the positions of the naval radio-compass stations at Pass a Loutre, Southwest Pass, and Grand Isle, La.

Transportation for the observer was furnished by Naval subchaser No. *191*.

At Burwood station signal and scaffold building was begun February 19, and observations were completed February 23.

The position of the station and the position of an iron tank were determined. An azimuth mark was established, and a north and south line was set inside the compass-station house, in the plane of the upper end of the radio-compass spindle carrying the coil.

At Pass a Loutre the light station was reported to have sunk 17 feet in the mud. The position of the central iron column of the lighthouse at the present surface of the ground was assumed to be in the position previously determined by this Bureau. The spindle at the top of the light structure had settled to the west. The amount of settlement was determined, and the change in azimuth between this position and that of South Pass Light station and tower at North East Pass was computed and found to be so small as to be negligible. A small supplemental triangulation was made to obtain the distance and direction of the radio-compass station and these were used to compute the position and azimuth required. An azimuth mark was established, and a north line was set inside the compass-station house.

At Grand Isle three old triangulation stations were recovered, and a triangulation was carried from the base Martigan-Barataria Lighthouse to the compass station. A short base was measured, and a check position was obtained to the old station wireless telegraph pole. The compass station was marked vertically below the lower end of the compass spindle, and the azimuth mark was marked as a reference mark for the compass station. A north line was marked inside the compass house in the plane of the upper end of the spindle.

## AIRPLANE PHOTOGRAPHY.

On July 1, 1919, two field parties were engaged in experimental work, determining the possibilities of airplane photography in connection with hydrographic and topographic surveying. E. F. Church was serving as secretary of the research committee engaged in the study of the application of airplane photography to mapping.

C. G. Quillian represented the Coast and Geodetic Survey at Atlantic City, N. J., during July, 1919, when experimental photographs were made of Atlantic City and the adjoining marshy area. He furnished the ground control while the Army and Navy Air Services made the aerial photographs. The Army officers experimented with two types of planes and two different cameras. The Navy officers used a hydroplane and a dirigible balloon and two types of cameras. The results of these experiments furnished a great deal of useful information and gave an indication of the many difficulties that must be overcome before airplane photographs can be used for mapping topographic features with accuracy.

During July, 1919, the party on the steamer *Hydrographer*, G. C. Mattison commanding, cooperated with the Naval Air Service at Key West, Fla., in experiments to determine the possibility of locating submerged rocks and coral

heads by means of aerial photography. Various types of cameras were used, as well as different makes of plates and light filters. The photographs were taken at various altitudes and under varying light conditions. The *Hydrographer* and launch appeared in each photograph for purposes of control. This series of experiments proved quite conclusively that airplane photography is of little practical use in locating submerged obstructions.

E. F. Church served on the research committee until September, 1919. During this time he kept in touch with developments in airplane mapping and did some office work on methods of control.

C. G. Quillian experimented with the Atlantic City photographs, and also made a study of the different problems connected with aerial mapping until December, 1919.

G. C. Mattison took up the duties connected with airplane photography on January 22, 1920. He continued the study of methods and kept in close touch with the progress being made by other bureaus and commercial firms. He went to New York City in March to inspect the latest types of cameras, and during the month of April, 1920, witnessed tests of cameras at Dayton, Ohio, by the Air Service of the Army. He was engaged in office work during the remainder of the year.

W. E. Parker served as vice chairman of the committee on photographic surveying, a subcommittee of the Board of Surveys and Maps.

### INTERNATIONAL LATITUDE STATION AT UKIAH, CALIF.

[F. J. NEUBAUER.]

During the fiscal year the identical observing program in use for the last six years was followed at the Ukiah observatory throughout the year. In all 2,079 star pairs were secured, divided about evenly per group.

The instrumental constants were determined at least once a month throughout the year. This enabled the observer to have the zenith telescope under perfect control. All indications seem to show the instrument in very good condition all the time.

The observer received twice during the past year emphemerides of apparent places of the stars observed. Thus approximate latitudes could be computed which served as an index relative to the observer's own observations.

A series of observations is under way for the determinations of new values of one revolution of the micrometer screw and the value of one division of each of the two latitude levels. To all appearances slight changes took place in the value of each. A new method of determination of the variation of latitude is at present under experimental investigation here. A photographic zenith tube designed by Professor Schlesinger, director of the Yale University Observatory, has been installed recently. Since the method of observing with this instrument is entirely automatic, it does not interfere with the observing program of the international program.

Upon the request of the observer funds were provided to carry on some very much needed repairs on the dwelling house, observatory building, and grounds. These repairs are under way and practically completed.

Respectfully,

E. LESTER JONES, *Director.*

To Hon. J. W. ALEXANDER,
*Secretary of Commerce.*

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SOUTH DAKOTA
WYOMING
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CALIFORNIA
NEVADA
UTAH
COLORADO
KANSAS
OKLAHOMA
ARIZONA
NEW MEXICO
TEXAS
LOWER CALIFORNIA
PACIFIC OCEAN
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BISMARCK
FARGO
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SAVANNAH
JACKSONVILLE
TALLAHASSEE
MOBILE
MERIDIAN
JACKSON
MEMPHIS
LITTLE ROCK
FORT SMITH
MUSKOGEE
OKLAHOMA CITY
TOPEKA
KANSAS CITY
JEFFERSON CITY
ST. LOUIS
WICHITA
DALLAS
AUSTIN
SAN ANTONIO
GALVESTON
BATON ROUGE
NEW ORLEANS
TAMPA
KEY WEST
HABANA
C U B A
B A H A M A I S L A N D S
G U L F O F M E X I C O
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30°
25°

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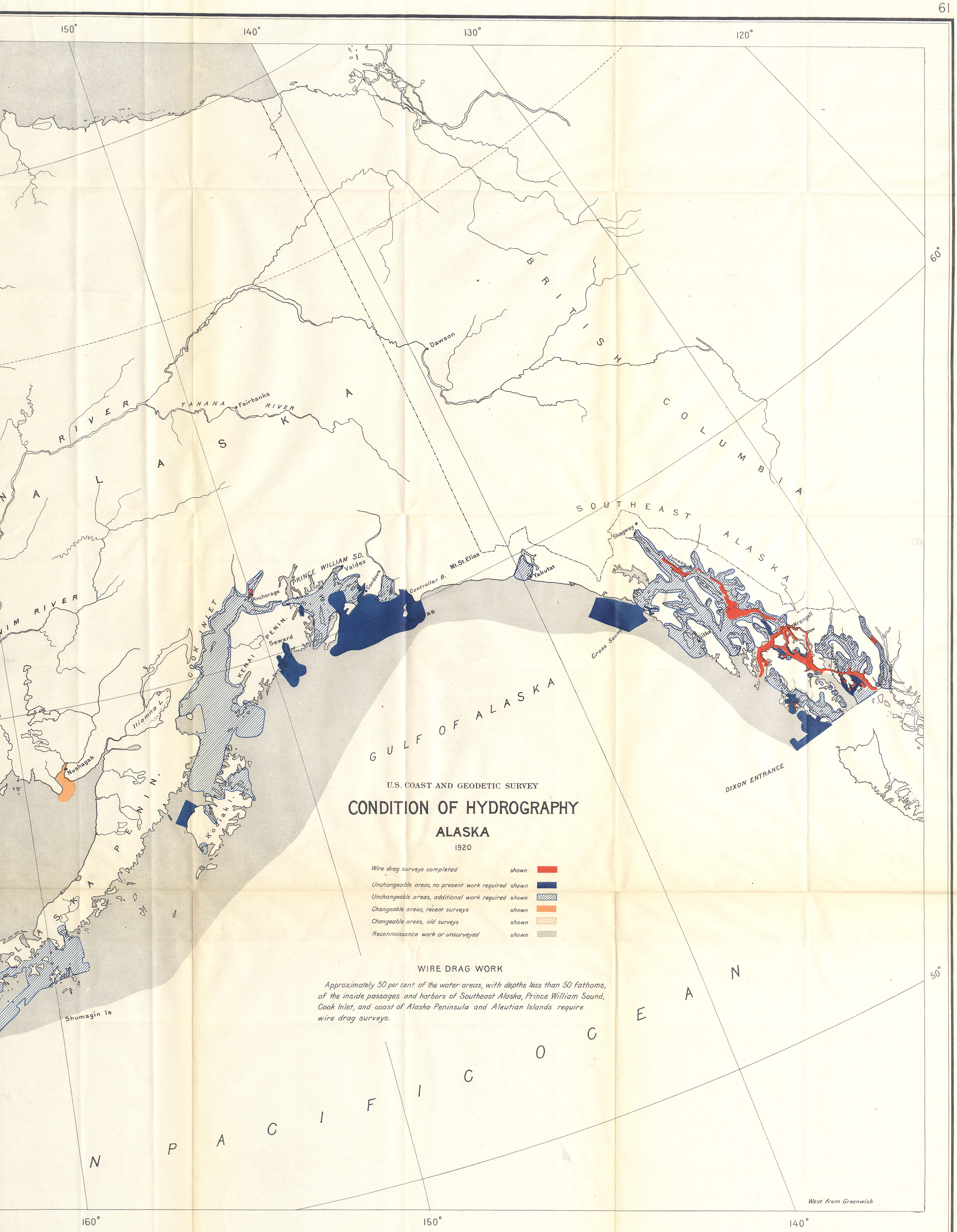
170°
180°
170°
160°
150°
60°
ARCTIC OCEAN
SIBERIA
Pt. Barrow
Icy Cape
Pt. Hope
BERING STR
Nome
St. Michael
YUKON RIVER
KUSKOKWIM RIVER
St. Lawrence I.
St Matthew I
Nunivak I.
Nushagak
BRISTOL BAY
Pribilof Is
BERING SEA
ALASKA PENINSULA
Unimak I.
Shumagin Is
Unalaska I
Umnak I.
Attu I
ALEUTIAN IS
Kiska I
Atka I
Tanaga I
N
East from Greenwich.
180°
170°
160°

C.& G.S. Print


150°
140°
130°
120°
60°
50°
160°
150°
140°
BRITISH COLUMBIA
Dawson
TANANA RIVER
Fairbanks
YUKON RIVER
ALASKA
SOUTHEAST ALASKA
Skagway
Juneau
Wrangell
Sitka
Yakutat
Mt. St. Elias
Controller B.
C. St. Elias
Gross Sound
PRINCE WILLIAM SD.
Valdez
Cordova
Anchorage
COOK INLET
KENAI PENIN.
Seward
Iliamna L.
Nushagak
ALASKA PENIN.
Kodiak I.
Shumagin Is
GULF OF ALASKA
DIXON ENTRANCE
NORTH PACIFIC OCEAN
West from Greenwich
U.S. COAST AND GEODETIC SURVEY
CONDITION OF HYDROGRAPHY
ALASKA
1920
Wire drag surveys completed shown
Unchangeable areas, no present work required shown
Unchangeable areas, additional work required shown
Changeable areas, recent surveys shown
Changeable areas, old surveys shown
Reconnoissance work or unsurveyed shown
WIRE DRAG WORK
Approximately 50 per cent of the water areas, with depths less than 50 fathoms, of the inside passages and harbors of Southeast Alaska, Prince William Sound, Cook Inlet, and coast of Alaska Peninsula and Aleutian Islands require wire drag surveys.